Reversing coral bleaching on Pacific reefs

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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 *in situ* response of bleached corals to temperature perturbations.

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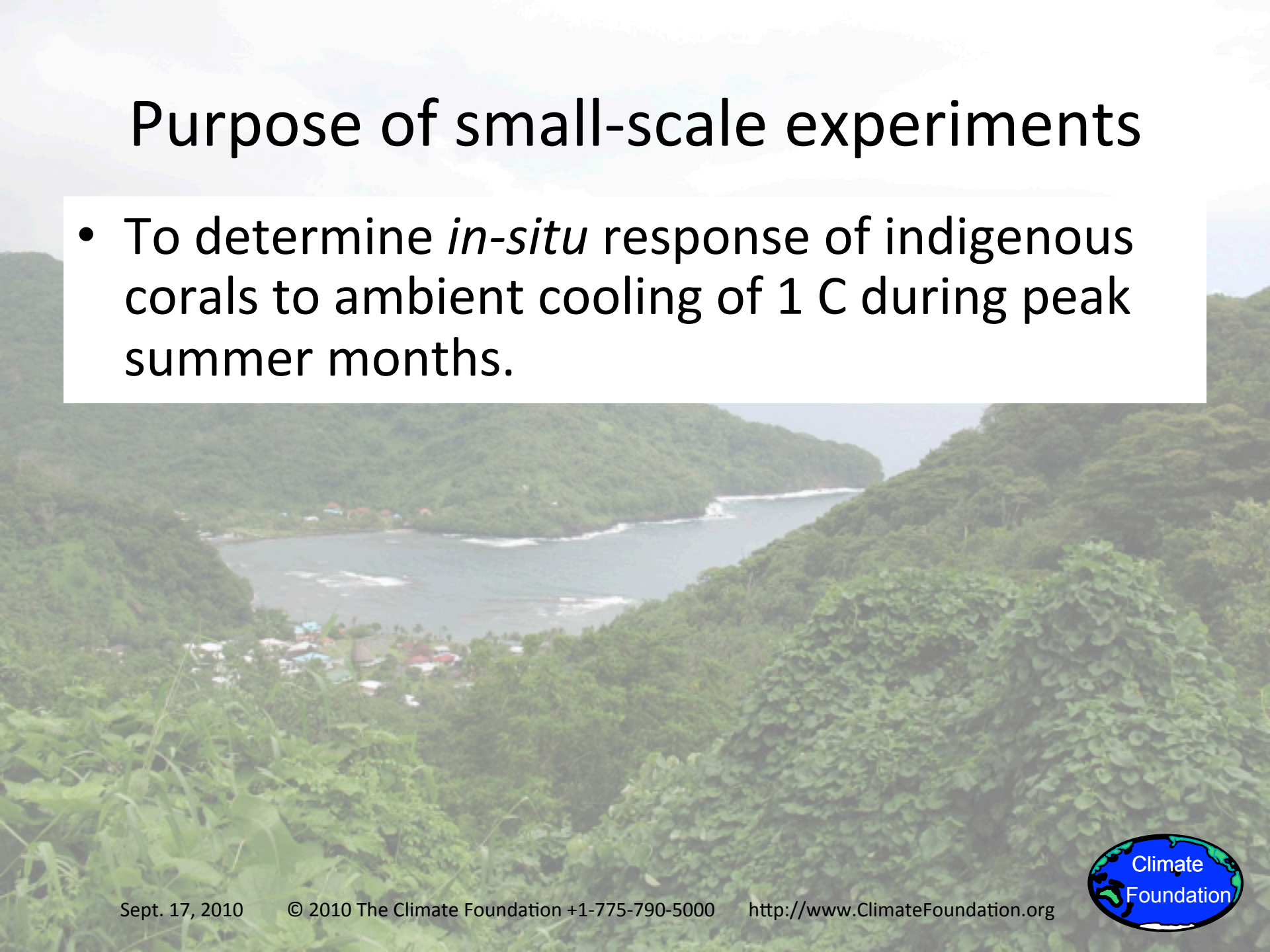
Purpose of small-scale experiments

- To determine *in-situ* response of indigenous corals to ambient cooling of 1 C during peak summer months.



