Papahānaumokuākea
Marine National Monument

Draft Monument Management Plan

U.S. Fish & Wildlife Service * National Oceanic and Atmospheric Administration * State of Hawai'i

Volume I

Papahānaumokuākea Marine National Monument

Draft Management Plan

April 2008

Prepared by:

Papahānaumokuākea Marine National Monument

United States Fish and Wildlife Service
300 Ala Moana Blvd., Room 5-231
Honolulu, Hawaii 96850

National Oceanic and Atmospheric Administration
6600 Kalanianaole Highway, Suite 300
Honolulu, Hawaii 96825

Hawai‘i Department of Land and Natural Resources
1151 Punchbowl Street, Room 130
Honolulu, Hawai‘i 96813

Papahānaumokuākea Marine National Monument
Draft Management Plan

Approval Submission

In accordance with Presidential Proclamation 8031, Establishment of the Northwestern Hawaiian Islands Marine National Monument (71 FR 36443), this Draft Monument Management Plan has been prepared for Papahānaumokuākea Marine National Monument to guide coordinated management of this vast marine protected area by the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and the State of Hawai'i. The plan also meets the requirements of the National Wildlife Refuge System Administration Act of 1966, as amended. After incorporating public comments, a final Monument Management Plan will be submitted for approval by all three Co-Trustee agencies.

Note to Reviewers:

The December 2006 Memorandum of Agreement for Promoting Coordinated Management of the Northwestern Hawaiian Islands Marine National Monument identified the Secretaries of Commerce and the Interior, and Governor of Hawaiʻi as Co-Trustees for the Papahānaumokuākea Marine National Monument. The agreement provided for the inclusion of the Office of Hawaiian Affairs into the Monument management process to provide a voice for Native Hawaiians and their legal rights. Through this Agreement and as described in the Monument Management Plan, the Co-Trustees will undertake coordinated, integrated management to achieve strong, long-term protection and perpetuation of Northwestern Hawaiian Island (NWHI) ecosystems, Native Hawaiian traditional and customary cultural and religious practices, and heritage resources for current and future generations.

The Co-Trustees will work together in a coordinated fashion to cooperatively manage areas where joint or adjacent jurisdiction exists, while continuing to honor the policies and statutory mandates of the various management agencies. Therefore, it is important to remember as you read this document that there are both coordinated agency activities and specific Co-Trustee responsibilities. Of course even where one agency has primary responsibility, input from another Co-Trustee can often be helpful, and this continuing coordination is presumed throughout the Monument Management Plan.

The authors of the Monument Management Plan identified three overarching areas, throughout the document, that are important pieces of information to keep in mind as you are reviewing this document. They are set forth below.

1) <u>Cooperative and Individual Co-Trustee Responsibilities</u>

Prior to its designation, several Federal conservation areas existed within the Monument, namely the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, managed by the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce, and the Hawaiian Islands and Midway Atoll National Wildlife Refuges, managed by the U.S. Fish and Wildlife Service (FWS) within Department of the Interior. Nothing in the Monument Management Plan will diminish the responsibilities and requirements by the Federal agencies to continue to manage these areas.

Furthermore, the Proclamation issued by President Bush on June 15, 2006, establishing the Monument expressly stated it did not diminish or enlarge the jurisdiction of the State of Hawaiʻi. In 2005 the State designated all of its waters in the NWHI as a Marine Refuge, and it has jurisdiction over the State Seabird Sanctuary at Kure Atoll, the northwesternmost emergent feature in the NWHI. To provide for the most effective conservation and management of the natural, cultural, and historic resources of the NWHI, Governor Lingle on December 8, 2006, entered into the aforementioned agreement with the two Secretaries to have State lands and waters in the NWHI managed as part of the Monument, with the three parties serving as Co-Trustees.

2) Specific Agency Requirements

FWS must develop Comprehensive Conservation Plans (CCPs) for all National Wildlife Refuges by October 2012. So that there would be a single management plan for the Monument, FWS moved its planning effort forward to have this Monument Management Plan also serve as, and meet the requirements of, the CCPs for the two refuges within the Monument.

Because this Monument Management Plan is a mixture of the draft sanctuary management plan, the refuge CCPs, and State plans, as fully described in Section 2.2 of the plan, it does not resemble typical sanctuary management plans, typical refuge CCPs, or typical State of Hawai‘i management plans. However, we believe this plan and accompanying environmental analysis meet all applicable Federal and State requirements.

3) Funding Estimates

This Monument Management Plan provides long-term guidance for management decisions over a 15-year horizon and sets forth desired outcomes, with strategies and activities to reach those outcomes, including the agencies' best estimate of future needs. These are sometimes substantially above current budget allocations and are included primarily for agency strategic planning and program prioritization purposes. Neither this draft nor the subsequent final plan constitutes a commitment of funds, or a commitment to request funds, by Federal or State agencies. All funding for current and possible future Monument activities is subject to the budgeting and appropriations processes of the Federal and State governments.

EXECUTIVE SUMMARY

Papahānaumokuākea Marine National Monument (Monument) in the Northwestern Hawaiian Islands comprises one of the largest protected areas in the world. The Monument, a vast, remote, and largely uninhabited marine region, encompasses an area of approximately 139,793 square miles (362,061 square kilometers) of Pacific Ocean in the northwestern extent of the Hawaiian Archipelago. Covering a distance of 1,200 miles, the 100-mile wide Monument is dotted with small islands, islets, and atolls and a complex array of marine and terrestrial ecosystems. This region and its natural and historic resources hold great cultural and religious significance to Native Hawaiians. It is also home to a variety of post-Western contact historic resources such as those associated with the Battle of Midway. As such, the Monument has been identified as a national priority for permanent protection as a Monument for its unique and significant confluence of conservation, ecological, historical, scientific, educational, and Native Hawaiian cultural qualities.

On June 15, 2006, President George W. Bush issued Presidential Proclamation 8031 establishing the Northwestern Hawaiian Islands Marine National Monument under the authority of the Antiquities Act of 1906 (16 U.S.C. 431). The Monument includes a number of preexisting Federal conservation areas: the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, managed by the Department of Commerce through the National Oceanographic and Atmospheric Administration (NOAA); and 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 (FWS). These areas remain in place within the Monument, subject to their applicable laws and regulations in addition to the provisions of the Proclamation.

The Northwestern Hawaiian Islands also include State of Hawaiʻi lands and waters, managed by the State through the Department of Land and Natural Resources as the Northwestern Hawaiian Islands 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.

The President accordingly assigned management responsibilities to the Secretaries of Commerce and the Interior, acting through NOAA and FWS. The President also directed the Secretary of Commerce, in consultation with the Secretary of the Interior and the State of Hawaii to modify, as appropriate, the plan developed by NOAA through the public sanctuary designation process and for the two federal agencies to promulgate additional regulations.

The joint implementing regulations for the Monument were promulgated on August 19, 2006 (50 CFR Part 404). These regulations codify the scope and purpose, boundary, definitions, prohibitions, and regulated activities for managing the Monument. Proclamation 8031 was later amended on March 6, 2007, to establish the Hawaiian name of the Monument, Papahānaumokuākea Marine National Monument, and clarify some definitions.

To provide the most effective management of the area, Governor Linda Lingle, Secretary of Commerce Carlos M. Gutierrez, and Secretary of the Interior Dirk Kempthorne signed a Memorandum of Agreement (MOA) on December 8, 2006, which provided for coordinated administration of all the Federal and State lands and waters within the boundaries of the Monument. The MOA provided that management of the Monument is the responsibility of the three parties acting as Co-Trustees: the State of Hawaiʻi, Department of Land and Natural Resources; the United States Department of the Interior, FWS; and the Department of Commerce, NOAA. It also established the institutional arrangements for managing the Monument, including representation of Native Hawaiian interests by the Office of Hawaiian Affairs on the Monument Management Board.

The organizational structure for the Monument consists of:

- a Senior Executive Board composed of a designated senior policy official for each party that is directly responsible for carrying out the agreement and for providing policy direction for the Monument;
- a Monument Management Board (that reports to the Senior Executive 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
- an Interagency Coordinating Committee representing other State and Federal agencies as appropriate to assist in the implementation of Monument management activities.

This Monument Management Plan (Plan) describes a comprehensive and coordinated management regime to achieve the vision, mission, and guiding principles of the Monument and to address priority management needs over the next 15 years. The Plan is organized into three main sections; introduction, management framework, and action plans that address specific issues related to priority management needs.

The introduction provides the vision and mission of the Monument. It also provides the background, setting, environmental and anthropologic stressors, as well as the status and condition of natural, cultural, and historic resources of the Monument.

The management framework for the Monument includes key elements to move toward an ecosystem approach to management. An ecosystem approach to management requires the implementation and coordination of multiple steps in a comprehensive and coordinated way. These key management framework elements include:

- the legal and policy basis for establishment of the Monument;
- the vision, mission, and guiding principles that provide the overarching policy direction for the Monument;
- institutional arrangements between Co-Trustees and other stakeholders;
- regulations and zoning to manage human activities and threats;
- goals to guide the implementation of action plans and priority management needs; and
- concepts and direction for moving toward a coordinated ecosystem approach to management.

The third section of the plan consists of 22 action plans that address 6 priority management needs and provide an organizational structure for implementing management strategies. These priority management needs are to understand and interpret Monument resources, conserve wildlife and their habitats, reduce threats to Monument resources, manage human activities, facilitate coordination, and achieve effective operations. Together the priority management needs, action plans, and strategies are aimed at achieving long-term ecosystem protection for the Monument.

The action plans contain strategies and activities that are aimed at achieving a desired outcome. Each action plan describes the issue or management need, the context and history of the action plan's particular issue or management need, and the strategies and activities planned for the Monument over the next 15 years. Ongoing evaluation and monitoring of these management actions will be conducted to provide informed decision-making and to provide feedback to management on the success of meeting the stated desired outcomes of each action plan.

The six priority management needs, action plans, and corresponding desired outcomes are as follows:

Understanding and Interpreting the Northwestern Hawaiian Islands

- Marine Conservation Science Action Plan
  - ❖ Increase understanding of the distributions, abundances and functional linkages of marine organisms and their habitats in space and time to improve ecosystem-based management decisions in the Monument.
- Native Hawaiian Culture and History Action Plan
  - ❖ Increase understanding and appreciation of Native Hawaiian histories and cultural practices related to the Monument and effectively manage cultural resources for their cultural, educational, and scientific values.
- Historic Resources Action Plan
  - ❖ Identify, document, preserve, protect, stabilize, and where appropriate, reuse, recover, and interpret historic resources associated with Midway Atoll and other historic resources within the Monument.
- Maritime Heritage Action Plan
  - ❖ Identify, interpret, and protect maritime heritage resources in the Monument.

Conserving Wildlife and Habitats

- Threatened and Endangered Species Action Plan
  - ❖ Protect marine mammals and aid in the recovery of threatened and endangered plants and animals within the Monument.
- Migratory Birds Action Plan
  - ❖ Conserve migratory bird populations and habitats within the Monument.
- Habitat Management and Conservation Action Plan
  - ❖ Protect and maintain all the native ecosystems and biological diversity of the Monument.

Reducing Threats to Monument Resources

- Marine Debris Action Plan
  - ❖ Reduce the adverse effects of marine debris to Monument resources and reduce the amount of debris entering the North Pacific Ocean.

- Alien Species Action Plan
  - ❖ Detect, control, eradicate where possible, and prevent the introduction of alien species into the Monument.
- Maritime Transportation and Aviation Action Plan
  - ❖ Investigate, identify, and reduce potential threats to the Monument from maritime and aviation traffic.
- Emergency Response Action Plan
  - ❖ Minimize damage to Monument resources through coordinated emergency response and assessment.

Managing Human Uses

- Permitting Action Plan
  - ❖ Implement an effective and integrated permit program for the Monument that manages, minimizes, and prevents negative human impacts by allowing access only for those activities consistent with Presidential Proclamation 8031 and the implementing regulations of the Monument.
- Enforcement Action Plan
  - ❖ Achieve compliance with all regulations within the Monument.
- Midway Atoll Visitor Services Action Plan
  - ❖ Offer visitors opportunities to discover, enjoy, appreciate, protect, and honor the unique natural, cultural, and historic resources of the Monument.

Coordinating Conservation and Management Activities

- Agency Coordination Action Plan
  - ❖ Successfully collaborate with government partners to achieve publicly supported, coordinated management in the Monument.
- Constituency Building and Outreach Action Plan
  - ❖ Cultivate an informed, involved constituency that supports and enhances conservation of the natural, cultural, and historic resources of the Monument.
- Native Hawaiian Community Involvement Action Plan
  - ❖ Engage the Native Hawaiian community in active and meaningful involvement in the Monument management.
- Ocean Ecosystems Literacy Action Plan
  - ❖ Cultivate an ocean ecosystems stewardship ethic, contribute to the Nation's science and cultural literacy, and create a new generation of conservation leaders through formal environmental education.

Achieving Effective Monument Operations

- Central Operations Action Plan
  - ❖ Conduct effective and well-planned operations with appropriate human resources and adequate physical infrastructure in the main Hawaiian Islands to support management of the Monument.
- Information Management Action Plan
  - ❖ Consolidate and make accessible relevant information to meet educational, management, and research needs for the Monument.

- Coordinated Field Operations Action Plan
  - ❖ Coordinate field activities and provide adequate infrastructure to ensure safe and efficient operations while avoiding impacts to the ecosystems in the Monument.
- Evaluation Action Plan
  - ❖ Determine the degree to which management actions are achieving the goals of the Monument.

Finally, the Appendices include supporting documents such as the unified permit policy, application, and instructions; Midway Atoll Conceptual Site Plan; Midway Atoll Visitor Services Plan; National Wildlife Refuge Appropriateness Findings and Compatibility Determinations; and information about maintaining wilderness character in the Proposed Hawaiian Islands Wilderness. It also includes reference materials such as Presidential Proclamations 8031 and 8112, Monument regulations (50 CFR Part 404), the Memorandum of Agreement for Promoting Coordinated Management of the Northwestern Hawaiian Islands Marine National Monument, and operational protocols and best management practices.

This page intentionally left blank.

TABLE OF CONTENTS i

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AAUS	American Academy of Underwater Sciences
ATBA	Areas to be Avoided
BRAC	Base Realignment and Closure
CFR	Code of Federal Regulations
COPPS	Community Oriented Policing and Problem Solving
CoRIS	NOAA Coral Reef Information System
CPUE	Catch-per-unit-effort
CRED	PIFCS Coral Reef Ecosystem Division
CRER	Coral Reef Ecosystem Reserve
DLNR	State of Hawaii Department of Land and Natural Resources
DOD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FAD	Fish Aggregation Device
FWS	U.S. Fish and Wildlife Service
FFS	French Frigate Shoals
GIS	Geographic Information System
HAR	Hawai‘i Administrative Rule
HAZWOPR	Hazardous Waste Operations and Emergency Response
HIMB	Hawai‘i Institute of Marine Biology
HINWR	Hawaiian Islands National Wildlife Refuge
HRS	Hawai‘i Revised Statutes
HURL	Hawai‘i Undersea Research Lab
ICC	Interagency Coordinating Committee
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LORAN	Long Range Aid to Navigation
MARPOL	International Convention for the Prevention of Pollution from Ships 1973
MBTA	Migratory Bird Treaty Act
MMB	Monument Management Board
MMPA	Marine Mammal Protection Act
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NCCOS	National Center for Coastal Ocean Science
NEPA	National Environmental Policy Act 1982
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMSP	National Marine Sanctuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service of the National Oceanic and Atmospheric Administration
NRC	National Research Council
NRDA	Natural Resource Damage Assessment

NRSP	Natural Resources Science Plan
NWHI	Northwestern Hawaiian Islands
NWR	National Wildlife Refuge
OHA	Office of Hawaiian Affairs
OPA	Oil Pollution Act
PCB	Polychlorinated Biphenyls
PIFSC	NOAA Fisheries Pacific Islands Fisheries Science Center
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
PSSA	Particularly Sensitive Sea Area
RAC	Reserve Advisory Council
ROP	Reserve Operations Plan
R/V	Research Vessel
SCUBA	Self-Contained Underwater Breathing Apparatus
SEB	Senior Executive Board
SHIELDS	Sanctuaries Hazardous Incident Emergency Logistics Database System
SMA	Special Management Area
SOU	Special Ocean Use
SPA	Special Preservation Area
SST	Scientific Support Team
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UXO	Unexploded Ordnance
VMS	Vessel Monitoring System

Introduction

1.1 Monument Setting
1.2 Status and Condition of Natural Resources
1.3 Status and Condition of Cultural and Historic Resources
1.4 Environmental and Anthropogenic Stressors
1.5 National and Global Significance

1.0 Introduction

Presidential Proclamation 8031, issued by President George W. Bush on June 15, 2006, set aside the Northwestern Hawaiian Islands (NWHI) as the Papahānaumokuākea Marine National Monument (Monument), thereby creating the largest fully protected marine conservation area in the world. This Monument designation adds to the moʻokūʻauhau, or the genealogy, of the NWHI, as a place of deep significance to Native Hawaiians, and now, to the Nation and the world.

In the Pacific, the NWHI have played a significant role in the culture and traditions of Native Hawaiians. Significant archaeological finds, as well as oral and written histories, confirm a deep relationship between the Hawaiian people and the NWHI. The region was also considered a sacred place, as evidenced by the many wahi kūpuna (ancestral sites) on the islands of Nihoa and Mokumanamana.

Monument Vision and Mission

Vision

That the health, diversity, and resources of the vast NWHI ecosystems and the wildlife they support – unique in the world – be protected forever.

Mission

Carry out seamless integrated management to achieve strong, long-term protection and perpetuation of NWHI ecosystems, Native Hawaiian traditional and customary cultural and religious practices, and heritage resources for current and future generations.

The NWHI have been the focus of various conservation efforts by the United States, beginning in 1903, when President Theodore Roosevelt sent in Marines to stop the slaughter of seabirds at Midway Atoll. Over the next 100 years, and through the efforts of six U.S. Presidents and one Hawaiʻi Governor, the region received increasing protection, with the culmination being Proclamation 8031 that created the Monument.

Globally, the NWHI are a natural and cultural treasure of outstanding scientific, conservation, and aesthetic value. The establishment of the Monument builds on the long-standing efforts of state and federal agencies, nongovernmental organizations, stakeholders, and the public to provide for long-term protection of the marine and terrestrial ecosystems of the NWHI and the preservation of cultural and historic resources.

Management of the Monument is the responsibility of three Co-Trustees: the State of Hawaiʻi, through the Department of Land and Natural Resources; the U.S. Department of the Interior, through the Fish and Wildlife Service (FWS); and the Department of Commerce, through the National Oceanic and Atmospheric Administration (NOAA). The Co-Trustees are committed to preserving the ecological integrity of the Monument and perpetuation of the NWHI ecosystems, Native Hawaiian culture, and other historic resources. NOAA and FWS promulgated final regulations for the Monument under 50 CFR Part 404 on August 29, 2006. These regulations codify the scope and purpose, boundary, definitions, prohibitions, and regulated activities for managing the Monument. In addition, the Co-Trustees developed and signed a Memorandum of Agreement on December 8, 2006, to establish roles and responsibilities of coordinating bodies and mechanisms for managing the Monument.

Proclamation 8031 states that the Secretary of Commerce, through NOAA, has primary responsibility regarding the management of the marine areas of the Monument, in consultation with the Secretary of the Interior. The Secretary of the Interior, through FWS, has sole responsibility for the areas of the Monument that overlay the Midway Atoll National Wildlife Refuge, the Battle of Midway National Memorial, and the Hawaiian Islands National Wildlife Refuge, in consultation with the Secretary of Commerce. Nothing in the Proclamation diminishes or enlarges the jurisdiction of the State of Hawai‘i. The State of Hawai‘i, through the Department of Land and Natural Resources, has primary responsibility for the Northwestern Hawaiian Islands Marine Refuge and State Seabird Sanctuary at Kure Atoll.

The Memorandum of Agreement also requires the Co-Trustees to develop a Monument Management Plan for ensuring the coordinated management of coral reef ecosystems and related marine environments, terrestrial resources, and cultural and historic resources of the Monument. To develop the Monument Management Plan, the Co-Trustees began with the final draft of NOAA's National Marine Sanctuary Program proposal. This document provided a good basis and background information from which to start. Requirements for the FWS National Wildlife Refuge System Comprehensive Conservation Planning process were added. Alternative plans and management approaches were developed and reviewed in an Environmental Assessment (see Volume II, Draft Environmental Assessment). Finally, through a process of review and synthesis, the draft plan was developed.

The Monument is situated in the northwestern portion of the Hawaiian Archipelago, located northwest of the Island of Kaua‘i and the other main Hawaiian Islands (Figure 1.1). A vast, remote, and largely uninhabited region, the Monument encompasses an area of approximately 139,797 square miles (362,075 square kilometers) of the Pacific Ocean. Spanning a distance of approximately 1,200 miles (1,043 nautical miles/1,931 kilometers), the 115-mile-wide (100 nautical mile/185.2 kilometer) Monument is dotted with small islands, islets, reefs, shoals, submerged banks, and atolls that extend from subtropical latitudes to near the northern limit of coral reef development.

The Monument includes a complex array of terrestrial and marine ecosystems. The NWHI are intimately connected to Native Hawaiians on genealogical, cultural, and spiritual levels. The region’s natural resources, together with its rich Native Hawaiian cultural and other historic resources, give this Monument a unique stature as one of the most significant protected areas in the world.

This Monument Management Plan describes a comprehensive and coordinated management regime to achieve the vision, mission, and guiding principles of the Monument and to address priority management needs over the next 15 years. The plan is organized into three sections including this introduction. This Introduction, section 1, describes the Monument’s setting and the current status and condition of the ecosystem and cultural resources based on existing scientific and historic knowledge. It also describes known anthropogenic stressors that affect Monument resources or may do so in the future.

The management framework for the Monument is described in section 2 and includes key elements to move toward an ecosystem approach to management. This framework comprises the following elements:

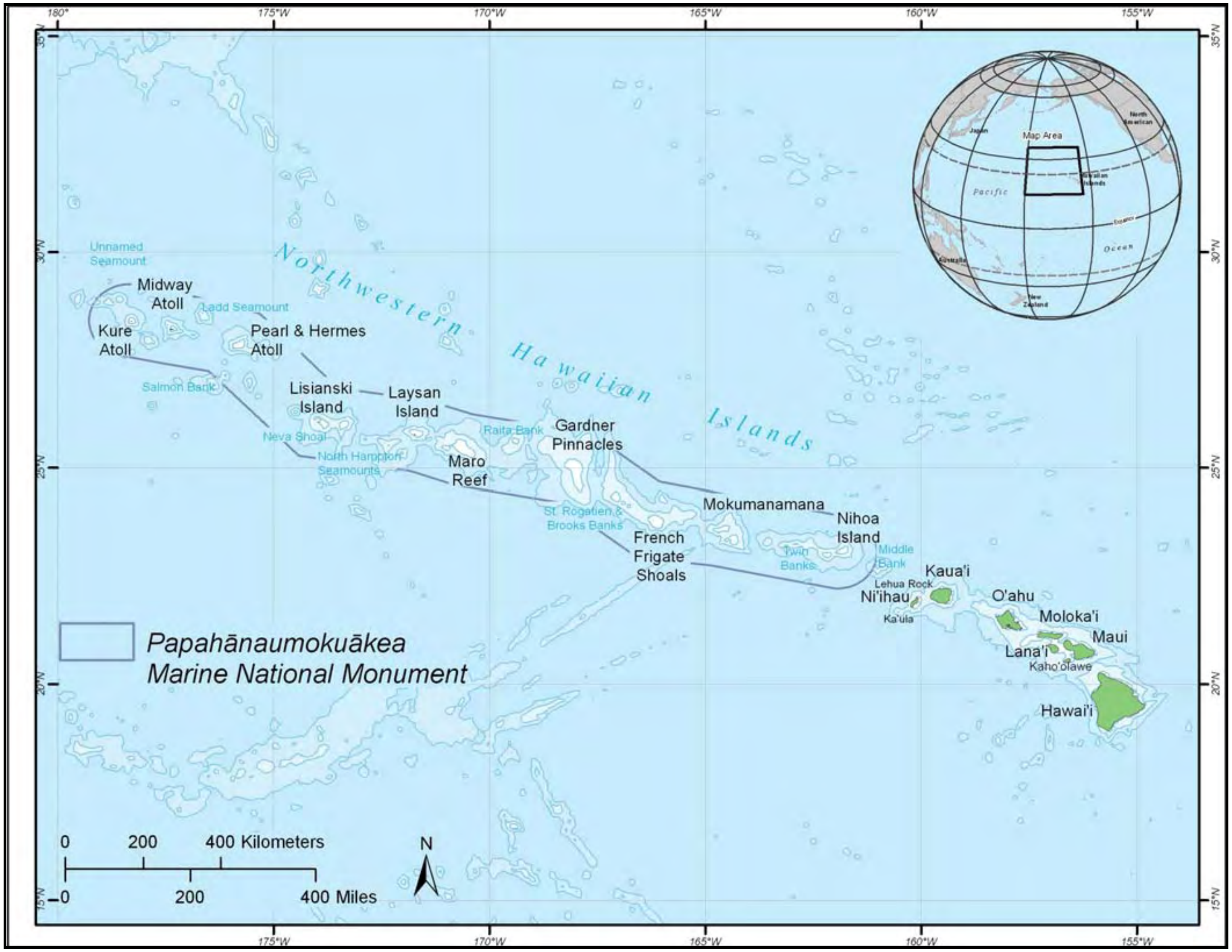
- The legal and policy basis leading to the establishment of the Monument
- Vision, mission, and guiding principles that provide an overarching policy direction for the Monument
- Goals to guide the implementation of specific action plans to address priority management needs
- Institutional arrangements for management among the Co-Trustees and other stakeholders
- Regulations and zoning to manage human activities and threats
- Concepts and direction to move toward a coordinated ecosystem approach to management

Section 3 presents action plans to address six priority management needs over a 15-year planning horizon. These priority management needs are:

- Understanding and interpreting Monument resources
- Conserving wildlife and their habitats
- Reducing threats to Monument resources
- Managing human activities
- Facilitating coordination
- Achieving effective operations

Each action plan consists of multiple strategies and activities to address one or more priority management needs and achieve a desired outcome. Performance measures will be developed to evaluate implementation of the Monument Management Plan. Monument regulations and other policy and operating instruments are provided in the Appendices, along with references.

Figure 1.1 Hawaiian Archipelago Including the Northwestern Hawaiian Islands (Nihoa Island to Kure Atoll) and Main Hawaiian Islands (Hawai'i to Kaua'i). Inset shows the Hawaiian Archipelago in the Pacific Ocean.



1.1 Monument Setting

Hānau Moku–The Birth of Islands

Birth is a core theme in Native Hawaiian culture. Pō, the primordial darkness from which all life springs and returns to after death (Kikiloi 2006), is seen as birthing the world and all of the Hawaiian gods. The union of her progeny, Kumulipo and Pōʻele, births all the creatures of the world beginning in the oceans with the coral polyp—a genealogy that starts with the simplest life form and moves to the more complex.

In keeping with the symbolism of birth, Native Hawaiians view the rising of magma from deep within the earth as birthing of the islands—the physical manifestation of the union between the earth mother, Papahānaumoku, and sky father Wākea. The symbolism of this union is also the foundation for the name of the Monument: Papahānaumokuākea.

From a Native Hawaiian perspective, the NWHI are the kūpuna (elders/grandparents) of Native Hawaiians. As a kupuna, each island is our teacher; each island has its own unique message. As the younger generation, humans are tasked to mālama (care for) our kūpuna. It is our kuleana (responsibility) to take the time to listen to their wisdom.

Overview – Geographic, Geological and Ecosystem Setting

As the world's largest marine protected area, the Papahānaumokuākea Marine National Monument encompasses a vast area of the Pacific. Extending for a distance of roughly 1,200 statute miles (1,930 kilometers) by 115 statute miles (185 kilometers), the Monument covers an area of approximately 140,000 square miles (362,100 square kilometers) and includes a rich, varied, and unique natural, cultural, and historic legacy. The Monument is located approximately between latitudes 22° N. and 30° N. and longitudes 161° W. and 180° W. within the north-central Pacific Ocean. Overlaid on a map of the continental United States, the Monument would cover a distance from the Midwest to the eastern U.S. coastline (figure 1.2).

