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Inventory & Monitoring Program

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Sea Level Rise & Anchialine Pools

Global sea level will rise between 0.2 m and 1.9 m by 2100 according to the Intergovernmental Panel on Climate Change (IPCC). Sea level rise is caused by a combination of processes including the melting of polar ice caps and glaciers, thermal expansion of ocean water, mining of groundwater aquifers, and, in places like Hawai'i Island, subsidence of land masses (the island is slowly sinking). Estimates of sea level rise vary depending on the trajectory of global greenhouse gas emissions, and are based on different scenarios established by the IPCC. The more extreme values of sea level rise (1.9 m) reflect a future emissions scenario in which global population growth is coupled with continued intensive fossil fuel use. In all scenarios, rates of sea level rise are accelerating and will continue to accelerate in the future.

Geospatial predictions of coastal change under sea level rise typically pair current coastal elevation data and future sea level scenarios. These models tend to be conservative because they often do not incorporate future tectonic uplift or subsidence, high wave events, or shoreline erosion which will exacerbate coastal inundation and change, especially during large episodic events (e.g. storms or tsunamis). In some coastal areas, groundwater floating on top of denser, more saline water, may also exacerbate flooding as sea levels rise. In all sea level rise models, predictions should be viewed with the understanding that there is considerable regional and local uncertainty in the future propagation of storms and waves, vertical land movement, and variation in basin wide processes such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation.

Parks at Risk

Coastal erosion, tsunamis, and coastal inundation due to waves and sea level rise will have serious impacts on the future shorelines of all Pacific island national parks. Cultural and natural resources are already being altered by sea level rise. Incorporating detailed elevation data and sea level rise predictions in the early stages of resource protection planning will aid in long term management of park trails, resources, and infrastructure, and could lessen negative long-term impacts. Furthermore, scenario planning for habitat migration due to rising ocean levels and retreating groundwater is essential so that the predicted future locations of important habitats, like potentially nascent anchialine pools, can be factored in. This is one of the major components of the National Park Service's Natural Resource Adaptation Strategy.

An anchialine pool in a popular area of Pu'uhonua o Hōnaunau NHP.

The pool and grounds were later inundated by a tsunami in 2011. The impacts of large waves from tsunamis and storms will intensify along the coast as sea levels rise, changing the landscape forever.

Predicting changes to anchialine pools

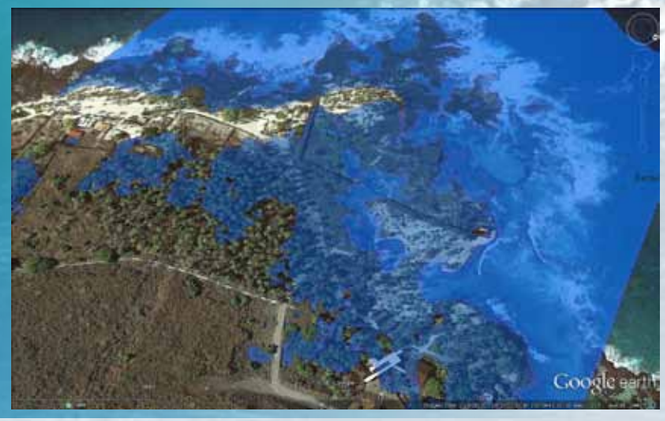
Anchialine pools are brackish coastal ecosystems without a surface connection to the ocean, where groundwater and ocean water (from underground) mix. In Hawai'i, groundwater flows through these pools and out to wetlands and coral reefs making them valuable indicators of broad-scale groundwater recharge and contamination. The NPS Inventory & Monitoring Program takes regular measurements of the water quality and overall health of park pools, which are found no other place in the United States outside of Hawaii. Hawaiian anchialine pools are tidally influenced, range in size from less than 1 m² to over 3000 m² and support diverse endemic plants and animals, including seven species listed as Candidate Threatened or Endangered Species. Anchialine pool shrimp and mollusk species disperse throughout the ocean as larvae and through groundwater as larvae or adults.