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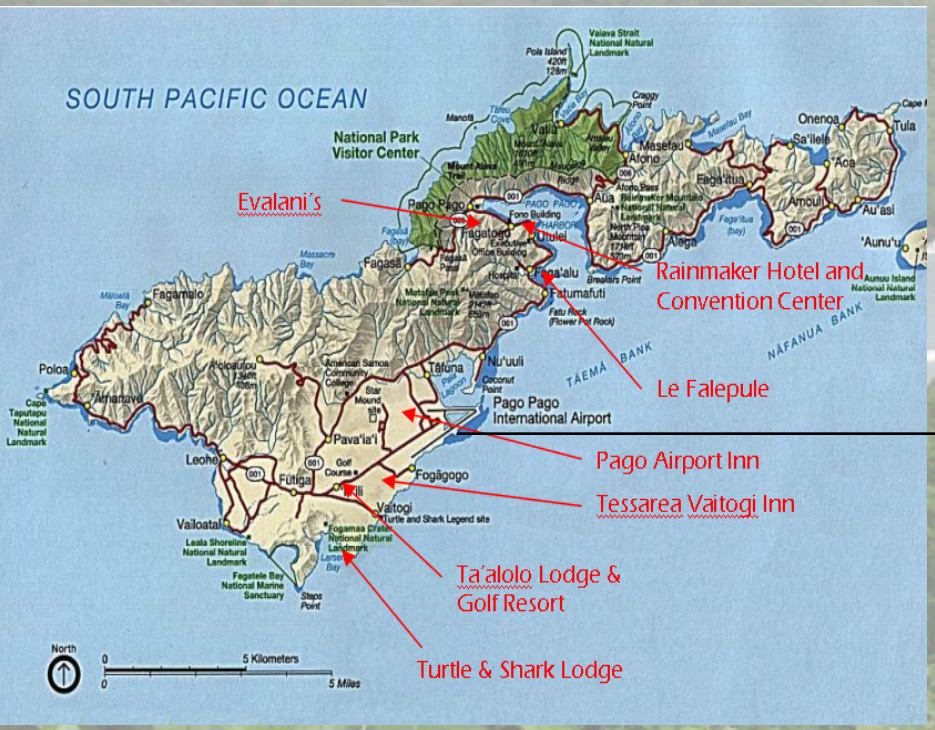
Site selection criteria

- 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

A



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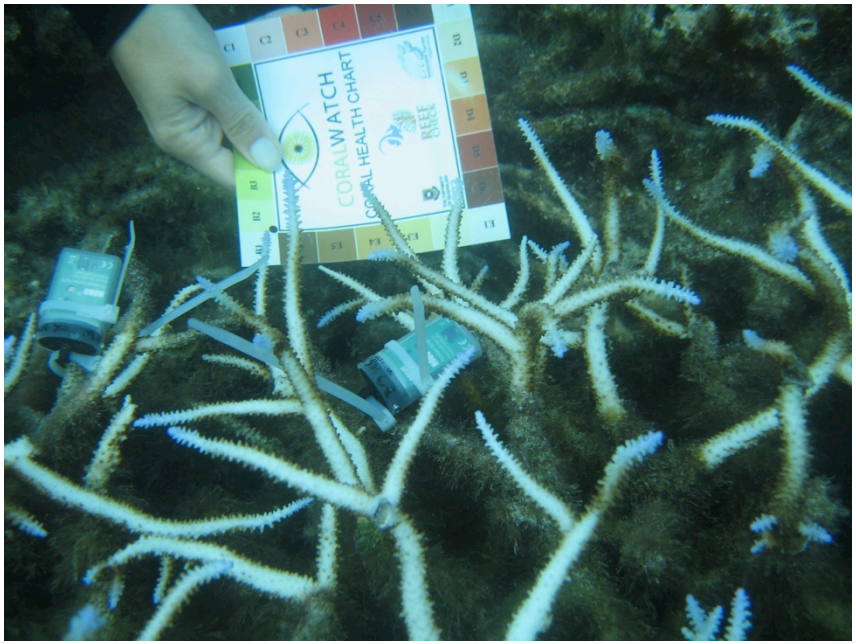
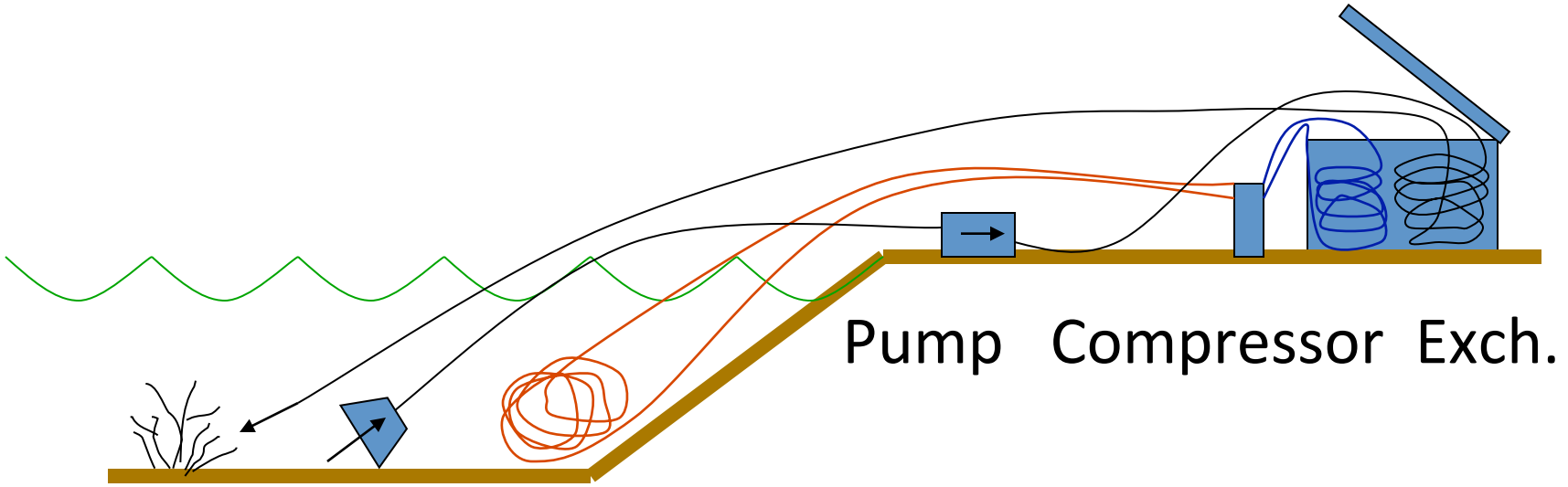
Coral bleaching