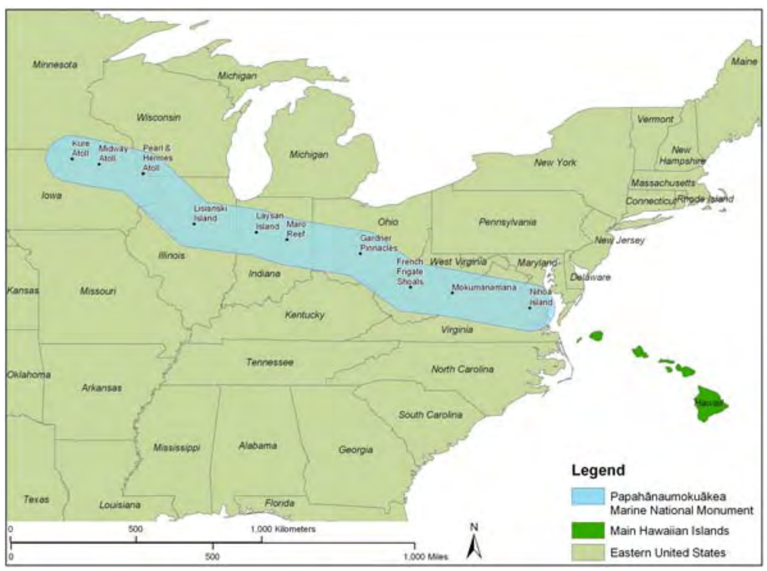


Figure 1.2 Papahānaumokuākea Marine National Monument Overlaid on Eastern North America.

The islands and atolls of the Monument constitute the northwestern three-quarters of the world's longest and most remote island chain. Formed millions of years ago, the islands were created by a sequential series of underwater shield volcanoes which, in combination with the main Hawaiian Islands, form the Hawaiian Archipelago. These once lofty islands have been transported northwest, as if on a conveyor belt, by the movements of the Pacific Plate to their current locations (Dalrymple et al. 1974). Due to the pervasive and unrelenting forces of subsidence and erosion, all that remains today are small patches of ancient land, and shoals and reefs now lie where magnificent mountains once loomed. Northwest of Kaua‘i and Ni‘ihau, the rocky islands, atolls, and reefs become progressively older and smaller.

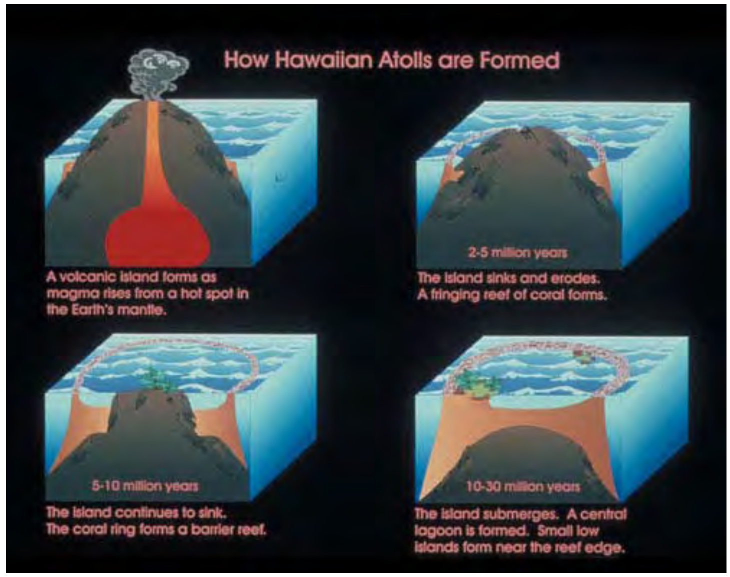


Figure 1.3 Atoll Formation.

Beginning 155 miles (249.4 kilometers) from the main Hawaiian Island of Kaua‘i, the 10 islands and atolls of this chain extend for 1,200 miles (1,931 kilometers) and are referred to as the NWHI, in past decades as the Leeward or Kūpuna Islands, and now as Papahānaumokuākea. None of these islands is more than 2 square miles (5 square kilometers) in size, and all but four have an average mean height less than 32 feet (10 meters). As a group, they represent a classic geomorphological sequence, consisting of highly eroded high islands, near-atolls with volcanic pinnacles jutting from surrounding lagoons, true ring-shaped atolls with roughly circular rims and central lagoons, and secondarily raised atolls, one of which has an interior hypersaline lake. These islands are also surrounded by over 30 submerged ancillary banks and seamounts. This geological progression along the Hawaiian Ridge continues northwestward beyond the last emergent island, Kure Atoll, as a chain of submerged platforms that makes a sudden northward bend to become the Emperor Seamounts, which extend across the entire North Pacific to the base of the Kamchatka Peninsula in Russia. This unbroken chain of progressively more senescent volcanic structures essentially tracks the movement of the Pacific tectonic plate over the past 80 million years, and has provided some of the most compelling evidence upon which current theories of hot-spot-mediated island formation and global plate tectonic movements have been based.

The Monument supports a diverse and unique array of both marine and terrestrial flora and fauna. With a spectrum of bathymetry and topography ranging from abyssal basins at depths greater than 15,000 feet (4,572 meters) below sea level to rugged hillslopes and clifftops on Nihoa and Mokumanamana (Necker) islands at up to 903 feet (275.2 meters) above sea level, the Monument represents a complete cross section of a Pacific archipelagic ecosystem. Habitats encompassed within the Monument include deep pelagic basins, submarine escarpments, deep and shallow coral reefs, shallow lagoons, littoral shores, dunes, and dry coastal grasslands and shrublands. Relatively high percentages of most taxonomic groups in the NWHI are found nowhere else on earth.

Nutrient conditions in the NWHI may be influenced by local and regional factors. Upwelling may occur in response to localized wind and bathymetric features. The Monument is located at the northern edge of the oligotrophic tropical Pacific, in the North Pacific central gyre ecosystem. (See figure 1.4). Regional factors are largely influenced by the position of the subtropical front and associated high chlorophyll content of waters north of the front. High-chlorophyll waters intersect the northern portions of the NWHI during southward winter migrations of the subtropical front. The influx of nutrients to the NWHI from these migrations is considered a significant factor influencing different trophic levels in the NWHI (Polovina et al. 1995). It is near the 18 °C sea surface isotherm, a major ecological transition zone in the northern Pacific. This boundary, also known as the "chlorophyll front," varies in position both seasonally and annually, occasionally transgressing the Monument boundary and surrounding the northern atolls of Kure and Midway. The movement of the front influences overall ocean productivity, and resultant recruitment of certain faunal elements such as Hawaiian monk seals and Laysan and black-footed albatrosses (Polovina et al. 1994.) The northernmost atolls also are occasionally affected by an episodic eastward extension of the Western Pacific warm pool, which can lead to higher summer ocean temperatures at Kure than are found in the more "tropical" waters of the main Hawaiian Islands further south. This interplay of oceanography and climate is still incompletely understood but is a dynamic not seen in most other tropical atoll ecosystems, and it provides a useful natural laboratory for understanding phenomena such as periodic coral bleaching and the effects of El Niño and La Niña ocean circulation patterns.

Ocean currents, waves, temperature, nutrients, and other oceanographic parameters and conditions influence ecosystem composition, structure, and function in the NWHI. The archipelago is influenced by a wide range of oceanographic conditions that vary on spatial and temporal scales. Spatial variability in oceanographic conditions ranges from a localized temperature regime that may affect a small portion of a reef to a temperature regime that influences the entire Monument. Temporal variability in ocean conditions may range from hourly and daily changes to seasonal, annual, or decadal cycles in nutrient inputs, sea level heights, current patterns, and other large-scale oceanographic processes (Polovina et al. 1994). Currents play an important role in the dispersal and recruitment of marine life in the NWHI. Surface currents in the NWHI are highly variable in both speed and direction (Firing and Brainard 2006), with long-term average surface flow being from east to west in response to the prevailing northeast trade wind conditions. The highly variable nature of the surface currents is due in large part to eddies created by local island effects on large-scale circulation. The distribution of corals and other shallow-water organisms is also influenced by exposure to ocean waves. The size and strength of ocean wave events have annual, interannual, and decadal time scales. Annual extratropical storms (storms that originate outside of tropical latitudes) create high waves during the winter. Decadal variability in wave power is possibly related to the Pacific Decadal Oscillation events (Mantua et al. 1997). A number of extreme wave events were recorded during the periods 1985 to 1989 and 1998 to 2002, and anomalously low numbers of extreme wave events occurred during the early 1980s and from 1990 to 1996. Marine debris accumulation in shallow water areas of the NWHI is also influenced by large- and small-scale ocean circulation patterns and El Niño and La Niña events (Morishige et al. 2007).

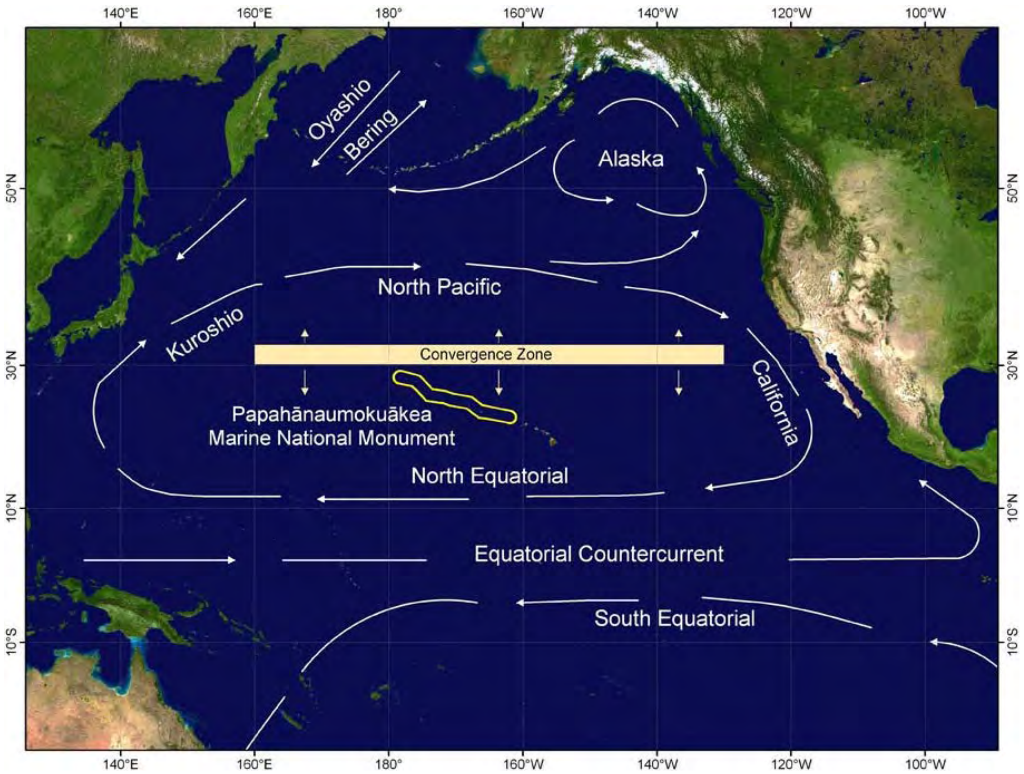


Figure 1.4 Diagram of Central Pacific Gyre. The North Pacific, California, North Equatorial, and Kuroshio currents along with atmospheric winds generate the North Pacific Subtropical Gyre. The Subtropical Convergence Zone, an area where marine debris is known to accumulate, shifts seasonally between 23º N and 37º N latitude.

The physical isolation of the Hawaiian Archipelago explains the relatively low species diversity and high endemism levels of its biota (DeMartini and Friedlander 2004). The direction of flow of surface waters explains biogeographic relationships between the NWHI and other sites, such as Johnston Atoll to the south (Grigg 1981), as well as patterns of endemism, population structure, and density of reef fish within the archipelago (DeMartini and Friedlander 2006).

The shallow marine component of the Monument is nearly pristine and has been described as a "predator-dominated ecosystem," an increasingly rare phenomenon in the world's oceans (Friedlander and DeMartini 2002). Large, predatory fish—such as sharks, giant trevally, and Hawaiian grouper—that are rarely seen and heavily overfished in populated areas of the world are extremely abundant in the waters of the Monument. For instance, such species comprise only 3 percent of fish biomass in the heavily used main Hawaiian Islands, but by contrast represent 54 percent of fish biomass in the waters of the Monument. The NWHI are also characterized by a high degree of endemism in reef fish species, particularly at the northern end of the chain, with endemics comprising over 50 percent of the population in terms of numerical abundance (DeMartini and Friedlander 2004).

Live coral cover is highest in the middle of the chain, with Lisianski Island and Maro Reef having 59.3 percent and 64.1 percent of their respective available substrate covered with living corals (Maragos et al. 2004). Coral species richness is also highest in the middle of the chain, reaching a maximum of 41 reported coral species at French Frigate Shoals (Maragos et al. 2004). The coral reefs of the Monument are undisturbed by fishing or tourism, with excellent health and high species richness; preliminary faunal inventories indicate that many of their constituent species remain undocumented, and new coral species are still being discovered in this area.

The majority of the Monument consists of deep pelagic waters that surround the island platforms. At least 15 banks lie at depths between 100 and 1,300 feet (30 and 400 meters) within the Monument, providing important habitat for bottomfish and lobster species, although only a few of these banks have been studied in any detail (Kelley and Ikehara 2006). These waters represent critical deepwater foraging grounds for Hawaiian monk seals (Parrish et al. 2002) as well as a spatial refugium for pelagic fishes such as tunas and their allies, which have been declared overfished in other regions throughout the world (Myers and Worm 2003).

Scientists using deep-diving submersibles have established the presence of deepwater precious coral beds at depths of 1,200 to 1,330 feet (365 to 406 meters); these include ancient gold corals whose growth rate is now estimated to be only a few centimeters every hundred years and whose ages may exceed 2,500 years (Roark et al. 2006). At depths below 1,640 feet (500 meters), a diverse community of octocorals and sponges flourish. These deepwater sessile animals prefer hard substrates devoid of sediments (Baco-Taylor et al. 2006). Even deeper yet, the abyssal depths of the Monument, while harboring limited biomass, are home to many odd and poorly documented fishes and invertebrates, many with remarkable adaptations to this extreme environment.

The deep waters are also important insofar as they support an offshore mesopelagic boundary community (Benoit-Bird et al. 2002), a thick layer of pelagic organisms that rests in the deep ocean (1,300 to 2,300 feet, or 400 to 700 meters) during the day, then migrates up to shallower depths (from near zero to 1,300 feet or 400 meters) at night, providing a critical source of nutrition for open-ocean fishes, seabirds, and marine mammals. Overall, the fauna of the Monument's waters below standard SCUBA diving depths remains poorly surveyed and documented, representing an enormous opportunity for future scientific research in a system largely undisturbed by trawling or other forms of resource extraction.

Rates of marine endemism in the NWHI are among the highest in the world. In addition, the sheer mass of apex predators in the marine system is simply not seen in areas subject to higher levels of human impact (DeMartini and Friedlander 2004). The Monument represents one of the last remaining unspoiled protected areas on the planet, and virtually every scientific exploration to the area is a voyage of discovery. In the course of just one 3-week research cruise in the fall of 2006, conducted as part of the global Census of Marine Life project, more than 100 potentially new species were discovered at French Frigate Shoals alone.

In contrast to its marine systems, the terrestrial area of the Monument is comparatively small but supports significant endemic biodiversity. Six species of endemic plants, including a fan palm, and four species of endemic birds, including remarkably isolated species such as the Nihoa finch, Nihoa millerbird, Laysan finch, and Laysan duck, one of the world's rarest ducks, are found only in the NWHI. In addition, over 14 million seabirds nest on the tiny islets in the chain, including 99 percent of the world's Laysan albatrosses and 98 percent of the world's black-footed albatrosses. Although still poorly documented, the terrestrial invertebrate fauna also shows significant patterns of precinctive speciation, with endemic species present on Nihoa, Mokumanamana, French Frigate Shoals, Laysan, Lisianski, Pearl and Hermes, and Kure.

Climate

The climate of the entire Hawaiian archipelago features mild temperatures year-round, moderate humidities, persistent northeasterly trade winds, and infrequent severe storms. Hawai'i's climate is notable for its low day-to-day and month-to-month variability (Giambelluca and Schroeder 1998). The climate is influenced by the marine tropical or marine Pacific air masses depending upon the season. During the summer, the Pacific High Pressure System becomes dominant with the ridge line extending across the Pacific north of Kure and Midway. This places the region under the influence of easterly winds, with marine tropical and trade winds prevailing. During the winter, especially from November through January, the Aleutian Low moves southward over the North Pacific, displacing the Pacific High before it. The Kure-Midway region is then affected by either marine Pacific or marine tropical air, depending upon the intensity of the Aleutian Low or the Pacific High Pressure System (Amerson et al. 1974). The surrounding ocean has a dominant effect on the weather of the entire archipelago.

Sea surface temperature is an important physical factor influencing coral reefs and other marine ecosystems. Maximum monthly climatological mean sea-surface temperature measured over the last 20 years at Kure is 80.6 ºF (27 ºC) in August and September (NOAA Pathfinder SST time series; Hoeke et al. 2006), with monthly minimums in February at 66.2 ºF (19 ºC). The large seasonal temperature fluctuations at the northern end of the archipelago result in the coldest and sometimes the warmest sea surface temperatures in the entire Hawaiian chain (Brainard et al. 2004). At the southern end of the Monument, the annual variation in sea surface temperature is much less, with French Frigate Shoals only varying between 74 and 81.5° F (23.3 and 27.5º C) throughout the year. During the period between July and September 2002, sea surface temperatures along the entire Hawaiian Archipelago were anomalously warm, resulting in widespread mass coral bleaching, particularly in the three northern atolls.

Air temperature at the northern end of the archipelago varies between 51 and 92 ºF (11 and 33° C). Air temperature measurements made at six sites on Nihoa Island (23º N. latitude) from March 2006 to March 2007 ranged between 61 and 94 ºF (16 and 34° C). Annual rainfall amounts at Tern Island, French Frigate Shoals are shown in figure 1.5. Annual rainfall over the last 26 years has been 28.85 inches (73.28 centimeters) on average, ranging between 15.99 and 41.04 inches (40.61 and 104.24 centimeters) per year.

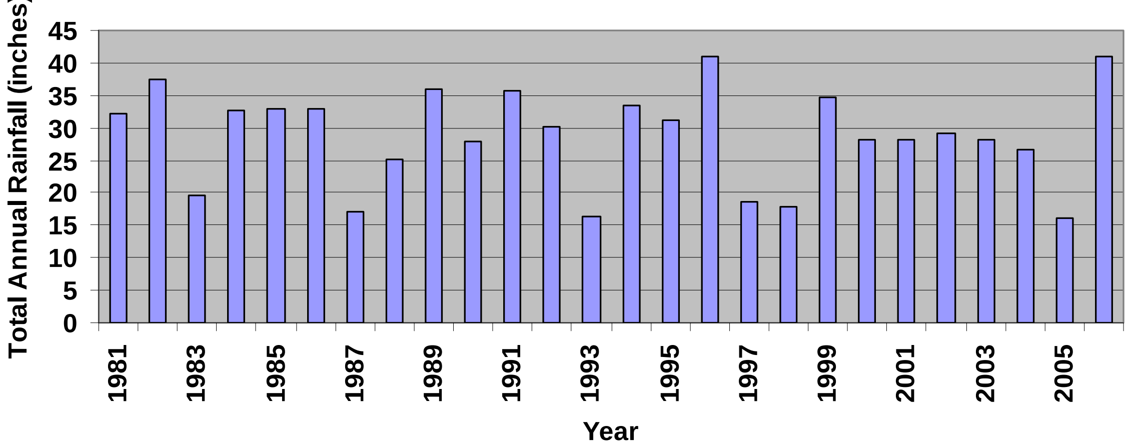


Figure 1.5 Annual Rainfall (inches) Tern Island, French Frigate Shoals.

On average, between four and five tropical typhoons or hurricanes are observed annually in the Central Pacific. Most of these storms develop in the eastern tropical Pacific, but some form in the central tropical Pacific, and occasionally typhoons approach the Monument from the Western Pacific. The strongest hurricane ever recorded in the Monument area was Patsy in 1959, which passed between Midway and Kure with wind speeds of greater than 115 mph (100 knots) (Friedlander et al. 2005). Only two hurricanes nearing the NWHI since 1979 were classified as Category 2 or weaker. No significant tropical storms have been observed in the NWHI since Hurricane Nele passed near Gardner Pinnacles in 1985.

Much more common, and perhaps more significant as a natural process affecting the geology and ecology of the Monument, are the extratropical storms and significant wave events that regularly move across the North Pacific in the boreal winter. These large wave events (>33-foot or 10-meter waves) influence the growth forms and distribution of coral reef organisms (Dollar 1982; Dollar and Grigg 2004; Friedlander et al. 2005) and affect the reproductive performance of winter-breeding seabirds nesting on low islets in the Monument. Most large (16 to 33 feet+ or 5 to 10+ meters) wave events approach the NWHI from the west, northwest, north, and northeast, with the highest energy generally occurring from the northwest sector. The southern sides of most of the islands and atolls of the NWHI are exposed to fewer and weaker wave events. Annually, wave energy and wave power (energy transferred across a given area per unit time) are highest (~1.3 W/m) between November and March and lowest (~0.3 W/m) between May and September. Extreme wave events (33+ feet or 10+ meter waves) affect shallow water coral reef communities with at least an order of magnitude more energy than the typical winter waves (Friedlander et al. 2005).

Islands and Marine Habitats of Papahānaumokuākea

The following section contains brief descriptions of the individual islands and marine habitats within the Papahānaumokuākea Marine National Monument, and their salient physical and biological characteristics. The most commonly used name for each island is given first, with alternative names, if any, provided in parentheses. It should be noted that for the islands northwest of Mokumanamana, the Hawaiian names provided are not yet in use on many modern maps. In addition, multiple Hawaiian names have been given to these islands, with the most ancient still being researched through the study of chants, stories, song, and documents written in the Hawaiian language.

Nihoa Island
23°03′ N., 161°56′ W.

"He puʻu kolo i Nihoa." ("Crawling up the cliffs of Nihoa"). This traditional Hawaiian saying is a compliment to one who perseveres. (Pukui 1997). Nihoa has many craggy cliffs, and the rough surf in the winter makes landing there even more difficult than during the summer. "Nihoa" literally means "firmly set," which could refer to the people who frequented such rugged conditions, and to the pounding that the island takes from the sea and wind. Nihoa has also been known as Moku Manu (bird island).

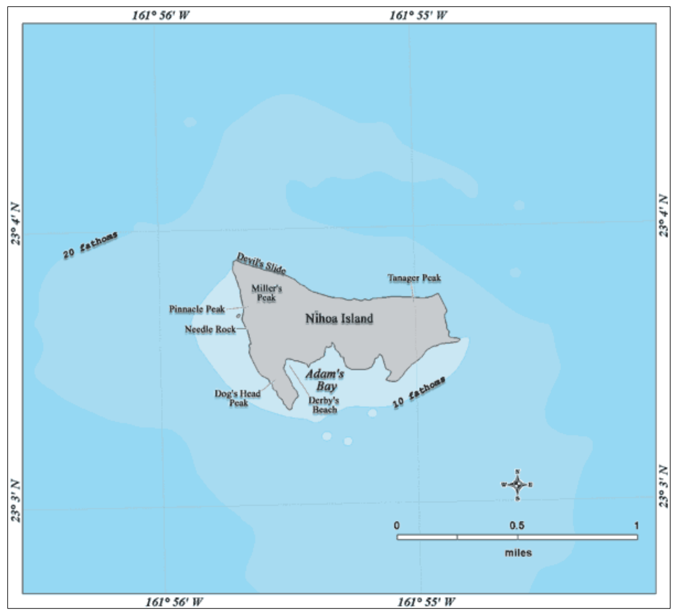


Figure 1.6 Nihoa.

Nihoa Island is located approximately 155 miles (249.4 kilometers) northwest of Kauaʻi, the closest of the main Hawaiian Islands. Measuring roughly 170 acres (0.68 square kilometers), this island is the largest emergent volcanic island within the Monument and the tallest, reaching an elevation of 903 feet (275.2 meters) at Miller Peak. It is also the geologically youngest island within the Monument, with an age calculated at 7.3 million years (Clague 1996). Nihoa is a deeply eroded remnant of a once-large volcano, and the large basaltic shelf of which it is a part stretches 18 miles (28.9 kilometers) in a northeast-southwest direction and averages between 112 to 217 feet (34.1 and 66.1 meters) deep (NOAA 2003b). The island's two prominent peaks and steep sea cliffs are clearly visible from a distance, rising like a fortress above the sea. The island's northern face is composed of a sheer cliff made up of successive layers of basaltic lava, within which numerous volcanic dikes are visible. The surface of the island slopes southward with an average slope of 23º (Johnson 2004). The island's surrounding submerged reef habitat totals approximately 142,000 acres (574.6 square kilometers) and is a combination of uncolonized hard bottom, macroalgae, pavement with sand channels and live coral, and uncolonized volcanic rock (NOAA 2003b), supporting at least 127 species of reef fish and 17 species of corals.

Nihoa's seabird colony boasts one of the largest populations of Tristam's storm-petrel, Bulwer's petrel, and blue noddies in the Hawaiian Islands, and very possibly the world. The island is a unique example of a lowland native community, resembling those lowland communities that once occurred on the main Hawaiian Islands but are now almost completely gone (Wagner et al. 1990). The island's vegetation can be classified as part coastal mixed community (*Sida* mixed shrub and grassland) and coastal dry shrubland dominated by ʻilima (*Sida fallax*), ʻāweoweo (*Chenopodium oahuense*), and ʻōhai (*Sesbania tomentosa*). The island supports 21 native plant species, including 3 endemics: a palm or loulu (*Pritchardia remota*), an amaranth (*Amaranthus brownii*), and an herb (*Scheidea verticillata*) (Wagner et al. 1999). The avifauna of the island includes two endemic passerine birds, the Nihoa finch (*Telespiza ultima*) and the Nihoa millerbird (*Acrocephalus familiarus kingii*), both listed as endangered under the Federal Endangered Species Act. The arthropod fauna of the island includes 33 species of mites, 3 species of spiders, and 182 species of insects, 17 of which are endemic, including a katydid (*Banza nihoa*), a giant tree cricket (*Thaumatogryllus conantae*), 2 species of endemic seed bugs (*Nysius nihoae* and *Nysius suffusus*), and an endemic trapdoor spider (*Nihoa mahina*) (Evenhuis and Eldredge 2004). Nihoa also has a rich cultural heritage, with at least 88 known wahi kupuna (ancestral sites) constructed by the precontact Hawaiians who inhabited the island for 700 years (until 1700 A.D.), and is listed on the National Register of Historic Places.

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

Mokumanamana is translated as a branching or pinnacled island, which aptly describes it, but many people who have studied its many religious and cultural sites suggest that the repetition of the word "mana" (spiritual power) after the Hawaiian word for "island" probably holds even more relevance. The facts that most of the 33 shrines on the island follow the kua (spine) of the island, the solar solstice hits the upright stones at a particular angle, navigational sites have been noted here, and the Hawaiian axes of life and death cross directly over Mokumanamana all potentially explain the reasoning behind the double mana in the name, and the concept of branching.

Figure 1.7 Mokumanamana (Necker Island)

Mokumanamana is a dry volcanic island shaped like a fishhook, and includes approximately 45 acres (0.18 square kilometers) of land. Geologists believe the island, with an estimated age of 10.6 million years, was once the size of Oʻahu in the main Hawaiian Islands, with a maximum paleo-elevation of 3,400 feet (1,036 meters) (Clague 1996), but due to centuries of erosion its highest point, at Summit Hill, is now only 276 feet (84.1 meters) above sea level. Wave action has eroded the remainder of the original island into a submerged shelf approximately 40 miles (64 kilometers) long and 15 miles (24 kilometers) wide. While this shelf holds more than 380,000 acres (1,538 square kilometers) of coral reef habitat supporting 125 reef fish species and 18 coral species, severe wave action and currents in the exposed areas tend to inhibit coral growth. The bank provides excellent habitat for spiny lobsters (*Panulirus marginatus*) and slipper lobsters (*Scyllarides squammosus*), especially in areas of less than 90 feet (27.4 meters) depth and high benthic relief (Parrish and Polovina 1994). Because of its limited size, Mokumanamana supports only 5 indigenous plant species and no land birds, but does harbor 3 species of mites, 2 species of spiders, and 70 species of insects, of which 11 are endemic, including a large weevil (*Rhycogonus biformis*), 2 species of seed bugs (*Nysius neckerensis* and *Nysius chenopodii*), and a trapdoor spider (*Nihoa hawaiiensis*) (Evenhuis and Eldredge 2004). Sixteen species of seabirds breed here, including the black noddy (*Anous minutus*), which historically was called the Necker Island tern.

Mokumanamana is also significant in Native Hawaiian culture. It bears 33 heiau (ceremonial sites) with standing stones that stretch the length of the island's central spine, suggesting that it was visited by Native Hawaiians for spiritual and possibly navigational purposes.

French Frigate Shoals (Mokupāpapa, Kānemiloha‘i)
23°145′ N., 66°10′ W.

