



Pacific Island Network Vital Signs Monitoring Plan

Appendix A: Ala Kahakai National Historic Trail Resource Overview

Page Else (HPI-CESU)

Pacific Island Network (PACN)

Territory of Guam

War in the Pacific National Historical Park (WAPA)

Commonwealth of the Northern Mariana Islands

American Memorial Park, Saipan (AMME)

Territory of American Samoa

National Park of American Samoa (NPSA)

State of Hawaii

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

Suggested citation:

Else, P. 2006. Appendix A: Ala Kahakai National Historic Trail resource overview. *In:* HaySmith, L., F. L. Klasner, S. H. Stephens, and G. H. Dicus. Pacific Island Network vital signs monitoring plan. Natural Resource Report NPS/PACN/NRR—2006/003 National Park Service, Fort Collins, Colorado.

Last revision: April 2005.

Organization contact information:

National Park Service (NPS), Inventory and Monitoring Program, Pacific Island Network, PO Box 52, Hawaii National Park, HI 96718, phone: 808-985-6180, fax: 808-985-6111, <http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU), University of Hawaii at Manoa, 3190 Maile Way, St. John Hall #408, Honolulu, HI 96822-2279

Hawaiian Volcano Observatory (HVO), Hawaii Volcanoes National Park, Hawaii National Park, HI 96718-0051

Pacific Island Ecosystem Research Center (PIERC), Kilauea Field Station, Building 344, P.O. Box 44, Hawaii National Park 96718

Acknowledgements:

This appendix was prepared with assistance from the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU), Task Agreement Number: J8080050039.

EXECUTIVE SUMMARY & INTRODUCTION

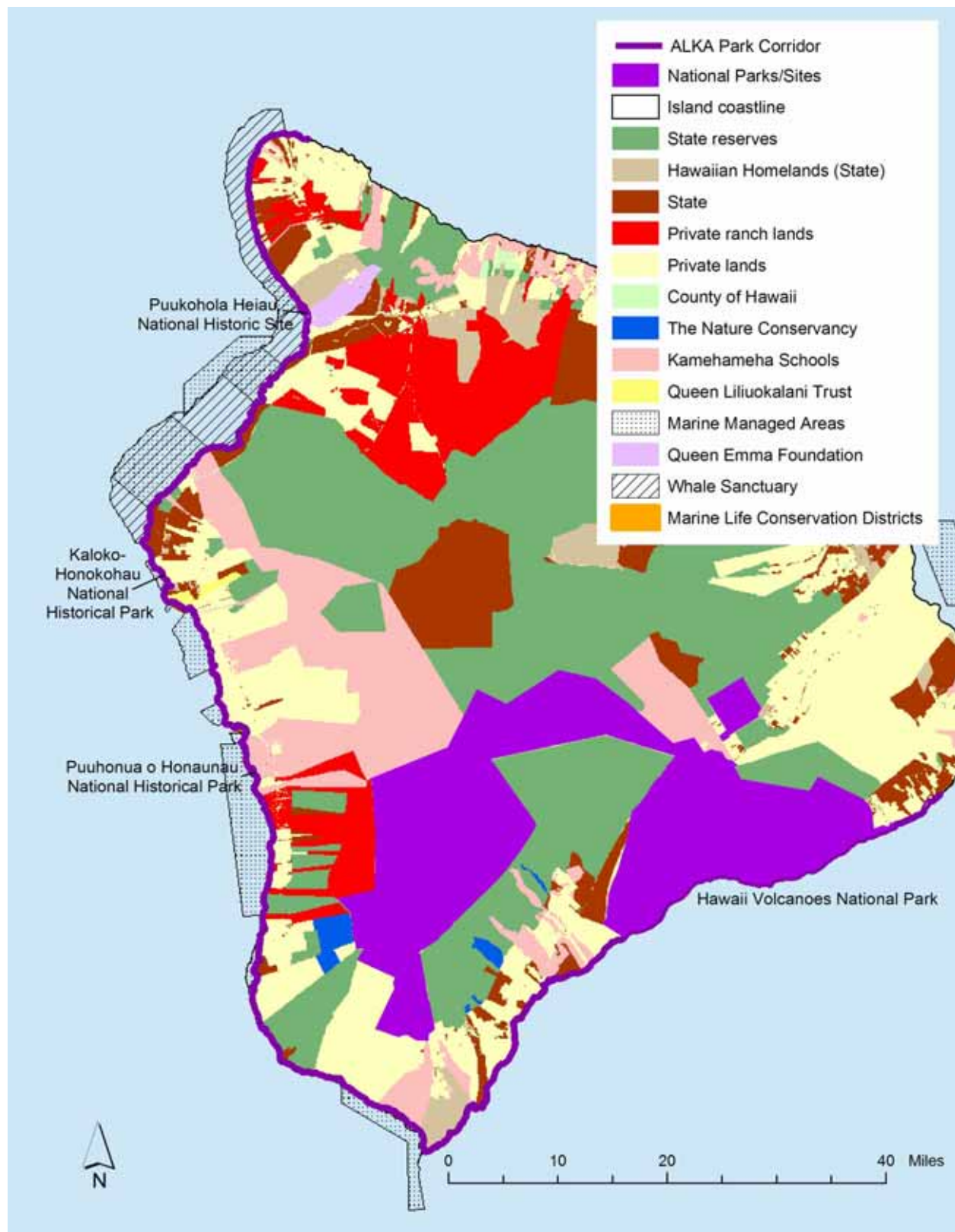
Enabling Legislation

Ala Kahakai National Historic Trail (ALKA) was designated in 2000 (Public Law 106-509). As a trail system, the Park Service must rely heavily on cooperative agreements with the land owners outside of the federal government, and the enabling legislation recognizes that dynamic. The legislation states that “No land or interest in land outside the exterior boundaries of any federally administered area may be acquired by the United States for the trail except with the consent of the owner of the land. Trail management shall: (i) encourage communities and owners of land along the trail, native Hawaiians, and volunteer trail groups to participate in the planning, development, and maintenance of the trail; and (ii) consult with affected Federal, State, and local agencies, native Hawaiian groups, and landowners in the administration of the trail.

To find enabling legislation documents on-line follow the “Policy & Legislation” link from the Pacific Island Network website (www1.nature.nps.gov/im/units/pacn).

Geographic Setting

The Ala Kahakai (in Hawaiian meaning "trail by the sea") corridor is a 175 mile long trail extending from Upolu Point on the north tip of Hawaii Island, down the west coast of the Island around the southern point, and ending at the east boundary of Hawaii Volcanoes National Park at the ancient shoreline temple known as Wahaula (see map below). West Hawaii is the leeward, or dry side, of the Big Island; the youngest and most volcanically active island in the chain. In keeping with the Hawaiian traditional land management system of ahupuaa (from mountain to sea), the trail system’s position along the coast clearly links its character and quality to land uses in the surrounding watersheds. Seventeen percent (17%) of the trail traverses all four NPS units on Hawaii Island, Hawaii Volcanoes National Park (HAVO), Puuhonua o Honaunau National Historic Site (PUHO), Kaloko-Honokohau National Historic Site (KAHO), and Puukohala Heiau National Historic Site (PUHE). The remaining 83% of the trail is not owned by NPS and traverses other federal, state, county, and private land holdings. Areas near the trail vary from vacation resorts and shoreline subdivisions to larger tracts of currently undeveloped or agricultural and grazing lands. South of PUHO, the Kipahoe and Manuka natural area reserves are managed by the state. These are pie shaped management areas with a narrow upland end and broader coastal segments that are small in comparison to adjacent unprotected areas. The trail is also bordered to the sea by several marine conservation areas and a whale sanctuary north of the Kona airport extending to Lapakahi state park north of PUHE.



Significant Natural and Cultural Resources

Coastal strands, wetlands, anchialine pools, and fishponds provide habitat for endangered waterfowl, rare shrimp, native insects, plants, and many organisms that are harvested for food. Threatened and endangered species and ecosystems occur in numerous locations along the corridor. Nearshore marine areas adjacent to the trail are pristine habitat for coral reefs and associated marine life.

This newest trail system in the Pacific islands cluster preserves and interprets ancient and historic trails called: ala loa (long distance trails), ala lawaia (trails used for fishing and gathering) and, in historic times, ala aupuni (government roads such as the "King's Highway"). The trail is associated with Hawaii Island's many prehistoric and historic habitation sites, nearly all the royal centers and major temples, with battlefields, the movement of armies, and with annual taxation.

Resource Management Priorities

A combined Comprehensive Management Plan and Environmental Impact Statement (CMP/EIS) is currently being developed for the trail. Given the potential impact of trail use on natural and cultural resources located within and adjacent to the trail's coastal corridor, current public scoping data results indicate a need to incorporate culturally appropriate shoreline management prescriptions for public use and resource protection. The trail system has included the identification of significant natural resources as a requirement in certification criteria for trail segments.