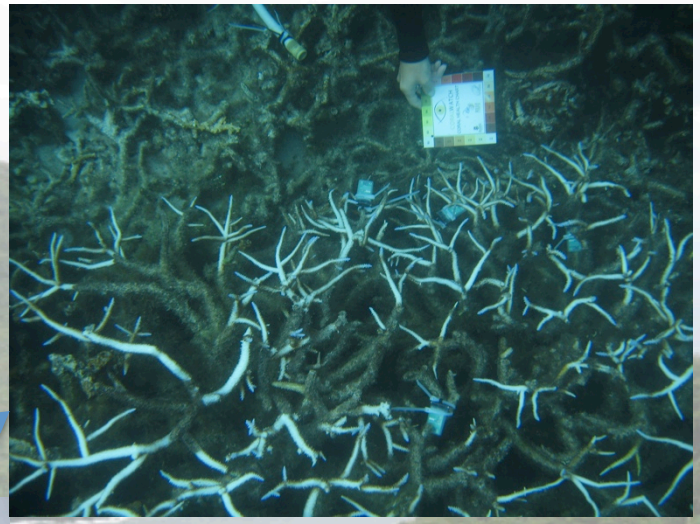


- Bleaching and temperature were monitored
- 2 species of *Acropora* were studied
- Reference and test sites were established
- Test sites were sequentially cooled for 24 hours approximately 1 degree C.

