Inventory & Monitoring Program
National Park Service
U.S. Department of the Interior
PACIFIC ISLAND NETWORK

INVENTORY OF MARINE VERTEBRATE SPECIES AND FISH-HABITAT UTILIZATION PATTERNS IN COASTAL WATERS OFF FOUR NATIONAL PARKS IN HAWAI'I

Inventory and Monitoring Program
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June 15, 2006

Report Number: NPS/PWR/PACN/NRTR-YYYY/###
Contract Number: xxxx-xxxx-xxxx

Funding Sources:
Inventory & Monitoring Program, National Park Service

File Name:
BEETS_2006_MarineVerts_20060615.doc

Organization Contact Information:
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Recommended Citation:
Beets, J., E. Brown, A. Friedlander. 2006. Inventory of marine vertebrate species and fish-habitat utilization patterns in coastal waters off four National Parks in Hawai'i. USDI National Park Service, Inventory and Monitoring Program, Pacific Island Network. Hawaii Volcanoes National Park, HI. 55 pg.

Key words:
Inventory, marine vertebrates, marine fishes, marine mammals, marine turtles

Place key words:
Hawaii, Pacific Island Network, Molokai, island of Hawaii, KAHO, KALA, PUHE, PUHO

Acronyms:

NPS	National Park Service
PACN	Pacific Island Network
I&M	Inventory & Monitoring Program
KAHO	Kaloko-Honokōhau National Historical Park
KALA	Kalaupapa National Historical Park
PUHE	Pu`ukoholā Heiau National Historic Site
PUHO	Pu`uhonua o Hōnaunau National Historical Park
NOAA	National Oceanic and Atmospheric Administration
USGS	United States Geological Survey
GIS	Geographic Information System
GPS	Global Positioning System
UTM	Universal Transverse Mercator

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ABSTRACT

Marine vertebrates were investigated at four national parks in Hawaii in 2005; Kalaupapa National Historical Park (KALA) - island of Moloka`i; Pu`ukoholā Heiau National Historical Park (PUHE), Kaloko - Honokōhau National Historical Park (KAHO), Pu`uhonua o Hōnaunau National Historical Park (PUHO) - island of Hawai`i. In addition to an inventory of marine vertebrate species, analyses of data collected on fish-habitat utilization patterns of marine fishes were conducted for each park. A total of 178 marine fish species were observed in the marine waters adjacent to all four parks (52.4% of the known reef and shore fishes), including 48 endemic species (27% of the total). Although the greatest number of species of marine fishes was observed for KAHO, the greatest abundance and biomass of marine fishes was generally observed at KALA. The greatest average values per sample for assemblage characteristics (species richness, numerical abundance, biomass, diversity) were observed for KALA, followed by PUHO and KAHO. PUHE had the lowest assemblage characteristic values observed and most dissimilar species composition, due to a greater proportion of sand and degraded habitats. KAHO and PUHO had the most similar species composition observed. Marine turtles, particularly the threatened green sea turtle (*Chelonia mydas*), are commonly observed in KAHO and PUHO, and also observed in KALA. Dolphins and whales are commonly observed in park and adjacent waters.

INTRODUCTION

The National Park Service (NPS) established the Inventory and Monitoring Program to scientifically document the range of features and resources within National Parks, which is the basis for improved management. Marine ecosystems, particularly, coral reef communities, present unique challenges for inventory and monitoring. Researchers frequently must work in difficult conditions in fragile communities where most organisms shelter in holes and crevices, often cryptically.

In order for the National Park Service to effectively manage their resources, resources must be identified and their current conditions documented. Numerous marine resources have been in decline for decades globally (Bellwood et al. 2004; Pandolfi et al. 2005) and locally (Hunter and Evans 1995; Friedlander and DeMartini 2002; Smith et al. 2002). Today, coastal resources in Hawai`i are facing unprecedented changes and declines due to numerous factors, particularly anthropogenic impacts, such as coastal development and overexploitation (*reviewed in* Friedlander et al. 2005; *see also* Lowe 1995; Smith 1993, Friedlander 2003). Marine vertebrates, especially fishes, have suffered enormous declines, estimated at over 90% decline globally for large predatory fishes (Myers and Worm, 2003). The near-extirpation of apex predators and heavy exploitation of lower trophic levels in the Main Hawaiian Islands (MHI) from intensive fishing pressure has resulted in a stressed ecosystem that does not contain the full complement of species and interrelationships that would normally prevail (Friedlander and DeMartini 2002).

