Reconstructing Past Climate Variability from Marshall Islands Corals

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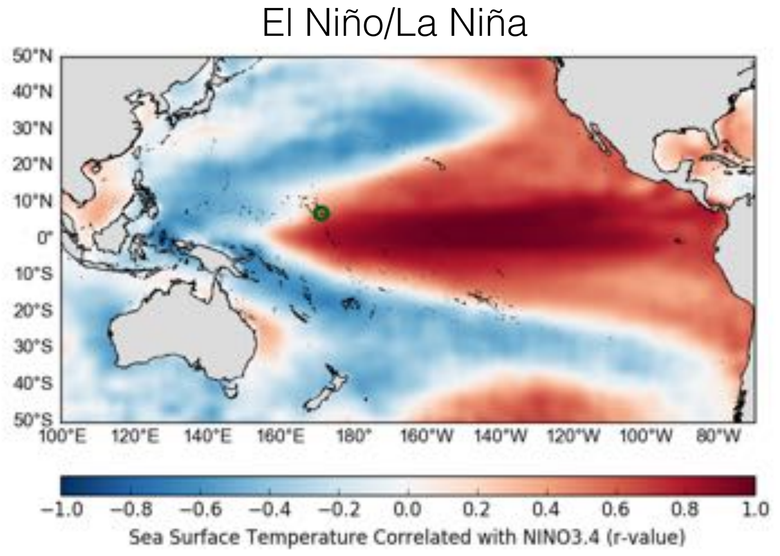
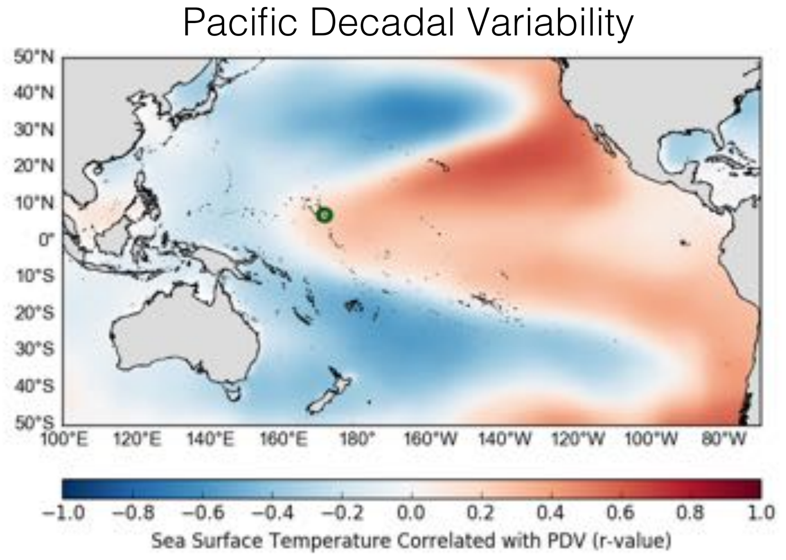
What is Pacific climate variability?

Changes in Pacific Ocean temperatures are linked to changes in winds, rainfall, and upwelling across the globe.

El Niño & La Niña: Patterns of warm/cold water that last ~3 months and occur every 2-7 years
Pacific Decadal Variability (PDV): A "slow El Niño"—a pattern of warm or cold water, superimposed on El Niño, that switches every 10-30 years



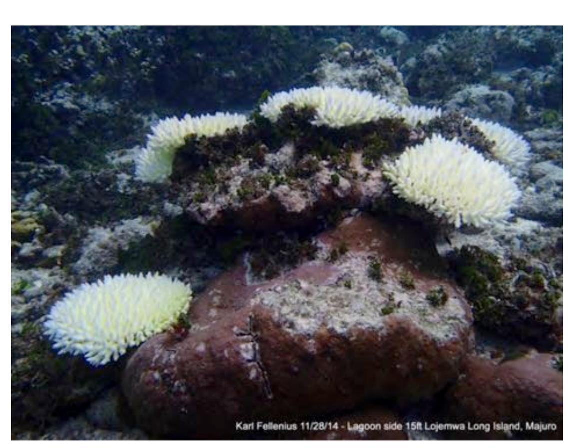


Above: Maps of relationships between ocean temperatures and El Niño/La Niña (left) and Pacific Decadal Variability (right). Field sites in the Marshall Islands are circled in green (OISSTv2, 1980-2016).

Why do we care?