The first atoll to the northwest of the main Hawaiian Islands, Mokupāpapa (flat, sand island) is also the midpoint of the archipelago and the largest coral reef area in Hawai‘i. Pāpapa means low and flat, like a reef, and that spelling is sometimes seen in the spelling of these shoals. This low, flat area is also where the goddess Pele is said to have left her brother, Kānemiloha‘i, to build up the land during her first journey to Hawai‘i from Kahiki (Tahiti).

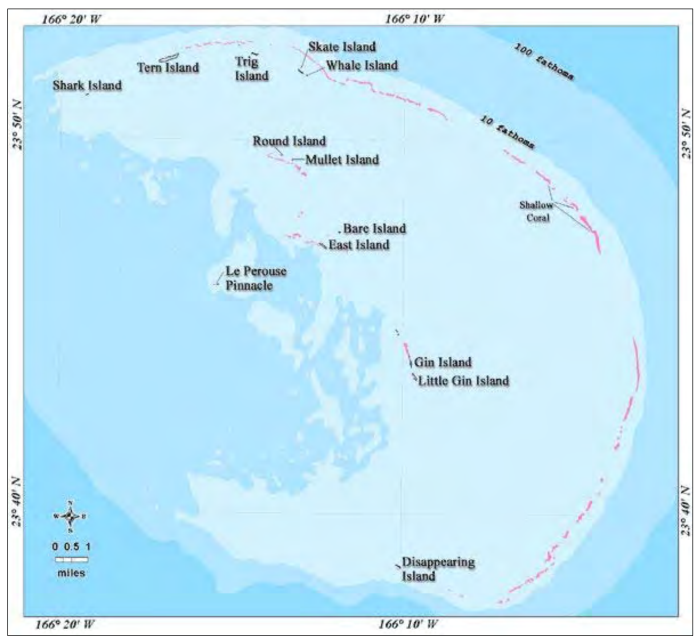


Figure 1.8 French Frigate Shoals.

French Frigate Shoals is the largest atoll in the chain, taking the form of an 18-mile (28.9 kilometers) long crescent. It is estimated to be 12.3 million years old (Clague 1996). The shoals consist of 67 acres (0.27 square kilometers) of total emergent land surrounded by approximately 230,000 acres (931 square kilometers) of coral reef habitat, with a combination of sand, rubble, uncolonized hard bottom, and crustose coralline algae in the windward and exposed lagoon areas, and patch and linear coral reefs in more sheltered areas (NOAA 2003b). Tern Island in the atoll is the site of a FWS field station, which occupies a former U.S. Coast Guard Long-Range Aids to Navigation (LORAN) station that closed in 1979. Within the NWHI, French Frigate Shoals is the center of diversity for corals (more than 41 species, including the genus *Acropora*, which is all but absent elsewhere in Hawai‘i) and reef fishes (178 species). A relatively deep (82 to 98 feet or 24.9 to 29.8 meters) coral reef at this atoll has been recently discovered to function as a spawning site for the giant trevally, *Caranx ignobilis* (Meyer et al. 2007); a rare discovery of spawning sites for top predators.

The lagoon is also unusual in that it contains two exposed volcanic pinnacles representing the last vestiges of the high island from which the atoll was derived, as well as nine low, sandy islets. The sand islets are small, shift position, and disappear and reappear. In 1923, the Tanager Expedition mapped 16 islets (Amerson 1971). In 1963, Whaleskate was a 16.8-acre (0.068 square kilometers), vegetated island (Amerson 1971); by 1998, it had completely disappeared (Antonelis et al. 2006). These islets provide highly important habitat for the world's largest breeding colony of the imperiled Hawaiian monk seal, which is listed as endangered under the Endangered Species Act and is also internationally recognized as endangered by the World Conservation Union. The atoll's sandy islets also provide nesting sites for 90 percent of the threatened green turtle population breeding in the Hawaiian Archipelago. In addition, 19 of Hawai‘i’s 22 seabird species are found on the island, giving it the highest species richness of breeding seabirds within the Monument. The dry coastal shrublands of the larger islets within the atoll also support an endemic seed bug (*Nysius frigatensis*), moth (*Agrotis kerri*), and mite (*Phauloppia bryani*) (Usinger 1942; Nishida 2002).

Gardner Pinnacles (Pūhāhonu)
25°02′ N., 168°05′ W.

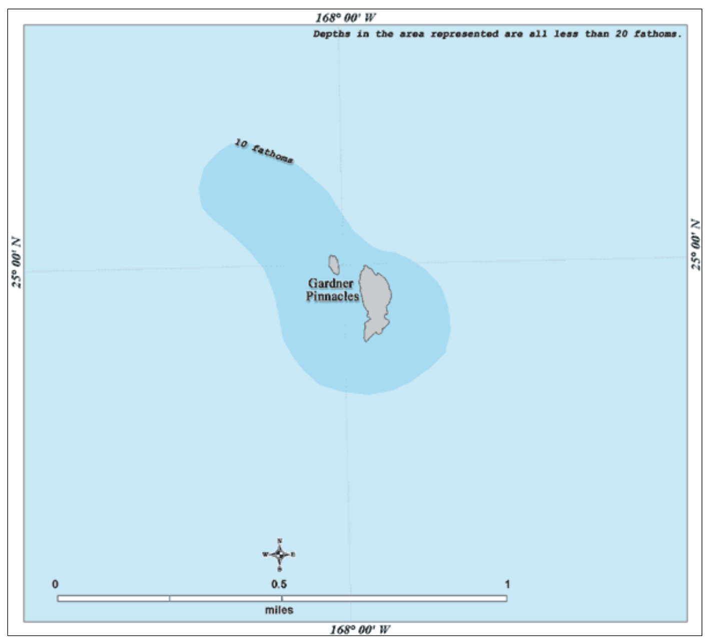


Figure 1.9 Gardner Pinnacles.

“He pūko‘a kū no ka moana.”(A large rock standing in the sea). This traditional Hawaiian saying is used to describe someone who is stubborn, unchangeable, and very determined. This is a suitable description for Pūhāhonu (surfacing of a sea turtle for air/breadth), which looks a bit like a turtle’s beak coming up for air and consists of two rocks, with the tallest of them 170-feet tall and 200 yards long.

Gardner Pinnacles consists of two emergent basaltic volcanic peaks estimated to be 15.8 million years in age (Clague 1996), which represent the oldest high islands in the Hawaiian chain. In scale, these pinnacles are small, the largest reaching only 180 feet (54.8 meters) high and having a diameter of approximately 590 feet (179.8 meters). Due to their limited size, they support only a single species of land plant (*Portulaca lutea*) and a few terrestrial arthropod species, but they are by contrast excellent habitat for seabirds (Clapp 1972). Guano from such seabirds gives the peaks a “frosted” appearance, indicating their importance as roosting and breeding sites for at least 12 subtropical species. Landings and terrestrial surveys rarely take place due to the difficulty of getting ashore under all but the most calm ocean conditions.

These remnant volcanic pinnacles are surrounded by approximately 600,000 acres (2,428 square kilometers) of coral reef habitat, most of which is in waters 60 feet (18.3 meters) or deeper, harboring 124 reef fish species and 27 species of corals. The intertidal bases of the pinnacles are studded with large populations of ‘opihi, endemic Hawaiian limpets that have been seriously depleted by overharvesting elsewhere in the main Hawaiian Islands.

Maro Reef (Nalukākala, Ko‘anako‘a)
25°22′ N., 170°35′ W.

The name Nakukākala describes surf that arrives in combers, such as the surf that froths over shallow reefs. The less well-known name of Ko‘anako‘a describes brave spacing between small altars, which could speak to the challenge of trying to steer through the shallow reefs of Maro, itself a huge, shallow island that is flooded by the ocean and surf at high tide.

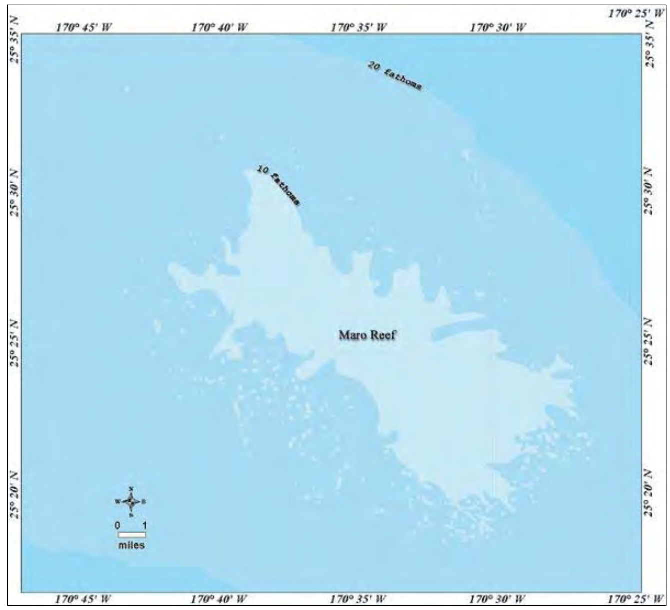


Figure 1.10 Maro Reef.

Maro Reef is a largely submerged open atoll 19.7 million years old (Clague 1996), with less than 1 acre (4,046.8 square meters) of periodically emergent land. At very low tide, only a small coral rubble outcrop of a former island is believed to break above the surface; as a result, Maro supports no terrestrial biota. In contrast, the shallow water reef system is extensive, covering nearly a half-million acres (2,023 square kilometers), and is the largest coral reef in the Monument. It is also one of the chain’s most ecologically rich shallow water marine ecosystems, with 64.1 percent coral cover over the entire area, among the highest percentage observed in the Monument (Maragos et al. 2004). The documented marine biota at Maro Reef includes 37 species of corals and 142 species of reef fish. Fish species endemic to the Hawaiian Archipelago make up half of all fish recorded here. Maro’s reefs are intricate and reticulated, forming a complex network of reef crests, patch reefs, and lagoons. Deepwater channels with irregular bottoms cut between these shallow reef structures, but navigation through them is difficult and hazardous. Cover types range from unconsolidated with 10 percent or less macroalgae cover to areas with greater than 10 percent coral or crustose coralline algae (NOAA 2003b). Because the outermost reefs absorb the majority of the energy from the open ocean swells, the innermost reticulated reefs and aggregated patch reefs are sheltered and have the characteristics of a true lagoon. Given the structural complexity of this platform, its shallow reefs are poorly charted and largely unexplored.

Laysan Island (Kauō)
25°46′ N., 171°45′ W.

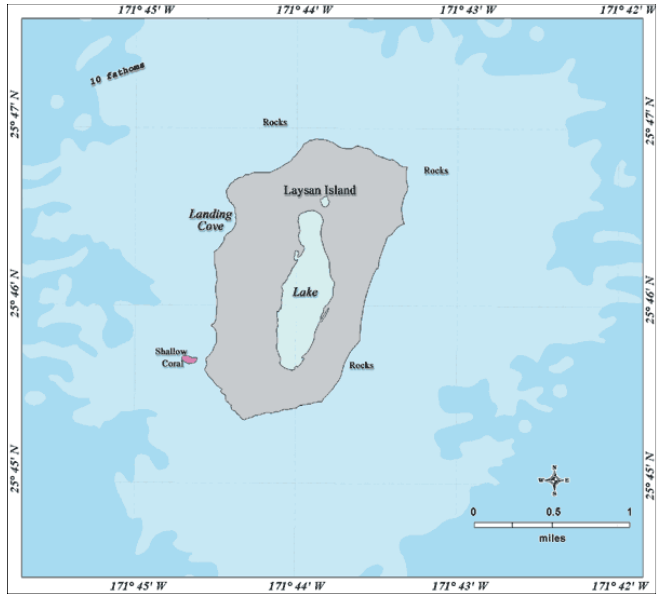


Figure 1.11 Laysan Island.

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

Laysan is a raised atoll, estimated to be 20.7 million years old (Clague 1996), with a maximum elevation of approximately 50 feet (15 meters) above sea level. It represents the second largest island in the Monument, with a land area of approximately 914 acres (3.7 square kilometers), surrounded by close to 100,000 acres (405 square kilometers) of coral reef. Most of the reef area at Laysan lies in deeper waters, with a small, shallow-water reef area in a bay off the southwest side of the island. The reef system as a whole supports 131 species of reef fishes and 27 species of corals. Laysan is home to a semi-permanent FWS field camp to support wildlife monitoring and habitat restoration.

The island's ring of sandy dunes surrounds a 100-acre (0.4 square kilometers) hypersaline interior lake, a feature unique within the Hawaiian Archipelago and rare within the Pacific as a whole. Because of its elevation of about 40 feet (12 meters), Laysan is well vegetated, supporting at least 30 species of flowering plants, including 5 endemic subspecies prior to human contact (Athens et al. 2007), many of which were driven to extinction by the misguided introduction of rabbits in 1902 during the guano mining era (Ely and Clapp 1973). The plant community is divided into five different associations arrayed in concentric rings around the interior hypersaline lake: (1) coastal shrubs, (2) interior bunchgrass, (3) vines, (4) interior shrubs, and (5) wetland vegetation (Newman 1988). The island also previously harbored five endemic birds, of which two, the Laysan finch (*Telespiza cantans*) and the Laysan duck (*Anas laysanensis*), still survive (Pratt et al. 1987). In addition, approximately 2 million seabirds nest here, including boobies, frigatebirds, terns, shearwaters, noddies, and the world's second-largest black-footed and Laysan albatross colonies. The island also supports a relatively rich arthropod fauna, including a large endemic weevil (*Rhyncogonus bryani*), four endemic moths, an endemic wasp, and three endemic mites. A successful 12-year eradication project to remove the sandbur *Cenchrus echinatus*, a plant that had displaced native vegetation over 30 percent of the island, has been completed, and an active ecological restoration project is under way to bring back a number of other plants and animals that were lost after the introduction of rabbits (Morin and Conant 1998).

Lisianski Island (Papaʻāpoho) and Neva Shoal
26°04′ N., 173°58′ W.

Papaʻāpoho describes a flat area with a depression or hollow, which is exactly how the island of Papaʻāpoho is shaped. Its highest point is a 40-foot-high sand dune, and its lowest point is a depression to the south that runs as a channel toward the ocean.

Figure 1.12 Lisianski Island and Neva Shoal.

Lisianski Island is another raised atoll, rising to 40 feet (12.1 meters) above sea level, and with approximately 400 acres (1.6 square kilometers) of emergent land is the third largest island within the Monument. This 23.4-million-year-old island (Clague 1996) is over 1.2 miles (1.9 kilometers) across, consisting of an elevated rim surrounding a broad central depression, although unlike Laysan it does not enclose an interior saline lake. The coral cover on the platform around the island, called Neva Shoal, is extensive, totaling over 290,000 acres (1,174 square kilometers) with an average of almost 60 percent cover of the substrate. There are 24 coral species at Lisianski, and 124 species of reef fish. Fish species endemic to the Hawaiian Archipelago compose 58 percent of all fish recorded here.

Lisianski suffered ecological perturbations similar to those on Laysan due to guano mining and the release of rabbits in 1903 (Tomich 1986). It supports no endemic land plant or bird species, although it does harbor an endemic seed bug (*Nysius fullawayi flavus*) and an endemic moth (*Helicoverpa minuta*) (Usinger 1942; Nishida 2002). The island also hosts large Bonin petrel and sooty tern colonies, as well as a variety of other seabirds. Lisianski also has the only grove of *Pisonia grandis* trees in the entire Hawaiian Archipelago; this tree is dispersed by seabirds and favored as a nesting site for many tree-nesting seabird species.

Pearl and Hermes Atoll (Holoikauaua)
27°50′ N., 175°50′ W.

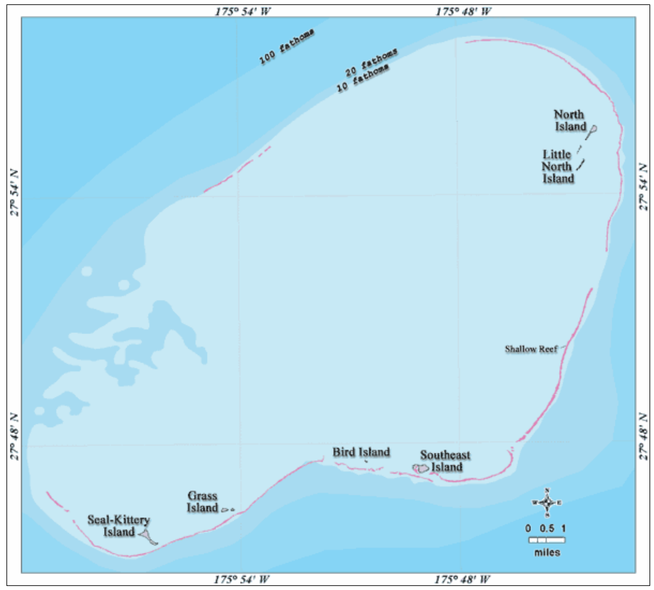


Figure 1.13 Pearl and Hermes Atoll.

The name Holoikauaua celebrates the Hawaiian monk seals that haul out and rest here. Pearl and Hermes Atoll is a large atoll with several small islets, forming 96 acres (0.38 square kilometers) of land surrounded by over 300,000 acres (1,214 square kilometers) of coral reef habitat. The atoll has an estimated age of 26.8 million years (Clague 1996) and is over 20 miles (32 kilometers) across and 12 miles (19.3 kilometers) wide, with dunes rising above sea level. Unlike Lisianski and Laysan to the southeast, Pearl and Hermes Atoll is a true atoll, fringed with shoals, permanent emergent islands, and ephemeral sandy islets. These features provide vital dry land for monk seals, green turtles, and a multitude of seabirds, with 16 species breeding here. The islets are periodically washed over when winter storms pass through the area. The atoll boasts the highest rate of reef fish endemism in the Hawaiian Archipelago, with 62 percent of fish species recorded endemic to the Hawaiian Archipelago out of 174 species overall. Coral species richness is high as well, with 33 species present. The permanent islands with higher dunes also support an endemic subspecies of native seed bug (*Nysius fullawayi infuscatus*) (Usinger 1942). Pearl and Hermes also hosts a small population of endangered Laysan finches that were translocated here in the 1960s.

Midway Atoll (Pihemanu)
28°15′ N., 177°20′ W.

Figure 1.14 Midway Atoll.

Pihemanu is aptly named for the loud din of birds that one hears on this atoll. Midway Atoll consists of three sandy islets (Sand 1,128 acres (4.56 square kilometers), Eastern 337 acres (1.36 square kilometers), and Spit 13 acres (0.05 square kilometers)) for a total of 1,464 acres (5.9 square kilometers) in terrestrial area, lying within a large, elliptical barrier reef measuring approximately 5 miles (8 kilometers) in diameter. The atoll, which is 28.7 million years old (Clague 1996), is surrounded by more than 88,500 acres (356 square kilometers) of coral reefs. In 1965, the U.S. Geological Survey took core samples and hit solid basaltic rock 180 feet (54.8 meters) beneath Sand Island and 1,240 feet (377.9 meters) beneath the northern reef. Numerous patch reefs dot the sandy-bottomed lagoon. These reefs support 163 species of reef fishes and 16 species of corals.

Although Midway's native vegetation and entomofauna have been greatly altered by more than a century of human occupation, the island boasts the largest nesting colonies of Laysan and black-footed albatrosses in the world, forming the largest colony of albatrosses in the world. The Navy, FWS, and U.S. Department of Agriculture-Wildlife Services (USDA Wildlife Services) successfully eradicated rats from Midway, and invasive ironwood trees have been entirely removed from Eastern Island. Currently the cover on all of the islands at Midway is approximately 30 percent paved or structures, 23 percent grass and forbs, 18 percent woodland, 7 percent sand and bare ground, 22 percent shrublands, and <0.23 percent wetland. A translocated population of Laysan ducks is thriving on the introduced insect community at Midway, and a large program of invasive weed eradication and native plant propagation is ongoing. Introduced canaries breed among historic buildings that mark the beginning of cable communication across the Pacific near the beginning of the 20th century. The atoll and surrounding seas were also the site of a pivotal battle of World War II, and Midway was an active Navy installation during the Cold War.

Kure Atoll (Kānemiloha‘i, Mokupāpapa)
23°03′ N., 161°56′ W.

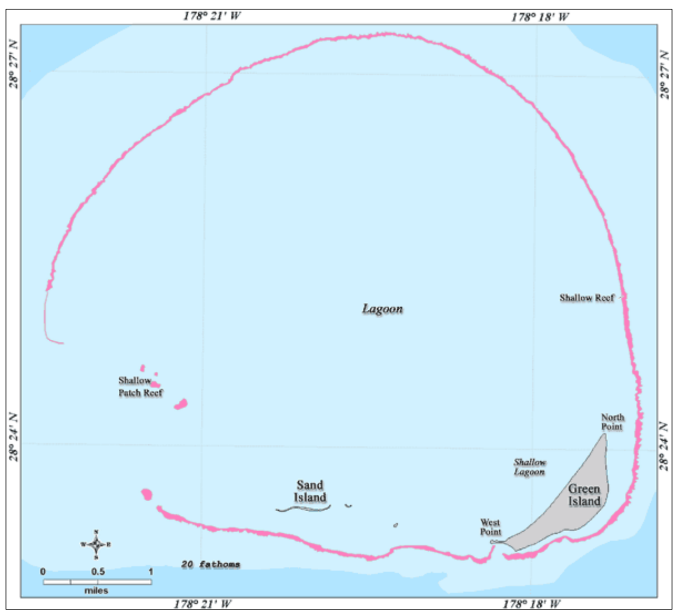


Figure 1.15 Kure Atoll.

There is a traditional Hawaiian saying of “Mai ka pi‘ina a a kalā i Ha‘eha‘e ai ka lā welo i Kānemiloha‘i” (From where the sun rises at Ha‘eha‘e (Kumukahi, Hawai‘i Island) to its setting at Kānemiloha‘i). This saying describes the entire Archipelago, following the arc of the sun, in the direction of pō, which is the “vast sea out of which land was born,” according to the Kumulipo, a Hawaiian genealogy chant of life and human origin. The saying also describes the westerly direction that Hawaiian spirits move to return to that lifesource. As part of a different origin history, Kānemiloha‘i is also the name of one of Pele’s older brothers. The volcano goddess Pele left her home in Kahiki (Tahiti) and arrived in the northern Hawaiian Islands, continuing down the Archipelago until finally settling in Kīlauea, Hawai‘i Island, where she is said to reside today.

Kure Atoll is the most northwestern island in the Hawaiian chain and occupies a singular position at the “Darwin Point”: the northern extent of coral reef development, beyond which coral growth cannot keep pace with the rate of geological subsidence. Kure’s coral is still growing slightly faster than the island is subsiding. North of Kure, where growth rates are even slower, the drowned Emperor Seamounts foretell the future of Kure and all of the Hawaiian Archipelago. As Kure Atoll continues its slow migration atop the Pacific Plate, it too will eventually slip below the surface.

This 29.8 million year old atoll (Clague 1996) is nearly circular, with a reef 6 miles (9.6 kilometers) in diameter enclosing a lagoon with two islets comprising over 200 acres (0.81 square kilometers) of emergent land, flanked by almost 80,000 acres (324 square kilometers) of coral reef habitat. The outer reef forms a nearly complete circular barrier around the lagoon, with the exception of passages to the southwest, and the associated marine habitats support 155 species of reef fishes. Fish species endemic to the Hawaiian Archipelago compose 56 percent of all fish recorded here. There are 27 species of coral found at the atoll. Of the two enclosed islets, the only permanent land is found on crescent-shaped Green Island, which rises to 20 feet (6.1 meters) above sea level and is located near the fringing reef in the southeastern quadrant of the lagoon. In addition to harboring an apparently endemic mite (*Hemicheyletia granula*), the atoll is also an important albatross breeding site, and the lagoon supports a population of spinner dolphins.

The U.S. Coast Guard established a LORAN station at Kure in 1960 (Woodward 1972) and occupied it until 1993. This land use had far-reaching effects on all the plants and animals at Kure Atoll, resulting in elevated invasive species problems and contaminants left behind when the base closed. As early as 1870, explorers documented the presence of Polynesian rats (*Rattus exulans*) here. These rodents influenced the species composition of the seabird community and the reproductive performance of the species that were there. In 1993, the State Department of Land and Natural Resources and USDA Wildlife Services eradicated rats from Kure Atoll.

Banks and Seamounts

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

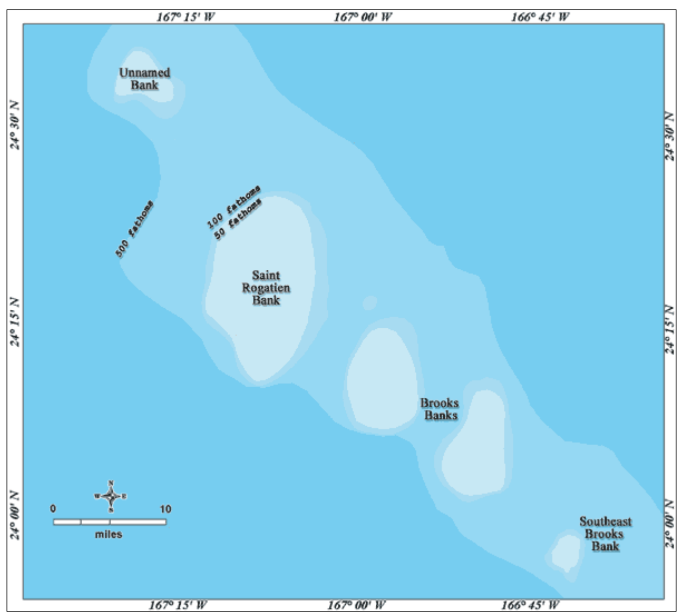


Figure 1.16 Banks and Shoals near French Frigate Shoals.

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

Mega- to macro-scale descriptions of bottomfish habitats made on Raita Bank, West St. Rogatien Bank, Brooks Bank, and Bank 66 indicate the distribution and abundance of bottomfish are patchy and appear to be associated with high relief and topographic features, including crevices and caves (Kelley et al. 2006). Nihoa sits on a broad double platform, with a large bank immediately to the west, and two smaller banks further to the northwest. Surrounding French Frigate Shoals is a series of submerged banks, including Southeast Brooks Bank, St. Rogatien Bank, and two other smaller banks to the west, plus another unnamed bank immediately to the east. Raita Bank lies nearly equidistant between Gardner Pinnacles and Maro Reef. Laysan has a small seamount to the southeast, and the large Northampton Seamounts to the southwest. In the vicinity of Lisianski, Pioneer Bank is only 22 nautical miles (25.3 miles or 40.7 kilometers) from Neva Shoals, and these features combine to form a major coral reef ecosystem with a variety of intermingled marine habitats, rich in biodiversity. Telemetry studies of Hawaiian monk seals unexpectedly have revealed that these animals spend considerable foraging time at subphotic depths on these banks, particularly in areas that have high levels of relief, such as pinnacles and walls (Parrish and Abernathy 2006).

All of these banks provide prime habitats for bottomfish-associated fish species that are important food sources for Hawaiian monk seals. Such banks also support populations of spiny and slipper lobsters, and colonies of precious gold, pink, and black corals that have been heavily disturbed in much of the remainder of the Pacific by the use of physically damaging harvest methods, such as trawling. These deep-living corals, below the depth where enough light penetrates for photosynthesis, rely on the capture of plankton from the water column with their tentacles rather than deriving energy from symbiotic dinoflagellate algae, known as zooxanthellae, that virtually all shallow-water reef-building corals harbor in their cells. Submersible surveys conducted at depths of 656 to 1,148 feet (199.9 to 349.9 meters) on Raita, West St. Rogatien, and Brooks Banks found little evidence of physical disturbances by bottomfishing from anchors and fishing gear (Kelley and Ikehara 2006).

Pelagic Habitats

The pelagic marine ecosystem is the largest ecosystem on earth. Biological productivity in the pelagic zone is highly dynamic; for example, in the equatorial Pacific Ocean, upwelling extends westward along the equator in a cold tongue of water from the coast of South America, eventually encountering a large pool of warmer water in the western Pacific (the cold tongue-warm pool system). The eastern cold-tongue system is characterized by high levels of primary production, and the western warm pool by lower levels of primary production.

