Anchialine Pool Habitats

Climate Vulnerability Assessment and Adaptation Strategies for Maui, Lāna'i, and Kaho'olawe

HABITAT DESCRIPTION

Anchialine pools are landlocked pools found on limestone or lava flows. They are characterized by subsurface hydrological connectivity, but lacking surface connection to the ocean. Pools vary in salinity, dissolved oxygen levels, and water level depending on distance to the sea, tidal fluctuations, groundwater input, and rainfall. The Hawaiian Islands have the largest concentration of anchialine pools in the world. The island of Maui has many anchialine pools, while Kaho'olawe has only one pool with very high salinity.

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HABITAT VULNERABILITY

Climatic changes such as precipitation shifts, storm surge, and saltwater intrusion may alter anchialine pool salinity or water depth. Development and water diversions may exacerbate these salinity and depth changes by altering groundwater recharge and withdrawal. Additionally, anchialine pools are sensitive to sea level rise, which may increase pool vulnerability to invasive species, as well as pool distribution, particularly if development blocks potential inland migration. Anchialine pool shrimp ('ōpae) are also sensitive to salinity changes, water temperature increases, and pollutants. Some habitat areas are protected, and restoration efforts have been successful. However, these habitats face competing interests with development and agriculture.

Drivers of Habitat Vulnerability

- **Climatic factors and disturbance regimes**: Precipitation amount & timing, water temperature, tropical storms/hurricanes, sea level rise, saltwater intrusion
- **Non-climate factors**: Residential & commercial development, water diversions, pollution & poisons, agriculture & aquaculture

PROJECTED FUTURE CHANGES	POTENTIAL IMPACTS ON ANCHIALINE POOL HABITATS
Changes in **precipitation**	• Reduced precipitation may increase pool salinity, with possible impacts on pool community structure • Reduced precipitation will reduce pool depth and restrict distribution by reducing groundwater recharge
Increased **water temperatures**	• Possible effects on 'ōpae'ula chromataphores and color • Two shrimp species (*Halocaridina rubra*, *Metabetaeus lohena*) are adapted to variable and high temperatures; other shrimp species may be more vulnerable
Increased frequency and strength of **tropical storms/ hurricanes**	• Storm surge may introduce marine fauna to pools • Temporary increases in sedimentation and pool salinity due to storm surge and extreme waves
Sea level rise; increased **saltwater intrusion** *+0.4 m (1.3 ft) to +3.3 m (10.8 ft) of sea level rise by 2100*	• Increased pool size and/or loss of some pools due to inundation • Possible pool creation where appropriate substrates exist • Increased vulnerability to invasive fish introductions due to enhanced connectivity between pools and other habitats (e.g., fishponds, manmade features) • Increased subsurface pool salinity, especially where groundwater levels decline

ADAPTIVE CAPACITY

Factors that enhance adaptive capacity:

+ Pools in Cape Hanamanioa have high integrity
+ High subsurface connectivity promotes pool resilience and wildlife colonization of new pools
+ Support several endemic 'ōpae and amphipods
+ Some pools are protected in the 'Āhihi-Kīna'u Natural Area Reserve
+ Some restoration and artificial pool creation efforts have been successful on other islands

Factors that undermine adaptive capacity:

– Typically small in size
– Few pools have been surveyed; relatively little is known about anchialine pools, keystone species, and climate change vulnerability
– Low-moderate public value and low societal support for pool conservation and management
– May compete for space and water with other land uses (e.g., development, agriculture)

ADAPTATION STRATEGIES FOR ANCHIALINE POOLS

Types of Adaptation Approaches	Adaptation Strategy	Specific Action
Resistance: Prevent climate change from affecting a resource *Near-term approach*	Maintain/improve water quality and quantity	• Investigate and reduce non-point source pollution
Resilience: Help resources weather climate change by avoiding the effects of or recovering from changes *Near- to mid-term approach*	Protect current and future habitat	• Use gap analysis planning to identify areas that need protection based on specific climate-informed criteria
	Implement climate-informed coastal zoning protections	• Revise setback requirements to account for projected sea level rise
Response: Intentionally accommodate change and adaptively respond to variable conditions *Long-term approach*	Anticipate and facilitate habitat migration	• Identify and protect currently vulnerable areas and areas of possible habitat migration based on available data, including existing infrastructure lifetime
Knowledge: Gather information about climate impacts and/or management effectiveness in addressing climate challenges *Near- to long-term approach*	Increase understanding of water resources and their values	• Monitor point- and non-point source pollutants associated with agriculture and development (e.g., fertilizers, insecticides, agricultural byproducts) • Increase knowledge of water needs of native ecosystems and species and the impacts of water withdrawals on these resources
Collaboration: Coordinate efforts and capacity across landscapes and agencies *Near- to long-term approach*	Build support for coastal habitat protection with climate-informed public education and advocacy	• Conduct climate-informed public education and outreach about protected areas and habitats at risk

EFFECTIVENESS
Likelihood of reducing vulnerabilities

EFFECTIVENESS \ FEASIBILITY	Low	Moderate	High
High	**Low F/High E**	Use gap analysis planning to identify areas that need protection based on specific climate-informed criteria Conduct climate-informed public education and outreach about protected areas and habitats at risk	**High F/High E** Identify and protect currently vulnerable areas and areas of possible habitat migration based on available data, including existing infrastructure lifetime Investigate and reduce non-point source pollution
Moderate	Monitor point- and non-point source pollutants associated with agriculture and development (e.g., fertilizers, insecticides, agricultural byproducts)	**Mod F/Mod E** Revise setback requirements to account for projected sea level rise	
Low	**Low F/Low E**	Increase knowledge of water needs of native ecosystems and species and the impacts of water withdrawals on these resources	**High F/Low E**

FEASIBILITY
Ease of action implementation

Further information and citations can be found in the Hawaiian Islands Climate Vulnerability and Adaptation Synthesis and other products available online at www.bit.ly/HawaiiClimate.

Reynier WA, Gregg RM. 2018. Anchialine Pools: Vulnerability and Adaptation Brief for Maui, Lānaʻi, and Kahoʻolawe. EcoAdapt, Bainbridge Island, WA.
Produced in cooperation with the Pacific Islands Climate Change Cooperative, with funding from the U.S. Fish and Wildlife Service.