Declines in marine resources in Hawai`i and worldwide require that we take a more holistic approach for better management and conservation of marine ecosystems. Ecosystem management has gained growing support in recent years (Pikitch et al. 2004). This approach relies on an improved understanding of ecological structure and ecosystem processes and function, especially in complex ecosystems such as coral reefs.

In order to attain the established goals for inventory in ecosystems in the National Parks, it is necessary to determine the presence and distribution of resources (both living and non-living features). Ideally, inventories should also include information on species composition, relative abundance, and spatial distribution of organisms and their habitat affinities for components of the ecosystem. Coupling the distribution of habitats and species habitat affinities using GIS technology enables the elucidation of species habitat utilization patterns for a single species and/or assemblages of animals. By integrating spatial data into the biological sampling design, significant progress can be made towards identifying and quantifying spatial dependencies in habitat utilization by marine vertebrates. This integrated approach is useful in quantitatively defining resource abundance, associations, habitat requirements (especially, essential habitats), and defining biologically relevant boundaries of marine protected areas. The combination of marine habitat mapping and spatially-explicit biological sampling has provided a unique opportunity for the National Park Service (NPS) working with collaborators to develop monitoring programs and protocols.

Information on marine resources within and adjacent to Hawaiian national parks has been provided in numerous investigations (e.g. Godwin and Bolick, 2006). However, data specific to marine vertebrates are limited and vary greatly among locations. This inventory project was developed to provide quantitative data on marine vertebrates at four national parks in Hawai`i .

The marine vertebrate inventory project in the four designated NPS units in Hawai`i had a broader scope than an inventory list of species. The goals and objectives developed by NPS included characterization of the marine vertebrate assemblages and the habitats that they utilize. The project was conducted to provide data for more informed management decisions and the development of sound monitoring protocols of identified vital signs and significant resources.

The selected NPS units included in this investigation were: (refer to Figure 1)
Island of Moloka`i:
Kalaupapa National Historical Park (KALA): waters within the park.
Island of Hawai`i :
Pu`ukoholā Heiau National Historical Park (PUHE): waters adjacent to the park
Kaloko - Honokōhau National Historical Park (KAHO): waters within the park.
Pu`uhonua o Hōnaunau National Historical Park (PUHO): waters adjacent to the park

The goals and objectives developed by NPS for this project were:

1. To develop an inventory list of all marine vertebrate species that occur or potentially occur in waters within/adjacent to designated NPS units.

2. To spatially characterize the distribution, species composition, and relative abundance of marine vertebrates, especially reef fishes.

3. To relate this information to *in-situ* data collected on associated habitat parameters.

4. Establish the knowledge base necessary for enacting management decisions in a spatial setting and to establish the efficacy of those management decisions.

5. To work with the National Coral Reef Monitoring Program to develop data collection standards and easily implemented methodologies for transference to other agencies and to work toward standardizing data collection throughout the US states and territories.