A total of 193 anchialine pools have been mapped at Kaloko-Honokōhau National Historical Park, 15 at Pu'uhonua o Hōnaunau National Historical Park (PUHO), and 16 at Hawai'i Volcanoes National Park. When the pool locations are overlain on maps depicting inundation scenarios, the extent of inundation can be calculated. At the 0.5 m sea level rise scenario at all three parks, current pools become larger but they are not generally inundated or connected overland to the ocean. In PUHO at a 1 m scenario, 50% of the pools are inundated and become connected to the ocean. For the 1.9 m scenario at the extreme tide, only a few pools continue to be isolated while 71% become inundated at PUHO.

Sea level rise scenarios

The current coastline with anchialine pool locations at Pu'uhonua o Hōnaunau NHP.

The projected coastline and current anchialine pools in 2100 with **a sea level rise of 0.5 meters.**



The projected coastline and current anchialine pools in 2100 with **a sea level rise of 1.9 meters.**

Incorporating detailed elevation data and sea level rise predictions in coastal planning should aid in long-term management of both developed and natural areas. In particular, this project aims to identify key areas to preserve for maintaining environmental and cultural integrity in the future. For example, while some features such as individual anchialine pools will be inundated, anchialine pool, fishpond and wetland habitats will emerge or shift in the landscape, essentially fostering new habitats. Protecting future potential habitat from development will conserve valuable land, and will reduce the need to repair or relocate infrastructure placed in these areas.

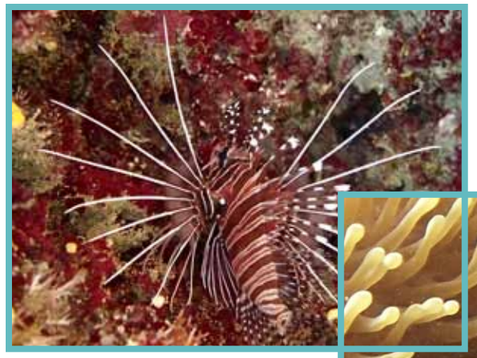
The goal of this project is to share sea level rise inundation scenarios with NPS staff as well as public and private partners so that everyone can plan for the future condition of Hawai'i's shorelines.

This summary is just the tip of the melting iceberg. For a much more in-depth report, read the source article by Lisa Marrack and Patrick O'Grady from the University of California, Berkley:

http://manoa.hawaii.edu/hpicesu/techr/188/v188.pdf

Fish & Benthic Monitoring Update on Guam

From June 23 to July 3rd, 2014, the Pacific Island Network carried out the marine benthic, fish, and marine water quality protocols for War in the Pacific National Historical Park (WAPA), Guam. A dive team consisting of Sly Lee (NPS Biotech), Eric Brown (NPS Marine ecologist), and I surveyed 30 sites across the park units of Asan and Agat. At the end our field sampling, a total of 30 reef structural complexity measurements, 750 underwater benthic photo images, and 96 marine water samples were taken; with 1,682 fishes counted and sized. Data entry, and sampling and image analyses are now underway.



Spotfin lionfish
(*Pterois antennata*)

Pink anemonefish
(*Amphiprion perideraion*)

We observed seven fish species that had never before been seen during Inventory & Monitoring Program sampling.... the pink anemonefish (*Amphiprion perideraion*), the spiny tooth parrotfish (*Calotomus spinidens*), the striated surgeonfish (*Ctenochaetus striatus*), the greasy grouper (*Epinephelus tauvina*), the spotfin lionfish (*Pterois antennata*), the globe head parrotfish (*Scarus globiceps*), and the tasseled scorpionfish (*Scorpaenopsis oxycephala*).

Our observations of the benthic community ranged from reef sites with a healthy amount of coral cover to that of an unhealthy reef, where a poorly managed watershed (pictured on the right) resulted in runoff; containing sediments and other pollutants that killed the living coral.

Healthy coral cover

Unhealthy reef

Coralline lethal orange disease "CLOD" forms a distinctive orange band

Benthic organisms can also become sick or infected with diseases and coralline algae is no exception. Unfortunately, coralline lethal orange disease or "CLOD" was observed on two occasions. CLOD is a bacterial disease and, as the name implies, is characterized by a band of bright orange. Normally healthy live coralline algae are pink to magenta in color. The band infects the algae as it moves across the surface, the bare white or dead portion is what remains.

