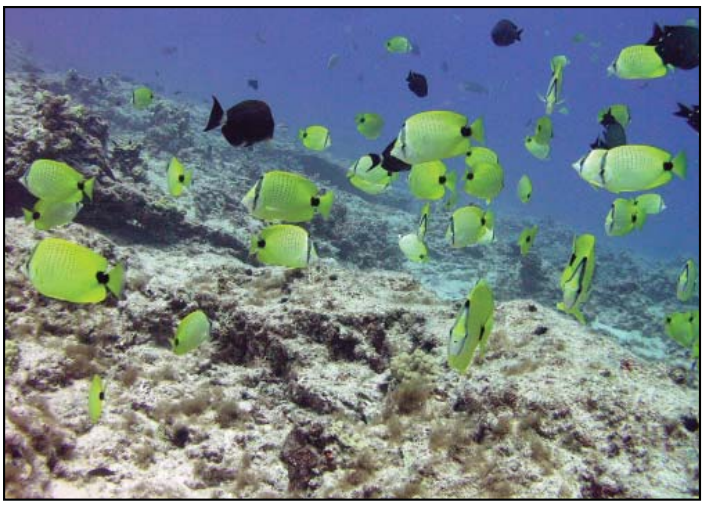
EXECUTIVE SUMMARY

The mission of NOAA's Office of National Marine Sanctuaries (ONMS) is to serve as the trustee for a system of marine protected areas, to conserve, protect and enhance biodiversity. To assist in accomplishing this mission, the ONMS has developed a partnership with NOAA's Center for Coastal Monitoring and Assessment's Biogeography Branch (CCMA-BB) to conduct biogeographic assessments of marine resources within and adjacent to the marine waters of NOAA's National Marine Sanctuaries (Kendall and Monaco, 2003).

Biogeography is the study of spatial and temporal distributions of organisms, their associated habitats, and the historical and biological factors that influence species' distributions. Biogeography provides a framework to integrate species distributions and life history data with information on the habitats of a region to characterize and assess living marine resources within a sanctuary. The biogeographic data are integrated in a Geographical Information System (GIS) to enable visualization of species' spatial and temporal patterns, and to predict changes in abundance that may result from a variety of natural and anthropogenic perturbations or management strategies (Monaco et al., 2005; Battista and Monaco, 2004).

Defining biogeographic patterns of living marine resources found throughout the Northwestern Hawaiian Islands (NWHI) was identified as a priority activity at a May 2003 workshop designed to outline scientific and management information needs for the NWHI (Alexander et al., 2004). NOAA's Biogeography Branch and the Papahanaumokuakea Marine National Monument (PMNM) under the direction of the ONMS designed and implemented this biogeographic assessment to directly support the research and management needs of the PMNM by providing a suite of spatially-articulated products in map and tabular formats. The major findings of the biogeographic assessment are organized by chapter and listed below.



The NWHI are home to a wide variety of ecosystems and living marine resources. Photos: J. Maragos.

Oceanography

- Sea surface temperature (SST) analyses suggest three latitudinal subunits:
  - North – Kure, Midway, Pearl and Hermes – temperature range 20-27 °C, among the largest variation in any coral reef ecosystem;
  - Middle – Lisianski to Gardner; and
  - Southern – French Frigate Shoals to Nihoa, average temperature range 23-27 °C.
- SST analysis suggest there may have been bleaching events in 1987 and 1991 based on temperature anomalies >1 °C during warm period (August-September).
- Sea surface fronts or eddies are active in the northern region from December to April with a peak in March. Few fronts are found in the southern portion and during mid-summer, fronts retreat to the north.
- Low productivity ocean water is increasing worldwide due to climate change and this water has reached the Hawaiian archipelago with major implications for ecosystem productivity.

Geology and Benthic Habitats

- Only 50% of shallow water habitats (0-30 m) have been mapped with more than one-half of this habitat consisting of hardbottom.
- Nearly complete high resolution bathymetric coverage from 3 to 3,000 m exists for Kure, Midway, Pearl and Hermes, Brooks Bank and French Frigate Shoals.
- Upchain islands (Kure, Midway, Pearl and Hermes and Lisianski) have steeper slopes compared to downchain islands. The highest rugosity (complexity) derived from multibeam data was at Pearl and Hermes.

Benthic Communities

- There are approximately 80 morphologically distinct coral "species" in the NWHI, and about 35 are likely to be endemic (44%). This represents some of the highest endemism of any coral assemblage found on earth. More than 25 NWHI species are still undescribed or unidentified, and once type specimens are collected and examined morphologically and genetically, then final determinations can be made on which corals are new species and possible endemics. Notwithstanding efforts to date, NWHI explorations are still inadequate, and it is likely that additional undescribed coral species will be encountered in the future.
- The highest species richness was observed at French Frigate Shoals and reflects optimal conditions for coral growth (optimal temperature, low wave exposure, large open atoll)
- Coral cover, based on tow board data, was 8% overall. Lisianski (19%) and Maro (15%) had the highest cover while Midway (2%) had the lowest. Coral cover on hard bottom only was highest at Maro (39%) and Lisianski (37%).
- No significant differences were found in coral cover at permanent locations between 2002 and 2006.
- Disease prevalence is low overall, <1%.
- Algal diversity is similar across the chain but brown algae are more abundant at the northern end of the chain (Midway and Kure). Algal endemism was calculated at 11% for French Frigate Shoals, and 7% for Gardner Pinnacles, however recent molecular evidence coupled with more detailed morphological observations are finding that a large percentage of the Hawaiian algal flora are likely incorrectly identified and may be species new to science.