Most of the Monument's area can be considered pelagic habitat. The estimated area of all parts of the Monument with depths greater than 1,000 fathoms (6,000 feet or 1.8 kilometers) is 117,375 square miles (304,000 square kilometers) (Miller et al. 2006). Pelagic habitat can be separated into the following five zones relative to the amount of sunlight that penetrates through seawater: (a) epipelagic, (b) mesopelagic, (c) bathypelagic, (d) abyssopelagic, and (e) hadalpelagic. Sunlight is the principal factor of primary production (phytoplankton) in marine ecosystems, and because sunlight diminishes with ocean depth, the amount of sunlight penetrating seawater and its effect on the occurrence and distribution of marine organisms are important. The epipelagic zone extends to nearly 656 feet (200 meters) and is the near extent of visible light in the ocean. The mesopelagic zone occurs between 656 feet (200 meters) and 3,281 feet (1,000 meters) and is sometimes referred to as the "twilight zone." Although the light that penetrates to the mesopelagic zone is extremely faint, this zone is home to wide variety of marine species. The bathypelagic zone occurs from 3,281 feet (1,000 meters) to 13,123 feet (4,000 meters), and the only visible light seen is the product of marine organisms producing their own light, which is called "bioluminescence." The next zone is the abyssopelagic zone (13,123 to 19,685 feet) (4,000 to 6,000 meters), where there is extreme pressure and the water temperature is near freezing. This zone does not provide habitat for very many creatures except small invertebrates such as squid and basket stars. The last zone is the hadalpelagic (19,685 feet (6,000 meters) and below) and occurs in trenches and canyons. Surprisingly, marine life such as tubeworms and seastars is found is this zone, often near hydrothermal vents.

Pelagic species are closely associated with their physical and chemical environments. Suitable physical environment for these species depends on gradients in temperature, oxygen, or salinity, all of which are influenced by oceanic conditions on various scales. In the pelagic environment, physical conditions such as isotherm and isohaline boundaries often determine whether the surrounding water mass is suitable for pelagic fish, and many of the species are associated with specific isothermic regions. Additionally, fronts and eddies which become areas of congregation for different trophic levels are important habitat for foraging, migration, and reproduction for many species (Bakun 1996).

At least 15 banks lie at depths between 100 and 1,300 feet (30 and 400 meters) within the Monument, providing important habitat for bottomfish and lobster species, although only a few of these banks have been studied in any detail (Kelley and Ikehara 2006). These waters represent critical deepwater foraging grounds for Hawaiian monk seals (Parrish et al. 2002) as well as a spatial refugium for pelagic fishes such as tunas and their allies.

The deep waters are also important insofar as they support an offshore mesopelagic boundary community (Benoit-Bird et al. 2002), a thick layer of pelagic organisms that rest in the deep ocean (1,300 to 2,300 feet, or 400 to 700 meters) during the day, then migrates up to shallower depths (from near zero to 1,300 feet or 400 meters) at night, providing a critical source of nutrition for open-ocean fishes, seabirds, and marine mammals. This community of organisms that inhabit the upper layers of the mesopelagic zone have been surveyed at French Frigate Shoals, Lisianski, Pearl and Hermes, Midway, and Kure using echosounding technology (Lammers et al. 2006). Their work confirmed the presence of a community of vertical migrators, consisting of fish, squid, and shrimp. This temporal variability in the structure of the biotic community is important to understand as the spatial patterns are studied. Mesopelagic fishes, in particular, are important prey for bigeye tuna, which tend to live at greater depths than the other tuna species. Overall, the fauna of the Monument's waters below acceptable SCUBA diving depths (100-130 feet or 30-40 meters) remains poorly surveyed and documented, representing an enormous opportunity for future scientific research in a system largely undisturbed by trawling or other forms of resource extraction.

Phytoplankton comprise more than 95 percent of primary productivity in the marine environment (Valiela 1995). These represent several different types of microscopic organisms requiring sunlight for photosynthesis living primarily in the upper 100 meters of the euphotic zone of the water column. Phytoplankton include organisms such as diatoms, dinoflagellates, coccolithophores, silicoflagellates, and cyanobacteria. Although some phytoplankton have structures (e.g., flagella) that allow them some movement, their general distribution is primarily controlled by current movements and water turbulence. Diatoms can be either single celled or form chains with other diatoms. They are mostly found in areas with high nutrient levels such as coastal temperate and polar regions. Diatoms are one of the major contributors to primary production in coastal waters, and occur everywhere in the ocean. Dinoflagellates are unicellular (one-celled) organisms that are often observed in high abundance in subtropical and tropical regions. Coccolithophores, which are also unicellular, are mostly observed in tropical pelagic regions (Levington 1995). Cyanobacteria, or blue-green algae, are often found in warm nutrient-poor waters of tropical ocean regions.

Oceanic pelagic fish including skipjack, yellowfin tuna, and blue marlin prefer warm surface layers, where the water is well mixed by surface winds and is relatively uniform in temperature and salinity. Other pelagic species—albacore, bigeye tuna, striped marlin, and swordfish—prefer cooler, more temperate waters, often meaning higher latitudes or greater depths. In fact, the largest proportion of the tuna catch in the Pacific Ocean originates from the warm pool, even though paradoxically this is a region of low primary productivity. Tuna movement to upwelling zones at the fringe of the warm pool may be key in resolving this apparent discrepancy between algal and tuna production. Preferred water temperature often varies with the size and maturity of pelagic fish, and adults usually have a wider temperature tolerance than subadults. Thus, during spawning, adults of many pelagic species usually move to warmer waters, the preferred habitat of their larval and juvenile stages.

Large-scale oceanographic events (such as El Niño) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species. Tuna are commonly most concentrated near islands and seamounts that create divergences and convergences, which concentrate forage species, and also near upwelling zones along ocean current boundaries and along gradients in temperature, oxygen, and salinity. Swordfish and numerous other pelagic species tend to concentrate along food-rich temperature fronts between cold upwelled water and warmer oceanic water masses (NMFS 2001). These frontal zones also function as migratory pathways across the Pacific for loggerhead turtles (Polovina et al. 2000). Loggerhead turtles are opportunistic omnivores that feed on floating prey such as the pelagic cnidarian, Vellela vellela ("by the wind sailor") and the pelagic gastropod Janthina spp., both of which are likely to be concentrated by the weak downwelling associated with frontal zones (Polovina et al. 2000).

The estimated hundreds of thousands of seabirds breeding in the Monument are primarily pelagic feeders that obtain the fish and squid they consume by associating with schools of large predatory fish such as tuna and billfish (Fefer et al. 1984, Au and Pitman 1986). These fish—yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), mahimahi (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), rainbow runner (*Elagatis bipinnulatus*), broadbilled swordfish (*Xiphias gladius*), and blue marlin (*Makaira indica*)—are apex predators of a food web existing primarily in the epipelagic zone. While both the predatory fish and the birds are capable of foraging throughout their pelagic ranges (which encompass the entire Monument and tropical Pacific Ocean), the birds are most successful at feeding their young when they can find schools of predatory fish within easy commuting range of the breeding colonies (Ashmole 1963, Feare 1976, Flint 1991). Recently fledged birds, inexperienced in this complex and demanding style of foraging, rely on abundant and local food resources to survive while they learn to locate and capture prey. Some evidence from tagging studies done by Itano and Holland (2000) suggests both yellowfin and bigeye tuna aggregate around island reef ledges, seamounts, and fish aggregating devices and are caught at a higher rate here than in open water areas. Yellowfin tuna in Hawai'i exhibit a summer island-related inshore-spawning run (Itano 2001).

Ashmole and Ashmole (1967) and Boehlert (1993) suggest that the circulation cells and wake eddies found downstream of oceanic islands may concentrate plankton and therefore enhance productivity near islands. Higher productivity, in turn, results in greater abundance of baitfish, thus allowing higher tuna populations locally. Johannes (1981) describes the daily migrations of skipjack tuna and yellowfin tuna to and from the waters near islands and banks. The presence of natural densities of these tunas within the foraging radius of seabird colonies enhances the ability of birds to provide adequate food for their offspring (Ashmole and Ashmole 1967; Au and Pitman 1986, Diamond 1978, Fefer et al. 1984.) Wake eddies also concentrate the larvae of many reef fishes and other reef organisms and serve to keep them close to reefs, enhancing survivorship of larvae and recruitment of juveniles and adults back to the reefs. For at least three of the seabird species breeding in the NWHI (brown noddies, white terns, and brown boobies), large proportions (33 to 56 percent) of their diets originate from the surrounding coral reef ecosystem, in other areas where their diet has been studied (Ashmole and Ashmole 1967; Harrison et al. 1983; King 1970; Diamond 1978).

This page intentionally left blank.

1.2 Status and Condition of Natural Resources

The NWHI can be characterized as a large marine ecosystem exposed to a wide range of oceanographic conditions and environmental and anthropogenic stressors. Submerged geomorphologic features, including reef, slope, bank, and seamount habitats, support a diverse range of shallow and deepwater marine life. Small islands and islets provide critical breeding grounds and nesting sites for endangered, threatened, and rare species, which forage on land and throughout the coral reef, deepwater, and pelagic marine ecosystems encompassing the NWHI. These natural systems hold important cultural value, as all archipelagic wildlife are regarded as ancestors to Native Hawaiians (Malo 1951). The life forms defined in this section are inhabitants of the NWHI and referred to in the Kumulipo, a genealogical oli (chant) that frames the evolution of life from the simplest of creatures to the most complex. In the Native Hawaiian worldview, the interface between natural and cultural resources is seamless.

Algae

The marine algal flora in the Monument are diverse and abundant. There are 353 species of macroalgae and 2 seagrass species known from the NWHI (McDermid and Abbott 2006). The species composition of the macroalgae community is relatively similar throughout the NWHI. Representatives of the Chlorophyta, Rhodophyta, Phaeophyta, branched coralline, crustose coralline, Cyanophyta, and turf algae occur in varying combinations, with green algae having the largest biomass and area coverage (Vroom and Page 2006). Green algae in the genus *Halimeda* was found in more than 70 percent of all quadrats during Monumentwide surveys in 2004. This calcified algae contributes greatly to sand formation (Vroom and Page 2006). An island-specific checklist of the nonvascular plants of the NWHI can be found in Eldredge (2002). The NWHI contain a large number of Indo-Pacific algal species not found in the main Hawaiian Islands, such as the green calcareous alga (*Halimeda velasquezii*). Unlike in the main Hawaiian Islands, where alien species and invasive algae have overgrown many coral reefs, the reefs of the NWHI are largely free of alien algae, and the high natural herbivory results in a natural algal assemblage.

Corals

Fifty-seven species of stony corals are known in the shallow subtropical waters of the NWHI (at depths of less than 100 feet (33 meters), which cover an area of 911,077 acres (3,687 square kilometers (Miller et al. 2004; 2006) in the Monument. Endemism of this group is high, with 17 of those species (30 percent) being found only in the Hawaiian Archipelago. These endemics also account for 37 to 53 percent of visible stony corals in all shallow reef areas surveyed (Friedlander et al. 2005). Fifteen of the 17 endemic species are in the genera *Montipora, Porites,* or *Pocillopora*.

Live coral cover is highest in the middle of the chain, with Lisianski Island and Maro Reef having 59.3 and 64.1 percent of their respective available substrate covered with living corals (Maragos et al. 2004). Coral cover varies significantly across the NWHI from these high rates at Maro and at Lisianski to very minimal coverage at most of the other reef sites (figure 1.16). Despite their high latitudes, a similar number of species of coral have been reported for the NWHI (57) as the main Hawaiian Islands (59) (Friedlander et al. 2005). Coral species richness is also highest in the middle of the chain, reaching a maximum of 41 reported coral species at

French Frigate Shoals (Maragos et al. 2004). Stony corals are less abundant and diverse at the northern end (Kure, Midway, and Pearl and Hermes) of the archipelago and off the exposed basalt islands to the southeast (Nihoa, Mokumanamana, La Perouse, and Gardner). At these sites, soft corals such as *Sinularia* and *Palythoa* are more abundant. Table coral in the genus *Acropora* is not found in the main Hawaiian Islands, but 7 species are recorded for Mokumanamana, Gardner, Pearl and Hermes, Neva, French Frigate Shoals, Maro, and Laysan, with the highest number of species and colonies at French Frigate Shoals. These colonies of coral may have been established from larvae traveling in currents or eddies from Johnston Atoll, 450 miles (724.2 kilometers) to the south (Grigg 1981; Maragos and Jokiel 1986). The Monument's coral reefs are relatively undisturbed by the impacts of fishing or tourism, with excellent health and high species richness. Preliminary faunal inventories indicate that many of their constituent species remain undocumented; even new coral species are still being discovered.

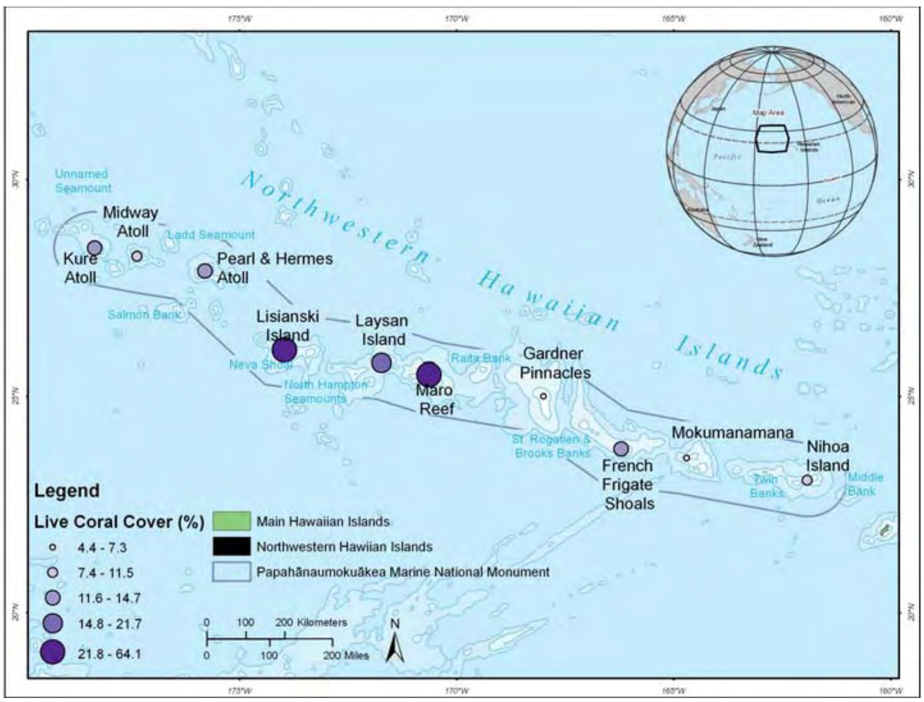


Figure 1.17 Differences in Coral Cover Among Regions Within the NWHI.
REA surveys were conducted at 173 sites in 2002. Coral cover was calculated from size frequency data of colony counts within transects. Data are mean and standard error. Based on unpublished data from PIFSC-CRED. Map by Friedlander and Wedding of the NCCOS/CCMA/Biogeography Team.

Benthic Shallow Water Invertebrates

With the exception of coral and lobster species, the marine invertebrates of the NWHI are very poorly known. Only two comprehensive collections of these groups of animals were conducted prior to 2000: the 1902 Albatross Expedition, in which the collected organisms were deposited at the Smithsonian Institution, and the 1923 Tanager Expedition, in which the collection was deposited at the Bishop Museum. In 2000, the NWHI Reef Assessment and Monitoring Program was established, and it continues to the present to assess the biota of all 10 emergent reef areas and shallow waters (< 65 feet or 20 meters) in the Monument (Friedlander et al. 2005). While this work is ongoing, a number of new species already have been recorded for Hawai'i, and some of these species may turn out to be endemic to the NWHI (DeFelice et al. 2002). By 2005, a total of 838 species from 12 orders had been identified, and many species are being worked on by taxonomic experts around the world and have yet to be identified (Friedlander et al. 2005).

One species of marine invertebrate for which some population data are available is the black-lipped pearl oyster (*Pinctada margaritifera*). This oyster was discovered in 1927 and heavily harvested at Pearl and Hermes Atoll until 1929, when the practice was prohibited by law. An estimated 150,000 oysters were harvested before a 1930 expedition estimated the remaining population at 100,000 oysters. More recent surveys in 1969, 1996, and 2000 found only a few oysters, indicating that the population had not recovered since the last harvest. Recent surveys conducted in 2003 at Pearl and Hermes Atoll mapped and measured over 1,000 individuals (Keenan et al. 2004). The average size of pearl oysters in the 2003 surveys was larger than the 1930 surveys (figure 1.18). It is unclear whether the number and size structure reflect a potential recovery of the species 70 years later or a more thorough sampling effort relative to the previous survey. However, the slow recovery of this species demonstrates the fragility of some of the Monument resources.

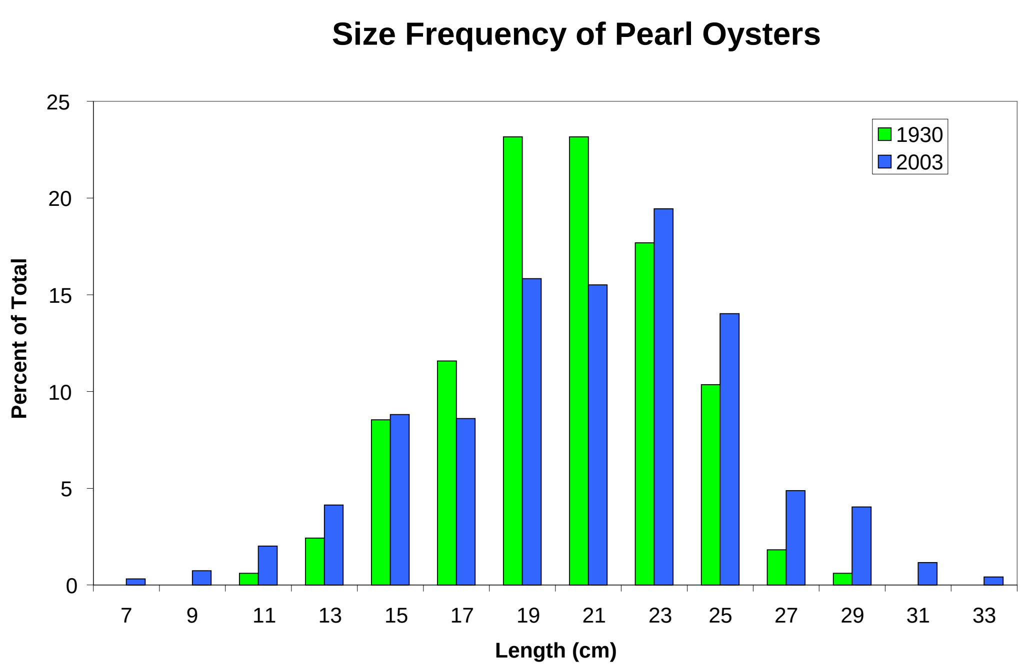


Figure 1.18 Size Frequency Distribution of Pearl Oyster Population at Pearl and Hermes Atoll in 1930 and 2003. Source: Keenan et al. 2004.

Crustaceans

The NWHI lobster trap fishery, which commenced in the mid-1970s, primarily targeted the Hawaiian spiny lobster *(Panulirus marginatus)* and slipper lobster *(Scyllarides squammosus)*. Three other species, green spiny lobster (*P. penicillatus*), ridgeback slipper lobster (*S. haanii*), and Chinese slipper lobster (*Parribacus antarcticus*), were caught in low abundance. (DiNardo and Marshall 2001).

Fishery statistics during the early developmental phase of the fishery (1976-1982) are scant. The total reported catch and landings of lobsters peaked in 1985 and generally declined from 1986 to 1995. Fishing effort peaked in 1986 and declined in 1988 before increasing in 1990. After 1990 fishing effort generally declined. The fishery initially targeted spiny lobster, but by 1985 gear modifications and improved markets led to an increase in slipper lobster landings. Catches of slipper lobster remained high from 1985 to 1987, fell into a general decline from 1988 to 1996, and increased significantly from 1997 to 1999. The fishery was closed in 2000 due to uncertainty in the population models used to assess the stocks (DeMartini et al, 2003).

A fishery-independent trap survey has been conducted annually by the PIFSC since 1984, with the exception of 1990, to (1) evaluate the performance of commercial and research survey gear, (2) calibrate gear types, and (3) monitor the relative abundance of local populations of lobster in the NWHI. The survey has also been used as a platform for short-term experiments (e.g., studies of handling mortality) and the collection of biological and oceanographic data. Since 1990 the abundance of spiny lobsters at Mokumanamana has generally decreased. Significant drops in abundance were observed in 1992, 1994, and 1998. The abundance of slipper lobsters has remained at relatively low levels at Mokumanamana between 1988 and 2006. Spiny lobster abundance at Maro Reef declined significantly after 1988 and remained low through 1999. An increasing trend in spiny lobster abundance has been detected at Maro Reef since 2000. Slipper lobster abundance at Maro Reef has generally been increasing, with significant increases occurring after 1991. These changes suggest a switch in species dominance at Maro Reef in 1990 (spiny to slipper lobster), and the initial phases of a spiny lobster population recovery in 2000.

Numerous hypotheses have been advanced to explain population fluctuations of lobsters in the NWHI including environmental (Polovina and Mitchum, 1992), biotic (e.g., habitat and competition) (Parrish and Polovina, 1994), and anthropogenic (e.g., fishing) (Polovina et al., 1995; Moffitt et al, 2006). Each hypothesis by itself offers a plausible, however simplistic, explanation of events that in fact result from several processes acting together. It is likely that population fluctuations of lobsters in the NWHI can be more accurately described by a mix of the hypotheses presented, each describing a different set of mechanisms (DiNardo and Marshall 2001).

Reef Fish

The extreme isolation of the NWHI chain and its distance from the diverse fish population centers of the Western Pacific contribute to a lower fish species diversity relative to other sites to the west (Mac et al. 1998). The long-term protection from fishing pressure that has been afforded the NWHI has resulted in high standing stocks of fish more than 260 percent greater than the main Hawaiian Islands. The fish community of the coral reef ecosystem of the NWHI also shows a very different structure than the main Hawaiian Islands and most other places in the world. The shallow-reef fish community is remarkable in the abundance and size of fish in the highest trophic levels. In this large-scale, intact, predator-dominated system, more than 54 percent of the total fish biomass on forereef habitats in the NWHI consists of apex predators. In contrast, the total fish biomass in the main Hawaiian Islands is dominated by herbivorus fish species (55 percent) with only 3 percent composed of apex predators (Friedlander and DeMartini 2002). Apex predator biomass on forereef habitats in the NWHI is 1.3 metric tons per hectare, compared to less than 0.05 metric tons per hectare on forereef habitats in the main Hawaiian Islands (figure 1.19).

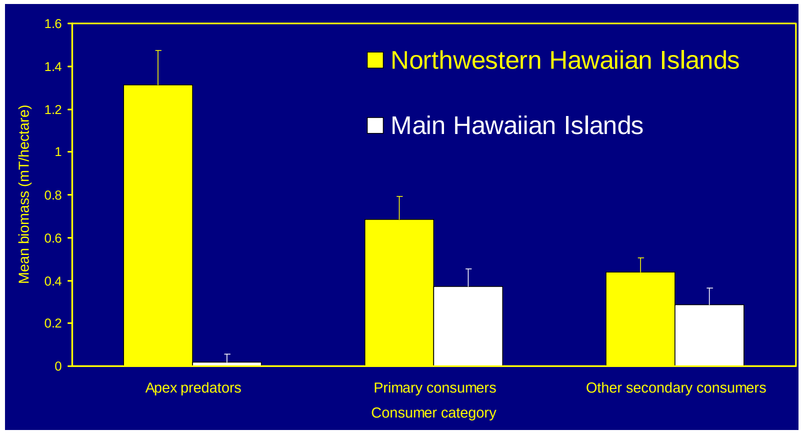


Figure 1.19 Comparison of Biomass in Major Trophic Guilds Between the Northwestern Hawaiian Islands and the Main Hawaiian Islands. Source: Friedlander and DeMartini 2002.

Areas with the highest apex predator biomass include Pearl and Hermes Atoll, followed by Lisianski and Laysan Islands (figure 1.20). Large, predatory fish such as sharks, giant trevally, and Hawaiian grouper that are rarely seen and heavily overfished in populated areas of the world are extremely abundant in the waters of the Monument.

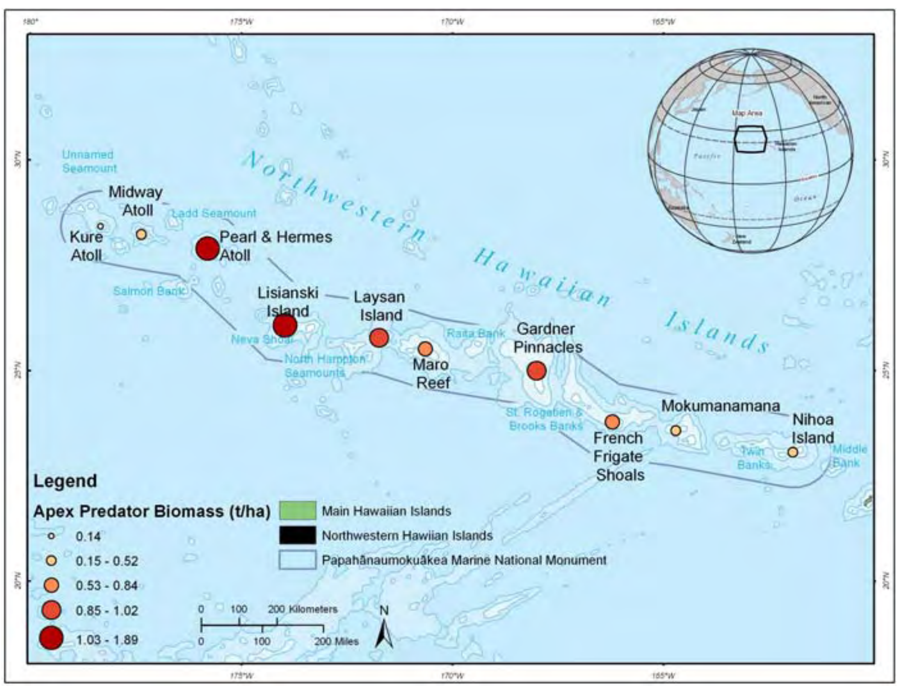


Figure 1.20 Geographic Pattern of Apex Predator Biomass Density (t/ha) at the 10 Emergent Northwestern Hawaiian Islands (NWHI) Reefs Surveyed During September/October 2000, 2001, and 2002. Based on data from DeMartini and Friedlander 2004. Map by Friedlander and Wedding of the NCCOS/CCMA/ Biogeography Team.

The NWHI are also characterized by a high degree of endemism in reef fish species, particularly at the northern end of the chain, with endemism rates well over 50 percent, making it one of the most unique fish faunas on earth (DeMartini and Friedlander 2004). Because of the decline in global marine biodiversity, endemic "hot spots" like Hawai'i are important areas for global biodiversity conservation. Overall fish endemism is higher in the NWHI compared to the main Hawaiian Islands (Friedlander et al. 2005; DeMartini and Friedlander 2004). Within the NWHI, endemism increases up the chain and is highest at the three northernmost atolls and Lisianski (figure 1.21). Another feature of the shallow-water reef fish community noticed by divers is that some species found only at much greater depths in the main Hawaiian Islands inhabit shallower water in the NWHI. This might be explained by water temperature preferences or by disturbance levels that vary between the two ends of the archipelago.

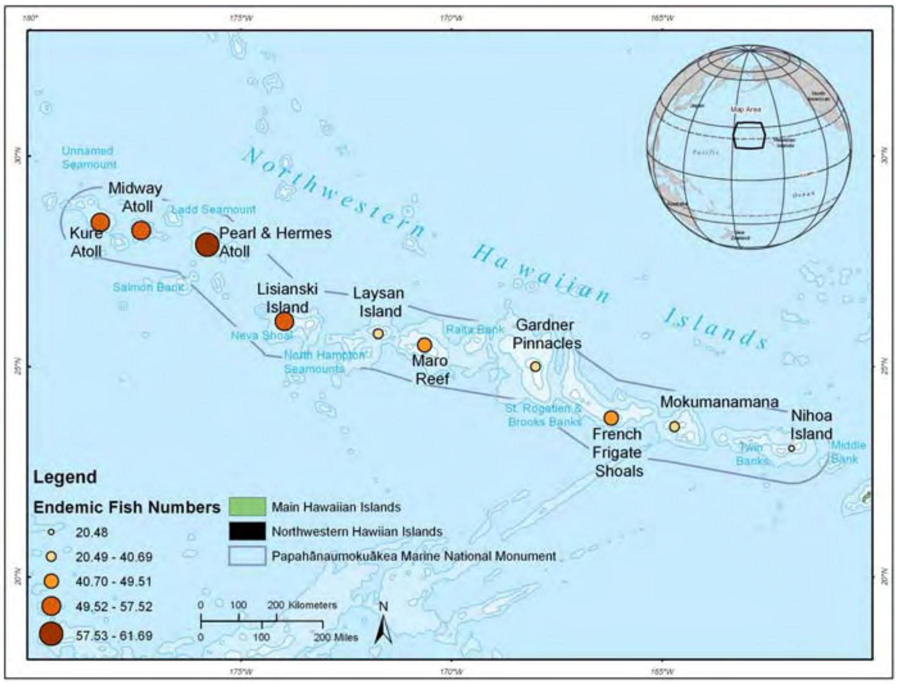


Figure 1.21 Percent Endemism (Based on Numerical Densities) at Each of 10 Emergent NWHI Reefs, Surveyed During September/October 2000, 2001, and 2002. Note patterns of endemism with latitude. Based on data from DeMartini and Friedlander 2004. Map by Friedlander and Wedding of the NCCOS/CCMA/Biogeography Team.

