Research reveals how climate change may affect Hawaiian fishpond aquaculture

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Moi (fish) from Heeia Fishpond. Credit: Paepae o Heeia

For centuries, indigenous peoples of the Hawaiian Islands practiced sustainable aquaculture by building walled fishponds in coastal estuaries. Historical records estimate that in the early 1900s an extensive network

of over 450 fishponds across the Hawaiian Islands produced upwards of 2 million pounds of fish annually and supported large thriving communities. Currently, worldwide aquaculture accounts for almost one-half of fish consumption.

Researchers with the University of Hawai'i at Mānoa's School of Ocean and Earth Science and Technology (SOEST) and Native Hawaiian fishpond stewards Paepae He‘eia formed a collaborative partnership to understand the role of climate change in subtropical coastal estuarine environments within the context of aquaculture practices in He‘eia Fishpond. He'eia is a traditional Hawaiian fishpond on O‘ahu. Results published recently in *Plos ONE* indicate that there is a relationship between two periods of high fish mortality at He‘eia Fishpond and changes in the climate.

"Today, a majority of Hawaiian fishponds have been lost to coastal development and urbanization, but a growing community-based movement is working to restore and revitalize Hawaiian fishponds as a cornerstone to sustainable food fish production and resilient communities in an era of declining reef fish stocks," said Hi‘ilei Kawelo, Paepae o He‘eia executive director.

However, these efforts are threatened by uncertainty over the effects of short and long-term environmental changes, specifically storms and fluctuations in extreme seawater temperature that bring new stressors and exacerbate existing management challenges.

Hiilei Kawelo tending to moi at Heeia Fishpond. Credit: Rosie Alegado, UHM

Throughout the 12-year study (2004-2016), the partners measured winds, tides, temperature, water height, water movement, and suspended material and phytoplankton in the water; and fish number, density and length. During this time, Hawai'i experienced periodic effects of El Nino such as slackening trade winds and warmer surface waters.

The partners correlated two periods of extremely high fish mortality at He‘eia Fishpond with weakened trade winds in the week preceding each mortality event, as well as surface water temperatures 2-3 degrees Celsius warmer than normal. They posit that the lack of trade wind-driven surface water mixing enhanced surface heating of the fishpond, leading to stagnant conditions and stress on fish populations.

"Our results provide empirical evidence regarding El Niño effects on the coastal ocean, which can inform resource management efforts about the potential impact of climate variation on aquaculture production," said Dr. Rosie Alegado, corresponding author of the study and assistant professor in the SOEST Department of Oceanography and University of Hawai'i Sea Grant College Program (Hawai'i Sea Grant).

Hiilei Kawelo and UHM oceanography Professor Margaret McManus at Heeia Fishpond. Credit: R Alegado

As climate change is predicted to alter the intensity, frequency and geographic patterns of El Niño events, the partners developed three recommendations to reduce the impact of warming events on fishponds and limit the mortality of moi. They recommended moving net pens closer to the mākāhā (sluice gates) with the highest flow rates of ocean water entering the fishpond which will decrease water temperatures and increase aeration in the pens. Additional steps include installing artificial aeration systems in the pens to limit stagnation and low oxygen, and implementing flexible harvest strategies at the onset of a warming event.

To broaden understanding of He'eia Fishpond, the partners will next examine the impact of restoration on water chemistry in the fishpond over the past 10 years using a longtime series of data funded by Hawai'i Sea Grant. Additionally, they are trying to determine how Native Hawaiians responded and adapted to these seasonal and episodic events.

To do this, they have initiated investigation into the Hawaiian language newspapers to understand how these large scale climate patterns affected Hawai‘i.

"Surprisingly, we have not seen evidence of historical fishkills, and we hypothesize that either fishponds were much less vulnerable to these events, or these events were much less severe, or that our kupuna (elder/ancestor) developed adaptive measures to combat these events," said Alegado.

More information: Daniel McCoy et al. Large-scale climatic effects on traditional Hawaiian fishpond aquaculture, *PLOS ONE* (2017). DOI: 10.1371/journal.pone.0187951

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