NATURAL RESOURCES

Focal Ecosystems and Processes

- Coastal strand communities, including intertidal areas and beaches
- Freshwater and brackish systems: streams, wetlands, fish ponds, and anchialine pools
- Groundwater dynamics and quality
- Traditional coastal harvesting and ethnobotanical resources
- Cave resources
- Threatened and endangered species

Coastal Strand Communities: This extensive coastal trail system encompasses several ecosystems supporting sensitive organisms which are a high priority for protection by the National Park Service. Beaches and intertidal areas provide foraging and resting areas for sea turtles and migratory shorebirds and recreational opportunities for humans. Adjacent to the shoreline, strips of coral sand support a unique ecosystem containing species adapted to salt spray, storm events, and a shifting substrate with limited water and nutrients. These coastal strand communities have aesthetic value and help prevent erosion of beach areas. Black and green sand beaches are also seen as unique and valuable aspects of this trail.

Freshwater and Brackish systems: Stream flow is imperative to the reproduction of native gobies; although streams exist only intermittently in West Hawaii and Kau. Fish ponds were constructed by native Hawaiians to grow and harvest desired fishes in a sustainable manner. Aimakapa and Kaloko fishponds, found within KAHO in North Kona, are bounded by wetlands which provide critical habitat to two species of endangered waterbirds and several other resident or migrant species. Anchialine pools in Hawaii provide habitat to many endemic organisms and have historically been used for drinking water. Birds, native bees, and damselflies utilize shoreline habitat and rely on many other protected or rare plants and animals associated with anchialine pools and wetland resources.

Ground water dynamics and quality: Freshwater in West Hawaii is primarily supplied by subterranean flow from the mountain slopes to the coast. The water comes to the surface in coastal areas through shoreline seeps and springs. Stream channels contain surface water only in periods of high flow, especially in modern times, due to upslope diversions. Development pressures deplete these groundwater resources, and are particularly threatening to anchialine pools, which rely on groundwater for their freshwater input. Groundwater hydrology needs to be better understood to model development impacts on trail resources.

Traditional coastal harvesting: Shoreline and spear fishing are common marine activities that provide food in addition to gathering of salt, various seaweeds, opihi from rocky shorelines, and endemic shrimp from anchialine pools. Tide pools and the coral reef also harbor an assortment reef fish, sea urchins, crustaceans, gastropods, and seaweeds that are harvested for consumption.

Cave resources: The lava geology of Hawaii has resulted in the formation of many caves and lava tubes that were used in ancient times for shelter and burial sites. Unique species have evolved within these cave ecosystems. Burial sites are sacred and not to be disturbed under traditional beliefs. The Cave Protection Act requires the Park Service to inventory cave resources but laws protecting native burials require that those sites be left undisturbed

Threatened and Endangered Species: The U.S. Fish and Wildlife Service (USFWS) lists the following terrestrial species as federally endangered that likely occur along the ALKA corridor. These include: one mammal, the Hawaiian hoary bat (opeapea, *Lasiurus cinereus semotus*), six birds, and six plants. The birds include the Hawaiian coot (alae keo keo, *Fulica Americana alai*), Hawaiian crow (alala, *Corvus hawaiiensis*), Hawaiian duck (kaloa maoli, *Anas wyvilliana*), Hawaiian goose (*Branta [Nesochen] sandvicensis*), Hawaiian hawk (io, *Buteo solitarius*), Hawaiian stilt (aeo, *Himantopus mexicanus knudseni*). The plants include the aiea (*Northocestrum breviflorum*), hilo ischaerum (*Ischaemum byrone*), kauila (*Colubrina oppositifolia*), kookoaula (*Abutilon mensiesii*), ohai (*Sesbania tomentosa*), and nau (*Gardenia brighamii*).

Endangered marine organisms include the humpback whale (*Megaptera novaeangliae*), hawksbill turtle (honu ea, *Eretmochelys imbricate*) and Hawaiian monk seal (*Monachus*

schauinslandi). Threatened species include one reptile, the green sea turtle (honu, *Chelonia mydas*). Species of concern include seven anchialine pool shrimps, one anchialine pool snail, and four plants.

Threats & Stressors

- Development and coastal habitat destruction
- Erosion leading to impairments in water quality or trail instability
- Pollution (including point source and military ordinance)
- Alien species overcoming native vegetation and wildlife
- Overharvest of natural resources
- Harbor impacts and activities
- Natural events such as earthquakes and tsunami
- Motorized vehicles damaging the trail and creating user conflicts
- Light pollution affecting the visitor experience
- Air quality - Vog (volcanic air pollution)

Development and coastal habitat destruction: Land use of the surrounding watershed may impact many aspects of this coastal park. Urban areas on Hawaii Island are expanding rapidly, decreasing wildlife habitat by removing native vegetation, introducing alien species, and increasing groundwater withdrawal. This degradation results in habitat quality being degraded by pollution, erosion, and runoff from road construction, industrial activities, golf courses, and residential cesspools upslope from water resources. Withdrawal and contamination of groundwater combine to affect connected water bodies including the marine environment.

Erosion: Beach and trail erosion is accelerated by motorized vehicles, foot traffic, feral goats, and construction activities together with natural geological processes. Fires on military lands could have significant erosional consequences, with attendant impacts on coastal water quality.

Pollution: Unsanitary conditions are common in popular recreational areas due to the lack of restrooms, trash receptacles, and potable water, raising the likelihood of pollution and misuse of fresh water resources. Increased visitor access to the many anchialine pools located in and near ALKA will degrade these sensitive systems. Other types of pollution are present in coastal areas in the form of hazardous materials, abandoned equipment, and unexploded ordinance remaining from the sugar industry and WWII related military operations.

Invasive Species: Predation by mongooses and feral cats diminish the opportunities for native birds to become reestablished in wetland habitats associated with anchialine pools and fishponds.

Overharvest of natural resources: Fishing and collection of marine and shoreline organisms will increase in newly accessible areas, adding to the strain on these resources.

The removal of black and green sands from beaches in Punaluu and Kau will contribute to the decline of these unique trail features.

Harbor impacts and activities: Industrial and recreational boat harbors in the region are slated for expansion in the near future. This will increase impacts to marine resources from commercial diving and fishing charters. The presence of these facilities contributes to oil releases, illegal dumping, noise pollution, alien species, and physical damage to reef resources.

Natural Stressors: Naturally occurring events such as wildfires, sea level rise, tsunamis, and high surf will also impact the coastal resources of the trail system.

Light Pollution: Due to the traditional importance of the night sky to Hawaiians for navigation and religion, and the presence of a world class observatory on Mauna Kea, light pollution is a serious issue. Resort and urban development and private homes along the shoreline should be conscious of night sky protection.

Air Quality: The main factor currently affecting air quality is volcanic emissions. However, cruise ships at anchor, automobile emissions, and other factors may contribute to degraded air quality.

Water Quality Designations

In Hawaii, water bodies are classified by their designated use according to the Hawaii Revised Statutes, Section 11, Chapter 54, which contains definitions and water quality standards for each water body type with respect to desired uses. Waters that do not meet the criteria for their designated uses are considered non-supportive and, if certain conditions are met, may be reported as impaired to the Environmental Protection Agency as per requirements of the Clean Water Act, Section 303(d). Groundwater designations are being developed by the state of Hawaii, but are not available at this time. Although Hawaii does not officially recognize outstanding natural resource waters, managers have identified the wetlands, anchialine pools, and nearshore marine waters of ALKA as unique or pristine resources worthy of special attention. Inland surface waters of ALKA are designated “Class 2”; protecting their use for recreational purposes, agricultural and industrial water supplies, and the support and propagation of aquatic life. Except for the North Kohala district and Kawaihae and Honokohau harbors, marine waters and marine bottom ecosystems occurring in the nearshore areas adjacent to ALKA are classed as “AA” and “I”, respectively; prohibiting pollution by humans and requiring maintenance of their natural wilderness character. The marine waters and benthic ecosystems north of Kawaihae and within Kawaihae and Honokohau harbors are classified as “A” and “II”, respectively, protecting their use for recreational and aesthetic enjoyment by regulating discharges and human alteration. Water quality along this trail is degraded near urbanized areas such as Kawaihae harbor near PUHE, Honokohau Harbor near KAHO, and the along the developed coastline of Kailua-Kona. Adjacent to PUHE, Pelekane Bay and Kawaihae Harbor are listed as impaired waterbodies due to sedimentation. Along the western coastline of ALKA, Spencer Park Beach, Hapuna Beach, Magic Sands Beach, and Kealakekua Bay, have demonstrated impairment for either turbidity, chlorophyll *a*, or

both. Kailua Bay, south of KAHŌ, was listed for exceeding criteria for total phosphorous. As of August 2004, the State of Hawaii, Department of Health, Environmental Planning Office has published their “Final 2004 List of Impaired Waters in Hawaii” prepared under CWA Section 303(d) and posted it at: <http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html#303pcd>.