Bottomfish

The bottomfish species in the NWHI are in the taxonomic groups *Lutjanidae* (snappers), *Serranidae* (groupers), *Carangidae* (jacks), and *Lethrinidae* (emperors). The bottomfish stocks in the NWHI Mau and Ho'omalu zones have not been determined to be overfished, but in 1990, the stocks in the Mau Zone were considered to be near the overfishing threshold. Since then, however, bottomfish harvest rates in the Mau Zone, including the Ho'omalu Zone, have resulted in a bottomfish stock complex that currently is considered "healthy and lightly exploited," particularly in comparison to the main Hawaiian Islands (Brodziak 2007).

Pelagic Marine Life

The oceanic Scombroid fish (billfish, tuna, wahoo) have zoogeographies much more like that of plankton than benthic fish. Most are cosmopolitan and occur in all oceans within the tropical and subtropical zones but may have very specific water temperature preferences (Longhurst and Pauly 1987). The yellowfin tuna, for instance, prefers water no cooler than 18 to 21 ºC, which coincides with the northern boundary of the Monument. All species undertake seasonal and age-related migrations, traveling between spawning grounds and feeding grounds appropriate for their sizes. They prey upon medium-sized pelagic fish, crustaceans, and cephalopods. Tagging studies of yellowfin tuna and bigeye tuna have demonstrated that while these species have enormous capacity to travel huge distances, they show very specific attraction to fish aggregating devices, island reef ledges, seamounts, and other elements of structure (Itano and Holland 2000). Lowe et al. (2006) similarly found that while two species of large sharks, tiger sharks (*Galeocerdo cuvier*) and Galapagos sharks (*Carcharhinus galapagensis*), are capable of long-distance travel, they showed more site fidelity than expected throughout the year, with 70 percent of tiger sharks exhibiting year-round residence at French Frigate Shoals. Some of the study subjects did make long-distance movements, with sharks marked at French Frigate Shoals showing up at Midway and on the Kona coast of the Island of Hawai‘i. The tremendous economic value of these fishes has resulted in serious declines of most populations due to industrialized fishing. Myers and Worm (2003) calculated that large predatory fish biomass today is only about 10 percent of pre-industrial levels worldwide. Large predatory fish populations remain healthy and robust in the Monument (Friedlander et al. 2005).

Reptiles

The five species of sea turtles that occur in the NWHI are the loggerhead (*Caretta carretta*), the Hawaiian green (*Chelonia mydas*), the olive ridley (*Lepidochelys olivacea*), the leatherback (*Dermochelys coriacea*), and the hawksbill (*Eretmochelys imbricata*). All of these species are protected by the Endangered Species Act. Of these species, only the green turtle comes ashore to bask and breed. French Frigate Shoals is the site of the principal rookery for the entire Hawaiian green turtle stock, with over 90 percent of the population nesting there (Balazs and Chaloupka 2004a). As adults, most of these turtles travel to foraging grounds in the main Hawaiian Islands or in Midway or Johnston atolls, where they graze on benthic macroalgae. They periodically swim back to the nesting grounds at French Frigate Shoals (or, in smaller numbers, to Lisianski and Pearl and Hermes Atoll) to lay eggs. Breeding adults remain extremely faithful to the colony in which they were hatched for their own reproductive activities (Bowen et al.1992). Hatchling turtles may spend several years in pelagic habitats foraging in the neritic zone before switching to a benthic algae diet as adults.

The Hawaiian population of green turtles has been monitored for 30 years, following the cessation of harvesting in the 1970s, and has shown a steady recovery from its depleted state (Balasz and Chaloupka 2004a). (See figure 1.22.) The transition zone chlorophyll front, located north of Monument waters most years, occasionally moves southward along with one of the species tightly associated with it, the loggerhead turtle. These turtles breed in Japan but feed on buoyant organisms concentrated at the convergent front in these high-chlorophyll waters, which support a complex food web including cephalopods, fishes, and crustaceans, also fed upon by albacore tuna (*Thunnus alalunga*) and a variety of billfish (Polovina et al. 2001).

The terrestrial herpetofauna of the NWHI is made up of introduced species of lizards including four gecko species and two skinks, and a tiny blind snake (*Ramphotyphlops braminus)* that was imported to Midway, most likely in soil. The greatest diversity of these introduced reptiles is found at Midway and Kure atolls.

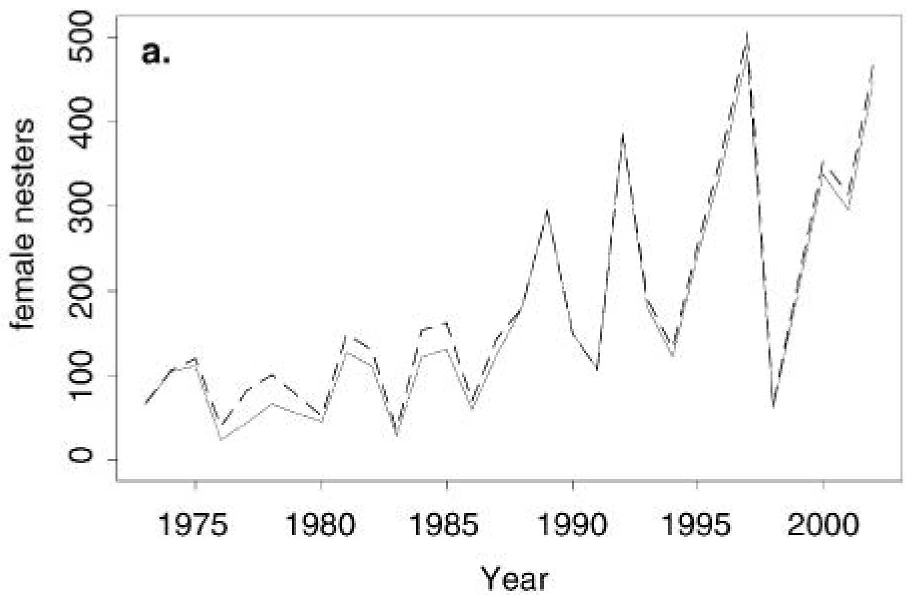


Figure 1.22 Long-Term Trend in the Abundance of Nesting Hawaiian Green Sea Turtles (dash lines represent Bayesian 95 percent credible region). Source: Balazs and Chaloupka 2004a.

Shorebirds

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

Seabirds

The importance of seabirds in the NWHI was recognized in 1909 with the establishment of the Hawaiian Islands National Wildlife Refuge. Early protection and active management have resulted in large, diverse, and relatively intact seabird populations. Seabird colonies in the NWHI constitute one of the largest and most important assemblages of tropical seabirds in the world, with approximately 14 million birds (5.5 million breeding annually), representing 21 species (Naughton and Flint 2004). (See table 1.1). Greater than 98 percent of the world's Laysan and black-footed albatrosses nest here. For several other species, such as Bonin petrel, Christmas shearwater, Tristram's storm-petrel, and the gray-backed tern, the Monument supports colonies of global significance. The last complete inventory of NWHI breeding populations was done between 1979 and 1984 (Fefer, et al. 1984). Population trends since then have been derived from more intensive monitoring at three islands. Population trends in the NWHI are stable or increasing for most species, but there is concern for a few, especially the albatrosses.

The conservation status of Hawaiian seabirds was assessed as part of the North American Waterbird Conservation Plan. Eleven of the 21 species were classified highly imperiled or of high conservation concern at the broad scale of the plan (eastern north Pacific, western north Atlantic, and Caribbean). (See table 1.1.) At the regional scale (Pacific Islands), 6 species were included in these highest concern categories: Laysan, black-footed, and short-tailed albatrosses; Christmas shearwater; Tristram's storm-petrel; and blue noddy.

Table 1.1 Seabird Species Known to Breed in Papahānaumokuākea Marine National Monument (FWS data)[1]

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

1 - Laysan and black footed albatrosses, Christmas shearwater, Tristram's storm-petrel, and blue-gray noddy are on the Birds of Conservation Concern list for the Hawaiian Bird Conservation Region, and black-footed albatrosses are on the national list (FWS 2002).

Distribution, population status and trends, ecology, and conservation concerns for each of these species are contained in the Regional Seabird Conservation Plan, Pacific Region (FWS 2005). The greatest threats to seabirds that reside in the NWHI are both local and global. These threats include introduced mammals and other invasive species, fishery interactions, contaminants, oil pollution, marine debris, and climate change. Over the past 20 years, active management in the National Wildlife Refuges and State Seabird Sanctuary has included the eradication of black rats (*Rattus rattus)* at Midway Atoll and Polynesian rats (*Rattus exulans)* at Kure Atoll; eradication or control of invasive plants; cleanup of contaminants and hazards at former military sites; and coordination with NOAA Fisheries and the Regional Fishery Management Councils, as well as industry and conservation organizations, to reduce fishing impacts.

Marine Mammals

The marine and littoral ecosystems of the Monument provide essential habitat for the Hawaiian monk seal (*Monachus schauinslandi*), one of the world's most endangered marine mammals. The Hawaiian monk seal was listed as an endangered species under the U.S. Endangered Species Act in 1976 (FR 51612). About 1,200 individuals exist (Antonelis et al. 2006; NMFS 2003; NMFS 2004a), and models predict that the population will fall below 1,000 individuals within the next 5 years. While a few Hawaiian monk seals coexist with humans in the main Hawaiian Islands, the great majority of the population lives among the remote islands and atolls of the Monument. Their range generally consists of the islands, banks, and corridors within the Monument, although individual animals may be found beyond this extensive area on occasion, sometimes farther than 50 nautical miles (92.6 kilometers) from shore.

In May 1988, NOAA Fisheries designated critical habitat under the Endangered Species Act for the Hawaiian monk seal from shore to 20 fathoms in 10 areas of the NWHI. Critical habitat for this species includes all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Pearl and Hermes Atoll; Kure Atoll; Midway Atoll, except Sand Island and its harbor; Lisianski Island; Laysan Island; Maro Reef; Gardner Pinnacles; French Frigate Shoals; Mokumanamana; and Nihoa Island (50 CFR §226.201). Critical habitat was designated to enhance the protection of habitat used by monk seals for pupping and nursing, areas where pups learn to swim and forage, and major haulout areas where population growth occurs.

Reproductive success of the Hawaiian monk seal population has declined, with the total mean nonpup beach counts at the main reproductive NWHI subpopulations in 2001 being approximately 60 percent lower than in 1958 (NMFS 2003). French Frigate Shoals has the largest Hawaiian monk seal breeding site and breeding subpopulation, followed by Laysan Island, Pearl and Hermes Atoll, and Lisianski Island (figure 1.23).

The foraging biogeography of the Hawaiian monk seal has been described in a number of recent reports (Stewart 2004a, b, and c; Stewart and Yochem 2004a, b, and c) and is illustrated in figure 1.23. Between 1996 and 2002, the movements and diving patterns of 147 Hawaiian monk seals in the NWHI (consisting of 41 adult males, 35 adult females, 29 juvenile males, 15 juvenile females, 12 weaned male pups, and 15 weaned female pups) were monitored with satellite-linked depth recorders. Overall findings of these studies include the following:

- Monk seal foraging range covers an area of approximately 18,593 square miles (48,156 square kilometers), or almost 14 percent of the total area of the Monument.

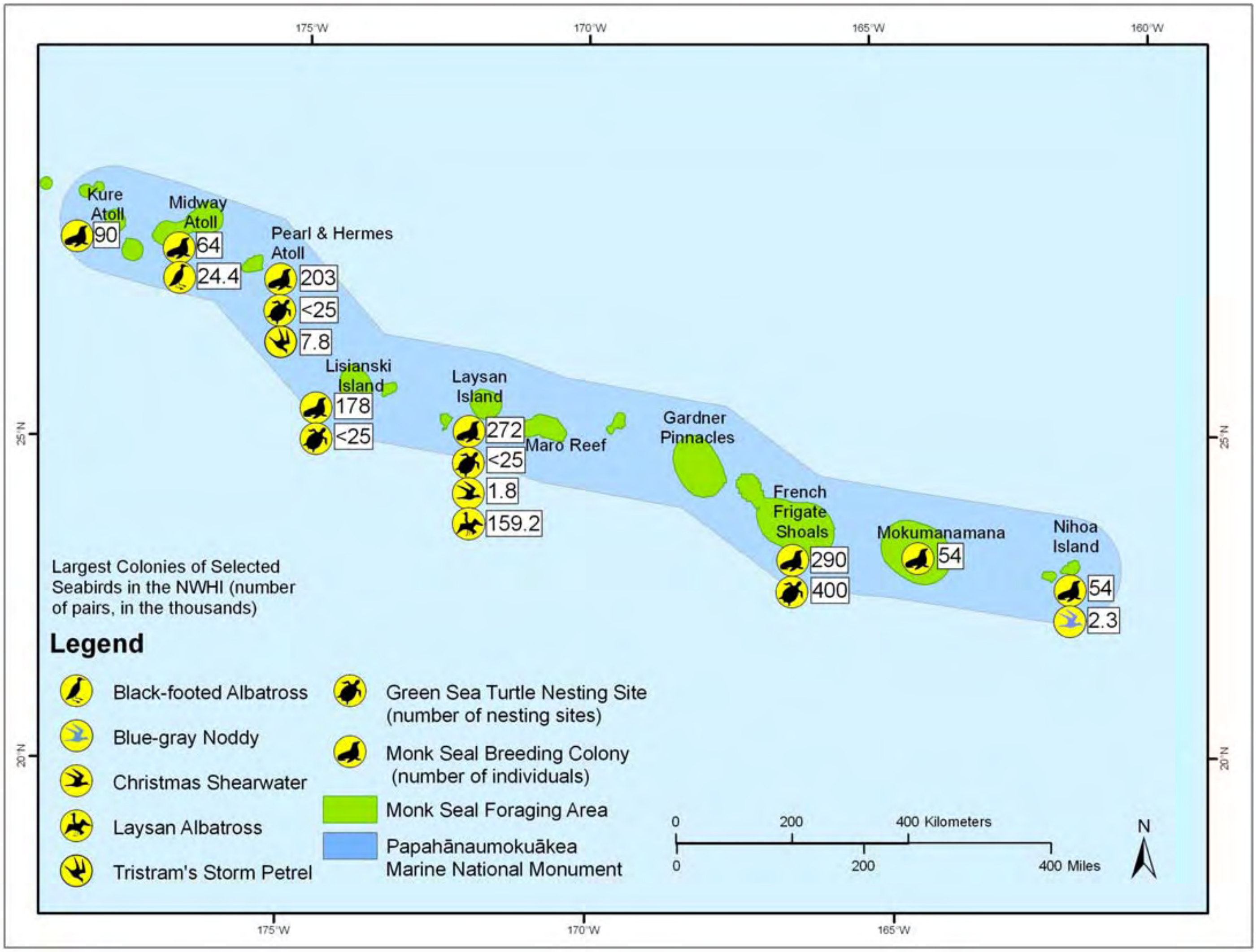


Figure 1.23 Map from NOAA Showing Hawaiian Monk Seal Breeding Sites and Subpopulation Sizes and Foraging Area (Stewart 2004a); Green Turtle Nesting Sites (Balazs and Ellis 2000); and Largest Nesting Sites for Seabird Species of Highest Concern for the Pacific Island Region in the Northwestern Hawaiian Islands (Kushlan et al. 2002; Fefer et al. 1984 for seabird colony size).

- Seals foraged extensively at or near their breeding sites and breeding subpopulations and haulout sites (95 percent within 20 miles of these sites), except at French Frigate Shoals, where foraging distances were demonstrated to be greater.
- The highest concentration of monk seal activity in the NWHI is focused on French Frigate Shoals and surrounding banks.
- Seals moved along specific corridors to travel between breeding sites and haulout sites. These corridors were closely associated with the NWHI submarine ridge. Seals likely forage along these corridors around subsurface features like reefs, banks, and seamounts.

Several banks located northwest of Kure Atoll represent the northern extent of the monk seal foraging range (Stewart 2004a). These areas have also been identified as important precious coral habitat as a result of recent research conducted with submersibles and remotely operated vehicles by NOAA's Office of Ocean Exploration (NOAA 2003c). The main terrestrial habitat requirements include haulout areas for pupping, nursing, molting, and resting. These are primarily sandy beaches, but virtually all substrates are used at various islands. The loss of terrestrial habitat is a priority issue of concern in the NWHI, especially habitat loss due to environmental factors such as storms and sea level rise that could further exacerbate this problem in the future. While some habitat loss (e.g., the subsidence of Whaleskate Island at French Frigate Shoals) has already been observed, sea level rise over the longer term may threaten a large portion of the resting and pupping habitat in the NWHI. Habitat loss has decreased available haulout and pupping beaches.

Past and present impacts to the monk seal population in the NWHI include hunting in the 1880s; disturbance from military uses of the area; entanglement in marine debris (Henderson 2001; 1990; 1984a; 1984b); direct fishery interaction, including recreational fishing (Kure Atoll) and commercial fishing prior to the establishment of the 50-mile Protected Species Zone around the NWHI in 1991 (NMFS 2003); predation by sharks (Nolan 1981); aggression by adult male monk seals; and reduction of habitat and prey due to environmental change (Antonelis et al. 2006).

The waters of the Monument are also home to over 20 cetacean species, six of them federally recognized as endangered and "depleted" under the Marine Mammal Protection Act, but comparatively little is known about the distributions and ecologies of these whales and dolphins (Barlow 2006). Recent research by Johnston et al. (2007) reveals that the Monument also hosts many more humpback whales than originally thought. The most well-studied cetacean species in the Monument is the Hawaiian spinner dolphin (*Stenella longirostris*). This geographically isolated subgroup of the spinner dolphin is genetically distinct from those of the Eastern tropical Pacific (Galver 2000). They occur off all of the main Hawaiian Islands and only four of the NWHI (Kure, Midway Atoll, Pearl and Hermes Atoll, and French Frigate Shoals) (Karczmarski et al. 2005). Andrews et al. (2006) found that the animals at the three northern sites were a genetically homogeneous population that was distinct from the group at French Frigate Shoals, which had some exchange with dolphins in the main Hawaiian Islands. Genetic isolation, together with an apparent low genetic diversity, suggests that spinner dolphins could be highly vulnerable to anthropogenic and environmental stressors (Andrews et al. 2004).

Terrestrial Invertebrates

Native terrestrial arthropods and land snail communities of the NWHI are the least well studied of the animal groups, but perhaps the most seriously affected by human activities and introductions. In particular, the many species of ants that have accidentally reached all the islands of the archipelago except Gardner Pinnacles have had enormous effects on these native terrestrial invertebrates.

The entomofauna of the Monument includes some groups of insects that demonstrate dramatic adaptive radiations. One such group is the seedbugs, specifically the genus *Nysius*, which shows the complete range of feeding types: from host-specific plant feeders, to diverse plant hosts, to omnivorous feeding, and finally to predator/scavengers. It is a rare occurrence to find herbivory and carnivory occurring within the same genus. Nowhere else in the world is there a lineage like the Hawaiian *Nysius* in which to explore the evolution of carnivory in Heteroptera. Some of these species are single-island endemics and of particular conservation concern because of their limited ranges.

Table 1.2 Number of Terrestrial Arthropod Species in the NWHI Summarized by Order and Island (Nishida 1998; Nishida 2001)

	Number of Terrestrial Arthropod Species by Island								
Terrestrial Arthropod Species	Nihoa Island	Necker Island	French Frigate Shoals	Gardner Pinnacles	Laysan Island	Lisianski Island	Pearl and Hermes Atoll	Midway Atoll	Kure Atoll
ARTHROPODA	221	84	108	11	235	55	109	508	155
Arachnida	42	10	10	4	34	6	16	85	35
Acari	31	2	5	2	22	4	13	63	25
Araneae	10	8	5	2	11	2	3	22	10
Pseudoscorpionida	1				1				
Insecta	174	69	94	7	195	49	87	412	115
Blattodea	4	2	3		5	2	3	8	4
Coleoptera	36	11	8	1	36	3	11	78	19
Collembola	2		3		5		10	19	4
Dermaptera	4	1	3	2	4	2	4	4	2
Diptera	28	12	18	1	31	20	15	62	23
Embiidina	2	2	1		2		1	1	
Heteroptera	15	4	9		9	4	8	14	8
Homoptera	10	7	10		15	4	8	21	12
Hymenoptera	37	7	14		21	4	7	105	16
Isoptera			1		1	1		3	
Lepidoptera	23	14	16	2	32	6	15	34	13
Mantodea								1	
Neuroptera					1		1	2	2
Odonata			1					1	1
Orthoptera	5	2	4		1	1		9	3
Pthiraptera		3	1	1	24		3	42	3
Psocoptera	3		1		3	1		1	2
Siphonaptera	1				1		1		
Thysanoptera	2	3	1		4	1		6	3
Thysanura	2	1						1	
Chilopoda	2	2	1		1		1	1	2

Number of Terrestrial Arthropod Species by Island

Terrestrial Arthropod Species	Nihoa Island	Necker Island	French Frigate Shoals	Gardner Pinnacles	Laysan Island	Lisianski Island	Pearl and Hermes Atoll	Midway Atoll	Kure Atoll
Anostraca					1				
Isopoda	3	3	3		3	3	5	9	3
Amphipoda						1			

Terrestrial Plants

The land plants of the NWHI are typically salt-tolerant and drought-resistant species of the beach strand and coastal scrub. The number of native species found at each site is positively correlated with island size but negatively influenced by the number of alien species occurring at the site. The three sites with airstrips and a longer history of year-round human habitation have much larger populations of alien species of land plants. (See table 1.3.) At least three species of NWHI endemic plants (*Achyranthes atollensis*, *Phyllostegia variabilis*, and *Pritchardia species* of Laysan) are believed to have gone extinct since European contact. Some other native species and genera have found refuge in areas of the NWHI where rats were never introduced, and now occur at much greater densities than they do in the main Hawaiian Islands (e.g., *Pritchardia remota* and *Sesbania tomentosa*, commonly known as ‘ohai).

At least six species of terrestrial plants found only in the region are listed under the U.S. Endangered Species Act, some so rare that due to the limited surveys on these remote islands, they may have already vanished from the planet. The World Conservation Network lists *Cenchrus agrimonioides* var. *laysanensis* as extinct, though biologists still hold hope that it may exist. *Amaranthus brownii*, endemic to Nihoa Island, is deemed critically endangered by the World Conservation Network, while *Pritchardia remota* is considered endangered.

Table 1.3 Biogeographic Description of Land Plants of Papahānaumokuākea Marine National Monument (number of species that have been observed at each site in previous 20 years). (Bruegmann, M.M. 1995; Starr, F., and K. Martz 1999; Starr, F., K. Martz, and L. Loope 2001; Morin, M., and S. Conant 1998; Wagner, W.L., D.R. Herbst, and S.H. Sohmer 1999.)

Island	Emergent land area (acres)	Island endemic	Indigenous to Hawai‘i and other Pacific Islands	Alien	Total no. of Species
Nihoa	171	3	14	3	20
Mokumanamana	46	0	5	0	5
French Frigate Shoals[1]	67	0	10	27	37
Gardner Pinnacle	5	0	1	0	1
Laysan Island	1015	1	22	11	34
Lisianski Island	381	0	15	5	20
Pearl and Hermes Atoll	80	0	15	10	25
Midway Atoll[1]	1540	0	14	249	263
Kure Atoll[1]	212	0	12	36	49

1 - Sites where an airfield and permanent human habitation has influenced immigraton of novel species.

Endangered and Threatened Species

Twenty-three species of plants and animals known to occur in the NWHI are listed under the Endangered Species Act (table 1.4). Specific threats and recovery actions related to these species are discussed in section 1.4, and in individual action plans presented in section 3.

Table 1.4 Species Observed in the NWHI Listed as Threatened or Endangered Under the Endangered Species Act[1]

Marine Mammals		
Hawaiian monk seal	*Monachus schauinslandi*	E
Humpback whale	*Megaptera novaeangliae*	E
Sperm whale	*Physeter macrocephalus*	E
Blue whale	*Balaenoptera musculus*	E
Fin whale	*B. physalus*	E
Sei whale	*B. borealis*	E
North Pacific right whale	*Eubalaena japonica*	E
Marine Turtles		
Olive Ridley turtle	*Lepidochelys olivacea*	T/E
Leatherback turtle	*Dermochelys coriacea*	E
Loggerhead turtle	*Caretta caretta*	T
Hawksbill turtle	*Eretmochelys imbricata*	E
Green turtle	*Chelonia mydas*	T
Terrestrial Birds		
Laysan duck	*Anas laysanensis*	E
Laysan finch	*Telespyza cantans*	E
Nihoa millerbird	*Acrocephalus familiarus kingi*	E
Nihoa finch	*Telespyza ultima*	E
Seabirds		
Short-tailed albatross	*Phoebastria albatrus*	E
Plants		
No common name	*Amaranthus brownii*	E
Kamanomano	*Cenchrus agrimoniodes* var *laysanensis*	E
No common name	*Mariscus pennatiformis* ssp *bryanii*	E
Loulu	*Pritchardia remota*	E
No common name	*Schiedea verticillata*	E
‘Ōhai	*Sesbania tomentosa*	E

1 - Under the Endangered Species Act of 1972, endangered species are those in danger of extinction. Threatened species are those likely to become an endangered species within the foreseeable future. E = endangered; T = threatened.

This page intentionally left blank.

1.3 Status and Condition of Cultural and Historic Resources

The Monument was established for its unique combination of natural and cultural resources, including Native Hawaiian and post-Western-contact historic resources. It is composed of terrestrial and marine areas that have special national and international significance in terms of conservation, ecology, history, science, education, culture, archaeology, and aesthetics. The establishment of the Monument also provides the framework for coordinated and comprehensive management of the area.

Native Hawaiian Cultural Foundation and Significance

Kū pākū ka pali o Nihoa i ka makani
The cliff of Nihoa stands as resistance against the wind
—Said of one who stands bravely in the face of misfortune (Pukui 1983: 1924)

Polynesian navigators began voyaging across the vast Pacific Ocean, unaided by Western instrumentations, about 300 B.C. or earlier. Over the next 1,300 years, these skilled and visionary wayfinders would leave their mark on a more than 10-million-square-mile area of the Pacific that has become known as the Polynesian triangle, its defining points being made by settlements on Aotearoa (New Zealand) in the West, on Rapa Nui (Easter Island) in the East, and on the Hawaiian archipelago in the North (Polynesian Voyaging Society 2007). A unique spirituality binds the multitude of Polynesian societies who today inhabit the hundreds of islands contained within this region. These Polynesian societies share many of the same cosmologies, genealogies, and oral histories, the origins of which can be traced either back to the wayfinders who first ventured through the Pacific or from subsequent voyagers who traveled across this massive water continent.

Canoes filled with those who would become Native Hawaiians first arrived in the waters of the remote Hawaiian Archipelago, most likely from Hiva or the Marquesas Islands, around 1,600 years ago or earlier (PVS 2007). Upon finding abundant natural resources, they decided to remain; living in harmony with nature to survive on such a remote island chain. They developed complex resource management systems and specialized skill sets to ensure the fertile soils and rich reef environments they found could be sustained for future generations. These included agricultural terraces; extensive water paddies for their staple food, kalo (taro); and incredibly productive fishponds, many of them acres in size, that sprawled over shallow coastal waters.

The ocean serves as a central source of physical and spiritual sustenance for Native Hawaiians on a daily basis. Poetically referred to as Ke kai pōpolohua mea a Kāne (the deep dark ocean of Kāne), the ocean was divided into numerous smaller divisions and categories, from the nearshore to the deeper pelagic waters (Malo 1951). Likewise, channels between islands were also given names and served as connections between islands, as well as a reminder of their larger oceanic history and identity.

Today, Native Hawaiians continue to maintain their strong cultural ties to the land and sea. This concept of interconnectedness transcends geography. Native Hawaiians understand the importance of managing the islands and waters as one, as they are inextricably connected to one another (Beckwith 1951; Lili‘uokalani 1978). Despite the fact that the NWHI were not used and experienced on a daily basis by most Hawaiians, they have always been seen as an integral part of the Hawaiian Archipelago and have been honored as a deeply spiritual location, as evidenced by the many wahi kūpuna, or sacred sites, on Nihoa and Mokumanamana.