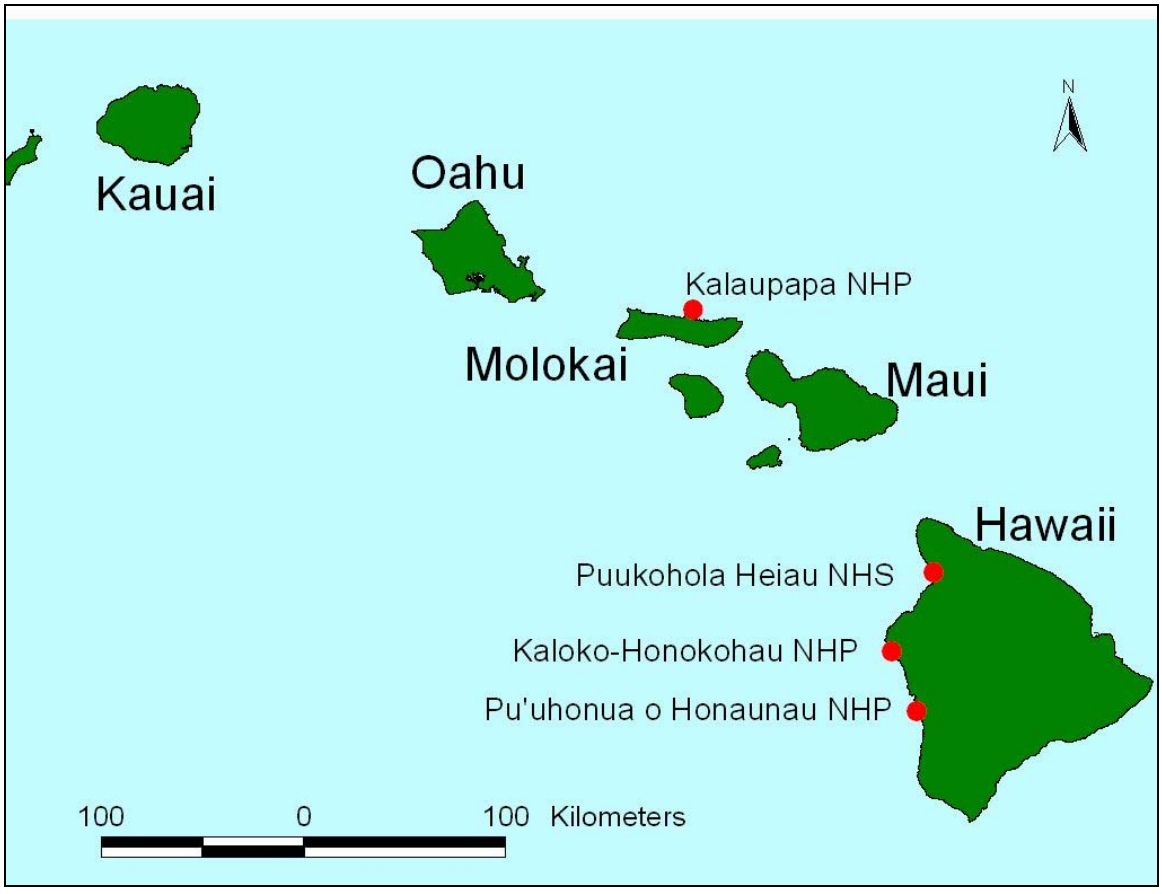


Figure 1. Location of the four National Parks sampled in Hawai`i during the marine vertebrate inventory in 2005.

METHODS

Sampling design and methodology

Most of the sampling effort for this investigation was allocated to marine fishes, since they account for the greatest proportion of marine vertebrate species found within these four national parks. We used non-destructive methods, recognizing that a large number of reef fishes are cryptic and cannot be sampled without the use of ichthyocides. The use of ichthyocides is not permitted by the State of Hawai`i , and therefore this type of sampling was not utilized in this study. Thus, the primary methods used were visual sampling methods adopted by NPS and NOAA (Friedlander et al. 2006). Project sampling was conducted from January through August, 2005. No specimens were collected and retained, therefore, no voucher specimens were accessioned.

Observations were made and records reviewed of marine reptile and marine mammal sightings to create a species list. Observations of activity were summarized for this report.

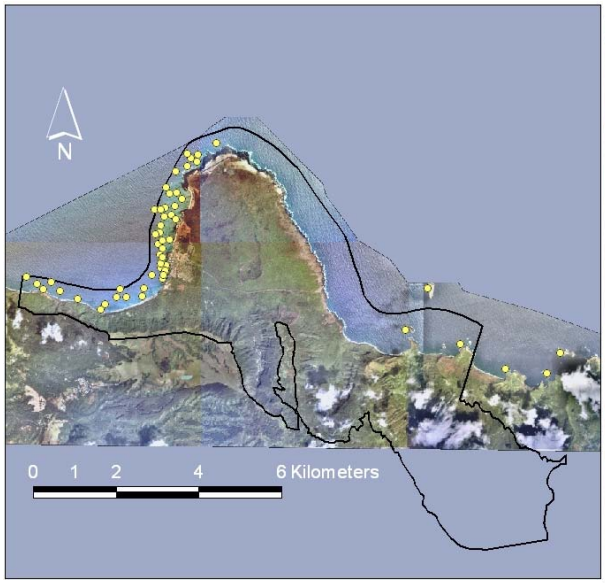
Sampling locations-site/habitat selection