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*

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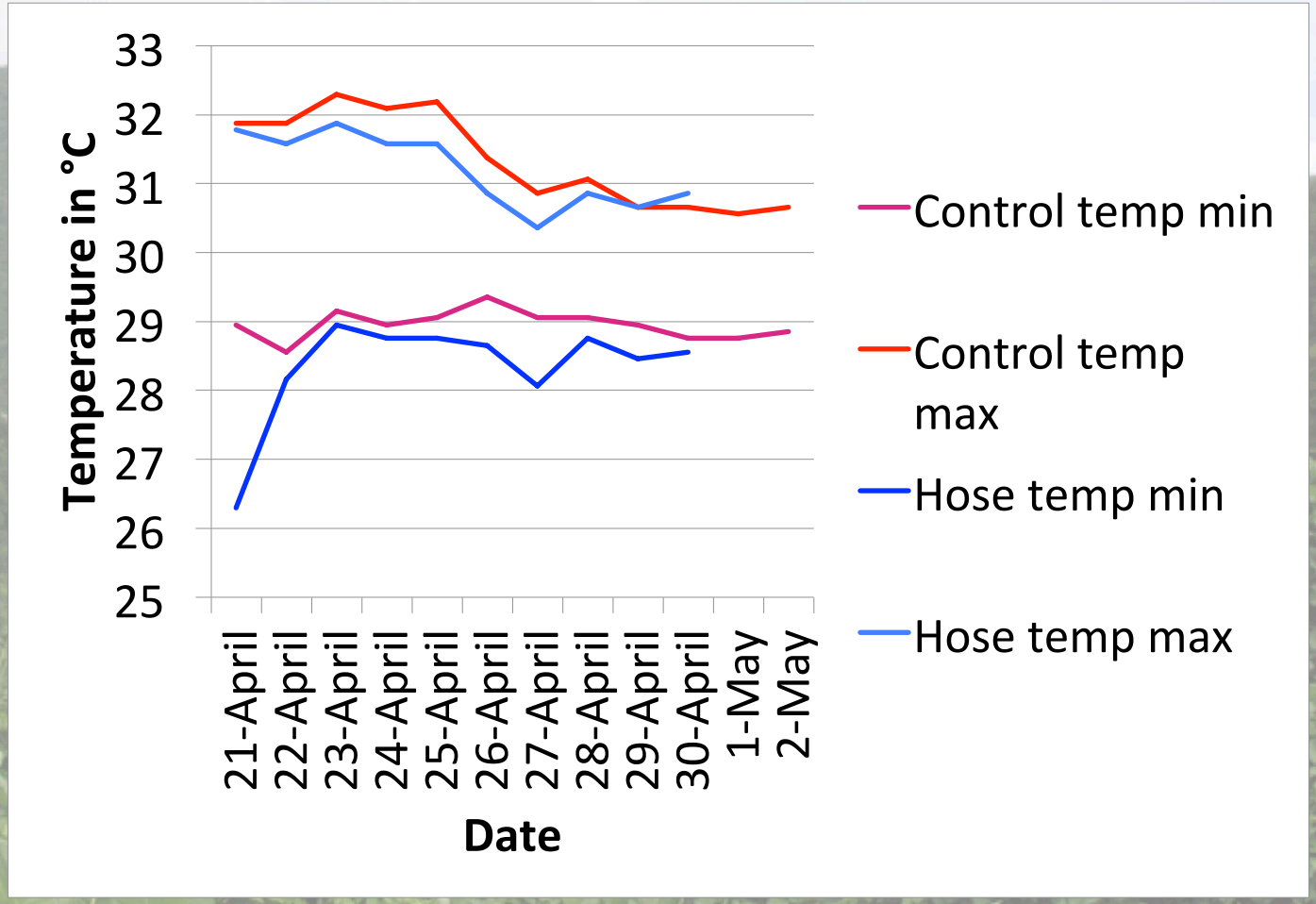
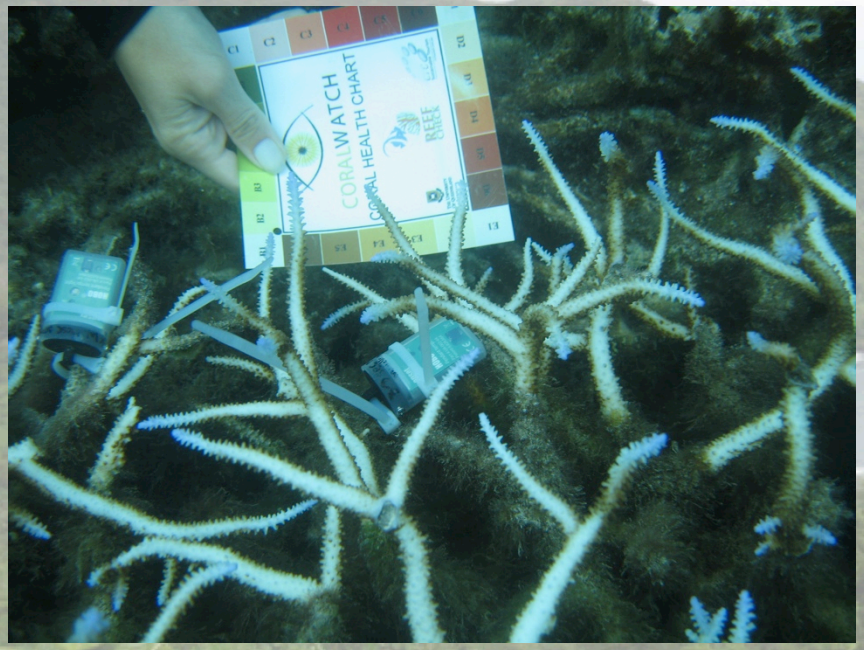
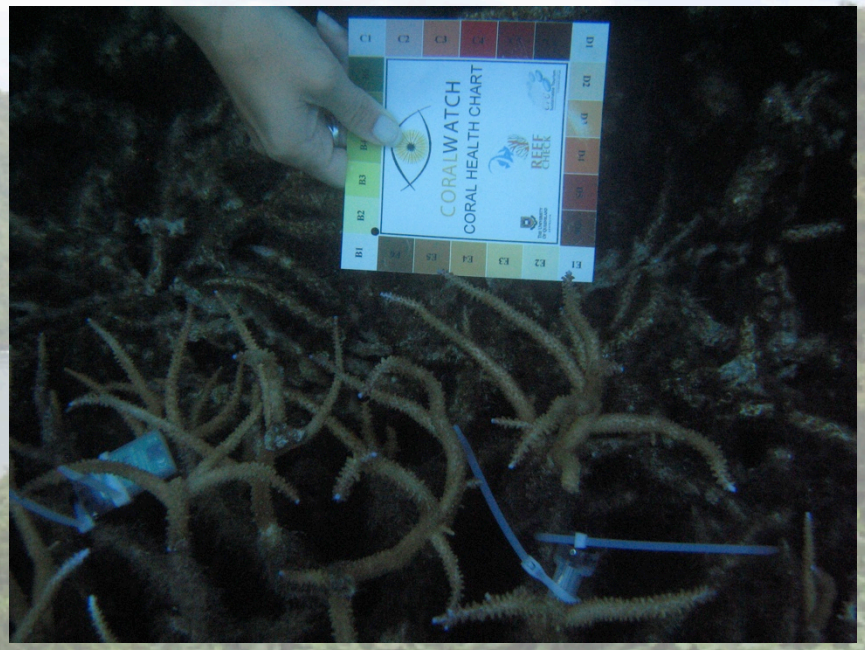
Diurnal temperature variations across control and test sites