CULTURAL ISSUES

- Protection of cultural sites from vandalism/looting/degradation
- Protection of traditional harvesting and recreational opportunities

The Ala Loa was the major land route connecting 600 or more communities of the island kingdom of Hawaii from 1400 to 1700. The trail is associated with many prehistoric and historic housing areas of the island of Hawaii, nearly all the royal centers and major temples of the island. Thus, the number of cultural features traversed by the trail is very high, with many features likely yet to be discovered. The potential exists for visitors to have a huge impact on these cultural sites, either intentionally or through over-eager exploration.

Shoreline access for recreation and harvesting of marine resources is a traditional part of Hawaiian culture. Baseline data on resource use and population is lacking in many cases. With increased access, the potential exists for over harvest.

MANAGEMENT ISSUES

Park Management

A combined Comprehensive Management Plan and Environmental Impact Statement (CMP/EIS) is currently being developed for the trail. Given the potential impact of trail use on natural and cultural resources located within and adjacent to the trail's coastal corridor, current public scoping data results indicate a need to incorporate culturally appropriate shoreline management prescriptions for public use and resource protection. The park has included the identification of significant natural resources as a requirement in certification criteria for trail segments. As such, I&M protocols, appropriately adapted to non-NPS owned trail segments, will be an important resource management tool for ALKA and its non-NPS partners. Watershed issues will also play a role in determining management priorities.

Park management documents (General Management Plan, Resource Management Plan, etc.) are available on-line at the NPS intranet site (www1.nrintra.nps.gov/im/units/pacn/parks/mgmt_docs.htm). This website is available only from NPS computer networks. Inquiries about public access should be directed to the park.

INVENTORIES

Existing and Ongoing Inventories

Geology: Field work for the island of Hawaii soil survey was completed in 1957. The classification and map unit names were finalized in 1968, and the Island of Hawaii Soil Survey was published in 1973 at 1:24,000 scale. An evaluation was made of the soil survey in 1993, with the determination that soil map unit delineations were accurate. However, one additional map unit was added to the soil survey to reflect present day soil survey concepts, soil classification, and soil interpretations. Amendments to the correlation document reflecting these changes are on file at the Natural Resources Conservation Service Hawaii State Office.

Halbig et al. (1985) performed a baseline study of soil geochemistry in the Kawaihae area.

Gardiner (1967) studied soils in the Kohala region as did Giza (1979).

Vegetation: The four West Hawaii national parks that intersect with ALKA have had fairly extensive vegetation surveys. Private developers have also commissioned vegetation surveys as part of their planning documents. The parks tend to be dominated by exotic vegetation with some native coastal strand species along the coastline. The coastal resorts generally have landscaping (often using exotic plants) along the shorelines, sometimes requiring irrigation, with sandy beaches, and lava rock outcroppings. There are areas of low density housing which may also have landscaped grounds. The major urban developments are at Kawaihae and between Kailua-Kona and Keauhou. Upper watersheds may still contain remnant natural forests, drylands, and cattle ranches. Some of the forest sites have been surveyed by forest researchers.

A checklist of all plant species located within PUHE was compiled between 1975 and 1976 (MacNeil and Hemmes 1977). A total of 50 species from 21 angiosperm families were recorded along with 2 ferns and 1 basidiomycete. Of the total number of species collected, 38 were introductions, 10 were indigenous, and 5 were endemic.

The PUHE plant community was surveyed again in 1996 (Pratt and Abbott 1996). Results demonstrated that the current vegetation cover of PUHE is predominantly alien. Of 104 vascular plant species found in the survey, 67% were alien species. The checklist was further revised by Pratt in 1998 to include a total of 124 species documented in the Park (Pratt 1998).

In 1989 an endangered fern study was initiated at PUHE on the pololei, (*Ophioglossum polyphyllum*, formerly *O. concinnum*).

Vegetation at KAHO was mapped by Canfield 1987 using aerial photographs 1959 and 1982, and was later surveyed by Pratt and Abbott (1996). In 1992-93, 116 vascular plant species were found within KAHO. Of these, 80 (69%) plant species were alien, four (3%) were Polynesian introductions, 27 (23%) were indigenous, and five (4%) were endemic. Fifty-six species (46 aliens, 9 indigenous, and 1 endemic) were additions to the known flora of the Park since the previous plant checklist (Canfield 1990). Three

candidate endangered species were found in the Park: kookoolau (*Bidens micrantha* subsp. *ctenophylla*), maiapilo (*Capparis sandwichiana*), and *Fimbristylis hawaiiensis*.

An invasive fountain grass (*Pennisetum setaceum*) was nearly ubiquitous in KAHO with highest estimated cover (>50%) in the northeastern and southern parts of the Park.

Yen (1971) conducted an ethnobotanical survey at PUHO and included suggestions for restoring historical conditions. Two vascular plant surveys have been completed at PUHO. The first complete vascular plant checklist was published in 1986 as the result of surveys made in the park during wet and dry periods over 3 successive years (Smith et al. 1986). New surveys were done in 1992-93 (Pratt and Abbot 1996). Vegetation surveys carried out in PUHO recorded a total of 134 vascular plant species. Nearly three-quarters of these, 96 species, were alien to Hawaii. About 17 percent (23 species) are indigenous (native to Hawaii, but occurring naturally outside of Hawaii), four percent (six species) are endemic (occurring naturally in Hawaii and found nowhere else), and 1.1 percent (15 species) are Polynesian introductions (brought to Hawaii many centuries ago by the first Polynesian settlers).

Terrestrial Vertebrates: Morin (1996) documented 16 bird species at PUHE in surveys conducted over four different months in 1992 and 1993. Two of the species (12%) were indigenous migratory shorebirds and the other fourteen (88%) were introduced non-native species. The paucity of indigenous avifauna and the complete absence of endemic species can be attributed directly or indirectly to human influences.

Morin (1996) documented 25 bird species out of 86 listed for KAHO, including two endangered waterbirds.

At PUHO, Morin (1996) documented 12 bird species from fall-winter and spring-winter surveys using 29 bird count stations located throughout the park. Species observations by park staff increase the total count to 26 species. Because of its heavily altered vegetation and other lowland characteristics (e.g., infestation with mosquitoes and other avian disease vectors, high numbers of mammalian predators), PUHO currently does not maintain endemic bird species (Morin 1996). The Park is a likely site for detecting the spread of introduced bird species, or even the occurrence of newly introduced species.

The endangered Hawaiian hoary bat is also present in the park. The Hawaiian Hoary Bat has been observed at KAHO and PUHO. A bat survey was completed in April, 1993 by Mark Aeder and David Jacobs.

An inventory of seabirds was conducted in 2001 using marine radar to identify seabird flight corridors within HAVO. Due to inaccessibility of coastal areas within HAVO, only one station, Holei sea arch, at the end of Chain of Craters road was surveyed, finding no evidence of Dark-rumped Petrel, Newell's Shearwater, or Band-rumped Storm Petrel colonies.

During the summer of 2004, an amphibian inventory was conducted in the West Hawaii parks by the PACN (Bazzano 2005). The focus of this inventory was on identifying what species are present, and collecting voucher specimens.

At PUHE, the blind snake (*Ramphotyphlops braminus*) is present in the park, along with the house gecko (*Hemidactylus frenatus*). The house gecko was far more dominant at PUHE than the other parks (Bazzano 2005)

KAHO provides numerous habitats and anchialine pools favorable to amphibian establishment. Five species of gecko and one skink were found. In the amphibian survey of the three West Hawaii parks, the snake-eyed skink (*Cryptoblepharus peopcilopleurus*) was seen only at KAHO near the anchialine pools. Only one house gecko, (*Hemidactylus frenatus*), which were dominant at PUHE, was observed at KAHO. One tree gecko (*Hemiphyllodactylus typus*) was observed. The gold dust day gecko (*Phelsuma laticauda*) appeared to be rapidly increasing in population at both KAHO and PUHO. The stump-toed gecko (*Gehyra mutilate*) and mourning gecko (*Lepidodactylus lugubris*) are less aggressive and were found in lower numbers.

There are no alien amphibian species of concern documented in West Hawaii parks yet. At KAHO and PUHO, the Jackson chameleon and coqui frog have been reported from locations close to the park.

Reptiles commonly found in PUHO include three species of geckos and three species of skinks according to the PUHO site conception plan. In a recent survey (Bazzano, 2005), the gold dust day gecko (*P. laticauda*) was found to be rapidly increasing in numbers. The green anole (*Anolis carolinensis*) was found at the upper garden plot, which tends to be wetter. As with KAHO, the stump-toed gecko (*G. mutilate*) and mourning gecko (*L. lugubris*) were found in smaller numbers. The house gecko (*H. frenatus*) was common at PUHO, a tree gecko (*H.s typus*) was observed, and the metallic skink (*Lampropholis delicate*) was found at the upland gardens only.