Fishes

- Endemism based on numbers is 52% and 21% based on species richness.
- Fish assemblages showed latitudinal affinities with more subtropical and temperate species found to the north and more tropical species to the south. The major faunal break occurs around Maro and Laysan.
- Midway and Kure have a distinct fish assemblage based on biomass as does Nihoa and Mokumanamana. These distinct assemblages at the extremes of the chain are likely the result of temperature and habitat.
- Grey reef sharks are more common downchain while Galapagos sharks are more common to the north. The transition occurred around Gardner and Maro.
- Ranking of fish assemblages (based on endemism, species richness, number of individuals, biomass, apex predator biomass and recruitment) show Pearl and Hermes with the highest rank, followed by Midway, and French Frigate Shoals, respectively.

Protected Species

- Fifteen cetacean species have been observed within the Monument boundaries. This group of organisms has not been well studied in the NWHI and it may represent an important area for these species.

- Hawaiian monk seals have shown dramatic declines since the late 1990s but these declines differ among locations and for various reasons. French Frigate Shoals currently supports the largest colony but has also shown the steepest decline (75% since 1989) with low juvenile survival. Laysan and Lisianski have remained fairly constant over the past decade. Pearl and Hermes is the only location to have shown an increase in the past 10 years. Low population numbers at Midway and Kure are likely the result of long histories of human disturbance.
- Green turtle populations continue to increase in the NWHI, representing a major conservation success story. French Frigate Shoals accounts for over 90% of the nesting population with Laysan, Lisianski, and Pearl and Hermes accounting for the remainder. Despite extensive potential beach nesting habitat at Midway and Kure, limited nesting has been observed at Midway and none at Kure.

Seabirds

- Twenty-two species of seabirds exist in the NWHI, representing one of the most important locations for seabirds in the tropics. Despite the importance of this region, long-term data collection has been restricted to a few species at a limited number of locations.
- Foraging areas range from only a few kilometers for some species (e.g. Little Terns) to over 1,000 km for species like the Laysan Albatross. Wide ranging species will require cooperative management at national and international levels.
- Changes in SST and primary production will result in changes in seabird populations over time and monitoring of these populations will be important to better understand the impacts of climate change.

Nonindigenous and Invasive Species

- The presence of invasive species is currently concentrated in harbors and when man-made objects are present.
- The blueline snapper (Taape) have spread from Oahu in 1958 to Midway in 1992, a distance of 1,180 nmi and observations at other islands in the chain show during this time period show a rate of spread of about 18-70 nmi/yr. On the other hand the Peacock grouper (Roi) has only made it as far as French Frigate Shoals or about 5-17 nmi/year.
- The current presence of invasive species is low but data are limited, particularly at deeper depths and more systematic sampling is currently being implemented.

Connectivity and Integrated Ecosystem Studies

- Advection-diffusion ocean current models show Kure, Midway, and Pearl and Hermes strongly connected. Scale of dispersal is on the order of 50-150 km.
- High-resolution ocean current data and computer simulation showed that for organisms with short larval duration (15 days – e.g., corals and some invertebrates), a narrow transitional region from Kauai to Nihoa included settlers from both the Main Hawaiian Islands (MHI) and NWHI. For typical fish larvae (45 day larval duration) there appeared to be little exchange between the NWHI and the MHI north of French Frigate Shoals. For the few organisms with longer larval durations (eg., Bottomfishes, lobster) nearly all regions of the MHI have at least some NWHI settlers where as most of the NWHI is self-seeding.
- Giant trevally (ulua) and jobfish (uku) show no inter-atoll movement over a several year period. They congregate around channels and reef passes and make seasonal, within-atoll movements to spawn.
- Genetic connectivity for opihi, the Hawaiian endemic limpet, between the MHI and NWHI is too low (less than three migrants per generation) to replenish MHI stocks and one species is not even found in the NWHI.

- Barriers to genetic dispersal occur between Pearl and Hermes and Midway, as well as between Niihau and French Frigate Shoals for some species however closely related species with similar ecology and reproductive biology have dramatically different patterns of connectivity.
- Potential bottom fish habitat was calculated among islands based on depth (100-400 m), slope (>20%), and hardness using available mapping data. Kure (31%) and Maro (30%) had the greatest percentage of potential bottom fish habitat to total area mapped. These results may indicate areas with high populations and therefore greater replenishment potential for other locations. These results may also be useful in identifying monk seal forage habitat.
- Stable isotope analysis indicates that benthic algae provide the majority of the trophic support for apex predators and the entire system consists of short (three to four trophic levels above primary production) food chain. These results are very consistent with the Ecopath model estimates of food web supporting fisheries production in the NWHI.

Management

- The complex meta-population dynamics observed in the NWHI requires a better understanding of how these populations replenish themselves and how they connect to other areas.
- The results show some areas of strong linkage and others with clear breaks in connectivity. This will require zoning and other spatial management tools to maintain ecosystem function.
- Current and future changes in the environment as a result of climate change will require more comprehensive assessment and monitoring along with the ability to respond in a timely manner to mitigate potential negative impacts to the ecosystem.
- The data gaps identified in the report (e.g., shallow-water maps, cetaceans, seabirds, deeper habitats, etc.) need to be addressed in order to have a better understanding of the entire ecosystem.
- A biogeographic assessment that integrates the MHI and NWHI would better help to explain ecosystem connectivity and processes.

For questions or more information, please visit http://ccma.nos.noaa.gov/about/biogeography/ or contact:

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