Within the four designated NPS units, sampling sites were selected based on discussions with NPS staff and using available benthic habitat maps. The National Oceanic and Atmospheric Administration (NOAA) produced benthic habitat maps for near-shore waters (to 25 meters depth) of a large portion of the main Hawaiian Islands, including three of the four NPS units included in the inventory project (KALA has not been mapped). These GIS-based benthic habitat maps were characterized by a high degree of spatial and thematic accuracy. The hierarchical spatial structure underlying the habitat classifications were explicitly designed to include ecologically-relevant locational (forereef, reef flat, lagoon, etc.) and typological (aggregated reef, colonized pavement, etc.) strata. This approach created an analytical construct within which nuances of community structure, such as resource distribution, abundance, and habitat utilization could be tested and resolved.

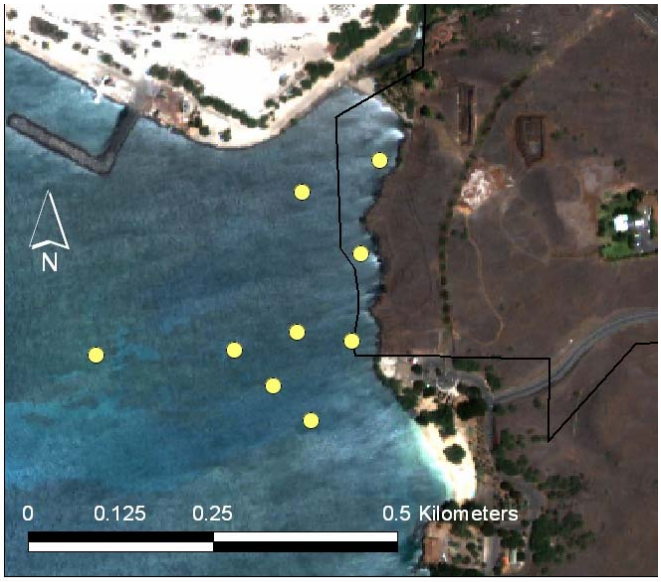
The GIS habitat maps created by NOAA's Biogeography Program have been reinterpreted at a finer scale by NPS and USGS in Hawai`i . All available datasets were used to select random sampling sites by habitat type, using established stratified random sampling protocols (Christensen et al. 2003; Friedlander et al. 2006) and GIS software (ArcGIS 8/9 and ArcView 3.3) to ensure complete coverage of the each of the four NPS units (**Figure 2 A-D**). Random points were assigned in major habitat strata (e.g., colonized hard bottom, uncolonized hard bottom, and unconsolidated sediment [sand]). Location points in latitude and longitude or UTM coordinates were downloaded into a GPS as waypoints for use in the field.

A field team consisting of three samplers navigated to waypoints using a GPS unit. Direction of each transect was determined randomly along the isobath of that point except in cases where that direction caused the transect to traverse multiple habitats. In those situations, transects was run within a habitat polygon at a similar isobath strata.

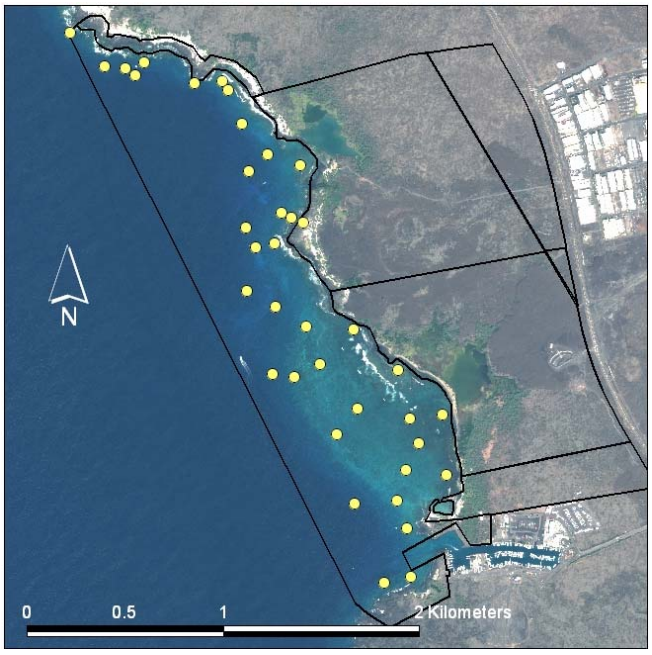
A. Kalaupapa National Historical Park (KALA) - Island of Moloka`i