Terrestrial Invertebrates: A survey of the insect fauna at KAHO in 1992 (unpublished) found relatively few native terrestrial arthropods aside from flies breeding in the pools. Sporadic insect collections have been made since then and the USGS has documented native bees in Kohanaiki, to the north of KAHO.

Out of a total of 609 insect species recorded for the Kona district, about 100 species have been collected within PUHO. Of these, 15 are considered native to Hawaii.

HAVO has the largest invertebrate specimen base than any other park in the PACN network. An intensive inventory of terrestrial invertebrates was conducted by the US International Biological Program Island Ecosystems Integrated Research Program between 1971 and 1976. However, only a small fraction of its more than 332,800 acres have been surveyed for terrestrial invertebrates, and the coastal region of the park is largely unsurveyed.

Freshwater and Anchialine Pool Communities: In 1972, Maciolek, and Brock described 318 anchialine pools along the Kona Coast and inventoried environmental and biological characteristics. The Natural Heritage Program of the Nature Conservancy of

Hawaii published a biological database of rare species and natural communities in anchialine pools in Hawaii in 1987.

General biological surveys of the anchialine pools at KAHO were done by Brock and Kam (1997). The USGS documented the locations of anchialine pools north and south of KAHO fishponds, inside and outside of KAHO boundaries. A preliminary inventory of anchialine resources was also a part of preparations for development of the Kohanaiki shoreline (Rutter/KW Kohanaiki 2003).

Chai (1999) measured temperature, salinity, pH, tidal fluctuation, and listed species present in an anchialine pool in PUHO. The study found that the overall ecological health of the pools is poor. The pools are not viable habitat for fish traditionally stocked for alii because of degraded water quality and competitive tilapia. The pools at PUHO are important from a biogeographical perspective since no other anchialine pools are located between Kailua-Kona and Milolii.

At HAVO, an inventory of fauna found in 19 anchialine pools was conducted in 1989 (Chai 1991) and other pools are known to exist in that park. The only fish habitats in HAVO are these brackish water anchialine pools along the coast. Chai (1991) found seven fish species and seven identifiable invertebrates in the anchialine pools. All the species were native except for an alien invasive species of prawn known to limit the populations of native shrimp species. One of the pool complexes (Wahaula Wet Cave) has since been covered by lava.

An inventory of anchialine pools in all Hawaii parks is currently underway, through a cooperative agreement between the USGS and NPS. This survey includes insects present around the pools, and the relationship between adjacent vegetation and the pool species. Accurate identification and mapping of these pools is another important component of these inventories.

Marine Communities: Preliminary surveys of Pelekane Bay adjacent to PUHE and Kawaihae Harbor were initiated in the 1970's, with subsequent studies in the 1990's. Cheney et al. (1977) documented a depauperate fish fauna of only 63 species. They also documented two alien fish species in anchialine pools in the park.

In 1996 Brian Tissot completed quantitative sampling of three 50-ft. transects on patch reefs in Pelekane Bay with a list of species and relative abundance of all species compiled for all habitats within the bay (Tissot 1998). The study found a striking decrease in abundance of all plants and animals, associated with major changes in species diversity and composition since the Cheney surveys. Thirteen species of benthic algae were collected offshore of PUHE by a University of Hawaii study team in 1976 (Ball 1977). All but one of these was indigenous, and no rare or unusual species were found. Tissot attributes the faunal reductions to long-term sedimentation stress caused by chronic terrestrial runoff. An additional factor is the reduced ocean circulation in Pelekane Bay associated with massive historical deforestation in the Pelekane watershed and construction of the Kawaihae Harbor revetment (Tissot 1998).

Sharks are frequently seen in Pelekane Bay offshore from the Heiau. Grey reef sharks (*Carcharhinus amblyrhynchos*), reef white tip sharks (*Triaenodon obesus*), and

particularly reef black tip sharks (*Carcharhinus limbatus*) are observed in Pelekane Bay. Park personnel occasionally record shark sightings.

In 2003 research by NPS and collaborators began near the West Hawaii parks studying the recruitment processes of key coral reef invertebrates and fishes (mainly aquarium species).

Brock and Kam (1997) inventoried fish and invertebrates within KAHO. Research on spinner dolphins (*Stenella longirostris*) was conducted in 1989 by Jan Ostman (<http://www.kulanaia.org/research2.html>) which included research on the behavior, movement, and population dynamics of a “resident” pod at KAHO. Recent data on fish in and near park waters are available from the State of Hawaii Department of Aquatic Resources. Parrish et al. (1990) documented 150 marine fish species within the KAHO park boundaries.

In 2003, the NPS Pacific Island Coral Reef Program (PICRP) started work with USGS, along with contractors for aerial photography, to produce high resolution coral reef habitat classification maps for the West Hawaii parks and coast. A comprehensive marine GIS data base will be constructed to improve knowledge for monitoring and management of the West Hawaii reef ecosystem structure. The database will also be used to track trends in ecological and oceanographic processes to detect changes in coral reefs in space and time.

Echinoid fauna in Kealakekua and Honaunau Bays were surveyed in 1971 (Ebert 1971). In 1968, Rhodes compiled field notes on observations of marine life near PUHO. Doty (1969) found 98 fish species and documented evidence of overfishing and commercial collection of corals. In comparison, Ludwig et al. (1980) found greater fish abundance and species diversity (163 fish species) indicating potential recovery from earlier, perhaps more intense, human disturbance.

The PUHO Resource Management Plan provides the following information about the benthic communities: Visible algae are almost entirely intertidal; benthic seaweed populations are sparse. A single red alga, (*Tolpocladia glomerata*), is generally observed at depths greater than two meters. The coral, *Pocillopora meandrina* is found to a depth of five meters, castle coral (*Porites pukoensis*) extends to a depth of 15 meters, and finger coral extends to a depth of 20 meters. Gastropods (cowries, cones, bivalves, clams and oysters) are present. *Echinometra mathaei* is the most abundant urchin in Honaunau Bay and the uncommon slate pencil urchin, *Heterocentrotus*, contributes greatly to biomass. The only larger crustacean seen in numbers is the cleaning shrimp, *Stenopus hispidus*. The most common fishes are yellow tang (*Zebrasoma flavescens*) and kole (*Ctenochaetus strigosus*).

Marine fish species were surveyed twice in waters just offshore of HAVO. Major (1976) produced an unpublished list of 54 fish species seen from reefs surveyed near the coastal backcountry campsite at Halape. Ball (1976) recorded 25 fish species (including 14 not recorded by Major), 106 invertebrate species, and 89 species of algae in the tide pools near the Halape campsite.

Water Quality: A baseline water quality data inventory has been conducted for each of the four parks traversed by ALKA (NPS 1999, NPS 2000, NPS 2002).

The Pelekane Bay watershed was identified in Hawaii's Unified Watershed Assessment as a Category I watershed: placing it as one of the State's watersheds in most urgent need of restoration. Soil erosion from the watershed has impaired water quality of Pelekane Bay. Data including physical and chemical parameters have been collected from 4 streams in the PUHE watershed by the US Geological Survey.

Air Quality: For a six months period particulate matter was measured at PUHO as part of VOGNET, the high school VOG monitoring network which measures volcanic aerosol emissions around the big Island. Particulate levels are acceptable within the park at sea level. No other studies have been conducted to estimate atmospheric nutrient input.

Landscape - Viewsheds: From May through June 2002 historic scenic viewsheds at various locations in HAVO were inventoried using a GPS and photographs. Due to the natural processes of forest succession affecting the character of historic views, these historic views need to be managed to preserve visual access to historic scenic viewsheds.

Landscape - Soundscapes: An inventory to characterize different acoustic environments at HAVO was conducted to provide baseline data for the development of the Air Tour Management Plan. As part of the acoustic survey, long term continuous 1/3 octave band sound levels, wind speed, and wind direction were collected at twenty two sites at HAVO. Other Hawaii parks were also sampled but less intensively.

Priorities for New Inventories

Vegetation: Status and trend data is needed on the health of native vegetation and the spread of invasives.

Terrestrial Vertebrates: An inventory of the Hawaiian hoary bat will be conducted across a broad array of habitats in the Hawaii National Parks. The study will also evaluate bat habitat usage and relative abundance.

Shoreline areas of the four Hawaii Island parks will be inventoried for seasonal waterfowl and shorebird migrants along designated routes. Seabirds, raptors, and native waterbirds will also be recorded. The objective of this project is to inventory avian species diversity and relative abundance along the park's shoreline.

Rats, mice, mongooses, feral cats, goats, and chickens are common introduced species all along the coastline. All pose threats to native species and habitat. No complete inventories of mammal species have been done for the parks along the trail system, and no vouchers of mammals for the park have been collected.

Terrestrial Invertebrates: Coastal invertebrates need to be inventoried at HAVO and other high value locations. The invertebrate fauna of areas outside of the parks along the trail is largely unknown.

Marine Communities: Analysis of baseline conditions is needed in order to ascertain the impacts of recreational use. With increasing cruise ship traffic and tourist visitation, water quality could be degraded and marine habitat and wildlife disturbed.