Much of the information about the NWHI has been passed down in oral and written histories, genealogies, songs, dance, and archaeological resources. Through these cultural resources of knowledge, Native Hawaiians have been able to recount the travels of seafaring ancestors between the NWHI and the main Hawaiian Islands. Hawaiian language archival resources have also played an important role in providing key documentation; a large body of information was published in local newspapers, some of it more than a hundred years ago (e.g., Kaunamano 1862; Manu 1899; Wise 1924).

More recent ethnological studies (Maly 2003) support the continuity of Native Hawaiian traditional practices and histories in the NWHI, and it is important to note that only a fraction of these have been recorded—many more exist in the memories and life histories of kūpuna. Nevertheless, the relationship of Native Hawaiians to the NWHI is marked by some irregularity, notably upon the arrival of Europeans to the Hawaiian Archipelago in the late 18th century. At the point of contact between the West and Hawai‘i, Native Hawaiians were thriving in the islands, with a population estimated between 300,000 and one million (for discussion on pre-contact Native Hawaiian population, see Stannard 1989). However, foreign diseases introduced into Hawai‘i over the next century would cause the Native Hawaiian population to fall into a steep decline. Thus, the sacred path traveled to the islands northwest of Kaua‘i saw few Native Hawaiians for a period of time, and this trend lasted through the early 19th century.

A renewed interest in the NWHI grew as successive Hawaiian monarchs focused on reuniting the entire Hawaiian Archipelago by formally incorporating the NWHI into the territory of the Kingdom of Hawai‘i. Throughout the 1800s, title to the islands and waters of the region was vested in the Kingdom of Hawai‘i (Mackenzie and Kaiama 2003). This came to pass due to the actions of Hawaiian monarchs, which included the following highlights:

- In 1822, Queen Ka‘ahumanu organized and participated in an expedition to locate and claim Nihoa under the Kamehameha Monarchy.
- Nihoa was reaffirmed as part of the existing territory of Hawai‘i in 1856 by authority of Alexander Liholiho, Kamehameha IV (March 16, 1856, Circular of the Kingdom of Hawai‘i).
- King Kamehameha IV made a round trip voyage between Honolulu and Nihoa in 1857 and instructed Captain John Paty of the *Manuokawai* to annex any lands discovered during further exploration of the region. In 1857, the islands of Laysan and Lisianski were declared new lands to be included into the domain of the Kingdom (Kingdom of Hawai‘i 1857).
- Lydia Lili‘uokalani, prior to becoming Queen, visited Nihoa with a 200-person party aboard the *Iwalani*.
- King David Kalākaua annexed Kure Atoll (Ocean Island) and announced formal possession of the island in 1886, through Special Commissioner Colonel James Harbottel (Harbottel-Boyd 1886).

In 1893, Queen Lydia Liliʻuokalani was overthrown by the self-proclaimed Provisional Government of Hawaiʻi, with the assistance of U.S. Minister John L. Stevens. Five years later, in 1898, the archipelago, inclusive of the NWHI, was collectively acquired by the United States through a domestic resolution, called the "New Lands Resolution."

The ea (sovereignty and life), as well as the kuleana (responsibility), for the entire Hawaiian Archipelago continues to exist in the hearts and minds of many present-day Native Hawaiians—a perspective recognized in law by the Apology Bill (U.S. Public Law 103-150), which is a joint resolution of Congress signed by President Clinton in 1993. The Apology Bill acknowledges the wrongful role of U.S. officers in the overthrow of the Kingdom of Hawaiʻi and "apologizes to Native Hawaiians on behalf of the people of the United States" for the unlawful overthrow and the "deprivation of the rights of Native Hawaiians to self-determination." It also recognizes that "the health and well-being of the Native Hawaiian people is intrinsically tied to their deep feelings and attachment to the land."

The stage was set for a reawakened relationship between Native Hawaiians and the NWHI in 2000, when President Clinton signed the Executive Orders creating the NWHI Coral Reef Ecosystem Reserve. With new channels of access possible, the cultural protocol group, Nā Kupuʻeu Paemoku, traveled to Nihoa on the traditional double-hulled voyaging canoe *Hōkūleʻa* in 2003 to conduct traditional ceremonies. The following year, in 2004, *Hōkūleʻa* sailed over 1,200 miles (1,931 kilometers) to the most distant end of the island chain, visiting Kure Atoll as part of a statewide educational initiative called "Navigating Change." Concurrently, officials of the Polynesian Voyaging Society saw that the ancient sailing route between Kauaʻi and Nihoa was an appropriate training course for the next generation of Native Hawaiians interested in reestablishing the traditional system of wayfinding practiced by their ancestors. In 2005, Nā Kupuʻeu Paemoku again sailed to the NWHI, this time to Mokumanamana, where they conducted protocol ceremonies on the Summer Solstice–the longest day of the year, June 21. On June 21, 2007, as a follow-up to the 2005 access, the Edith Kanakaʻole Foundation ventured to Nihoa and Mokumanamana to conduct its own cultural research initiatives and to better understand the relationship between the wahi kūpuna (ancestral places) and the northern pathway-of-the-sun.

Native Hawaiians' longstanding and deeply spiritual relationship with the NWHI over millennia reaffirms the importance of positioning the Hawaiian culture as the lens through which the significance of the region, as well as the Hawaiian Archipelago as a whole, is viewed.

Native Hawaiian Cultural Resources

Most family genealogies of Native Hawaiians begin with the Kumulipo, or creation chant (Malo 1951). The Kumulipo depicts the history of creation, beginning with the simplest of organisms and gradually reaching higher levels of complexity in the natural world, eventually completing the cycle of life with humans. As with most oral traditions, different families had variations of the creation chant, and different stories evolved as the chant moved closer to the evolution and naming of humans. It is through the perpetuation of chants like the Kumulipo—and other ancient traditions, practices, and protocols—that Native Hawaiians have passed on their spiritual belief that the people are deeply related to the natural environment, and in fact, all of the natural resources are also cultural resources.

Physical remnants of wahi kūpuna (ancestral places), Hawaiian language archival and oral resources, and historical accounts provide evidence of the various past uses of the NWHI and the surrounding ocean by Native Hawaiians (Kaunamano 1862 in Hoku a ka Pakipika; Manu 1899 in Ka Loea Kalaiaina; Wise 1924 in Nupepa Kuokoa). Evidence indicates that the area served as a home and a place of worship for centuries. It is posited that the first Native Hawaiians to inhabit the archipelago frequented Nihoa and Mokumanamana for at least a 500- to 700-year period (Emory 1928; Cleghorn 1988; Irwin 1992). They brought many of the skills necessary to survive with them from their voyaging journeys throughout Polynesia. Over time, they developed complex resource management systems and additional specialized skill sets to survive on these remote islands with limited resources (Cleghorn 1988).

The impressions left by ancient Hawaiians can be seen through the distinctive archaeology of Nihoa and Mokumanamana. The ceremonial terraces and platform foundations with upright stones found on both Nihoa and Mokumanamana are not only amazing examples of unique traditional Hawaiian architectural forms of stone masonry work, but they also show similarities to samples from inland Tahiti (Emory 1928). The structures are some of the best preserved early temple designs in Hawaiʻi, and have played a critical role in understanding Hawaiʻi's strong cultural affiliation with the rest of Polynesia, and the significant role of Native Hawaiians in the migratory history and human colonization of the Pacific (Cleghorn 1988).

It is believed that Mokumanamana played a central role in Hawaiian ceremonial rites and practices a thousand years ago because it is directly in line (23° 34.5' N latitude) with the rising and setting of the equinoctial sun along the Tropic of Cancer. In Hawaiian, this path is called "ke ala polohiwa a Kāne," or the "way of the dark clouds of Kāne," which has been translated to mean death or the westward pathway of the ancestral spirits. Because Mokumanamana sits on the northernmost limit of the path the sun makes throughout the year, it sits centrally on an axis between two spatial and cultural dimensions: pō (darkness, creation, and afterlife) and ao (light, existence). On the summer solstice (the longest day of the year), the sun travels slowest across the sky on this northern passage, going directly over Mokumanamana. The island has the highest concentration of ceremonial sites anywhere in the Hawaiian archipelago. All of these sites are strategically placed and act as physical reminders of the important spiritual role these sites play in Hawaiian culture. The sites and structures are channels for the creation of new life, and facilitate Native Hawaiians' return to source after death. (Liller 2000).

Nihoa and Mokumanamana islands are both listed on the National and State of Hawaiʻi registers of historic places, and there are more than 140 documented archaeological sites on these two islands. Though they are quite barren and seemingly inhospitable to humans, the number of cultural sites is testimony to the pre-Western-contact occupation and use of these islands. On Nihoa, a total of 89 known archaeological sites are known, including residential features, agricultural terraces, ceremonial structures, shelters, cairns, and burials. This island also has significant soil development for agriculture along with constructed terraces, which suggest investment in agricultural food production. On Mokumanamana, a total of 52 archaeological sites have been documented, including 33 ceremonial features, which makes it the highest concentration of religious sites found anywhere in the Hawaiian archipelago.

While Nihoa and Mokumanamana are thought to have been frequented until about 700 years ago, voyages to these islands and others in Papahānaumokuākea for the gathering of turtles, fish, bird feathers, and eggs continued into the 20th century, particularly from Kaua'i and Ni'ihau (Tava and Keale 1989; Maly 2003). Cultural practices like these continue to remind and teach Native Hawaiians of the connections and relationships their ancestors have passed down from generation to generation.

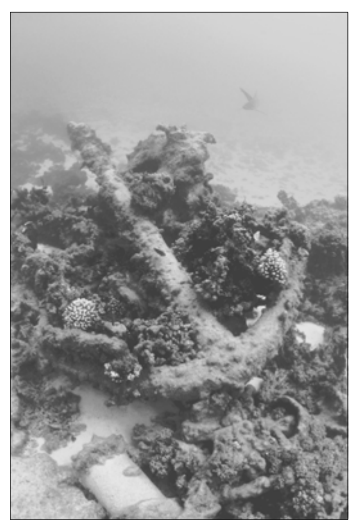
Maritime Heritage Resources

"I had just put my hand upon my coat when the ship struck with a fearful crash...I sprang upon deck… to find ourselves surrounded with breakers apparently mountain high, and our ship careening over upon her broadside..."
—Thomas Nickerson, on the loss of the ship Two Brothers at French Frigates Shoals, 1823 (Nantucket Historical Association MS 106 folder 3.5)

The Monument enjoys a rich maritime history, with ocean vessels from around the world having traveled into the NWHI—although not all who came in made it back out.

Long before Western ships sighted the NWHI, Native Hawaiians and other Polynesians journeyed in large double-hulled canoes to these resource-rich islands and atolls as they explored the vast Pacific Ocean without aid of western instrumentation. Guided by the stars, currents, and weather patterns, the Native Hawaiians set the stage for the intrepid ships and crews who would enter the waters of the NWHI beginning in the early part of the 19th century. It is believed that Native Hawaiians frequently sailed along the ancient voyaging routes that connect Kaua'i to the settlements on Nihoa and Mokumanamana.

In addition to the rich Native Hawaiian cultural setting, maritime activities following Western contact with the Hawaiian Islands have left behind the historical and archaeological traces of a unique past. Currently, more than 60 ship losses are known among the NWHI, the earliest loss dating back to 1818. These, combined with 67 known aircraft crashes, amount to more than 120 potential maritime and military heritage resources. Many of these resources reflect the distinct phases of historical activities in the remote atolls (Van Tilberg 2002).



Anchor from an unidentified 19th century whaling ship at Kure Atoll. Photo courtesy of James Watt.

As American and British whalers first made passage from Hawai'i to the seas near Japan in 1820, they encountered the low and uncharted atolls of the NWHI. Some of these early voyages gave rise to the Western names of the islands and atolls as we know them today. Pearl and Hermes Atoll is named for the twin wrecks of the British whalers *Pearl* and *Hermes*, lost in 1822. Midway was originally sighted by Captain Daggett of the New Bedford whaler *Oscar* in 1839. Laysan was reportedly discovered by the

American whaleship *Lyra* prior to 1828. Gardner Pinnacles was named by Captain Allen on the Nantucket whaler *Maro* in 1820, the same year the ship encountered, and gave its name to, Maro Reef.

The history of American whaling is a significant part of our national maritime heritage and is a topic that encompasses historic voyages and seafaring traditions set on a global stage, as these voyages had political, economic, and cultural impacts. The United States was intimately involved in the whaling industry in important and complex ways. Ten whaling shipwrecks are known in the NWHI. Three of these have been located (American whaler *Parker* and British whalers *Pearl* and *Hermes*), and their archaeological assessment is under way (Van Tilberg and Gleason, in prep). Whaling vessel wreck sites from the early 19th century are quite rare, and the study and preservation of heritage resources provide a unique glimpse into our maritime past.

Despite being slowly integrated into navigational charts, the NWHI remained an area of low and inconspicuous reefs and atolls for many years, frequented by shipwrecks and castaways. Crews were often stranded for many months while they constructed smaller vessels from salvaged timbers and set out for rescue. Some vessels were lost with all hands. Russian and French ships of discovery transited the NWHI, and sometimes found themselves upon the sharp coral reefs. Nineteenth-century Japanese junks of the Tokugawa Shogunate period, drifting away from their home islands and into the Pacific, were reportedly washed onto the sands of the atolls. Hawaiian schooners and local fishing sampans voyaged into the archipelago, many not to return. Marine salvage expeditions based out of the main Hawaiian Islands profited from the area, although existing records of their cruising activities are scarce. These types of sites have the potential to tell us about early-historic-period voyages in the Pacific and about the seafaring traditions of many cultures.

The strategic geographical location of the NWHI proved early on to be a valuable "commodity." The opening of China and Japan to commerce in the mid-19th century and the transition to steam propulsion brought with it the need for Pacific coaling stations. In August 1869, Captain William Reynolds of the USS *Lackawanna* took formal possession of Midway Atoll for the United States. Soon after, the USS *Saginaw,* a Civil-War-era side-wheel gunboat, was assigned to support improvement efforts at Midway. However, work to open a channel into the lagoon remained incomplete, and the *Saginaw,* on a return voyage from Midway with the contracting party, wrecked on the reef at nearby Kure Atoll on October 29, 1870. The wreck site was discovered in 2003, allowing research into the early technology of the "Old Steam Navy" (Van Tilberg 2003a).

From this inauspicious beginning, the strategic location of Midway and the NWHI continued to grow in importance for commercial and military planners. The Spanish-American War in 1898 led to the American colonization of Guam and the Philippines, as well as annexation of the Hawaiian Islands. This greatly expanded American colonial presence made transpacific communication a priority. By 1903, the first transpacific cable and station were in operation, and employees of the Commercial Pacific Cable Company settled at Midway. In the 1930s, Pan American Airways' "flying clippers" (seaplanes) were crossing the ocean, arriving at Midway from Honolulu on their 5-day transpacific passages (Cohen 1985). In 1939, the U.S. Navy expanded its interest in Midway, and millions of dollars were awarded to the Pacific Naval Air

Base Consortium. Construction of the naval air facility at Midway was begun the following year.

Naval activities increased during World War II. French Frigate Shoals was the temporary staging site for Japanese seaplanes, as well as a U.S. naval air facility at a later time. The Navy built an important submarine advance base at Midway Atoll, dredging the reef to form a channel and harbor for submarine refit and repair. The wreck of the USS *Macaw*, a Navy submarine salvage vessel lost in 1944 during the rescue of the submarine *Flier,* testifies to the dangerous nature of Pacific operations at Midway (Van Tilberg 2003a; Van Tilberg 2003b). Eastern Island at Midway possessed the main airfield in the early days of the war, while submarine and seaplane support operations were concentrated on Sand Island. Together, these areas constituted a vital center for undersea, surface fleet, and naval aviation operations. In fact, the Hawaiian Sea Frontier forces stationed patrol vessels at most of the islands and atolls. Tern Island, in French Frigate Shoals, was expanded after the Battle of Midway through dredging to create a naval air facility for staging aircraft from the main Hawaiian Islands and to provide faster resupply of Midway.

In June 1942, the Battle of Midway took place in seas north of Midway Atoll. Four Japanese aircraft carriers and one American carrier were sunk, and the Japanese military was forced to withdraw from a planned invasion. Although most of the battle took place 100 to 200 miles to the north, an intense air fight was waged directly over and around the atoll. Training exercises before and after the battle also took their toll. At least 30 naval aircraft, both American and Japanese, crashed or were ditched into the nearshore waters of Midway and Kure Atolls, many of them combat losses for both American and Japanese navies. Many of these crash sites are war graves. This battle proved to be the most decisive U.S. victory and was the turning point of World War II in the Pacific (Prange 1982).

All of these maritime activities have left a scattered material legacy around and on the islands: whaling ships, Japanese junks, navy steamers, Hawaiian fishing sampans, Pacific colliers, salvage vessels, and navy aircraft (Rauzon 2001). Many of these sites, as defined by State and Federal preservation laws (the National Historic Preservation Act, Archaeological Resources Protection Act, and the Abandoned Shipwreck Act), are of national and international historical significance. Programmatic mandates have been established to ensure their preservation and protection. NOAA's Maritime Heritage Program focuses on the discovery and investigation of these heritage resources for the benefit of present and future generations. These sites are the physical record of past activities in the NWHI, and embody unique aspects of island and Pacific maritime history.

Heritage Resources of Midway Atoll

"They had no right to win. Yet they did, and in doing so they changed the course of a war…Even against the greatest of odds, there is something in the human spirit – a magic blend of skill, faith and valor – that can lift men from certain defeat to incredible victory."
—Walter Lord

Designated as a National Memorial, Midway Atoll preserves the physical remains of the rich historic past in the Monument. With its defensive structures and military architecture, both residential and industrial, the atoll serves as a memorial to the pivotal Battle of Midway. While its role in that battle has earned Midway a prominent place in history, it was the atoll's strategic location that first drew the attention of the world nearly 100 years earlier. Called the "Middlebrook Islands" by Captain N.C. Brooks when he landed there in 1859 (Helber Hastert & Fee 1995; *Paradise of the Pacific* 1936), Midway's location soon proved attractive to transpacific commercial traders, triggering a century of development and manipulation of the landscape to meet the needs of commerce and the military, as well as occasional shipwreck survivors.

Physical improvements started almost immediately after the United States took possession in 1869, with a Congressional appropriation for development of the Sand Island entrance channel. Though the crew of the USS *Saginaw* worked on the channel during their 6½-month stay, the project stalled when the underlying solid limestone reef was encountered and the estimated costs to complete it proved prohibitive.

Interest in the atoll waned for a period, with its only sporadic inhabitants being the survivors of two notable shipwrecks that occurred in the late 1880s. The *General Seigel,* a schooner on a shark-hunting expedition with a crew of eight, wrecked in November 1886. Three crewmen died and one, Adolfe Jorgenson, was marooned by the remaining four members when they sailed from Midway on June 28, 1887. Seven months later, on February 3, 1888, the *Wandering Minstrel* was wrecked on the coral reef during a similar quest for sharks. The crew of 40, which included Captain F.D. Walker and his wife and sons, were surprised to find Adolfe Jorgensen still alive on Sand Island. After spending 14 months stranded on Midway, the Walker family and remaining crew were finally rescued in April 1889. Though none of the structures from this era remain, the stories of the survivors, including tales of murders, mutiny, escapes, buried treasure, and rescue, inspired Robert Louis Stevenson's novel "The Wrecker."

Interest in Midway was renewed in 1903, when the Commercial Pacific Cable Company chose Sand Island for a relay station on its route across the Pacific from San Francisco to the Far East. Armed with plans drafted by San Francisco architect Henry Meyers, Superintendent Ben W. Colley arrived in April 1903 with a staff and several carpenters to construct the station. The innovative reinforced concrete and steel buildings were plumbed and wired for electricity supplied by an acetylene generator. The graceful, two-story design offered shaded verandahs, a library, and billiard room along with kitchens and bedrooms. An ice-making plant, cold storage house, and windmills were also constructed. Superintendent Colley adapted the stark landscape to meet the needs of the cable company by importing soil from Honolulu to make a garden for growing fresh vegetables and by planting vegetation such as naupaka (*Scaevola*), grasses, ironwood trees, and coconuts to control the white sand that drifted everywhere (Colley n.d.). The first round-the-world telegram was issued by President Theodore Roosevelt on July 4, 1903. The remains of the cable station and its landscape can still be observed on the atoll.

In 1935, Pan American Airways began constructing a refueling base at Midway, which consisted of a wooden dock and a mooring barge in the lagoon where the seaplanes landed and discharged cargo and passengers (Yoklavich 1993). The facilities included a prefabricated hotel with a solar-heated hot water system, lounge, dining room, and 40 guest rooms as well as tennis courts, baseball fields, and even a sandy nine-hole golf course that required the use of black golf balls. None of these structures survives today, though historic photographs and film footage remain to tell the story.

Military interest in Midway accelerated as World War II started in Europe and war in the Pacific appeared inevitable. The strategic importance of an air base at Midway was considered second only to Pearl Harbor (Yoklavich 1993), and construction of the Naval Air Base was authorized in 1939. Architect Albert Kahn of Detroit, Michigan, one of the country's foremost industrial designers, prepared plans for the buildings in 1940 (Woodbury 1946:76 in Yoklavich 1993:24). Development of the military station changed the civilian character of Midway, creating a base landscape that replaced the individual units or "towns" that had defined the cable station and Pan American Airways' presence. The new base design clearly demonstrated the Navy's authority by placing the officer's housing in the center of Sand Island and developing a road system that linked the military's buildings. The architectural style of the buildings enhanced the perception of military control because of its uniform, simple, and efficient design.

On December 7, 1941, two Japanese destroyers shelled Sand Island for almost 2 hours (Hazelwood n.d. in Yoklavich 1993:26). Marine guns returned fire, but the Japanese ships caused extensive damage to several buildings, including the seaplane hangar and power plant. First Lieutenant George H. Cannon was fatally wounded in the shelling, and posthumously became the first Marine to receive the Medal of Honor in World War II (Heinl 1948:13 in Yoklavich 1993:26).

The capture of Wake Island and Guam by the Japanese, along with their aggressive offensive operation in the Pacific, caused military strategists to look more closely at Midway as the key to retaining any hope of U.S. success in the Pacific Theater. If Midway fell, it would be a short hop from there to Honolulu and other West Coast cities.

The historic events of the Battle of Midway have been explored in great detail in numerous reports, books, and articles, so only a brief synopsis is included here. In spring 1942, Midway Atoll was thought to be the target of an imminent Japanese attack. To learn their plans, Fleet Admiral Chester William Nimitz sent a command over the secure cable for Midway to broadcast a false distress message. The intelligence trap proved successful when a Japanese message was decoded 2 days later stating that the target "AF was having trouble with its fresh water distillation system" (Cressman et al. 1990). With the Japanese target clearly identified, Admiral Nimitz focused on planning for the impending battle.

Nimitz inspected the islands on May 2, 1942, to spur every effort to fortify the island with men and equipment. Nearly every inch of Sand and Eastern islands was covered with men and equipment. While most of the new equipment was sent to the European Theater, Nimitz tried to find resources for Midway sufficient to repel a Japanese landing. Several groups of Marine and Navy air detachments as well as Navy PT (patrol torpedo) boats were sent to the atoll to support existing forces.

PBY (patrol bomber-Y) Catalina seaplanes, the famous "flying boats" of World War II, were housed in the seaplane hangar and used the seaplane ramp in Sand Island harbor to make regular patrols. On the morning of June 4, 1942, a Navy PBY pilot radioed a contact report of "the main body" at approximately 700 miles away, headed northeast (Cressman et al. 1990). Though the pilot had actually seen part of the occupation force rather than the attacking force, the report immediately put the U.S. forces on alert.

All aircraft were already prepared to launch when the radar on Sand Island began picking up the incoming enemy flight at about 0630. As 108 Japanese planes zoomed toward Midway, 25 defending U.S. Marine fighters tried valiantly to slow their progress. Eastern Island's airfield was eerily quiet for the few minutes prior to attack, with all but a few airplanes safely launched. Meanwhile, torpedo bombers flew to attack the enemy aircraft carriers. The Japanese military strategy was simple–destroy the air base at Midway and clear the way for occupation.

The attack lasted only 17 minutes, but left the installations on both Sand and Eastern Islands in shambles. The seaplane hangar was hit and set ablaze. The fuel oil tanks 500 yards north of the seaplane hangar were also hit, sending a thick black column of smoke that could be seen for miles. The men on Midway were unable to effectively return fire on such advanced aircraft, which could drop bombs well out of reach of the anti-aircraft guns.

Meanwhile, an epic air battle was unfolding at sea. Against all odds and despite devastating losses of aircraft and pilots as well as the sinking of the USS *Yorktown*, the U.S. forces dealt a fatal blow to the Imperial Japanese Navy. Japanese naval commander Admiral Yamamoto had lost his entire fast carrier group, with its complement of some 250 planes, most of the pilots, and about 2,200 officers and men. On the morning of June 5, he gave the surprising order for a general retirement of his fleet, even though he still maintained overwhelming gunfire and torpedo superiority. In all its long history, the Japanese Navy had never known defeat (Morison 1963). This was America's greatest victory in the Pacific Theater and changed the course of history.

Midway as a military base was closed after World War II, reactivated during the Korean War, closed again, and reactivated in 1953. Crucial to the new radar technology tracking system during the Cold War, Midway served as a primary base for the "Pacific Barrier" operation, providing a radar line from Midway Atoll to Adak Island, some 1,300 miles to the north (NAS Barbers Point 1962). Continuous coverage for each 14-hour run necessitated a staggered flight schedule, with the radar planes, called "Willy Victors," leaving Midway every 4 hours (Sheen pers. com. 1998).

During the Vietnam War, Midway was selected as the site for the June 8, 1969, meeting of President Thieu of the Republic of Vietnam and U.S. President Richard Nixon. President Thieu, fearful of riots if he came to the United States, asked for a remote and safe location for a meeting. The base commander's home (Building 414) at Midway was the site of this momentous meeting (Denfeld in Yoklavich et al. 1994).

Since its designation in 2000, FWS has managed Midway Atoll as the National Memorial to the Battle of Midway, ensuring that those who fought and died in that battle will always be remembered for their sacrifice. Among Midway's 63 existing National Register-eligible historic properties are 6 defensive structures related to the Battle of Midway that were listed together as a National Historic Landmark in 1986. These structures, together with the cable station buildings, the Albert Kahn-designed Naval base, and war memorials, provide a tangible link to the past and the historic events that have transpired on this small speck of land in the middle of the Pacific.

This page intentionally left blank.

1.4 Environmental and Anthropogenic Stressors

Despite their remote location and largely uninhabited condition, the NWHI are subject to a wide range of environmental and anthropogenic stressors. Marine pollution, dredging, invasive species, fishing, and vessel groundings are some of the factors that have affected or may cause harm to the resources of the NWHI. An understanding of past and present stressors and potential future threats provides a backdrop for identifying priority management needs and informing an ecosystem-based management approach. In recent years, increased efforts have focused on documenting terrestrial and coral reef ecosystem health and the effects of priority environmental and anthropogenic stressors identified by the U.S. Fish and Wildlife Service Seabird Conservation Plan – Pacific Region (FWS 2005). This section describes the environmental and anthropogenic stressors in the NWHI.

Coastal Development

A century ago, coastal development in the NWHI consisted of guano mining at Laysan Island and the establishment of the Commercial Pacific Cable Company on Midway. Then in 1938, Congress authorized the Hepburn Board, a fact-finding group in the Navy, to make a strategic study of the need for additional U.S. naval bases. This study resulted in the construction of base facilities, airfields, and seadromes during 1939 and 1940 (Hepburn Board Report 1939, Time 1939). One of these facilities was Midway Naval Air Station. Facility construction included dredging a channel and building a seaplane basin and a turning basin. All of this work was accomplished through the dynamiting of coral heads by “skindivers” and by draglines and dredges mounted on land and barges. Approximately 3 million cubic yards (2.29 million cubic meters) of coral and material was removed. An estimated 2,800 feet (853 meters) of sheetpiling bulkhead was installed on Sand Island. Dredged material was pumped behind this bulkhead, creating new land for a seaplane parking-mat (U.S. Navy Bureau of Yards and Docks 1947).

After the Battle of Midway, the Navy recognized the need to be able to resupply Midway within hours, not the days or weeks required for ships to travel there. In less than 5 months, the Navy SeaBees and contractors dredged 660,000 cubic yards (504,600 cubic meters) of coral, enlarging Tern Island (at French Frigate Shoals) threefold to create a refueling stop for aircraft between O‘ahu and Midway (U.S. Navy Bureau of Yards and Docks 1947).

The Navy occupied Midway, French Frigate Shoals, and Pearl and Hermes during the first half of the 20th century. The U.S. Coast Guard constructed Long-Range Aids to Navigation (LORAN) stations after World War II at Kure and French Frigate Shoals and operated them for several decades (USCG 1994a). Several Cold War operations were conducted at French Frigate Shoals, such as the recently declassified “Corona Project,” the first operational space photo reconnaissance satellite system. French Frigate Shoals served as a tracking and recovery station for this project in the early 1960s.

