Case Study 10:
Recognizing Coral Adaptations to Environmental Stressors, *National Park of American Samoa*

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The coral reef in Ofu Lagoon is threatened by warming waters and ocean acidification, but is proving to be surprisingly resilient in comparison to nearby reefs. Image credit: NPS.

Goals

Ofu Lagoon, part of the National Park of American Samoa, contains a healthy coral reef habitat that supports a diversity of species. The park is working with university partners towards the goal of understanding the unique adaptations of the coral in Ofu Lagoon to multiple environmental stressors associated with climate change.

Challenges and Needs

The coral reefs in and around the park support more than 975 fish species and 250 coral species, and a high diversity of invertebrates. Disturbances such as cyclones are expected to increase with climate change, but the principal threat to coral reefs is global warming, which increases nearshore water temperatures and, in turn, increases coral disease and coral bleaching events. Coral reefs within the park and worldwide are expected to experience substantial mortality, up to 90% loss by the end of the century. Ocean acidification, which is caused by increased levels of carbon dioxide in the atmosphere, prevents corals from absorbing the calcium carbonate they need to maintain their skeletons, and dissolves the stony skeletons that support corals and reefs.

The corals in Ofu Lagoon are remarkably resilient to the multiple environmental stressors affecting them, such as high daily temperatures (regularly exceeding 31°C/88°F) and large fluctuations in temperature (range of 4.4°C/8°F), pH (varying by more than 0.5 units of pH), and dissolved oxygen (from 50% to 200%). In 2002 and 2003, increased water temperatures caused extensive coral bleaching, an event in which the heat-stressed coral polyps expel their symbiotic zooxanthellae, which are tan colored, causing coral to look white or "bleached." Surprisingly, the corals in Ofu Lagoon experienced less bleaching than other nearby reefs. Although the Ofu Lagoon corals are better adapted to the lagoon environment than corals transplanted from other reefs in American Samoa, they do not fare as well when they are transplanted to areas outside the lagoon.

More research would help the National Park Service (NPS) to understand this unique tolerance to high temperatures and other stressors, and the implications of this resilience for the health of corals worldwide; to identify areas of reefs in Samoa that would benefit most from protection and conservation; and perhaps to use these corals to reseed areas where corals have been lost to climate change impacts.

Responsive Actions

The park works closely with territorial government agencies and advisory groups to develop solutions to concerns related to coral reef health and expected impacts of climate change. This is not only an effective collaboration but it is also necessary, because the park leases rather than owns the lands and waters within its boundaries, and so must negotiate management plans and actions with traditional landowners and village councils in addition to American Samoa government agencies.

To study and support research on this unique coral reef system, the park operates a laboratory facility on the island of Ofu. This facility supports park and university researchers, and includes an experimental coral tank system that the park designed and built to study the effect of temperature shifts on living coral. Local Samoan interns provide field assistance and monitor experiments while researchers are away.

Results from recent research indicate that heat tolerance derives from both the coral polyps and also from their symbiotic photosynthesizing zooxanthellae. The gene expression of heat-sensitive corals can change in response to heat stress, but the most resilient corals in the Ofu Lagoons already have those thermal tolerance genes "turned on." Additionally, the zooxanthellae in Ofu corals are of four different genotypes, or clades; the corals with clade D were found to be more resilient to heat stress but less tolerant of cooler waters in comparison to coral with other clades. Over time, selection for the thermal tolerance gene expression and the clade D zooxanthellae may allow coral reefs to adapt to higher temperatures and fluctuations. This appears to already have occurred in Pool 300 in the park's section of the Ofu reef lagoon, making these corals some of the most heat tolerant known.

Related studies conducted near the park found that discharging cooler water onto heat-stressed reefs could speed and sustain recovery from coral bleaching events. Furthermore, ultraviolet protection from shade cloth improved coral health. The park is conducting baseline studies of corals within park waters; data will allow comparison with future coral cover. The NPS Pacific Islands Network Inventory and Monitoring Program also provides water quality data and natural resources inventories for the park.

Results of these studies help the park in planning long-term management efforts, such as identifying new candidates for marine protected areas. It would be most effective to target areas that are expected to have higher resiliency to climate change provided that other locally controlled stressors (such as destructive fishing practices) are reduced; examples include shaded areas at the base of cliffs, and reef edges that experience cold-water upwelling events. Although actions such as shading and cool-water discharge would not allow coral to adapt to changing conditions or slow climate change, these strategies could be implemented for short-term solutions, such as briefly protecting small areas of reef, while longer-term management decisions are resolved.

In addition to working with agencies and community groups on broad efforts to protect island reefs and other natural and cultural resources, the park has also developed educational outreach programs focusing on how to minimize individual contributions to climate change.

This project is ongoing and is an example of the following adaptation strategies:

- Incorporating climate change into policies, plans, and regulations
- Reducing non-climate stressors (e.g., destructive fishing practices)
- Coordinating planning and management across institutional boundaries
- Increasing/improving public awareness, education, and outreach efforts
- Conducting/gathering additional research, data, or products

The park laboratory on the island of Ofu supports coral reef research. Graduate student Lupita Ruiz-Jones lifts a crate of coral samples from Ofu Lagoon. Image credit: Carlo Caruso, NPS.

Local NPS interns Sui Fautua and Vano Alosio take water samples while assisting visiting researchers. Image credit: Carlo Caruso, NPS.

For more information:

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