Water Quality: More data is needed on water quality baseline parameters and trends.

Visitor Use: The NPS tracks the number of vehicles and people visiting the parks. Data is available on the Internet at <http://165.83.32.36/mpur/> PUHE has received approximately 50,000 visitors as a yearly average recently, the second most visited West Hawaii park. PUHO has received almost half a million visitors annually in the past few years.

MONITORING

Existing and Ongoing Monitoring

Vegetation:

The U.S. Fish & Wildlife Service collaborates with a variety of organizations on research projects such as the Kona Dryland Forest Project. The intent of this project is to restore one of the finest examples of dryland forest ecosystem remaining in Hawaii. Research activities include restoration monitoring, invasive species eradication, and ungulate control. Collaborators in this project include the Hawaii Forest Industry Association (HFIA), Hawaii Division of Forestry and Wildlife (DOFAW), National Tropical Botanical Garden (NTBG), Kamehameha Schools Bishop Estate (KSBE), Potomac Investment Associates Kona Partnership (PIA), Hannah Springer and Mike Tomich of Kukuiohiwai, Basil Hansen; Hualalai Ranch, The Nature Conservancy, U.S. Army Pohakuloa Training Area, Will and Judy Hancock from Kalopi, and the U.S. Forest Service.

Forest researchers from HAVO, the University of Hawaii, and other academic institutions have studied the forests in which clouds supply significant nutrient and moisture inputs. There are several research plots located in the Kohala mountains and along the slopes of Hualalai Volcano above Kona. Restoration, stabilization, and outplanting efforts in coastal strand communities at HAVO have been monitored by NPS.

Terrestrial Vertebrates: Wetland bird populations are monitored at Aimakapa Pond through an agreement with Ducks Unlimited. Ducks Unlimited has been monitoring the Hawaiian stilts that have colonized a man-made wetland four miles to the north of KAHO at Keahole Point.

Invertebrates: Populations of a native damselfly, *Megalagrion xanthomelas*, breeding in the KAHO pools have been monitored for several years, but surveys for other important species have been sporadic.

Marine Communities: George Balasz, of The National Marine Fisheries Service, along with the Hawaii Preparatory Academy, has been conducting green sea turtle monitoring

in West Hawaii since the 1980s. Data is collected on turtle growth, food sources, and the existence of tumors. The population of green sea turtles in Hawaii has been recovering from past levels, but the incidence of tumors seems to be on the rise. The University of Hawaii at Hilo has recently begun sea turtle forage studies and anchialine pool studies.

Kawaihae Coral Transplant and Monitoring Project: Corals have been collected and moved with hanging baskets to transplant the corals to new sites away from the “footprint” of the new breakwater. At each of the eight transplant sites, there are four sediment traps to monitor suspended matter settling on the reef (Jokiel et al., In Review). The project is a cooperative effort between the U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish and Wildlife Service (USFWS), State of Hawaii Division of Aquatic Resources (DAR) and the University of Hawaii Institute for Marine Biology. The transplant sites were suboptimum habitat (since prime habitat was already colonized). The corals survived the transplant operation but subsequently succumbed to adverse conditions and storm destruction.

West Hawaii Aquarium Project (WHAP) has studied aquarium fish at 23 sites along the West Hawaii coast since 1998 (Tissot 2003, 2004). They are researching the effects of aquarium fish collecting by comparing results from Marine Protected Areas and Fish Replenishment Areas with those open to collection. Data collected include fish densities, recruitment patterns, coral cover, abundance, diversity, distribution, and rugosity (habitat relief/structure).

The marine soundscape is under analysis, with sensors recently placed to focus on low frequency sounds in the vicinity of Honokohau Harbor.

The annual Hawksbill turtle monitoring program, which began in 1989, is the only marine monitoring program at HAVO. Between June and December, this project uses mainly volunteer help to collect field observations and to monitor nesting beaches in and outside the park.

Water Quality: The Hawaii State DOH monitors monthly for enterococci and *Clostridium perfringens* using the membrane filtration method at Kawaihae Harbor, Spencer County Beach Park, Hapuna State Beach Park, two sites near Puako Bay, Anaehoomalo Bay, two sites at Honokohau Harbor, two sites in Kailua Bay, “Banyans” surf spot, Disappearing Sands County Beach Park, Kahaluu County Beach Park, and Keauhou Bay. Portable meters are used at these collection sites to measure temperature, salinity, turbidity, dissolved oxygen, and percent dissolved oxygen.

A subset of a large complex of anchialine pools in Waikoloa was established as the Waikoloa Anchialine Pond Preservation Area (WAPPA) in 1986 by a resort development, which filled in all but twelve acres of the original pool complex. The water quality and fauna of these ponds is reassessed annually to detect ecological impacts from the surrounding development, which contains luxury resorts, golf courses, residential housing and associated infrastructure (Brock and Kam 1985, 1988, 1990, 1994). Salinity,

dissolved oxygen, temperature, total organic carbon, silicate, chlorophyll *a*, nutrients, and pesticides are monitored along with the abundance of native shrimp. Biweekly assays for bacteria are being conducted by AECOS lab at a man-made recreational pond inside a resort at Kaupulehu.

The Mauna Kea Soil and Water Conservation District is a watershed partnership that is monitoring stream dynamics and erosion upslope from the park. They have instigated changes in land use aimed at decreasing the impacts from cattle ranching, stream diversion, and recent drought. Management partnerships have been developed with cattle ranches that include vegetative growth studies and water storage and distribution strategies that will aid in fire suppression. Other projects include precipitation, sediment and vegetative cover monitoring by University of Hawaii, Hilo staff and students. New rain gauges and check dams are being installed to monitor the watershed, and an automatic sampling device has been installed under a bridge over Makeahua Stream. This device automatically measures and stores data on flow rate and turbidity upon flood events and at regular intervals when the stream is running. Another automatic sampler is planned for Makahuna Stream. MKSWD is actively involved in developing a useful monitoring plan for the marine area of Pelekane Bay.

The Natural Energy Laboratory of Hawaii has been performing a Comprehensive Environmental Monitoring Program since the early 1980s that includes nearshore transects, surface and abyssal seawater, anchialine pools and groundwater.

Bacterial monitoring is also conducted on a saltwater swimming pool inside the Royal Sea Cliff Condominiums south of Kailua by AECOS.

The National Park Service Inventory and Monitoring Program initiated an inventory of the anchialine pools that includes limited water quality monitoring.

A two-year project funded by NPS Water Resources Division to monitor nutrient fluctuations in KAHO's wells, anchialine pools, Kaloko Fishpond and Aimakapa Fishpond was implemented in 2004. This project will perform dye tracer studies to determine the residence time of water in the pools and ponds and will collect samples to analyze for biologically available nitrogen and phosphorus in the groundwater. Salinity, dissolved oxygen, silica, chlorophyll *a* and other pigments will also be monitored.

The upper reach of Kiilae Stream, which passes through PUHO, was monitored for physical and chemical water quality parameters by the USGS from 1974 to 1982. The stream flow gauge is now inactive, and the stream is considered intermittent.

The EPA implemented their Hawaii coastal EMAP in 2002 which included eight randomly selected sites along the coast of ALKA; all located between Keahole and Upolu Points. The USEPA updated the 2002 Hawaii coastal EMAP sample design to include open coastal areas as well as embayments in the 2004 assessment. Preliminary site selection maps indicate nine (five regular and four reserve) sampling locations along the ALKA corridor. Sample collection has been delayed until early in 2005.

Geology: Volcanic activity is monitored by the U.S. Geological Survey's Hawaiian Volcano Observatory. Regular monitoring of eruption activity, seismic activity, ground deformation, and volcanic gases aid in the prediction of volcanic events.

Air Quality: HAVO is classified as a Class I area, under the Clean Air Act, making monitoring for visibility mandatory. Monitoring of visibility, particulate matter, dry deposition, gaseous pollutants, wet deposition, cloud or fog water, solar radiation, meteorology, and climate is or has been conducted at HAVO. Monitoring stations are operated by the Environmental Protection Agency, the National Park Service, U.S. Geological Survey, Hawaiian Volcano Observatory, the Pacific Island Ecosystem Research Center, and the University of Hawaii at Manoa. For a six months period particulate matter was measured at PUHO as part of VOGNET, a volcano emission monitoring network. VOGNET is a collaborative project between the NOAA CMDL observatory at Mauna Loa and the Hawaii Island high schools.

Weather: Weather observations at PUHO and HAVO are recorded daily and reported to the National Weather Service. The Weather Service is the data repository, but hard copies of the observations are maintained at parks. Some of the data is available online from the National Weather Service. The weather data recorded is maximum and minimum temperature, temperature at time of observation, and precipitation from a rain gauge.

Soundscape: During 1986, PUHE park maintenance personnel systematically recorded the presence of helicopters or other aircraft overhead. Overflight sound vibrations could damage the un-mortared walls of the cultural sites, and impact visitors' experience.