We'll look for these species and issues, and make other observations when we return for monitoring in 2015.

–Sheila A. McKenna, NPS
Marine ecologist

'Ōpae Kala'ole

A.K.A. –spineless shrimp, mountain 'ōpae, or Atyoida bisulcata

Description: These endemic Hawaiian freshwater shrimp can grow to a length of about 2 inches. They do not have claws like the invasive Tahitian prawn (*Macrobrachium lar*) but rather have pincers with bristle-like hairs, which can be extended to form a fan used to catch and filter food particles from the water column.

Habitat & diet: ʻŌpae kalaʻole are superb climbers and can be found in the highest stream reaches in Hawaii. They prefer to be in and around rocks in the fastest flowing part of the stream. Here is the really cool part. They have two distinct feeding patterns. The first is used in strong currents. They position themselves in the direction of the current, then they spread out the bristle-like hairs on their front legs to form tiny baskets. These baskets allow them to catch particles coming toward them with the current. They then put the food particles directly into their mouths. The second feeding method is used in slow moving waters. This behavior is common among other crustaceans. It involves simply using their pincers to extract food items from the stream floor.

Reproduction: Breeding occurs all year round in Hawaiian streams. More often than not, when you come across a female of the species, she will be carrying eggs. She carries about 3,000 eggs attached to her swimmerets on the underside of her tail. The eggs hatch after about 2 months. As with other native Hawaiian stream animals ʻōpae kalaʻole are amphidromous. The newly hatched larvae wash down the stream and into the ocean where they develop for several months before returning back to a stream where they will spend the rest of their lives.

Tidbit: These ʻōpae are known as some of the best climbers in the whole Hawaiian stream community. They have been found upstream of 100 foot waterfalls. These resourceful little critters have also been found in storm drains, agricultural ditches, and taro fields.

Threats: Habitat loss and degradation is one of the biggest threats to ʻōpae kalaʻole and other stream animals. An increasing human population on the Hawaiian islands is leading to changes in the way streams naturally flow. Streams have been diverted, channelized, and dammed to accommodate city infrastructure and agriculture. This results in reduced water flow, higher temperatures, and an abundance of harmful introduced species.

ʻŌpae kalaʻole in Pacific island national parks: The Inventory & Monitoring Program monitors stream animal populations annually as well as stream water quality parameters every quarter. These special shrimp are found in abundance in the upper reaches of Waikolu Stream in Kalaupapa NHP and Palikea Stream in Haleakalā NP. The upper reaches have the fast, cool, and clear waters that the ʻōpae prefer. They also have significantly fewer invasive species like the Tahitian prawn. Click here to see a simple video of this ʻōpae in a stream.

Freshwater streams monitoring and video link

–Anne Farahi, NPS
Biological technician

From Mauka to Makai

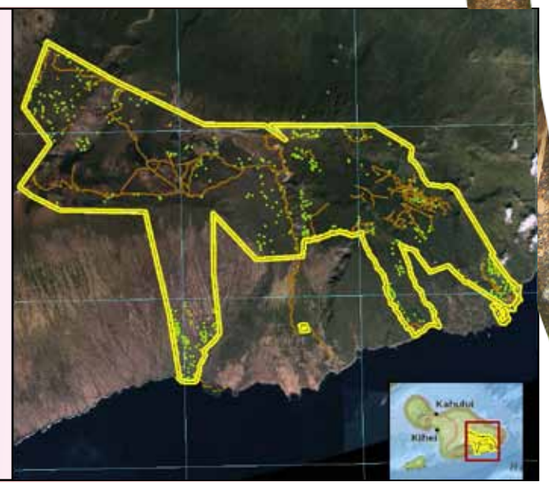
Vegetation Mapping at Haleakalā National Park