Thermally-induced bleaching reversal





Before treatment After treatment

Time elapsed: 24 hours

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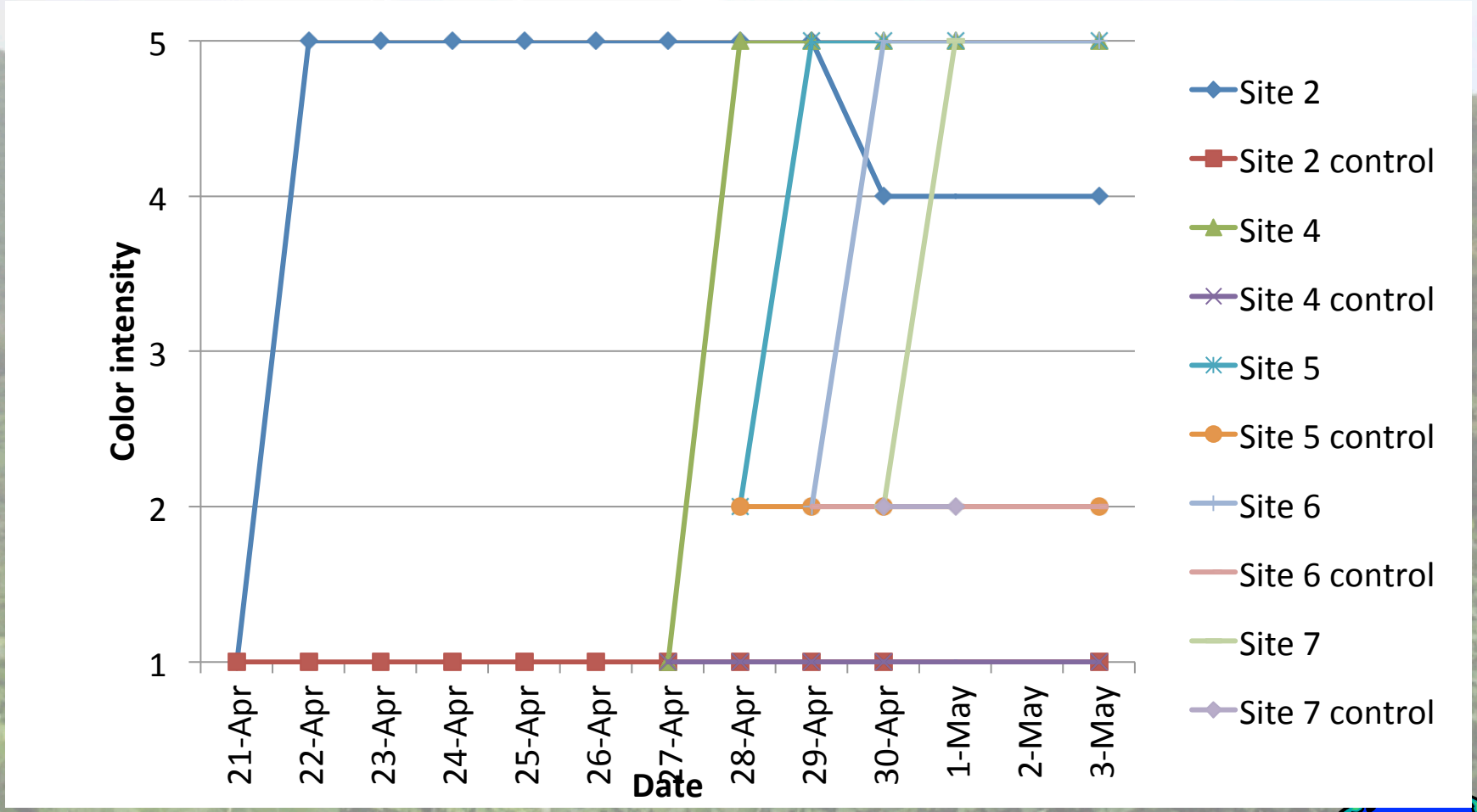
Bleaching reversal across multiple sites