A management report dated 10/25/02 states that "No data on helicopter overflights was (sic) collected over the last 5-7 years. As an estimate however, compared to the previous reported number of 930 overflights, a significant decrease has been noticed and we would guess about 350 overflights are occurring annually."

Priorities for New Monitoring

Vegetation: The spread of exotic species should be monitored, along with trends in native vegetation.

Terrestrial Vertebrates:

Bird populations should be monitored, along with trends in the populations of exotic mammals and amphibians.

Invertebrates: Native bees and damselflies are in need of monitoring along the trail system. The spread of exotic insects is important to track.

Marine Communities: Biologically, the natural gathering of sharks in Pelekane Bay represents an important biotic dynamic and presents a research opportunity to gather data on shark behavior. The relationships between shark concentrations, congregations of

prey populations, watershed water quality, and sedimentation need to be studied. Better baseline data on shark presence and behavior is needed to monitor and manage impacts.

Recreational and harvest impact studies are needed on coastal resources.

Freshwater Communities: Populations of candidate endangered insects and aquatic invertebrates should be monitored.

Water Quality: Groundwater quantity and quality are of primary concern as development around the trail system increase.

Soundscape: PUHE staff no longer systematically monitor overflights. Park staff have met with military and Federal Aviation officials to discuss Memorandums of Understanding for overflight issues. Agreements are in place for military pilots to keep a prescribed distance from the site. However, with increasing development around the harbor, tourism traffic, and military facilities, it could be important for the Park to have a system in place to note non-military overflights and violations of the Memorandum of Agreement.

CONCLUSIONS

ALKA is the only trail system in the Pacific Island Network. As a trail system, it integrates and connects the other coastal parks on the island. Culturally, the trail system can preserve traditional Hawaiian uses of the land, and represent the traditional Hawaiian ahupuaa land management system connecting mountains to sea. It provides an opportunity to link research on upper watershed health and ecosystem processes to those of the coast.

Hawaii has legislation to protect shoreline access for the public, but clauses in the legislation have resulted in locations where public shoreline access has been lost. This trail system presents an opportunity to preserve public access. The success of this park depends on cooperation between land owners and NPS. Therefore, NPS needs to identify ways to benefit land owners who cooperate with trail certification and management.

REFERENCES

- Advisory Council On Historic Preservation. 1971. Summary 106 report: Honokohau Settlement National Historic Landmark.
- Aecos. 1979. Hawaii coral reef inventory.
- Aeder, Mark and David Jacobs, 1993 Puuhonua o Honaunau National Park bat survey.
- Apple, Russell A. 1975. Ancient Hawaii shore zone fishpond: an evaluation of survivors for historical preservation: National Park Service.
- Author Unknown. No Date. Breeding season for endangered Hawaiian Stilt
- Author Unknown.. 1982. Environmental impact statement for the proposed Kohala Makai I residential development, for submission to: Hawaii County Planning Department
- Author Unknown. 1984. Environmental assessment for the Lalamilo Wind Farm: District of South Kohala, County of Hawaii
- Author Unknown. 1985. Environmental impact statement for development of Kawaihae Small Boat Harbor, Kawaihae, Hawaii, Hawai'i
- Author Unknown. 1985. Waikoloa Beach Resort anchialine ponds, Waikoloa, South Kohala District, Island of Hawaii, State of Hawaii [microform]: draft environmental impact statement, US Department of the Army permit application
- Author Unknown. 1987. Final environmental impact statement, the Ritz-Carlton Mauna Lani: Mauna Lani Resort, South Kohala, Hawai'i
- Author Unknown. 1992. Draft environmental impact statement for Kawaihae ten-year master plan, Kawaihae, South Kohala, Hawaii
- Bailey-Brock, Julie H., Brock, Richard E. 1974. The marine fauna of the coast of northern Kona, Hawaii : an inventory of fishes and invertebrates recorded during summer, 1972, Sea Grant advisory report: University of Hawaii Sea Grant Program.
- Ball 1977. Benthic marine algae of the coastal waters of Puukohola Heiau National Historic Site; Puukohola Heiau National Historic Site marine flora
- Banko, Winston E. 1987. History of endemic Hawaiian birds Part I, population histories-species accounts, freshwater birds : Hawaiian Coot Alae-keokeo CPSU/UH Avian History Report 12C: University of Hawaii.
- Banko, Winston E. 1987. History of endemic Hawaiian birds Part I, population histories-species accounts, freshwater birds : Hawaiian Gallinule Alae-ula CPSU/UH Avian History Report 12A: University of Hawaii at Manoa.
- Banko, Winston E. 1987. History of endemic Hawaiian birds Part I, population histories-species accounts, freshwater birds : Koloa-maoli CPSU/UH Avian History Report 12B: University of Hawaii at Manoa.
- Banko, Winston E. 1988. History of endemic Hawaiian birds Part I Population histories -- species accounts, freshwater birds: Hawaiian stilt Aeo Avian history report 12 A B C D: Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa.

- Barnard, J. L. 1976. The cavernicolous fauna of Hawaiian lava tubes, 9. Amphipoda (Crustacea) from brackish lava ponds on Hawaii and Maui. *Pacific Insects*: 17:2-3, p.267-299.
- Bazzano, Jason. 2005. Herpetological Survey of West Hawaii parks. NPS Inventory and Monitoring Program presentation.
- Belt, Collins, And Associates. 1967. The Kohala coast resort region / Island of Hawaii: a land development plan
- Belt, Collins, And Associates. 1980. Environmental impact statement for Lalamilo water system, South Kohala, Hawaii
- Belt, Collins, And Associates. 1981. Revised environmental impact statement for the proposed Mahukona Resort
- Belt, Collins, And Associates. 1982. Revised environmental impact statement for the proposed Kohala Makai I residential development: for submission to Hawaii County Planning Department
- Belt, Collins And Associates. 1985. Draft environmental impact statement: revised master plan for Mauna Lani Resort, South Kohala, Hawaii
- Belt, Collins And Associates. 1987. Final environmental impact statement, South Kohala Resort, South Kohala, Island of Hawaii
- Belt, Collins And Associates. 1989. Draft environmental impact statement, Mauna Lani Cove Mauna Lani Resort, South Kohala, Hawaii
- Belt, Collins And Associates. 1990. Final environmental impact statement for the installation and management of permanent and day-use moorings in Anaehoomalu Bay, South Kohala, Hawaii/
- Belt, Collins And Associates. 1990. Final supplemental environmental impact statement, Mauna Lani Cove Mauna Lani Resort, South Kohala, Hawaii
- Bhambare, D.N. 1996. Design and development of a remotely controlled mobile data acquisition system for continuous and long-term monitoring of water quality in Hawaiian anchialine ponds : water quality characteristics of Kaloko Pond: a small case study: University of Hawai'i at Manoa, Civil Engineering Department.
- Bienfang, P. 1980. Water quality characteristics of Honokohau Harbor: a subtropical embayment affected by groundwater intrusion. *Pacific science*: 34: p.279-291.
- Bienfang, P., Johnson, W. 1980. Planktonic properties of Honokohau Harbor: a nutrient-enriched subtropical embayment. *Pacific science*: 34: p.293-300.
- Brasher, A., Dendel, P. 1997. Bird & turtle log-field notes.
- Brasher, Anne M. 1999. Development of a monitoring program to assess physical, chemical and biological components of Kaloko Fishpond at Kaloko-Honokohau National Historical Park on the Island of Hawaii.
- Brock, Richard E, No Proceedings Author. 1987. Status of the anchialine pond system of the Kona, Hawai'i coast, International Symposium on Indo-Pacific Marine Biology: *Bulletin of Marine Science*: p. p. 633.