Field work for the Accuracy Assessment stage of Haleakalā National Park's vegetation mapping project commenced in January 2014. The purpose of Accuracy Assessment is to understand the strengths and weaknesses of the draft vegetation map (see below). This is done by on-the-ground assessment of the vegetation and referencing an established vegetation classification. The field data is then compared to the draft map to determine if the satellite imagery of the park's vegetation has been properly assigned into vegetation classification types. This process involves field crews navigating to randomly selected points throughout Haleakalā NP and assessing the site's vegetation within a 40 meter radius circle or designated polygon, and assigning a vegetation type that has been previously described at the park. The project included over 600 target points with over 50 possible vegetation types. These vegetation types occur at designated elevational and climatic zones and are classified by the dominant plant species present. At Haleakalā NP, these types range from the semi-natural lowland dry forest, dominated by the non-native kiawe tree (*Prosopis pallida*), to the montane wet forest dominated by the native ʻōhiʻa (*Metrosideros polymorpha*) and ʻōlapa trees (*Cheirodendron trigynum*). This project provided the opportunity for field crews to explore the amazingly diverse and unique landscapes of Haleakalā from mauka to makai, a Hawaiian phrase simply translated as 'from the mountain to the ocean'.

It is no small feat to map the vegetation of the 34,000+ acres that comprises Haleakalā NP. The process started over three years ago with the initial field classification plots and observations, and will be completed this spring when the final map and report are published. Once complete this comprehensive vegetation map will serve as a dynamic tool for park managers and research scientists. Accuracy Assessment is the final stage of the field work for the project and took no less than 15 Park staff, contractors, and volunteers to accomplish over a seven month period.

Lobelia gloria-montis

What is a vegetation map?
A vegetation map displays what type of plant communities exist in a specific area on Earth. Plant communities are named based on dominate (highest % cover) species, and defined by ecological factors (e.g. geology, elevation, precipitation, etc.). Together, these variables are used to develop a plant community classification. Using Geographic Information Systems (GIS) programming and remote sensing data (i.e satellite imagery), the classification can be applied across a larger landscape to develop a map of the various plant communities described within a specific area, such as Haleakalā National Park.



The field crew takes in the exquisite beauty of *Trematolobelia macrostachys*

"Crew members had to be ready to endure many physical challenges, but were often blessed with the spectacular scenery of Maui and the rare beauty of its flora and fauna."

–E. Urbanski

Haleakalā has some of the most diverse and unique environments in the world. Habitats include the mosaic Subalpine Shrubland, the sparse cindery Crater, the Greensword Bogs of the Northeast Rift, the ephemeral grasslands of Nuʻu, and the Wet Forests of Kīpahulu Valley and ʻOʻheo Gulch.

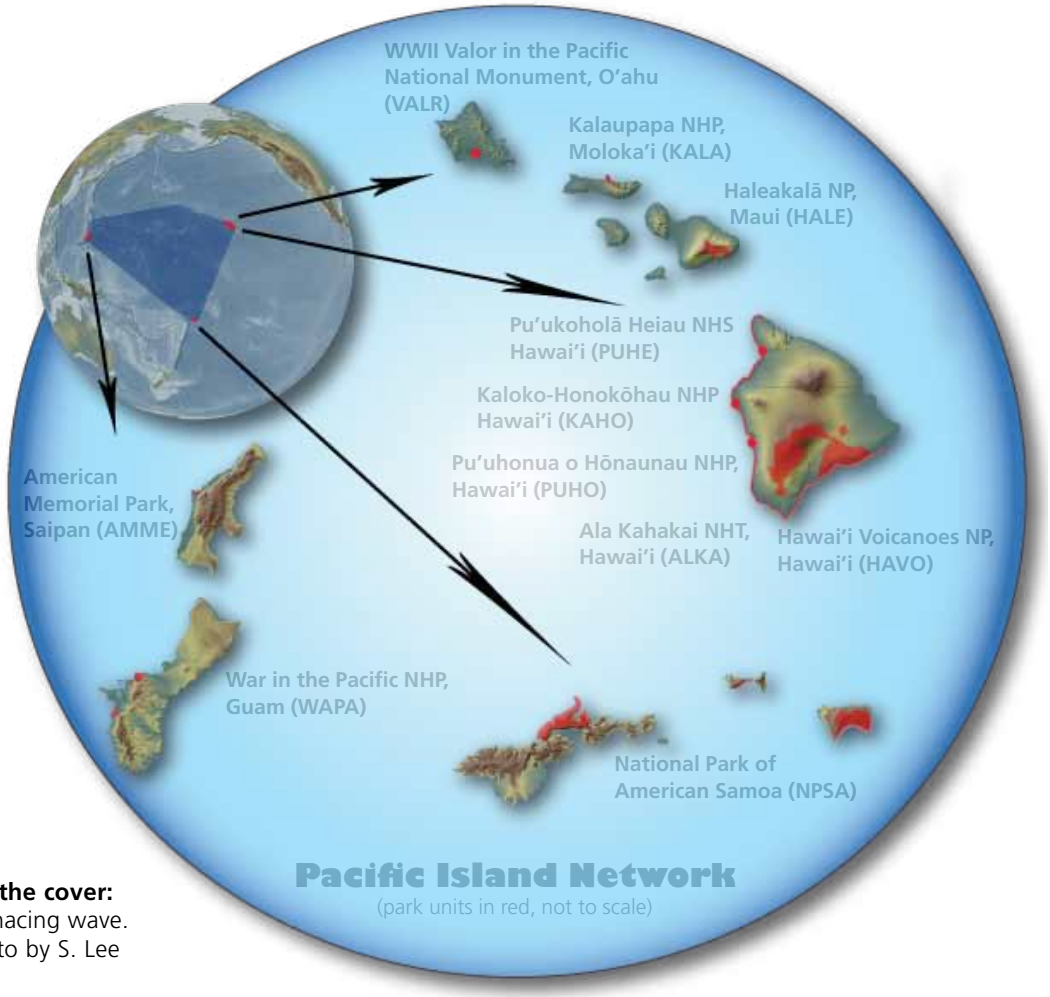
Six hundred and one points were observed with many requiring camping in remote backcountry areas of the park. Reaching points often involved traversing through dense vegetation, across varied terrain, and in inclement weather.