During the Cold War, French Frigate Shoals housed up to 300 personnel at a time in support of the different classified and unclassified missions (Bill Wood pers. com. 2001). An additional 100 people were stationed at French Frigate Shoals to monitor the aboveground nuclear testing at Johnston Atoll. The Midway Naval Air Station supported several hundred to several thousand soldiers and dependents during the pre- to post-World War II era, before the atoll was transferred to FWS in 1996. Various islands of French Frigate Shoals, Midway, Kure, and Pearl and Hermes Atolls were used in military training exercises that included the use of landing craft, helicopters, and boats.

These types of coastal development activities alter current flow, temperature regimes, and shoreline configuration, and as a result, may significantly alter coastal erosion patterns. Reef disturbances due to storm or human activities are believed to create favorable environments for the formation of ciguatera toxin in marine life (Lehane and Lewis 2000, Van Dolah 2000, Ruff 1989, Kaly and Jones 1994). Operation of housing and other facilities on some islands and the creation of dumps contribute to point and nonpoint sources of pollution to the terrestrial and marine environments.

Since the closure of Navy and Coast Guard facilities, coastal development activities have been limited to small-scale conversion of abandoned Coast Guard buildings on Tern Island at French Frigate Shoals and Green Island at Kure to biological field stations. The only recent coastal construction has been the repair of the seawall protecting Tern Island's small runway and buildings and construction of a small boat ramp at French Frigate Shoals in 2004. This construction was needed to halt the erosion of the island and to eliminate the risk of injury and death to endangered monk seals, threatened green turtles, and migratory seabirds previously trapped in eroding seawall sheet piling that has now been removed from the island.

Current human population levels are limited to a few agency staff and volunteers at French Frigate Shoals, Laysan Island, Lisianski Island, and Pearl and Hermes and Kure atolls. In addition to a small number of agency staff and volunteers at Midway Atoll, approximately 50 contract employees operate the infrastructure required to maintain Henderson Airfield as an emergency landing site for commercial transpacific airliners.

Marine Pollution

Marine pollution can be defined as the introduction by humans, whether directly or indirectly, of substances or energy to the marine environment, resulting in deleterious effects such as hazards to the health of marine life and humans, hindrance of marine activities, and impaired water quality. Marine pollution may originate from land-based or sea-based human activities in the form of point-source discharges, groundwater discharges, or nonpoint-source runoff. Studies conducted by the FWS, Coast Guard, Navy, and the University of Hawai‘i have documented contamination in soil, sediment, and biota at French Frigate Shoals, Kure, and Midway. Direct impacts to black-footed albatrosses, in the form of reduced hatching success, have been linked to high organochlorine levels (Ludwig et al., 1997). Finkelstein et al. (2007) found a correlation between levels of organochlorines and elevated levels of mercury and impaired immune function in black-footed albatrosses.

Marine debris, such as derelict fishing gear and discarded plastics, is a global problem. The increase in reliance on plastic materials that float and are persistent in the environment, as well as improper disposal, has led to an abundance of these materials in our oceans. Marine debris degrades the aesthetic value of the coastal environment, creates navigational hazards, and has negative ecological impacts. There are documented cases of maritime disasters resulting in loss of human life due to vessel entanglement with marine debris (Cho 2004), and loss of marine animals due to entanglement and drowning in derelict fishing gear (Henderson 1990, 2001). In addition, hazardous waste has washed ashore; for example, at Laysan Island a diverse complement of hazardous materials has been found, including compressed gas cylinders, phosphorus flares, petroleum, and a 55-gallon drum marked "Toluene Diisocyanate." A container of the pesticide carbofuran is suspected to have washed ashore at Laysan Island, and the area dubbed "The Dead Zone" remained a hazard on the island from 1987 until it was remediated by FWS in 2002.

Impacts of marine debris upon the ecological health of the NWHI have not been fully documented due to the large size and remoteness of the region, as well as the historical and ongoing nature of the problem. It is known that fishing and cargo nets lost at sea are carried by currents to shallow water environments of the NWHI, causing physical damage to corals and creating entanglement hazards for monk seals and other marine organisms. Mortality due to entanglement in derelict fishing gear, primarily nets, has been documented for several mobile marine species in the NWHI, with impact upon the Hawaiian monk seal being of greatest concern due to the highly endangered status of this animal (Boland and Donohue 2003). Mean annual entanglement rates for monk seals are in a range that is higher than that shown to be detrimental to other pinniped populations, and documentation of entanglements is only available for those seals that return to shore; thus, it is highly probable that the actual impact is underestimated. From 1982 and 2003, 238 Hawaiian monk seal entanglements were documented in the NWHI, of which 162 were disentangled and freed, 61 escaped or had freed themselves, 8 were found dead, and 7 met an unknown fate (Henderson 2006 pers. com.). Other threatened or endangered marine animals, such as sea turtles, have been found entangled in marine debris, and often the only evidence of their drowning is the remains of their bones or shells still caught in the debris. In 2004, the skeleton of a subadult loggerhead sea turtle and the carcass of a small whale were found in a large floating net (NMFS 2004b).

Derelict fishing gear also degrades reef health by abrading, smothering, and dislodging corals and other benthic organisms, as well as preventing recruitment on reef surfaces (Donohue and Brainard 2001). Estimates of the overall impact of debris on shallow water habitats are difficult to quantify and are complicated by the likelihood that debris acts as a vector for alien species and introduction and spread of disease.

In the NWHI, much of the marine debris is in the form of derelict fishing nets, mostly trawl nets, from North Pacific fisheries. No trawl net fisheries are active in Hawaiian waters, but active domestic and international fisheries use this type of gear in Pacific Rim fisheries. Other types of debris include gill nets, seine nets, lobster traps, fishing floats, Fish Aggregation Devices (FADs), hazardous materials (e.g., barrels, gas cylinders), and plastics. Because much of the debris comes from international fisheries, U.S. activities aimed at prevention are complicated. Debris produced from illegal activities, such as the unauthorized deployment of FADs and unlicensed fishing throughout the Pacific, makes the problem even more complex and harder to quantify.

Since 1997, regular marine debris removal efforts have been conducted through a multi-agency effort led by NOAA, in collaboration with FWS, the State of Hawai‘i, City and County of Honolulu, Honolulu Waste Disposal, U.S. Coast Guard, U.S. Navy, University of Hawai‘i Sea Grant College Fund, Schnitzer Steel Hawai‘i Corporation (formerly Hawai‘i Metals Recycling

Company), The Ocean Conservancy, and other local agencies, businesses, and nongovernmental partners. Since then, this effort has resulted in the removal of more than 563 tons (502 metric tons) of derelict fishing gear and other marine debris from the coral reef ecosystems of the NWHI (figure 1.24). Marine debris survey and collection activities have been conducted at Kure Atoll, Midway Atoll, Pearl and Hermes Atoll, Lisianski Island, Laysan Island, and French Frigate Shoals. Removal operations have targeted areas where marine debris has accumulated over the past several decades. It is estimated that the accumulation rate is 57 tons (52 metric tons) per year. Until substantial efforts are made to significantly reduce the sources of debris and until debris can be effectively removed at sea, similar amounts are expected to continue accumulating indefinitely in the reef ecosystems of the NWHI.

Smaller types of marine debris made of plastic, such as disposable lighters, bottle caps, and other fragments, are ingested at sea by adult albatrosses, wedge-tailed shearwaters, and other seabirds when they feed at sea (Fry et al. 1987). These objects are subsequently fed to chicks in Monument colonies and may reduce their survival by causing direct injury to the gut, accumulating and reducing the chicks' ability to swallow full-sized meals, and placing them at greater risk of dehydration, a common cause of death in young albatrosses (Sileo et al. 1990; Sievert et al. 1993, Fry et al. 1987; Auman et al. 1997). Additionally, this debris may increase the birds' exposure to and ingestion of organochlorine contaminants from plastic surfaces (Carpenter and Smith 1972).

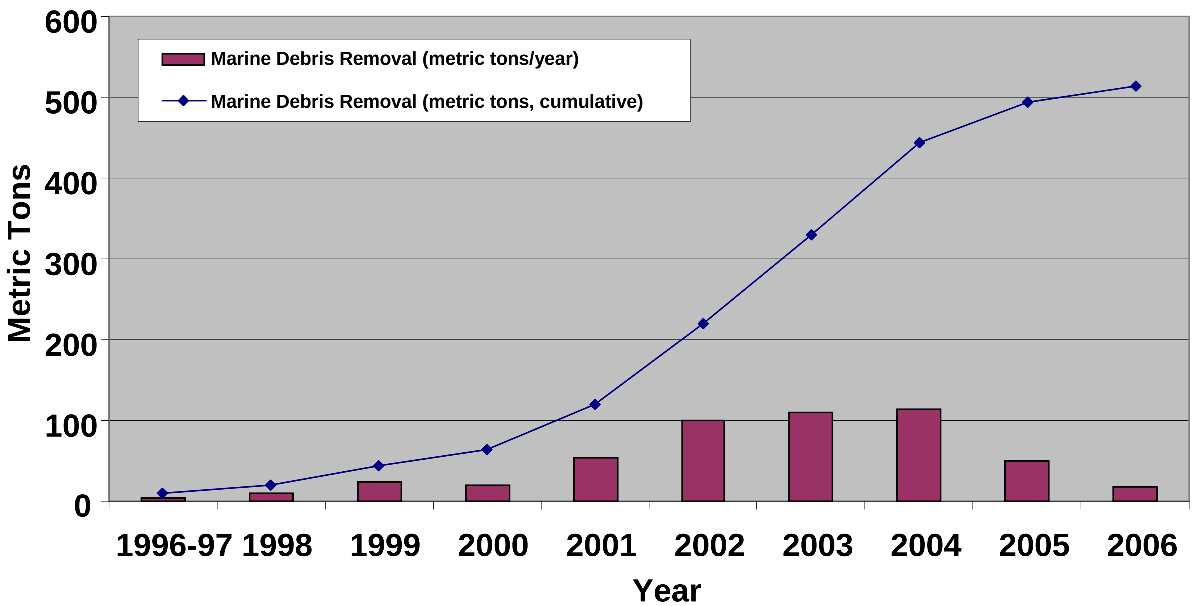


Figure 1.24 Quantity of Marine Debris Removal in the Northwestern Hawaiian Islands. Source: PIFSC-CRED unpublished data.

Terrestrial Pollution

Past uses have left a legacy of modification and contamination throughout NWHI, especially at French Frigate Shoals, Midway Atoll, and Kure Atoll. The NWHI have hosted an array of polluting human activities, including guano mining, fishing camps, Coast Guard LORAN stations, U.S. Navy airfields and bases, and various military missions. Contamination at all these sites includes offshore and onshore contaminated debris such as batteries (lead and mercury), transformers with polychlorinated biphenyls (PCBs), capacitors, and barrels. Debris washing ashore is another source of contamination on the islands. Birds, such as shorebirds, may ingest soil while foraging. Studies have shown that soil can constitute up to 30 percent of the material a bird consumes (Hui and Beyer 1998, Beyer et al. 1994). If the consumed soil is contaminated, this can result in direct intake of toxic substances by foraging birds. Direct ingestion of sand contaminated by carbofuran, a pesticide that washed ashore with marine debris on Laysan Island, caused the deaths of endangered Laysan finches until the source was identified and removed by the FWS (Campbell et al. 2004, David et al. 2001).

Uncharacterized, unlined landfills remain on some of these islands. Kure Atoll and French Frigate Shoals both have point sources of PCBs due to former LORAN stations. While the Coast Guard has mounted cleanup actions at both sites, elevated levels of contamination remain in island soils, nearshore sediment, and biota.

During Coast Guard residency at Tern Island (French Frigate Shoals), an area on the north side of the island across from the barracks was used as a general dump and for the burning of garbage and trash. Waves, rust, and erosion slowly destroyed the northern seawall, and it was breached in late 1980, exposing the dump. Further erosion revealed a great deal of scrap metal, cable, wire, batteries, and electronic equipment such as capacitors and transformers. Coast Guard investigations removed exposed debris over the course of several years. PCB concentrations in the soil ranged from nondetect (<0.033) to 2,300 milligrams/kilogram. In an agreement forged by the Coast Guard and signed by the FWS, EPA, and Coast Guard, a cleanup level for soil was set at 2 milligrams/kilogram. In 2001, the Coast Guard excavated the landfill (U.S. Coast Guard 2002). Despite the removal of a large amount of material, the Coast Guard left intact an area of approximately 95 by 60 feet (29 by 18.3 meters) that is a jumble of concrete blocks and metal debris from which numerous capacitors, batteries, and transformers have been removed over the years. PCB concentrations in 10 soil samples collected from this debris pile ranged from 0.14 to 54 milligrams/kilogram PCBs, with 5 of the 10 samples exceeding the cleanup level of 2 milligrams/kilogram (U.S. Coast Guard 2003). The most highly contaminated sample (54 milligrams/kilogram PCB) is considered hazardous waste. Unfortunately, this area is open to the lagoon, so it is washed by tides and storms. It is also frequented by monk seals and turtles.

During Coast Guard residency at Kure, garbage and scrap metal were disposed of and burned at a dump site located at the southwestern edge of the island. Included in the pit were hazardous materials such as batteries and PCB-containing capacitors. The Coast Guard reported PCBs in the eroding dump to range from nondetect to 393 milligrams/kilogram (U.S. Coast Guard 1994b). In 1994, the Coast Guard remediated the landfill on Kure, excavating and putting into containers soil from the landfill that exhibited a concentration equal to or greater than 25 milligrams/ kilogram. A total of 36 cubic yards (27.5 cubic meters) of soil was removed from the landfill. Scrap metal, cable, nonliquid-containing drums, and remaining soil in the landfill (metal debris and soils with PCB concentrations below 25 milligrams/kilogram) were removed from the landfill and re-interred in the "reburial pit." The depth of the reburial pit was set 15 feet below ground surface, which was estimated to be 2 feet above the groundwater (U.S. Coast Guard 1994b). Confirmation sampling by the Coast Guard found concentrations of PCBs exceeding the cleanup goal and in excess of 100 milligrams/kilogram.

French Frigate Shoals and Pearl and Hermes Atoll were used for World War II seaplane refueling operations. Leaking underground fuel storage tanks at French Frigate Shoals resulted in petroleum contamination of soil.

Midway Atoll was the site of a U.S. Navy airfield. Before control of the atoll was transferred to the Department of the Interior in 1996, numerous contaminated sites throughout the atoll were identified and cleaned up under the U.S. Department of Defense's Base Realignment and Closure process. Contamination identified and remediated included petroleum in the groundwater and nearshore waters; pesticides (e.g., DDT) in the soil; PCBs in soil, groundwater, and nearshore sediments and biota; metals, such as lead and arsenic, in soil and nearshore waters; and unlined, uncharacterized landfills. While most of the known areas were remediated, several areas warrant continued monitoring for potential releases. Since the airfield's closure, the Navy has returned on several occasions to conduct further remediation.

Midway has several landfills left behind by the Navy. Some of these landfills were created during base closure for the disposal of construction rubble and asbestos. Other landfills were created during Navy occupancy for disposal of materials associated with operations. One area that needs continued monitoring and potentially further remediation is known as the Old Bulky Waste Landfill. This site is an uncharacterized landfill that was created by the disposal of scrap metal, used equipment, and unconsolidated waste off the south shore of Sand Island to create a peninsula approximately 1,200 feet long by 450 feet (average) wide by 9 feet high (366 meters long by 137 meters wide by 2.7 meters high)(Navy 1995). It is surrounded on the three seaward sides by an approximately 10-foot-thick (3-meter-thick) band of concrete and stone rip-rap. Wastes known to have been deposited in the landfill are metals (lead, cadmium, chromium, and nickel), gasoline, battery acid, batteries, mercury, lead-based paint, solvents, waste oil, PCBs, dioxins, furans, transmission and brake fluids, vehicles, equipment, tires, and miscellaneous debris (U.S. Navy 1996). The Old Bulky Waste Landfill is subjected to groundwater infiltration from the north and seawater infiltration from the other three sides.

Erosion of the Bulky Waste Landfill on Sand Island, Midway Atoll.

The Technical Memorandum for Evaluation of Remedial Alternatives (U.S. Navy 1995) stated that all remedial alternatives considered for the Old Bulky Waste Landfill would require groundwater monitoring. Alternatives considered were (1) containment, by constructing a multilayer cap in place and providing a lateral barrier extending below the lagoon floor along the landfill periphery; (2) removal, by excavating the landfill and disposing of nonhazardous wastes further inland; (3) covering, by constructing a multilayer cap in place; and (4) no action. Ultimately, the Old Bulky Waste Landfill was covered in approximately 2 to 2.5 feet (0.6 to 0.8 meters) of soil. Currently the landfill is eroding, and the soil placed on top is sifting into the debris, causing large holes to open up around the edge and in the center of the landfill. Additionally, burrowing birds are bringing up buried soil and nesting below the cover. Over 500 bird burrows have been counted in the landfill.

Pollution generated by past and present human activities, from sea-based and land-based sources, continues to stress the NWHI ecosystem. Emergency response mechanisms and ongoing cleanup and restoration activities will be maintained and enhanced to address these issues. In the case of marine debris, the NWHI is the recipient, not the source of this type of marine pollution. This provides the Monument with an important opportunity, as well as a challenge, to facilitate global and Pacific regional cooperation to help solve this problem.

Climate Change

Recent decades have brought increased awareness of the changing global environment and the implications this change may have on ecological processes. The increase in average global temperatures, sea level rise, and change in chemical concentrations in the world's oceans are typically cited as the results of global climate change. Changes in the global climate are being brought about by three factors: increasing concentrations of carbon dioxide and other gasses in the atmosphere, commonly referred to as the greenhouse effect; alterations in the biogeochemistry of the global nitrogen cycle; and ongoing land use and land cover change. Change in land use is considered the single most important component of global change affecting ecological systems (Vitousek 1994). While there is some debate regarding the extent of the impact these changes will have on Earth's environment, several trends have been well documented. The four areas of impact linked to global climate change that may have the greatest potential effect on the Monument are weather changes, coral bleaching, sea level rise, and oceanic chemical composition change.

Central patch reef, Kure Atoll, September 2002. Bleached *Pocillopora meandrina* with initial overgrowth by turf algae. Photo: Jean Kenyon

According to findings of the Intergovernmental Panel on Climate Change (IPCC), scientific understanding of anthropogenic warming and cooling influences on climate has improved in the last few years, leading to very high confidence that the global average net effect of human activities since 1750 has been one of warming. The IPCC also concluded that global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities (IPCC 2007).

Regional predictions for the North Central Pacific Gyre area within the life of the Monument Management Plan are for surface temperature increases of 0.9 to 1.8° F (0.5 to 1.0 °C), which is a smaller increase than that predicted for the Arctic and Northern hemisphere continental areas.

Projected precipitation maps indicate a decrease of 10 to 20 percent of average precipitation by 2090 in the Monument area. It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with higher peak wind speeds and heavier precipitation associated with ongoing increases of tropical sea surface temperatures. Extratropical storm tracks will likely move poleward and be associated with changes in wind, precipitation, and temperature patterns. Projection of the magnitude of sea level rise by 2090 from thermal expansion of water and the melting of land-based ice sheets is less certain, but the estimate ranges from 0.6 to 1.9 feet (0.18 to 0.59 meters) (IPCC 2007). A rise of that magnitude (1.6 feet or 0.48 meters) is predicted to cause the loss of 3 to 65 percent of the terrestrial habitat in the Monument (Baker, et al. 2006). Evidence also suggests that the world's oceans are regionally divisible with regard to historic fluctuations in sea level. Localized variations in subsidence and emergence of the sea floor and plate-tectonics activity prevent extrapolations in sea level fluctuations and trends between different regions. Thus, it may not be possible to discuss uniform changes in sea level on a global scale, nor the magnitude of greenhouse-gas-forced changes, as these changes may vary regionally (Michener et al. 1997). As an example, tide gauge records on the Atlantic coast indicate a sea level rise of 0.06 to 0.16 inches/year (0.89 to 0.99 centimeters/year) over the past century, whereas they have indicated a 0.35 to 0.39 inches/year (0.15 to 0.4 centimeters/year) increase along the Gulf Coast of the United States (Michener et al. 1997). More recent modeling indicates that melting could occur faster than the IPCC has predicted (Overpeck et al., 2006). Increases in sea level may also affect low-lying equatorial islands and atolls. Shoreline erosion and saltwater intrusion into subsurface freshwater aquifers have been noted throughout the Pacific (Shea et al. 2001).

Weather Changes

Weather changes, such as reductions in the amount of precipitation and changes in soil moisture and temperature, will affect vegetation communities by changing species compositions, seasonalities, and biomass. This is turn may affect the reproductive capabilities of insects and land birds that depend on this vegetation. Increased storm frequency and intensity will have impacts on coral health by direct damage due to breakage and smothering as sand moves around, and on terrestrial systems due to overwashing of islands.

Coral Bleaching

Coral bleaching occurs when zooxanthellae, symbiotic algae that live in coral tissue, leave the coral as a result of thermal and other types of stress. Corals can die or become diseased without their energy-producing zooxanthellae and can be subsequently colonized by turf algae and sessile invertebrates. Above-normal mean sea-surface temperatures have been shown to cause bleaching and mortality in corals, both in nature and in the laboratory, with bleaching generally occurring in shallower waters (Floros et al. 2004). Other variables have also been implicated in bleaching and mortality events, including extended periods of high temperatures, low wind velocity, clear skies, calm seas, low rainfall, high rainfall, salinity changes, high turbidity, or acute pollution. Smith and Buddemeier (1992) state, "Reef damage from anthropogenic environmental degradation (nutrient runoff, siltation, overexploitation) is widespread, represents a much greater threat than climate change in the near future, and can reinforce the negative effects of climate change." Floros et al. (2004) goes on to note, "The causes of coral bleaching are debatable, but widely thought to be the result of a variety of stresses, both natural and human-induced, that cause the degeneration and the loss of the colored zooxanthellae from the coral tissues."

Sea surface temperature anomalies resulting from regional and global-scale climatic phenomenon are believed to cause bleaching in the NWHI. Mass coral bleaching in the NWHI occurred during late summer 2002 (Aeby et al. 2003; Kenyon and Brainard 2006), the first time it was recorded or known to exist in the NWHI. Coral bleaching occurred again at high levels in 2004, but was only detected at low rates in 2006 (Kenyon et al., 2006). Furthermore, the NWHI were believed to be less susceptible to bleaching due to their high latitude location. Bleaching was most severe, however, at the three northernmost atolls (Pearl and Hermes, Midway, and Kure), which experience both higher and lower sea water temperatures than the other reef areas of the NWHI. Bleaching occurred but was less severe at Lisianski Island and farther south in the NWHI.

Oceanic Chemical Concentration Change

Glacial and interglacial periods in the Earth's history cycle have been associated, respectively, with low and high concentrations of carbon dioxide, as measured from deep Antarctic ice cores. However, recent increases fall outside the range of peak prehistoric carbon dioxide levels. The rate of increase is also 5 to 10 times more rapid than any of the sustained changes in the ice-core record (Vitousek 1994). Carbon dioxide levels have increased from 280 to 355 µL/L (microliters per liter) since 1800, a level of increase otherwise never reported during the past 160,000 years. Data suggest this increase is linked to fossil fuel combustion and not deforestation (Vitousek 1994). As a result of anthropogenic release of carbon dioxide since 1750, the acidity of the ocean has increased (IPCC, 2007.) Change in carbon dioxide levels will increase the partial pressure of carbon dioxide in seawater, thus reducing the oversaturation of aragonite, a form of calcium carbonate that is the major building block for coral reefs (Vitousek 1994). Additionally, changes in ocean pH are predicted to create the dissolution of coral substrate as waters become more acidic (Fine and Tchernov 2007). The comprehensive result of the predicted change in ocean chemistry is uncertain, but it is thought that it will reduce the rate at which corals can deposit calcium carbonate and, additionally, decalcify existing coral skeletons, thus reducing the rate or capability of coral reefs to keep up with any increases in sea-level elevations. Moreover, increased ocean acidity can similarly affect the carbonate-based island atolls.

Chemical composition changes in the atmosphere may also affect terrestrial ecosystems. For instance, the quantity of nitrogen available to organisms affects species composition and productivity. Increase in nitrogen can alter species composition by favoring those plant species that respond to nitrogen increases (Vitousek 1994). Increased carbon dioxide can also influence photosynthetic rates in plants, change plant species composition, lower nutrient levels, and lower weight gain by herbivores.

Diseases

The incidence of diseases affecting marine organisms is increasing globally; however, the factors contributing to disease outbreaks are poorly known and hampered due to a lack of information on normal disease levels in the ocean (Harvell et al. 1999). The incidence of coral disease is lower in the NWHI (Aeby 2006). The NWHI provide unique opportunities to document baseline levels of disease in coral reefs in the absence of a resident human population (Aeby 2006).

Recent studies in the NWHI have begun to document baseline levels of coral disease (Work et al. 2004; Aeby 2006). Tumors, as well as lesions associated with parasites, ciliates, bacteria, and fungi have been found on a number of coral species. The overall average prevalence of disease (number of diseased colonies/total number of colonies) was found to be very low in the NWHI, estimated at 0.5 percent (ranging from 0 to 7.1 percent) (Aeby 2006), compared to the average prevalence of disease of 0.95 percent in the main Hawaiian Islands (Friedlander et al. 2005). The prevalence of disease varies among different genera of coral (figure 1.25), with the highest prevalence in species of the genera *Acropora* and *Montipora*. A protocol for characterizing coral disease has now been incorporated into regular coral surveys and monitoring of the NWHI.

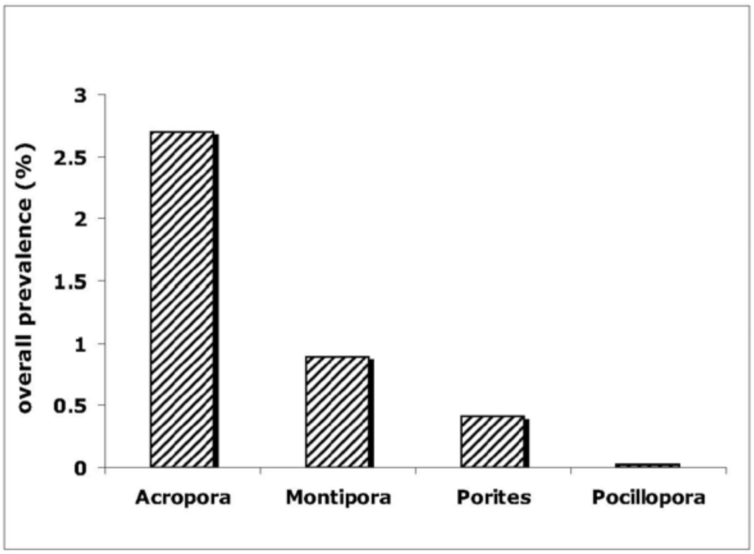


Figure 1.25 Overall prevalence of disease in the four major coral genera in the NWHI. Seventy-three sites were surveyed in July 2003. Prevalence (all surveys combined) is calculated as the number of diseased colonies per genera/total number of colonies per genera x 100. Source: Aeby 2006.

The threatened Hawai'i population of the green turtle is affected by fibropapillomatosis (FP), a disease that causes tumors in turtles. The prevalence of FP in the Hawaiian green turtle population was estimated at 40 to 60 percent, with the majority of cases found among juvenile turtles (Balazs and Pooley 1991). The herpes virus has been suggested as the possible cause or as a cofactor of FP (Herbst 1995). The majority of recent turtle strandings are by juvenile turtles with FP (Work et al. 2004). As a result, FP may pose a major threat to the long-term survival of the species (Quackenbush et al. 2001).

Marine Alien Species

Marine alien species can be defined as aquatic organisms that have been intentionally or unintentionally introduced into new ecosystems, resulting in negative ecological, economic, or human health impacts. A total of 12 marine alien invertebrate, fish, and algal species have been recorded in the NWHI (table 1.5). Alien species may be introduced unintentionally by vessels, marine debris, or aquaculture, or intentionally, as in the case of some species of groupers and snappers and algal species.