- Brock, Richard E. 1975. Fishes of the mixohaline lava ponds of the Kona, Hawai'i coast. Transactions of the American Fisheries Society.
- Brock, Richard E. 1980. Colonization of marine fishes in a newly created harbor, Honokohau, Hawai'i. Pacific science: 34:p.313-326.
- Brock, Richard E., Kam, Alan K. H. 1997. Biological and water quality characteristics of anchialine resources in Kaloko-Honokohau National Historical Park PCSU Technical Report 112: Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa.
- Brock, Richard E., Norris, James E., Ziemann, D.A., Lee, M.T. 1987. Characteristics of water quality in anchialine ponds of the Kona, Hawai'i, USA coast. Pacific Science: 41:1-4, p.200-208.
- Cabrera, Theresa. 1993. Untitled: Unpublished field notes from Kaloko bat survey.
- Canfield, Joan E. 1990. Description and map of the plant communities of Kaloko-Honokohau National Cultural Park PCSU Technial Report 73: Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa/University of Hawaii Press.
- Chai, David K. 1991. An inventory and assessment of Kaloko Pond, marsh, and anchialine pools at Kaloko-Honokohau National Historical Park, North Kona, Hawai'i Technical report 76: Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa.
- Chai, Mitchell. 1999. Restoration on the Pu'uhonua o Honaunau anchialine fish ponds
- Chang, Deborah L. 1994. Description of anchialine ponds.
- Cheney, Daniel P., Hemmes, Don E., Nolan, Ronald. 1977. The physiography and marine fauna of inshore and intertidal areas in the Pu'ukohola Heiau National Historic Site.
- Cluff, D.E. 1969. An archaeological survey of the seaward portion of Honokohau #1 and #2, North Kona, Hawai'i Island Department of Anthropology Report Series 69-5: Bishop Museum.
- Daehler,, Curt. 2003. Fire as a tool for restoring native pili grasslands at Puu Kohola National Historic Site. Unpublished report, Department of Botany, University of Hawai'i
- Davis, Dan A., Yamanaga, George 1968. Preliminary report on the water resources of the Kona area, Hawai'i; Circular - Hawai'i Division of Water and Land Development
- Dollar, S. 2001. Benthic marine biota monitoring program at Keahole Point, Hawaii. Prepared for The Natural Energy Laboratory of Hawaii Authority, Honolulu, Hawaii.
- Doty, Maxwell S. 1968 The ecology of Honaunau Bay, Hawaii: final report; Botanical science paper
- Douglas, Christine J., Hotchkiss, Sara C. No Date. The pollen record at 'Aimakapa fishpond.
- Ebert, Thomas A. 1971. A preliminary quantitative survey of the echinoid fauna of Kealakekua and Honaunau Bays, Hawaii. Pacific Science: 25:1, p. 113-131
- Elliott, Linda S. 1994. Kaloko-Honokohau National Historical Park avian botulism rehabilitation program.

- Elliott, Margaret E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands: University of Hawaii at Manoa.
- Emory, Kenneth P., Soerhen, Lloyd J. No Date. Archaeological and historical survey: Honokohau area, North Kona, Hawai'i Bishop Museum Report 61-1: Department of Anthropology.
- Gallagher, Brent. 1980. Physical structure and circulation in Honokohau, a small Hawai'ian harbor affected by groundwater. *Pacific Science*: 34:3, p.301-311.
- Gardiner, Harold C. 1967. Genesis of a climosequence of soils in the Kohala region. University of Hawaii at Manoa.
- Giza, Beverly Jean. 1979. Geology of northwest Kohala Mountain, Island of Hawai'i. University of Hawaii at Manoa.
- Halbig, Joseph B., Walther M. Bernard, S.E. Johnston, R.A. Butts, and S.A Bartlet. 1985. A baseline study of soil geochemistry in selected areas on the Island of Hawai'i.. Hawaii Department of Planning and Economic Development, Honolulu, HI.
- Hanatani, R. Y. 1987. Drytilt stations on Mauna Loa and Hualalai volcanoes, Hawaii, U S Geological Survey Open file report: OF 87-0650.
- Hardy, D. Elmo, Delfinado, Mercedes D. 1980. Insects of Hawaii volume 13: Diptera: Cyclorrhapha III, Insects of Hawaii; a manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc: University of Hawaii Press.
- Hardy, D. Elmo. 1964. Insects of Hawaii volume 11: Diptera: Brachycera II-Cyclorrhapha I, Insects of Hawaii; a manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc: University of Hawaii Press.
- Hardy, D. Elmo. 1981. Insects of Hawaii volume 14: Diptera: Cyclorrhapha IV, Insects of Hawaii; a manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc: University of Hawaii Press.
- Hauanio, Lizabeth. 1995. A study of Naio in Kaloko-Honokohau National Historical Park.
- Hawai'i Audubon Society. 1996. Hawai'i's birds: Hawai'i Audubon Society.
- Hawaii Heritage Program, USGS-Biological Resources Division. 1996. Essential habitat for the recovery of plants protected under the US Endangered Species Act: not published.
- Howarth, Francis G. 1993. High-stress subterranean habitats and evolutionary change in cave-inhabiting arthropods. *The American Naturalist*: 142:supplement, p.S65-S77.
- Hu, Darcy, et. al. 2000. A Study Plan to Inventory Vascular Plants and Vertebrates: Pacific Islands Network, National Park Service.
- Jackson, William L., Rosenlieb, Gary. 1989. Anchialine pond water concerns Kaloko-Honokohau National Historical Park, North Kona, Hawaii.
- Jokiel, P.L., Cox, E.F., Te, F.T., and Irons, D., in review, Mitigation of reef damage at Kawaihae Harbor through transplantation of reef corals: Coastal Management

- Kimura, Larry Lindsey. 1969 Algae: Honaunau, South Kona, Hawai'i
- Kinzie, Robert A. 1979. The impact of small boating activities on the reefs in Honaunau Bay. Review copy, draft.
- Leishmann, Jack 1986. Vegetation map of Puuhonua o Honaunau National Historical Park, Hawaii
- Ludwig G.M., Taylor, L.R., Jr., Imose, D.M, 1980. Summer census of the reef-fish community of waters adjacent to Pu'u honua`o Hononau National Historical Park, summers 1974-78.
- Lipp, 1993. *Ophioglossum concinnum* Brack: status in the Hawaiian Islands. University of Hawaii, Botany Department, Manoa.
- Kay, E. Alison, Lau, L. Stephen, Stroup, Edward D., Dollar, Stephen J., Fellows, David P., Young, Reginald H. F. 1977. Hydrologic and ecologic inventories of the coastal waters of west Hawai'i Technical Report No. 105, Sea Grant Cooperative Report UNIH-SEAGRANT-CR-77-02: Water Resources Research Center, University of Hawaii.
- Kido, Sunao. 1971. A report on Kaloko Fishpond and the Honokohau Settlement National Historic Landmark: State of Hawai'i.
- Kikuchi, William K. 1976. Prehistoric Hawaiian fishponds. *Science*: 193:4250, p.295-299.
- Kikuchi, William K., Belshe, J. 1971. Examination and evaluation of fishponds on the leeward coast of the Island of Hawai'i.
- Kimura International. 1996. Kaloko Town Center, North Kona, Hawai'i: final environmental impact statement: Kaloko International Inc.
- Kridler, Eugene. 1973. Bird observations at Opaepa and Aimakapa Ponds, Hawai'i. `Elepaio: 33:10, p.107.
- Maciolek, John A., Brock, Richard E. 1974. Aquatic survey of the Kona Coast Ponds, Hawai'i Island UNIH-SeaGrant-AR-74-04: University of Hawaii.
- Macneil, James D., Hemmes, Don E. 1977. Pu'ukohola Heiau National Historic Site plant survey; Cooperative National Park Resources Studies Unit Technical Report Series
- Moore, R. B, Clague, D. A. 1991. Geologic map of Hualalai Volcano, Hawaii, Miscellaneous Investigations Series U S Geological Survey.
- Morin, Marie P. 1994. Avian botulism. (paper in KAHO park files)
- Morin, Marie P. 1994. Hawai'ian fishponds and endangered waterbirds on the Kona coast. *Transactions of the Western Section of the Wildlife Society*: 30:p.66-71.
- Morin, Marie P. 1995. Kaloko bird observation database 1992-1995. Report in park files.
- Morin, Marie P. 1996. Birds of Kaloko-Honokohau National Historical Park Technical report 104: Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa.
- Morin, Marie P. 1996. Response of a remnant population of endangered waterbirds to avian botulism. 1996 *Transactions of the Western Section of the Wildlife Society*: 32:p.23-33.
- Morin, Marie 1996 Bird inventory of Pu'ukohola Heiau National Historic Site, South Kohala, Hawai'i Island

- Morin, Marie 1996. Birds of Pu`uhonia O Honaunau National Historical Park. Technical report 106: Cooperative National Park Resources Studies Unit, University of Hawai`i at Manoa.
- Morin, Marie P. 1998. Endangered waterbird and wetland status, Kaloko-Honokohau National Historical Park, Hawai`i Island Technical report 119: Cooperative National Park Resources Studies Unit, University of Hawai`i at Manoa.
- National Park Service, Honokohau Study Advisory Commission. 1974. Draft environmental statement Proposed Kaloko, Honokohau National Cultural Park, Hawai`i: U.S. National Park Service.
- National Park Service. 1988. Resource management plan (draft) Kaloko-Honokohau National Historical Park: U.S. Dept. of the Interior.
- National Park Service. 1988. Statement for management, Kaloko-Honokohau National Historical Park: U.S. Dept. of the Interior.
- National Park Service. 1991. Resource management plan, Kaloko-Honokohau National Historical Park, Hawai`i.
- National Park Service. 1992. Draft general management plan/environmental impact statement: Kaloko-Honokohau National Historical Park, Hawai`i: United States. Department of the Interior/National Park Service.
- National Park Service. 1994. General management plan / environmental impact statement [Kaloko-Honokohau National Historical Park].
- National Park Service. Hono-Ko-Hau Study Advisory Commission. 1974. The Spirit of Ka-loko hono-ko-hau: a proposal for the establishment of a Ka-loko hono-ko-hau national cultural park: U.S. National Park Service.
- National Park Service. Kaloko-Honokohau National Historical Park. 1987. Resource management plan, Kaloko-Honokohau National Historical Park, Hawai`i [PRELIMINARY DRAFT]: U.S. National Park Service.
- National Park Service, Pu`uhonua o Honaunau National Historical Park. 2000. PUHO site conception plan.
- National Park Service, Water Resources Division. 1999. Baseline water quality data: inventory and analysis: Pu`uhonua`o Honaunau National Historical Park.
- National Park Service Water Resources Division. 2000. Baseline water quality data inventory and analysis Kaloko-Honokohau National Historic Park Technical Report NPS/NRWRD/NRTR-99/247: United States Department of the Interior, National Park Service, Water Resources Division.
- National Park Service Water Resources Division. 2001. Baseline water quality data inventory and analysis Puukohola Heiau National Historic Site
- Natural Heritage Program, Nature Conservancy of Hawaii. 1987. Biological database of rare species and natural communities in anchialine ponds in the state of Hawaii: Natural Heritage Program, Nature Conservancy of Hawaii.