Manawainui is an area on the south side of Haleakalā positioned between Kaupō Gap on the west and Kīpahulu Valley on the east. It sits at 5,000 feet elevation above a spectacular valley that often displays numerous ribbons of waterfalls streaming down its cliffs, inspiring the name Manawainui which translates as 'powerful spirit water'. At the end of June, NPS Inventory and Monitoring crewmembers Meagan Selvig (University of Hawaiʻi cooperator), Joey Latsha (volunteer), and I had the opportunity to stay at ʻŌhiʻa Camp, a backcountry shelter in Manawainui, to assess the vegetation types and explore this unique area. Misty clouds gusted by us as we navigated to target points through mossy gulches, narrow ridges, and dense thickets of the vining fern uluhe (*Dicranopteris linearis*). We would call out to each other as we passed by a rarely seen plant or caught a glimpse of a native bird fluttering by. In one gulch we were delighted to see a population of over 20 *Lobelia gloria-montis*, a rare plant that is truly the glory of the mountain. Later as we proceeded to cross another gulch and head up a steep slope of uluhe, we happened upon a fully blooming *Trematolobelia macrostachys* with its branching inflorescence of magenta flowers. A rare and wonderful sight we were fortunate to behold as one of the great highlights of our field season at Haleakalā National Park.

–Elizabeth Urbanski, NPS Biological technician
–Meagan Selvig, UH-Hilo Vegetation mapping coordinator

Field Schedule

	October	November	December
Anchialine monitoring			
Invasive plants	E. D. Pilot HALE, HAVO	E. D. Pilot HALE, HAVO	Field Training HAVO
Vegetation communities			Field Training HAVO
Water quality	HALE	KAHO (marine)	All Parks Except HALE
Stream animals		HALE	
Ground water			
Benthic marine		KAHO	
Marine fish		KAHO	
Vegetation mapping			Field Review HALE
Climate (on-going)	All Parks----------	----------	----------



On the cover:
Menacing wave.
Photo by S. Lee

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The National Park Service (NPS) has implemented natural resource inventory and monitoring (I&M) on a servicewide basis to ensure all park units possess the resource information needed for effective, science-based management, decision-making, and resource protection.

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KALA – Paul Hosten
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PUHE – Sallie Beavers/Daniel Kawaiaea
PUHO – Adam Johnson
VALR – Eric Brown
WAPA / AMME – Mike Gawel

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NOTE: Unless indicated all photos and articles are NPS.

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