Reversing coral bleaching on Pacific reefs

Brian Von Herzen, Ph.D.  
The Climate Foundation*  
Doug Fenner, Ph.D., DMWR  
Kelley Anderson, M.Sc.

*Work supported in part by the Pacific Islands Climate Change Cooperative (PICCC), US Fish and Wildlife Service
Project genesis

- 2008 Climate Foundation project:
  - thermal exchange of deep water using upwelling pumps. Youtube video, under “recycling CO2”
- ICRS 2008 conference:
  - photo-thermal bleaching is a principal stressor for many corals
- Doug Fenner, DMWR: annual bleaching at back reef of airport, Tutuila, American Samoa.
  - good test bed for validating bleaching reversal.
Beyond Monitoring

- Reef managers have historically been unable to act on bleaching warnings (other than to monitor them).
- Previously no experiments have been attempted to observe \textit{in situ} response of bleached corals to temperature perturbations.
Purpose of small-scale experiments

• To determine \textit{in-situ} response of indigenous corals to ambient cooling of 1 C during peak summer months.
Site selection criteria

• In order to test methods of reversing coral bleaching in 2009 we needed an area that
  – Bleached annually
  – Was near to shore
  – Was near a power source

• Initial project was conducted from March - May 2009
Airport back-reef where bleaching reversal work was done
Coral bleaching

• Bleaching and temperature were monitored
• 2 species of *Acropora* were studied
• Reference and test sites were established
• Test sites were sequentially cooled for 24 hours approximately 1 degree C.
Test coral response to cooler water
“Cool Reef 1”

Local reef water was cooled by 1-2° C and directed onto bleached Acropora muricata and Acropora pulchra

Sept. 17, 2010
© 2010 The Climate Foundation +1-775-790-5000
http://www.ClimateFoundation.org
Diurnal temperature variations across control and test sites

![Graph showing temperature variations over time]

- **Control temp min**
- **Control temp max**
- **Hose temp min**
- **Hose temp max**

**Dates:** 21-24 April, 25-28 April, 29 April, 30 April, 1-2 May
Thermally-induced bleaching reversal

Before treatment

Time elapsed: 24 hours

After treatment
Bleaching reversal across multiple sites
Vision: Svalbard of the coral reefs

- Svalbard, stores genetic samples from around the world
- Aug 17, 2010:
  - “Mass Die-off at Coral Reef Triggered by 93-Degree Ocean”
  - scientists generally agree that bleaching and acidification are the two greatest future threats to coral reefs
- 50 kW of shaft power provides 100 MW of thermal cooling, enough to cool a 350-acre reef.
  - Based on upwelling and heat exchange
  - 50 KW can be provided through thermal-electric conversion
- High-value reefs could possibly be kept alive while the global economy tries to restore carbon balance.
- Such reefs provide genetic resources to re-seed reefs in the future.
Economics: how to scale thermal reef management systems

1. If coupled to salt water air conditioning systems, high-value reefs near resorts, population centers and military bases can be thermally managed. Req: >3 MW cooling load

2. Thermo-electric junctions can generate enough electricity to pump cold water to the surface. These can power pump impellers, enabling thermal management of reefs far from shore on a large scale.
Building an effective strategy

• 1. test for biological response using portable cooling system
• 2. design and procure regional scaled cooling system in preparation for a bleaching forecast.
• 3. Reef managers can deploy thermal management systems to ensure survival during major thermal bleaching events (6-12 weeks).
Strategy of shared cold-water air conditioning and scaled cooling system

- Cold salt water provides thermal sink for air conditioning system
- Use the remaining cooler water to cool coral reefs
- The remainder is sent offshore
- Pelagic fisheries restoration
  - Ocean productivity down 40% in the last 100 years
- Landscape Conservation Cooperatives—LCC’s—government, NGO and industry partnerships to conserve natural resources
2010: enabling coral bleaching reversal response measurement at remote sites

Solar cooling  shading  control coral
Challenges and opportunities

• Power sources—shore power, solar, thermal power.

• Collaboration and assistance from American Samoan government
  – Dept. Marine & Wildlife Resources (DMWR)
  – Airport operations
  – NOAA
  – FAA

• Waves, tides, currents and typhoons
  – rapid deployment and recovery conserves assets.
Future work

• Expand cooling experiments using solar-powered systems to enable testing far from AC power sources (works in doldrums).

• Prevent bleaching from starting by reef thermal management.

• Test *in situ* coral response to shading and reduced ocean acidity.

• Select sites for first efficient scaling of reef thermal management.
Acknowledgements

• PICCC (Pacific Island Climate Change Cooperative)
• FWS (US Fish and Wildlife Service)
• DMWR (Department of Marine & Wildlife Resources)
  – Government assistance, permitting
• FAA (Federal Aviation Administration)
• ASPA (American Samoa Power Authority)
• USGS – (US Geological Survey) Santa Cruz, CA
• Climate Foundation private contributors