Table 1.5 Marine Alien Species in the Northwestern Hawaiian Islands[1]

Species	Taxa	Native Range	Present Status in NWHI[2]	Mechanism of Introduction
Acanthophora spicifera	Algae	Indo-Pacific	Established (MID)	Fouling on ship hulls (hypothesized)
Hypnea musciformis	Algae	Unknown; Cosmopolitan	Not Established; in drift only (MAR)	Intentional introduction to Main Hawaiian Islands (documented)
Diadumene lineata	Anemone	Asia	Unknown; on derelict net only (PHR)	Derelict fishing net debris (documented)
Pennaria disticha	Hydroid	Unknown; Cosmopolitan	Established (PHR, LAY, LIS, KUR, MID)	Fouling on ship hulls (hypothesized)
Balanus reticulatus	Barnacle	Atlantic	Established (FFS)	Fouling on ship hulls (hypothesized)
Balanus venustus	Barnacle	Atlantic and Caribbean	Not Established; on vessel hull only (MID)	Fouling on ship hulls (documented)
Chthamalus proteus	Barnacle	Caribbean	Established (MID)	Fouling on ship hulls (hypothesized)
Amathia distans	Bryozoan	Unknown; Cosmopolitan	Established (MID)	Fouling on ship hulls (hypothesized)
Schizoporella errata	Bryozoan	Unknown; Cosmopolitan	Established (MID)	Fouling on ship hulls (hypothesized)
Lutjanus kasmira	Fish	Indo-Pacific	Established (NIH, NEC, FFS, MAR, LAY, and MID)	Intentional introduction to Main Hawaiian Islands (documented)
Cephalopholis argus	Fish	Indo-Pacific	Established (NIH, NEC, FFS)	Intentional introduction to Main Hawaiian Islands (documented)
Lutjanus fulvus	Fish	Indo-Pacific	Established (NIH and FFS)	Intentional introduction to Main Hawaiian Islands (documented)

Notes:
1 Zabin et al. 2003, Godwin 2002, DeFelice et al. 2002, Godwin 2000, DeFelice et al. 1998, McDermid (pers. com.)
2 NIH=Nihoa, NEC=Necker, FFS=French Frigate Shoals, MAR=Maro, PHR=Pearl and Hermes, LAY=Laysan Island, LIS=Lisianski Island, MID=Midway, KUR=Kure Atoll

Recent compilations of marine alien species in Hawaiʻi (Eldredge and Carlton 2002) include some 343 species: 287 invertebrates, 24 algae, 20 fish, and 12 flowering plants. Information concerning marine aquatic invasive species in the NWHI is more recent and judgments as to whether organisms are invasive or native are based on knowledge of marine aquatic alien species that has been gained in the main Hawaiian Islands over the last decade. This is due both to the lack of taxonomic information for many invertebrate groups and the minimal historical sampling effort in the NWHI. The status of the taxonomy of many non coral marine invertebrate groups and algae is not fully developed for the NWHI and comprehensive species inventories have yet to be produced, although efforts to correct this are presently underway (Godwin et al., 2006).

The known data concerning marine aquatic alien species in the NWHI was collected from a single focused marine invasive species survey by the Bishop Museum at Midway Atoll in 2000 and subsequent multi agency RAMP cruises in 2002 and 2003. The results of these efforts have recorded a total of 11 aquatic invasive marine fish, invertebrate, and algae species in the NWHI. Table 1.5 shows the species, the native range of each, their present status in the NWHI, and the hypothesized or documented mechanism of introduction.

Eleven species of shallow-water snappers (*Lutjanidae*) and groupers (*Serranidae*) were purposely introduced to one or more of the main islands of the Hawaiian Archipelago in the late 1950s and early 1960s. Two snappers, the bluestripe snapper (taape, *Lutjanus kasmira*) and the blacktail snapper (*Lutjanus fulvus*), and one grouper, the peacock grouper (*Cephalopholis argus*), are well established and have histories of colonization along the island chain that are reasonably well documented (Randall 1987). Bluestripe snappers have been by far the most successful fish introduction to the Hawaiian coral reef ecosystem. Approximately 3,200 individuals were introduced on the island of Oʻahu in the 1950s. The population has expanded its range by 1,491 miles (2,400 kilometers), until it has now been reported as far north as Midway in the NWHI (figure 1.26). These records suggest a dispersal rate of about 18-70 nautical miles (33-130 kilometers) per year. The other two species have only been recorded as far north as French Frigate Shoals and are present in much lower numbers than bluestripe snappers.

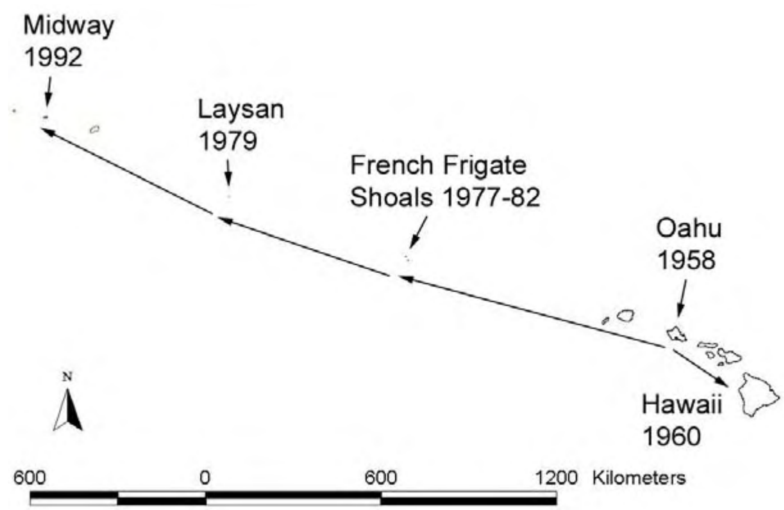


Figure 1.26 Spread of Bluestripe Snapper Throughout the Hawaiian Archipelago after Introduction to Oʻahu in 1958. Source: Friedlander et al. 2005.

The magnitude of the problem of aquatic alien species is far greater in the main Hawaiian Islands than the NWHI. Efforts to control the accelerated introduction of alien species in the NWHI will focus on transport mechanisms, such as marine debris, ship hulls, and discharge of bilge water from vessels originating from Hawaiian Island and other ports, to effectively reduce new introductions. Existing Monument regulations and permitting requirements greatly reduce the chance of new introductions. Monitoring is needed as an early warning system for response actions to be effective. Natural transport mechanisms, such as larval transport in currents, also play a role in the spread of aquatic invasive species.

Terrestrial Alien Species

Human occupation at Midway Atoll has continued uninterrupted since the Commercial Pacific Cable Company took up residence there in 1903. The cable company attempted to make the settlement as self-sufficient as possible through the cultivation of gardens and small livestock. Initial garden attempts failed due to the lack of organic soil on the islands. To remedy this, barge loads of soil were brought from Oʻahu and Guam, and contained not only the organic matter that made gardening possible, but also all the associated soil organisms such as ants, centipedes, fungi, etc. In addition to the introduction of vegetables, trees and ornamentals were also planted, such as ironwoods, eucalyptus, and acacia. So successful were these introductions that, by 1922, an estimated two-thirds of Sand Island was covered with imported vegetation. Livestock and poultry were also raised. While the black rat (*Rattus rattus*) was successfully exterminated on Midway in 1997, mice (*Mus musculus*), along with various species of ants, wasps, ticks, and mosquitoes continue to plague the wildlife and humans. Mosquitoes are of special concern as they are potential vectors for diseases such as West Nile virus, avian malaria, and avian pox.

Laysan Island was the site of another attempt at colonization. In 1890, Captains Freeth and Spencer initiated the mining of guano, resulting in the removal of thousands of tons of guano and the disturbance of hundreds of acres of habitat. The most devastating action on Laysan was the introduction of domestic rabbits, Belgium and European hares, and guinea pigs by Max Schlemmer in 1903. Schlemmer, known as the "King of Laysan," introduced these animals partly to amuse his many children and as potential livestock for a meat-canning business. Schlemmer's activities, which included feather exporting, were outlawed with the establishment of the Hawaiian Islands Reservation; however, by then, the rapidly reproducing rabbits had extirpated most of the vegetation on Laysan. The U.S. Bureau of Biological Survey sent an expedition on the *Thetis* in the winter of 1912-13 to exterminate them but ran out of ammunition after 5,000 rabbits were killed; this still left several thousand, which continued to destroy the vegetation (Ely and Clapp 1973, Rauzon 2001). The rabbits were finally exterminated in 1923 by the Tanager Expedition, which was a joint expedition by the U.S. Bureau of Biological Survey, the Bishop Museum, and the U.S. Navy (Rauzon 2001). In only a few years, the rabbits destroyed almost all of the vegetation and associated insects of the island, causing the extinction of three species of birds: the Laysan honeycreeper (*Himantione sanguinea freethii*), the Laysan rail (*Porzana palmeri*), and the Laysan millerbird (*Acrocephalus familiaris familiaris*).

The number of alien land plants in the NWHI varies from only 3 introduced at Nihoa to 249 introduced at Midway Atoll. The level of threat from introduced plants also varies between species. For example, the invasive plant golden crownbeard (*Verbesina encelioides*) displaces all native vegetation in nesting areas, causing entanglement and heat prostration and killing hundreds of albatrosses each year. At Southeast Island, Pearl and Hermes Atoll, *Verbesina* has displaced all native plants, and when it dies back each year, the endangered Laysan finches (*Telespiza cantans*) there suffer severe food and cover restrictions. This plant has quickly covered nesting habitat on Sand, Eastern, and Spit islands of Midway Atoll, Green Island of Kure Atoll, and Southeast Island of Pearl and Hermes Reef.

Sandbur (*Cenchrus echinatus*) is an aggressive invasive grass currently occurring at Kure and Midway Atolls, Pearl and Hermes Reef, Lisianski Island, and French Frigate Shoals. An intensive *Cenchrus* eradication effort at Laysan Island that took 10 years to complete has restored that island's vegetation community. Laysan Island has also been invaded by Indian Pluchea (*Pluchea indica*), *Sporobolus pyramidatus*, and swine cress (*Coronopus didymus*). Additionally, several species of invasive ants have quickly established and are lethal when they swarm on young seabird chicks.

The invasive gray bird locust (*Schistocerca nitens*) was first detected at Nihoa Island in 1984, and by 2000 was periodically reaching large population levels that were causing damage to the native plant community, including three endemic species listed as endangered. This grasshopper species has now also spread to Mokumanamana, French Frigate Shoals, and Lisianski Island.

To prevent further importation of invasive plants, animals, or insects, mandatory quarantine protocols are enforced for any visitors to all the islands in the NWHI, with the exception of Midway Atoll and Tern Island. These protocols require the use of brand new or island-specific gear at each site and treatments such as cleaning, using insecticide, and freezing to minimize the transport of potentially invasive species to the islands.

Fishing

Fishing and other resource extractive uses have occurred in varying degrees in the NWHI. Native Hawaiians traveled to these areas as early as 500 A.D. During the western exploration period (1750 to 1920s), explorers and whalers from France, Russia, Japan, Britain, and the United States harvested Hawaiian monk seals, whales, fish, seabirds, and guano from various parts of the NWHI. In more recent history (1920s to 1970s), fishing and other resource extractive uses were punctuated by the overexploitation of the endemic black-lipped pearl oyster (1928 to 1931), the beginning of a Hawai‘i-based fishing fleet (1930s to 1940s), a cessation of commercial uses during World War II, a resumption of commercial fishing (1945 to 1960) (during which Tern Island was used as a transshipment point for fresh fish flown to Honolulu), and a proliferation of foreign fishing vessels from Japan and Russia (1965 to 1977).

Commercial fishing in the NWHI has, in recent decades, been managed according to Federal fishery management plans developed for fisheries for precious corals, bottomfish and seamount groundfish, and pelagic, crustacean, and coral reef fisheries. According to the management scheme, no precious coral or coral reef species fisheries have been permitted in the NWHI. Pelagic longline fishing within 50 nautical miles (92.6 kilometers) of the NWHI has been prohibited since 1991, the year the Longline Protected Species Zone was designated to prevent interactions with endangered species (50 C.F.R. 665.21 (2007) Subpart C). The crustacean (lobster-trap) fishery has not had a harvest guideline set for the NWHI since that time; no crustacean fishery has operated in the NWHI since 2000. However, Proclamation 8031 allows commercial fishing by federally permitted bottomfish fishery participants who have valid permits until mid-2011 (71 FR 36443, June 26, 2006). This amounts to a maximum of eight permitted bottomfish vessels that fish within the Monument.

The only commercial fishery occurring in the Monument is the Federal bottomfish fishery. This fishery operates according to the management regime specified in the Fishery Management Plan for Bottomfish and Seamount Groundfish Fisheries in the Western Pacific Region. In the NWHI, the bottomfish fishery is a hook and line fishery that targets a range of snappers, jacks, emperors, and groupers that live on the outer reef slopes, seamounts, and banks at depths of approximately 50 to 400 fathoms. The management regime includes several precautionary measures that minimize potential effects of this fishery. For instance, the bottomfishery participants do not operate in the presence of the monk seals so as to avoid any direct or indirect effects of the fishery on the species (50 C.F.R. 665.61(2007) Subpart E). Also, it is known that the vessels operations do not negatively impact habitat (Kelley and Ikehara 2006). Finally, the annual catch limit in the NWHI is set by regulation at 300,000 lbs. of bottomfish and 180,000 lbs. of pelagic species (50 CFR Part 404). In practice, bottomfish harvest is below catch limits and is thought not to be the contributing factor to the overfishing status of the bottomfish stocks in the archipelago.

Transportation Hazards and Groundings

Hazards to shipping and other forms of maritime traffic such as shallow submerged reefs and shoals are inherent in the NWHI's 1,200 miles (1,931 kilometers) of islands and islets. 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. Likewise, aircraft landing at Midway Atoll or Tern Island pose certain risks to wildlife and other resources, including bird strikes, introduction of alien species, aircraft crashes, and fuel spills. Certain management practices, such as requiring night landings and runway sweeps during albatross season at Midway and alien species inspections can minimize these risks.

The many types of vessels operating in and transiting through the NWHI pose different threats to the marine environment based on their size, age, draft, port of origin, frequency of visits, activities conducted, navigational protocols, and operations that could disturb or injure wildlife or coral reef ecosystems, as well as the volume, type, and location of discharges. The range of vessel types include 20- to 60-foot fishing and recreational vessels, 150- to 250-foot research vessels, 500- to 700-foot passenger cruise ships and freighters, 700- to 1,000-foot tankers, as well as Coast Guard, military, and international ships of all sizes and types.

Vessel Groundings, Oil and Fuel Spills, and Loss of Cargo Overboard

In 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. All vessels pose a risk to the environment. Periodically, accidental loss of cargo overboard causes marine debris or hazardous materials to enter sensitive shallow-water ecosystems.

Twelve of the 60 ship losses known to have occurred in the region have been located and include whaling vessels, navy frigates, tankers, and modern fishing boats. Additionally, 67 planes are known to have been lost in the region, mainly naval aircraft (many from World War II), but only 2 have been located. Some of these ship and aircraft wreck sites fall into the category of war graves associated with major historic events.

Unexploded ordnance, debris, and modern shipwrecks, such as the fishing vessels *Houei Maru #5* and *Paradise Queen II* at Kure Atoll or the tanker *Mission San Miguel* lost at Maro Reef, are not protected as 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 species, 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) growth when the iron begins to dissolve (corrode). This is especially a problem on atolls and low coral islands where basalt or volcanic rock is absent in the photic zone and natural dissolved sources of iron in seawater are even lower. 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 can have long-term detrimental effects, that in most cases, can be worse than any short-term damage to the environment caused by the removal action.

In 1998, the *Paradise Queen II* ran aground at Kure Atoll, spilling 11,000 gallons of diesel fuel and 500 gallons of hydraulic fluids and oil. The vessel also lost 3,000 pounds of frozen lobster tails, 4,000 pounds of bait, 11 miles of lobster pot mainline, and 1,040 lead-weighted plastic lobster traps. Traps rolling around in the surf broke coral and coralline algal structures. Two years later, researchers found broken coral and 600 lobster traps among piles of nets surrounding the decaying wheelhouse (Maragos and Gulko 2002).

When the 85-foot longliner *Swordman I,* carrying more than 6,000 gallons of diesel fuel and hydraulic oil, ran aground at Pearl and Hermes Reef in 2000, vessel monitoring system technology allowed agents to track the disaster and quickly send out equipment for a cleanup that cost upward of $300,000, a cost that the government had to sue to recover.

By comparison, the grounded chartered marine debris cleanup vessel *Casitas* caused less environmental damage. Following the removal of 33,000 gallons of fuel and oil, the 145-foot motor vessel *Casitas* was successfully extracted from the reef at Pearl and Hermes Atoll and entombed northwest of the atoll in approximately 7,200 feet (2,195 meters) of water. However, the crew fleeing the sinking vessel was forced to camp on a quarantine island without "clean gear." It has yet to be determined whether any invasive species came ashore with the shipwecked crew. The ship was conducting marine debris cleanup operations under a NOAA charter when it ran aground on July 2, 2005. Unified Command representatives from the Coast Guard, State of Hawai'i, and Northwind Inc. (owner of the *Casitas*), in cooperation with the Federal trustees FWS and NOAA, oversaw the operation to prevent further damage to the coral reef ecosystem and islands.

On June 1, 2007, a grounded vessel named *Grendel* was discovered inside Kure Atoll's lagoon on the northeast reef. Metal debris from the vessel was found on the reef extending along a 500' path from the vessel northeast to the emergent reef, indicating that the vessel entered the lagoon over the northeast reef. The level of fouling on the steel hulled sloop suggested that the vessel wrecked approximately 3-4 months earlier in February or March. The vessels sails, sheets and lines were tangled around the mast, stays, and railings creating a wildlife entanglement hazard. Approximately 275 pounds of entanglement hazards were removed using snorkeling gear. A battery, 300 pounds of chain, three anchors, and several broken pieces of metal were also removed from the site. The MMB is coordinating with Army, Navy, and Coast Guard officials to remove the wreck in the spring of 2008.

Waste Discharge

The International Convention for the Prevention of Pollution from Ships (MARPOL 1973/78) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It addresses potential sources of pollution, such as oil, chemicals, harmful substances in packaged form, garbage, sewage, and air pollution. (The United States is not a signatory to those parts of the Convention addressing the last two sources.)

The Convention's regulations are aimed at preventing and minimizing pollution from both accidental events and routine operations.

Vessel waste generally consists of solid waste, sewage, gray water, and bilge water. Solid waste may consist of food, cans, glass, wood, cardboard, paper, and plastic. Sewage discharge can contain bacteria or viruses, or medical wastes that can cause disease in humans and wildlife or affect the ecosystem by increasing nutrient load. Gray water is wastewater from sinks, showers, laundry, and galleys. It may contain a number of pollutants such as suspended solids, ammonia, nitrogen, phosphates, heavy metals, and detergents. Bilge water can contain fuel, oil, and wastewater from engines and machinery that collects in the bottom of the ship's hull as a result of routine operations, spills, and leaks. Discharge in the Monument is tightly regulated by the Proclamation and permit requirements. Monument staff are investigating the potential impacts of various types of discharges and will continue to update permit requirements as need to safeguard the marine resources.

Ballast Water Exchange

Ballast water discharged from ships is one of the primary pathways for the introduction and spread of aquatic nuisance species. In response to national concern regarding these species, the National Invasive Species Act of 1996 was enacted, which 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 Coast Guard regulations establishing 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.

Introduction of Alien Species

Introduction of marine alien species, including pathogens, is of great concern. The prohibitions on ballast discharge in the Proclamation and the actions outlined in the Alien Species Action Plan (section 3.3.2) aim to prevent the introduction of alien species to the marine environment. 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.

Anchor Damage to Reefs

Vessel anchoring has the potential to affect the ecosystem depending upon many factors, such as the size of the ship and anchor system, weather conditions, and the location and vicinity of the anchorage relative to sensitive ecosystems, such as coral reefs. Because of the potential for impacts to the ecosystem, anchoring on or having a vessel anchored on any living or dead coral with an anchor, anchor chain, or anchor rope is prohibited. Anchoring on all other substrates is strictly regulated.

Anchors and chains can destroy coral and live rock, directly affecting fishes and benthic organisms and their habitat. To prevent this type of damage, mooring buoys are sometimes used in places where frequent or extended anchoring is necessary. Depending on site conditions and mooring type, such buoys can reduce impacts to the ecosystem. The National Marine Sanctuary

Program has successfully used mooring buoys to mitigate ecosystem damage in high-use areas in the Florida Keys National Marine Sanctuary. Similarly, in Hawai‘i, the State Department of Land and Natural Resources minimized coral reef and benthic habitat damage at Molokini Islet’s popular anchorage with mooring buoys. Data are available to study potential mooring buoy locations using anchor logs from ships that currently operate, or have done so historically, in the Monument.

Light and Noise Impacts

Light and noise generated by people in the marine environment have been the subject of attention in recent years because of concerns that they may negatively affect a variety of species. In the NWHI, seabirds are attracted to and become disoriented by ship lights at night. With emergent land areas in the NWHI providing breeding and nesting area for millions of seabirds, ships’ nightlights attract birds, which can strike the vessel and become injured. The extent of the impact of lights on the seabirds is affected by many factors, including the amount of light, the size of the vessel, the vessel location relative to nesting areas, the season, and the type of birds in the vicinity. Shearwaters, petrels, and juvenile birds are especially vulnerable to nightlights and deck injuries. Lights from vessels can also attract green turtle hatchlings, making them more vulnerable to predators. Lights and lighted structures on land contribute to seabird mortality by causing collisions and disoriention. Light sources in the vicinity of turtle nest-sites may disorient hatching marine turtles so they travel inland and perish.

Anthropogenic noise may also affect some species in the NWHI environment. Sound is a common element of the marine and terrestrial environment, originating from a variety of natural sources such as wind, waves, earthquakes, and marine organisms. Humans introduce sound incidentally into the environment through activities such as low-flying aircraft, shipping, fishing and other vessel use. People also introduce sound intentionally using sonar for research or military applications, seismic arrays, fish finders, and other tools that help people “see” underwater, and to better understand or exploit the marine environment. The amount and intensity of sound in the ocean is increasing as human activities expand.

Underwater sounds of both human and natural origin may affect the behavior and, in some cases, the survival and productivity of individual marine mammals. The nature and significance of effects depend on a number of factors involving the intensity, duration, and frequency of the sound, as well as particular aspects of the habitat and the animal it may affect. Of particular concern is midfrequency tactical sonar used by military vessels. This type of sonar has been implicated as the cause of several recent marine mammal stranding events (Marine Mammal Commission 2005). Deep-diving species, such as beaked whales, appear to be particularly at risk from these sound sources. Beaked whales occur throughout the Hawaiian Archipelago, including within the Monument (Barlow 2003).

Little is currently known about noise levels and sources in the Monument. Future assessment of the anthropogenic noise in the NWHI will be conducted in close coordination with the Marine Mammal Commission, NOAA Fisheries, and other partners. The Marine Mammal Commission maintains a Sound Program and Advisory Committee on Acoustic Impacts on Marine Mammals to address the effects of anthropogenic sound on marine mammals.

The following information summarizes the main types of vessels operating in the Monument. All vessels carry with them some degree of risk associated with groundings, discharge, alien species introductions, and wildlife interactions and other potential threats, which are addressed in different sections throughout this plan or directly though prohibitions or permit requirements.

Fishing Vessels

Eight commercial fishing permits are eligible for use in the Monument until June 2011. The fishermen average 2 to 10 trips per year per vessel, with duration ranging from 3 to 22 days per trip. For the most part, these vessels bottomfish around the atolls and banks at the 100-fathom depth, and troll in deep water and across banks as they transit between islands. Annual catch limit is set by the Proclamation and codified by regulation (50 CFR Part 404). Crew size ranges from one to four people. The Proclamation prohibits further commercial bottomfish and associated pelagic fishing after June 15, 2011.

Vessels Conducting Research and Management Activities

Several vessels are engaged in research or management activities in the Monument. These include NOAA’s *Oscar Elton Sette*, *Hi‘ialakai*, *Ka‘imimoana*, and the University of Hawai‘i’s R/V *Kilo Moana* and R/V *Kaimikai-O-Kanaloa*, as well as chartered vessels for marine debris removal and for FWS management activities. These vessels are most active in the NWHI during the months of April through November. They average 200 feet in length; weigh 2,300 tons; and carry 50 crew, researchers, and other staff. The Coast Guard sends a buoy tender to the NWHI once a year. This mission also serves as a law enforcement patrol. In addition, the Coast Guard may occasionally send other ships to the area as needed (Havlik 2005 pers. com.).

Cruise Ships

A small number of cruise ships visit the Midway Atoll Special Management Area each year. The Seven Seas Voyager visited Midway once, and the Pacific Princess visited twice in 2004. In 2005, 2006, and 2007, one cruise ship visited the atoll each year (Maxfield 2005 pers. com.). Due to their size and the narrow width of the entrance channel at Midway, as well as port security requirements, cruise ships offload passengers 3 to 4 miles outside the lagoon and transport them ashore in small boats.

Worldwide, cruise ships constitute a large and growing industry, and like other ships, present a potential environmental threat to the Monument. Large cruise ships can carry thousands of passengers and crew, producing hundreds of thousands of gallons of wastewater and tons of garbage each day. The cruise industry has attracted a lot of attention regarding the treatment of waste at sea, and the Monument closely monitors scientific and regulatory developments that may influence management decisions associated with these ships.

Merchant Vessels

U.S. flag and international merchant vessels, including container ships, bulk carriers, and tankers, transit the waters surrounding the NWHI regularly. Data on routes and volume of shipping traffic are in the process of being compiled. Vessel traffic passes to the north of the island chain, following great circle routes to and from ports on the west coast of North America and East Asia. Vessels also pass through the Monument. Vessels have been observed using the pass between Pearl and Hermes Atoll and Lisianski Island because it allows vessels to maintain an east-west heading while transiting through the island chain (Tosatto 2005 pers. com.). Periodically, accidental loss of cargo overboard causes marine debris or hazardous materials to enter sensitive shallow water ecosystems.

Native Hawaiian Practices and Education

Between 2003 and 2007, several trips for Native Hawaiian cultural practices, education, and documentary film and photography projects were conducted on vessels in the Monument. Vessel size varied, as did anchoring and waste discharge practices. Some of the trips, such as the *Hōkūle‘a* voyage to Kure in 2004 as part of the "Navigating Change" program, included both FWS and NOAA personnel.

1.5 Global Significance

The Monument is important both nationally and globally, as it contains one of the world's most significant marine and terrestrial ecosystems, areas of cultural significance, and the world's largest fully protected marine area. It serves as an example of ongoing geological processes, biological evolution, and the effects humans have had on the natural environment. These volcanic rocks, large atolls of sand and coral, and islets surrounded by reefs and waters provide unique habitats for endemic and rare species of animals and plants, with outstanding and universal value from scientific, conservation, 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.

More recently, the recognition of the uniqueness of the NWHI has led the State of Hawai‘i, on behalf of the Co-Trustees, to work with the National Park Service International Programs Office to work toward nomination of the Monument as a United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Mixed Site for its natural and cultural values, and as part of the world heritage of mankind. The U.S. submitted a new World Heritage tentative list to UNESCO in January 2008, which included the Monument as one of the sites for consideration in the United States World Heritage portfolio because the NWHI:

- Are an outstanding example representing a major stage of the earth's evolutionary history;
- Are an outstanding example representing significant ongoing geological processes, biological evolution, and man's interaction with his natural environment;
- Contain unique rare and superlative natural formations and features and areas of exceptional natural beauty; and
- Provide habitats where populations of rare and endangered species of plants and animals still survive.

UNESCO rules require a minimum 1-year delay between the time a Nation submits its tentative list and the time it makes an actual nomination to designate a site from that list as a World Heritage Site. The U.S. submitted its new Tentative List to UNESCO on January 24, 2008.

Conserving the NWHI contributes to international community efforts aimed at conserving biodiversity and ecosystem integrity around the world. These efforts include work by organizations such as the World Conservation Union, the world's largest environmental knowledge network; the Convention on Biological Diversity; the South Pacific Regional Environment Program; and UNESCO. Conservation and management of Monument resources contributes to the reduction in the current rate of loss of biological diversity at the global, national, and regional levels, for the benefit of all life on earth.

Remote, uninhabited, and relatively pristine in comparison to other marine ecosystems in the world, the Monument serves as one of the few modern sentinels 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 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.

On July 13, 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. The U.S. proposal for PSSA designation was submitted in April 2007 for consideration by the IMO's Marine Environment Protection Committee at its July meeting. 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. The proposed area of the PSSA is coterminous with the Marine National Monument.

PSSA designation will augment domestic protective measures by alerting international mariners to exercise extreme caution when navigating through the area. Additionally, as part of the PSSA designation process, on October 8, 2007, 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 will be implemented in May 2008. The PSSA received final designation by the Marine Environment Protection Committee in April 2008.

Nevertheless, the Monument is not immune from local, regional, and global-scale influences. The millions of pounds of marine debris that have accumulated in the NWHI illustrate the impact people have on faraway, uninhabited ecosystems at an international scale. Therefore, the Co-Trustees are committed to preserving and protecting the cultural, historic, and natural resources of the NWHI by developing and implementing this Monument Management Plan to care for and manage these unique insular and marine ecosystems.