B. Pu`ukoholā Heiau National Historical Park (PUHE) - Island of Hawai`i



C. Kaloko - Honokōhau National Historical Park (KAHO) - Island of Hawai`i



D. Pu`uhonua o Hōnaunau National Historical Park (PUHO) - Island of Hawai`i

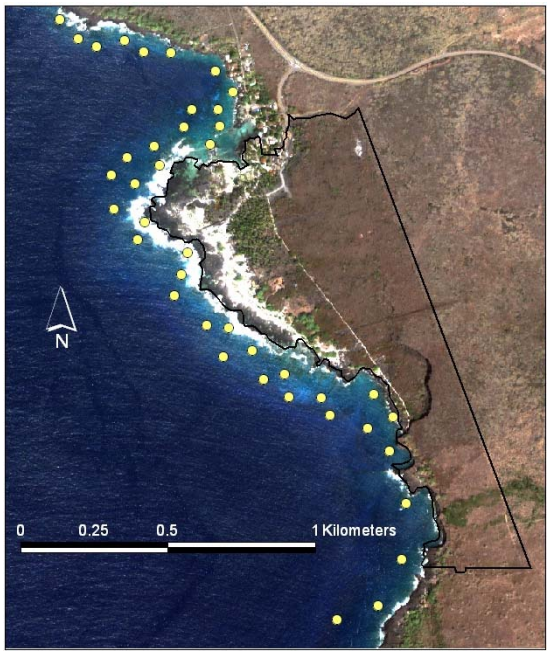


Figure 2. Locations of marine fish subtidal sampling stations in the four National Parks in Hawai`i sampled during 2005. Black lines denote park boundaries.

Marine fish sampling methodology

Three different zones were identified for marine fish sampling: subtidal, shoreline, tidal pools. Different methods were used within zones.

Reef fish subtidal sampling

Sampling in subtidal habitats extended from the mean low water line to 30 m. Reef fishes at each random point were sampled on Scuba using the visual belt transect survey method (VE Brock 1954; RE Brock 1982). During visual belt transect survey method, each Scuba diver swam a 25m x 5m transect at a constant speed (~ 15 min/transect) and enumerated all fishes, identified to the lowest possible taxon, visible within 2.5 m to either side of the centerline (125 m^2 transect area). The diver visualized out to the end of the transect and enumerates all individuals that are potentially leaving the census area. In this manner, we were able to partially account for the behavior that targeted species acquire in areas that are frequented by spearfishers. Nomenclature followed Randall (1996). Total length (TL) of fish was estimated to the nearest centimeter. Length estimates of fishes from visual censuses were converted to weight using the following length-weight conversion: $W = aSL^b$ - the parameters a and b are constants for the allometric growth equation where SL is standard length in mm and W is weight in grams.

Shoreline fish sampling

Shoreline sampling was conducted by snorkeling at KAHO and PUHO starting at the mean low tide level and extending seaward 5-10 m. The shoreline habitat at most sites was lava benches which rapidly dropped to 3-5 m. A few sites consisted of gentle beach or rock pavement that sloped gently into shallow water. KALA and PUHE were not sampled using this method.

Haphazard sampling along the shoreline was conducted using the Roving Diver Fish Count method (NPS Channel Islands National Park Kelp Forest Monitoring Handbook 1997). During Roving Diver Fish Counts (RDFC), paired samplers recorded all fish species observed. This method produced two indices of fish abundance: one scaled from 0 to 10, and an actual estimated count expressed in categories (single = 1, few = 2-10, common = 11-100, and many = >100). A modification to this method was employed since sampling was conducted along irregular shoreline benches. Instead of sampling along both sides of a transect, fishes were recorded along a section of shoreline.

Tidal Pool fish sampling

Tidal pool sampling was conducted using qualitative sampling methods. Tidal pools were selected from discussions with NPS staff and shoreline surveys. A combination of visual observations and small net collection were used to identify species. All specimens were returned following identification.