- Nature Conservancy 1987 Biological database of rare species and natural communities in anchialine ponds in the state of Hawaii. Natural Heritage Program, Nature Conservancy of Hawaii
- Neighbor Island Consultants. 1972. An assessment of environmental impact resulting from the development of a boat launching ramp and deepening of the existing navigational channel, Honaunau Bay, Hawai'i
- NOAA. 1977. Kealakekua Bay to Honaunau Bay.
- Nolan, R.S., Cheney, D.P. 1981. West Hawai'i coral reef inventory/West Hawai'i coral reef atlas.
- Oceanic Institute. Summer Aquaculture Workshop Students And Staff. 1992. Evaluation of anchialine fishponds Hele 'I Palala at Pu'uhoonua o Honaunau National Historical Park, Honaunau, Hawai'i
- Oki, Delwyn S., Tribble, Gordon W., Souza, William R., Bolke, E. L. 1999. Ground-water resources in Kaloko-Honokohau National Historical Park, Island of Hawaii, and numerical simulation of the effects of ground-water withdrawals U.S. Geological Survey Water-Resources Investigations Report 99-4070: U.S. Geological Survey.
- Parrish, James D., Smith, Gordon C., Norris, James E. 1990. Resources of the marine waters of Kaloko-Honokohau National Historical Park: Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa/University of Hawai'i Press.
- Paton, Peter W. C. 1985. American Coot and Black-necked Stilt on the Island of Hawai'i. *Western Birds*: 16:p.175-181.
- Paton, Peter W. C., Taylor, Avery, Ashman, Philip R. 1984. Blue-winged Teal nesting in Hawai'i. *The Condor*: 86:p.219.
- Peterson, John A. and Orr, Maria K. 2004. Draft: I 'Ono Ke Kole, I'a Ono Ke Kole – Sweet Conversation, Sweet-tasting Fish: A Marine Ethnography of Kaloko-Honokohau National Historic Park, Kailua-Kona, Hawaii. International Archaeological Research Institute, Inc., Honolulu, Hawai'i.
- Polhemus, Dan A. 1996. The orangeblack Hawaiian damselfly, *Megalagrion xanthomelas* (Odonata: Coenagrionidae): clarifying the current range of a threatened species. *Bishop Museum Occasional Papers*: 45:p.30-49.
- Polhemus, Dan A. 1997. Phylogenetic analysis of the Hawaiian damselfly genus *Megalagrion* (Odonata: Coenagrionidae): implications for biogeography, ecology, and conservation biology. *Pacific Science*: 51:4, p.395-412.
- Polhemus, Dan A., Maciolek, John, Ford, John. 1992. An ecosystem classification of inland waters for the tropical Pacific Islands. *Micronesica*: 25:2, p.155-173.
- Pratt, H. Douglas. 1987. Occurrence of the North American Coot (*Fulica americana*) in the Hawai'ian islands, with comments on the taxonomy of the Hawai'ian Coot. *'Elepaio*: 47:3, p.25-28.
- Pratt and Abbot 1996. Vascular plants of Pu'uhoonua O Honaunau National Historical Park; Cooperative National Park Resources Studies Unit Technical Report Series #105.

- Pratt, Linda W., Abbott, Lyman L. 1996. Distribution and abundance of alien and native plant species in Kaloko-Honokohau National Historical Park CPSU Technical Report 103, Cooperative National Park Resources Studies Unit Technical Report Series: Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa/University of Hawai'i Press.
- Pratt, Linda. 1996. Kona Parks Vegetation Management Scoping Session: National Biological Service, Pacific Islands Science Center, p.20.
- Pratt, Linda and Lyman Abbott, 1996. Vascular plants of Pu'ukohola Heiau National Historic Site, Hawai'i Island; Cooperative National Park Resources Studies Unit Technical Report Series #101.
- Pratt, Linda W. 1998. Vegetation management strategies for three National Historical Parks on Hawaii Island CPSU Technical report 121, Cooperative National Park Resources Studies Unit Technical Report Series: Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa.
- Reed, Michael. 1994. Progress report for Hawai'ian Stilt research.
- Renger, Robert C. 1970. Archaeological reconnaissance of coastal Kaloko and Kukio I, North Kona, Hawai'i Bishop Museum Report 70-10: Department of Anthropology.
- Renger, Robert C. 1974. Human adaptation to marginal coastal environments: the archaeology of Kaloko, North Kona, Hawai'i: University of California, Santa Barbara.
- Ridgley, M.A., Chai, D.K. 1990. Evaluating potential biotic benefits from conservation: anchialine ponds in Hawai'i, USA. *Environmental Professional*: 12:3, p.214-228.
- Rhodes, Raymond J. 1969. A summary of the Kona Coast general oceanography for the City of Refuge National Historical Park, Honaunau, Hawai'i and Report on marine biology study at City of Refuge.
- Rosenlieb, Gary W., Long, Barry A., Martin, Larry, Hagemann, Matt, Irwin, Roy J., Tilmant, Jim. 1998. Potential influences of wastewater discharges on Aimakapa Pond and nearby anchialine pools, Kaloko-Honokohau National Historic Park: U.S. National Park Service, Water Resources Division.
- Rutter/KW Kohanaiki. 2003. The Shores at Kohanaiki: Special Management Area Use Petition.
- Shallenberger, R.J. 1977. An ornithological survey of Hawai'ian wetlands Contract DACW 84-77-C-0036: U.S. Army Engineering District : Ahuimanu Productions.
- Smith, Clifford W., Stemmermann, L., Higashino, Paul K., Funk, E. 1986. Vascular plants of Puuhonua O Honaunau National Historical Park, Hawai'i; Cooperative National Park Resources Studies Unit Technical Report Series #56
- Smith, Clifford W. 1993. Checklist of the plants in the management area around Aimakapa Pond CA8039-2-0001.
- Smith, J.E., Hunter, C.L., Smith, C.M. 2002. Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. *Pacific Science*: 56:3, p.299-315.

- Stewart, Carolyn. 2003. Draft watershed restoration action strategy for Pelekane Bay Watershed, S. Kohala, Hawaii. Mauna Kea Soil and Water Conservation District.
- Stone, Charles P, Aeder M., Ha'o S., Texeira J. , Stone D.B., 2002, Distribution and Abundance of Native and Alien Mammals at Kaloko-Honokohau National Historical Park. Unpublished document. 8pp
- Stone, D.B, Stone, D.B., Stone, D.B. 1989. Hawai'i's wetlands, streams, fishponds and pools, Conservation Biology in Hawai'i: Univ. of Hawai'i Press, p.125-136.
- Stromquist, C. Dale. 1996. Untitled: Well completion reports, Honokohau-NPS, monitor wells.
- Tissot 1998 Changes in the Marine Habitat and Biota of Pelekane Bay, Hawaii over a 20-Year Period, University of Hawaii at Hilo
- Tissot, B. N., and L. E. Hallacher. 2003. Effects of aquarium collectors on coral reef fishes in Kona, Hawaii. Conservation Biology. 17:1759-1768.
- Tissot, B. N., W. J. Walsh, and L. E. Hallacher. 2004. Evaluating effectiveness of a Marine Protected Area Network in West Hawai'i to increase productivity of an aquarium fishery. Pacific Science. 58:175-188.
- U.S. Army Corps Of Engineers. 1983. A decade of ecological studies following construction of Honokohau small boat harbor, Kona, Hawai'i Special report, Honolulu District.
- West Hawaii Aquarium Project. Descriptions provided online at <http://coralreefnetwork.com/kona/>
- Wyban, Carol A. 1996. Feasibility study for Kaloko fishpond-Kaloko-Honokohau National Historical Park, Island of Hawai'i.
- Yen, Douglas. 1971. An ethnobotanical survey of the national parks at Honaunau and Kalapana on the Island of Hawai'i and Kipahulu, Maui.