Pacific climate variability influences:

- The rate of global climate change[1]
- Drought frequency/intensity[2]
  - *For example, the 2015-16 El Niño drought depleted freshwater provisions and led the Marshall Islands to declare a state of emergency*
- Ocean temperatures[2]
  - *Heat extremes can bleach or kill corals*
- The rate of regional sea level rise
  - *Marshall Islands are near sea level and flood frequently*



Upper left: The Marshall Islands are 2m (~6 ft) above sea level, and are vulnerable to flooding and rising seas. Left: Waves breach a breakwall in Majuro during during king tide. Right: Coral bleaching during the 2015-16 El Niño.

Key Questions

- How has Marshall Islands ocean temperature varied historically?
- How has Marshall Islands salinity (and rainfall) varied historically?
- How could climate variability influence future sea level rise?
- How does climate variability influence coral health?

Instrumental records are too short to answer these questions (~1950-present). Instead, we use corals, which contain chemical signatures that reflect past climate. By measuring coral geochemistry, we can reconstruct regional climate over the past 100+ years.

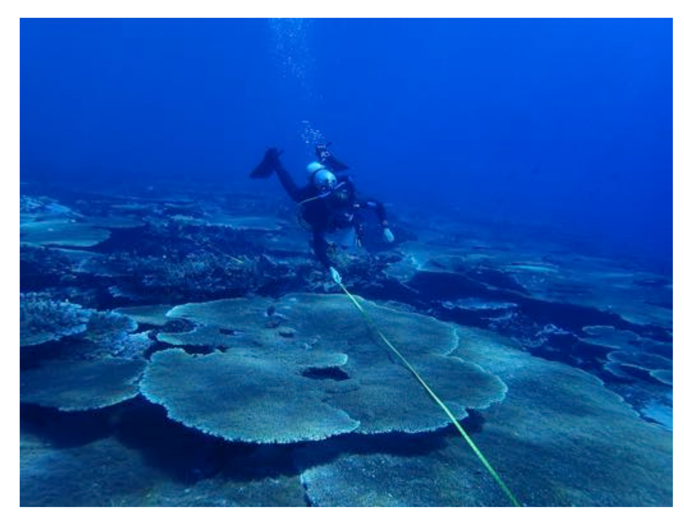
Field Work

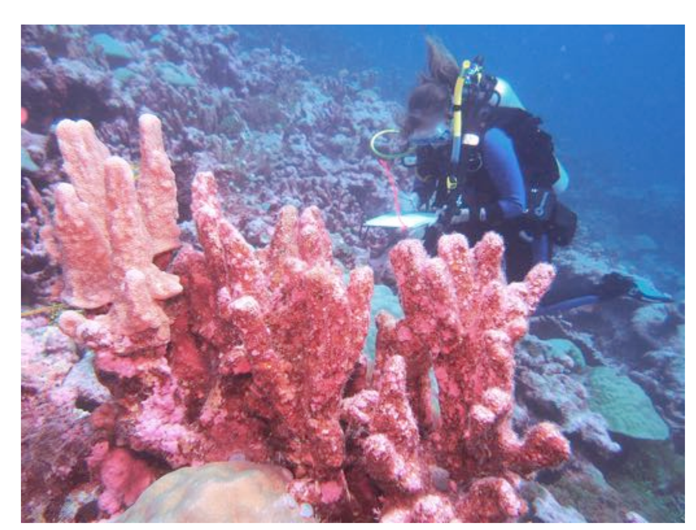
Summer 2016:

- Identified large living & fossil corals to core in 2017
- Performed surveys of coral health
- Installed loggers to monitor ocean temperature

Summer 2017:

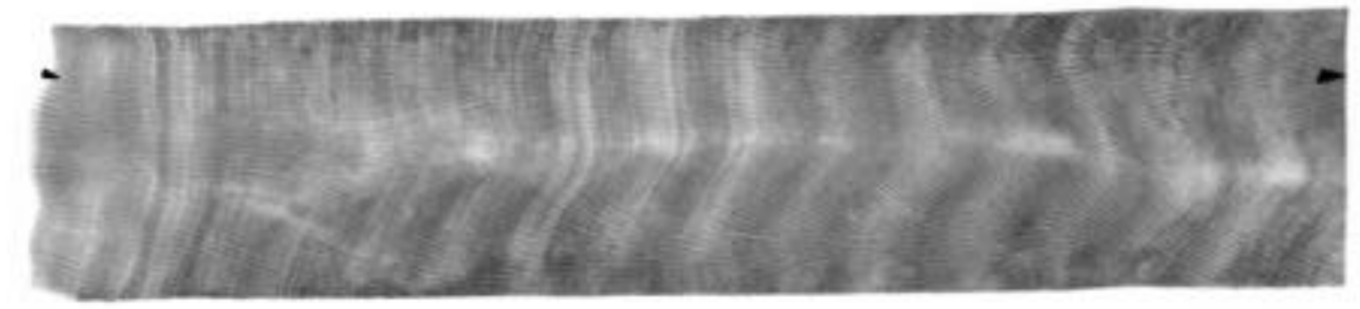
- Take cores from priority corals
- Recover temperature loggers





Top: Reef survey sites (blue markers) in Majuro and Arno Atolls (Google Earth). Above left: large *Porites* coral. Right: Performing coral health surveys along a transect line.