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.

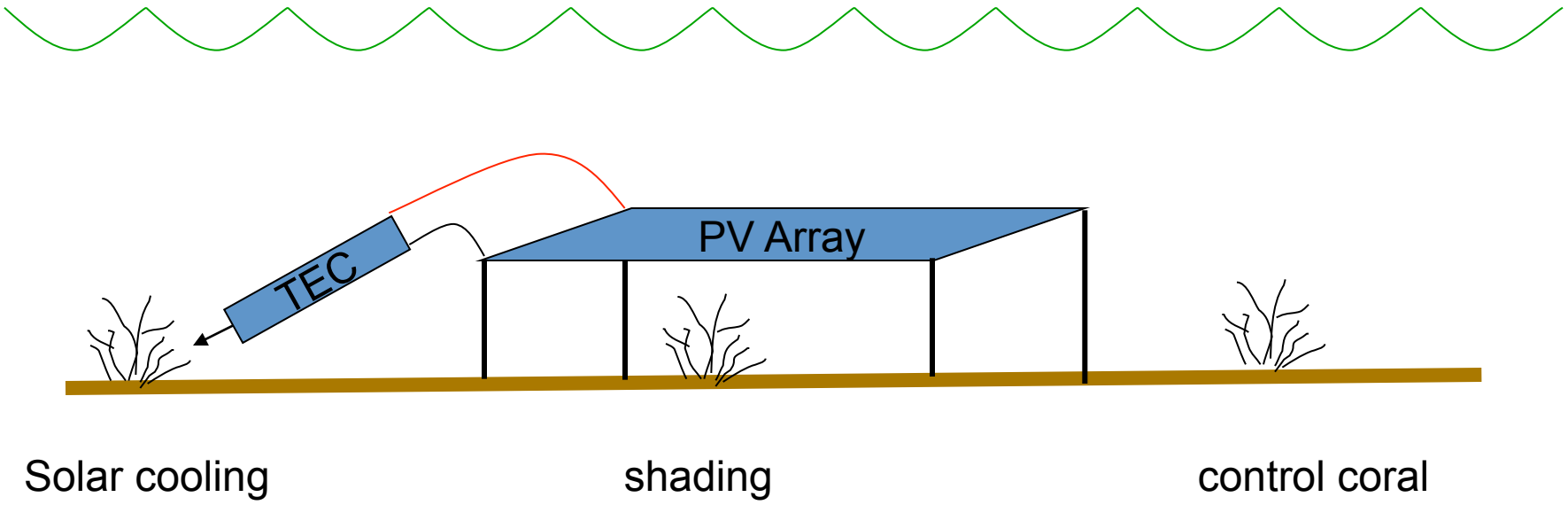
Building an effective strategy

- 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



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)
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