ENSO variability in Galapagos coral records:
New insights on variability and trends

Julia Cole
University of Michigan
Earth and Environmental Sciences

Sandy Tudhope, University of Edinburgh
Diane Thompson, Gloria Jimenez, Anson Cheung,
Jessie McCraw, Emma Reed, Larry Edwards
Lael Vetter, Stephan Hlohowskyj
ENSO signal in Galápagos corals

Mean SST (°C)

23  24  25  26°C
ENSO signal in Galápagos corals – Isla Darwin

- Skeletal geochemistry tracks SST:
  - $\delta^{18}O$: tracks SST and salinity, but in Galápagos it is mainly SST

- Sr/Ca: tracks SST, and several modern corals agree on calibration
Northern Galápagos warming – Isla Wolf

Jimenez et al. 2018
Northern Galápagos warming

- Red lines: Sizer trend analysis says significant warming in corals
- Sharp demarcation between Wolf and Puerto Ayora / Puerto Chicama
- Warming in northern Galápagos may endanger the last remaining coral reefs in Galápagos

Observed SST trend 1982-2014

Jimenez et al. 2018
Isla Darwin (2)  
Isla Wolf (3)  
Bahia Urbina (3)  
Punta Pitt (1)  

9 SST reconstructions,  
3 older published (1990s)  
6 new from our group
Changes in Galápagos SST since 1550

- Corals reflect known geographic offsets
- Post 1950 SST is warmer

Published records:
- D94 = Dunbar et al. 1994
- S92 = Shen et al. 1992
- S99 = Schrag 1999
- J18 = Jimenez et al. 2018
Changes in Galápagos SST and variance since 1550

• Corals reflect known geographic offsets
• Post 1950 SST is warmer

• Variance is highest in 20th century
• Early 20th century as high as later
• Suggestion of high-variance periods ~1600 and ~1760s

Published records:
D94 = Dunbar et al. 1994
S92 = Shen et al. 1992
S99 = Schrag 1999
J18 = Jimenez et al. 2018
More to come

• Substantial fossil material dating 200-4500 yrs old
• Temperature loggers on Darwin and Wolf –2015-6 event

Age distribution of fossil coral samples, Jan 2015
What explains the strong decadal variability in the Darwin record?
Is decadal variability at Galapagos reflecting the PDO/IPO?

Inverse relation between E and W Pacific

Expectation:

- Warm conditions in Galapagos = cool/dry at Bramble Cay
- Cool conditions at Galapagos = warm/wet at Bramble Cay
When Bramble Cay is dry, Galápagos is cool.

When BC is wet, Galápagos is warm.

This is opposite expectations!

What causes this?

Compare with W Pacific record on decadal time scales: Bramble Cay.
When Bramble Cay is dry, Galápagos is cool.

When BC is wet, Galápagos is warm.

This is opposite expectations!

What causes this?

Compare with W Pacific record on decadal time scales: Bramble Cay

$r = 0.60, \quad 95\% \text{ sig.}$
Central Pacific ENSO an important contributor to Pacific decadal variability

When CP warms, EP cools

Central vs Eastern Pacific El Nino

EP El Nino
Extensive warmth

CP El Nino
Warm in CP
Cool/neutral in EP

Dewitte et al. 2012
Central vs Eastern Pacific El Nino

EP El Nino
Extensive warmth
Mostly interannual

CP El Nino
Warm in CP
Cool/neutral in EP
Mostly decadal

Dewitte et al. 2012
Sullivan et al. 2017
In Galapagos, CP events have opposite impact on decadal vs interannual scales: 1994-5 example

1994-5 event: Observed SST anomaly

Sullivan et al. 2017
In Galapagos, CP events have opposite impact on decadal vs interannual scales: 1994-5 example

1994-5 event: Interannual component of SST anomaly ➔ WARMING

Sullivan et al. 2017
In Galapagos, CP events have opposite impact on decadal vs interannual scales: 1994-5 example

1994-5 event:

Decadal component of SST anomaly

⇒ COOLING

Sullivan et al. 2017
By separating components, we can learn more about decadal variability.
Paleo records from the ocean are critical to understanding decadal Pacific variability

- Instrumental data are insufficient
- A network of coral sites can fill gaps and extend record
Takeaways/what’s next?

• Galapagos corals preserve information about past SST and ENSO

• New fossil and modern material highlights large variability in late 20C – but also earlier.

• Decadal variability in Galapagos reflects CP ENSO events

• New samples, new data on the way