Coral Proxies



X-ray positive of an example *Porites* core from the northern Great Barrier Reef. Each pair of alternating dense (dark) and less dense (light) bands correspond to one year's growth.

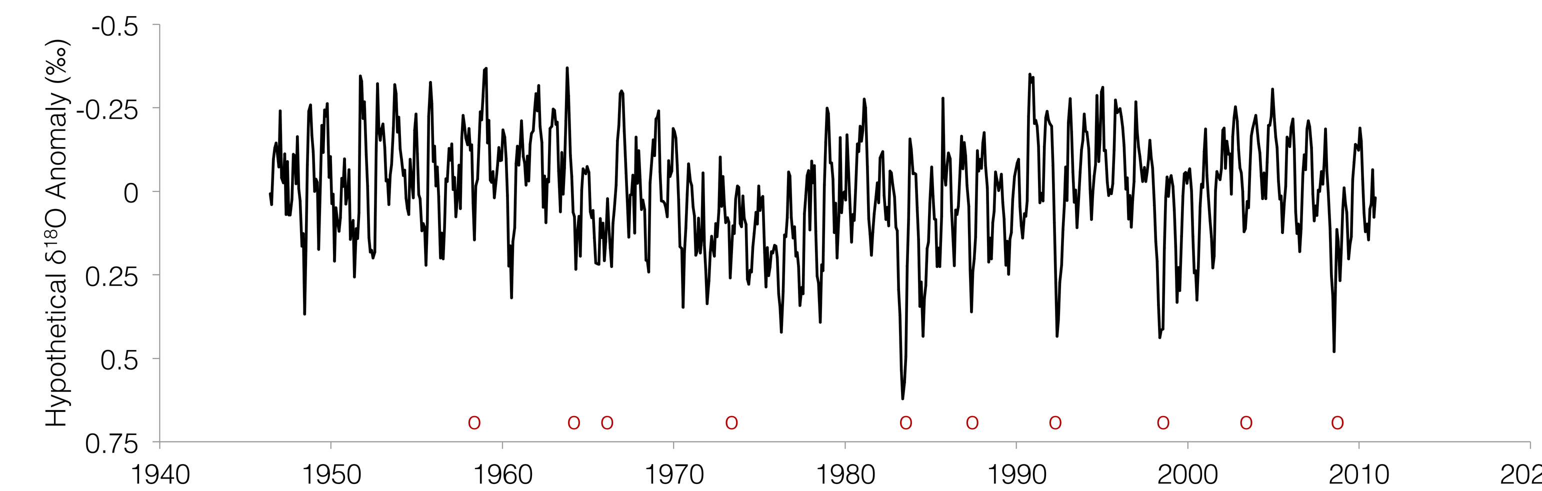
Geochemistry

Sr/Ca	Sea surface temperature (SST)[3]
$\delta^{18}O$	SST + Salinity[3]
$\delta^{18}O_{SW}$	Salinity
U/Th	Age (fossil corals)

Growth Banding

Density, Extension, Calcification
Coral growth rate[4]

How will we use these coral records?



Above: A hypothetical Marshall Islands $\delta^{18}O_{coral}$ record (modeled with SODA, HadISST). Low values (top of graph) denote warmer and/or fresher water. Red circles correspond to moderate/strong El Niño events.

- Track variation and/or trends in rainfall and temperature
- Identify relationships with Pacific climate variability
- Improve sea level rise predictions (associated with warming and Pacific climate variability)

The Bottom Line

- Coral geochemistry can record changes in climate over 100+ years
- We can reconstruct Pacific climate variability, which occurs too slowly to capture in short instrumental records
- We can use past climate to anticipate future trends.
- Stay tuned!

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References: [1] Newman, M., et al. 2016. *J. Clim.* 29:12:4399-427. [2] Pacific Climate Change Science Program. 2011. *Climate Change in the Pacific: Scientific Assessment and New Research.* [3] Beck, J.W., et al. 1992. *Science* 257:644-7. [4] Lough, J.M. 2008. *Mar. Ecol. Prog. Ser.* 373:257-64.