The Future of Coral Reefs: Does It Depend On Help From Fish?

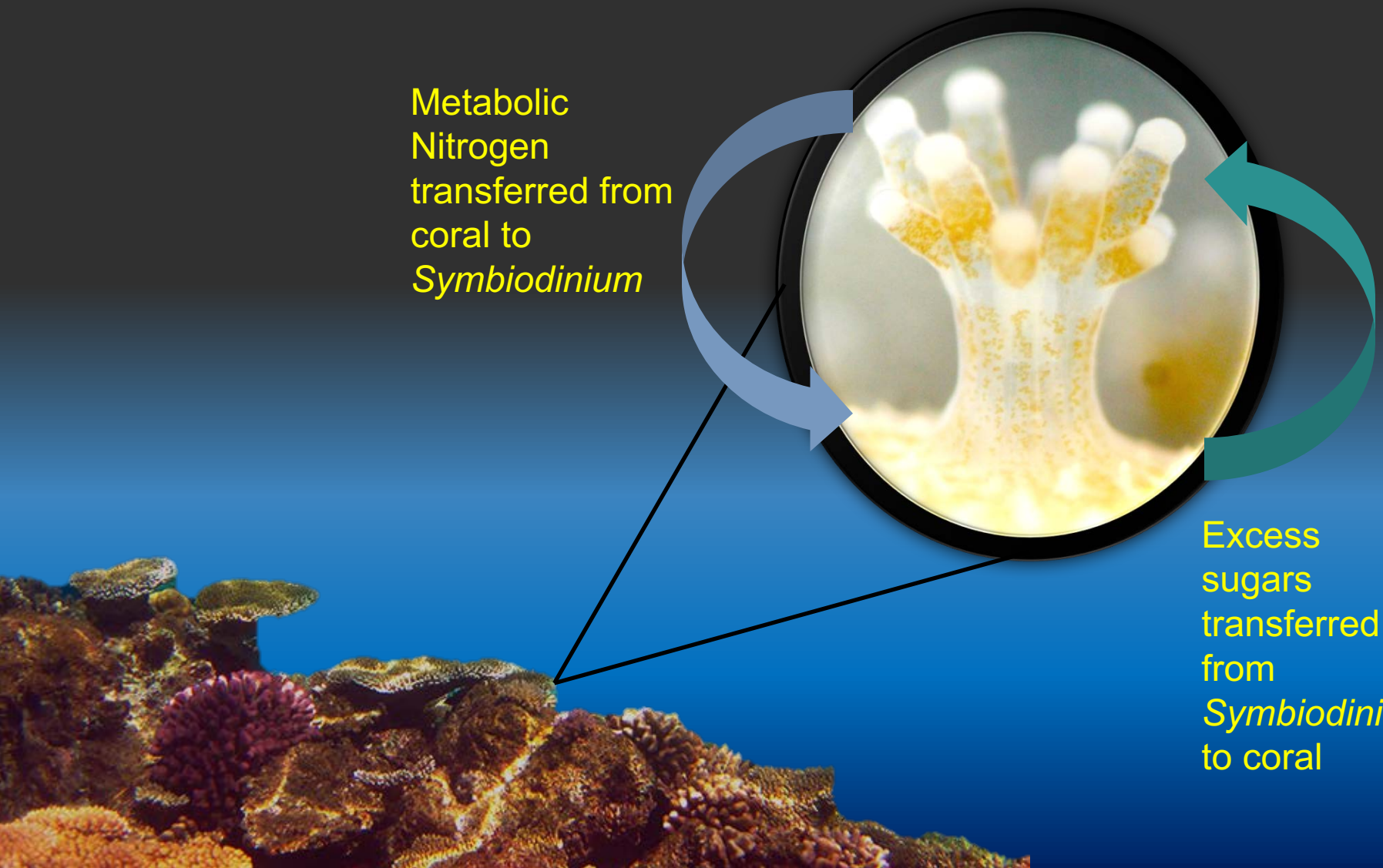
Deron E. Burkepile

University of California, Santa Barbara

Moorea Coral Reef LTER

Coral-*Symbiodinium* Mutualisms
The Engine of Coral Reefs

Metabolic Nitrogen transferred from coral to *Symbiodinium*

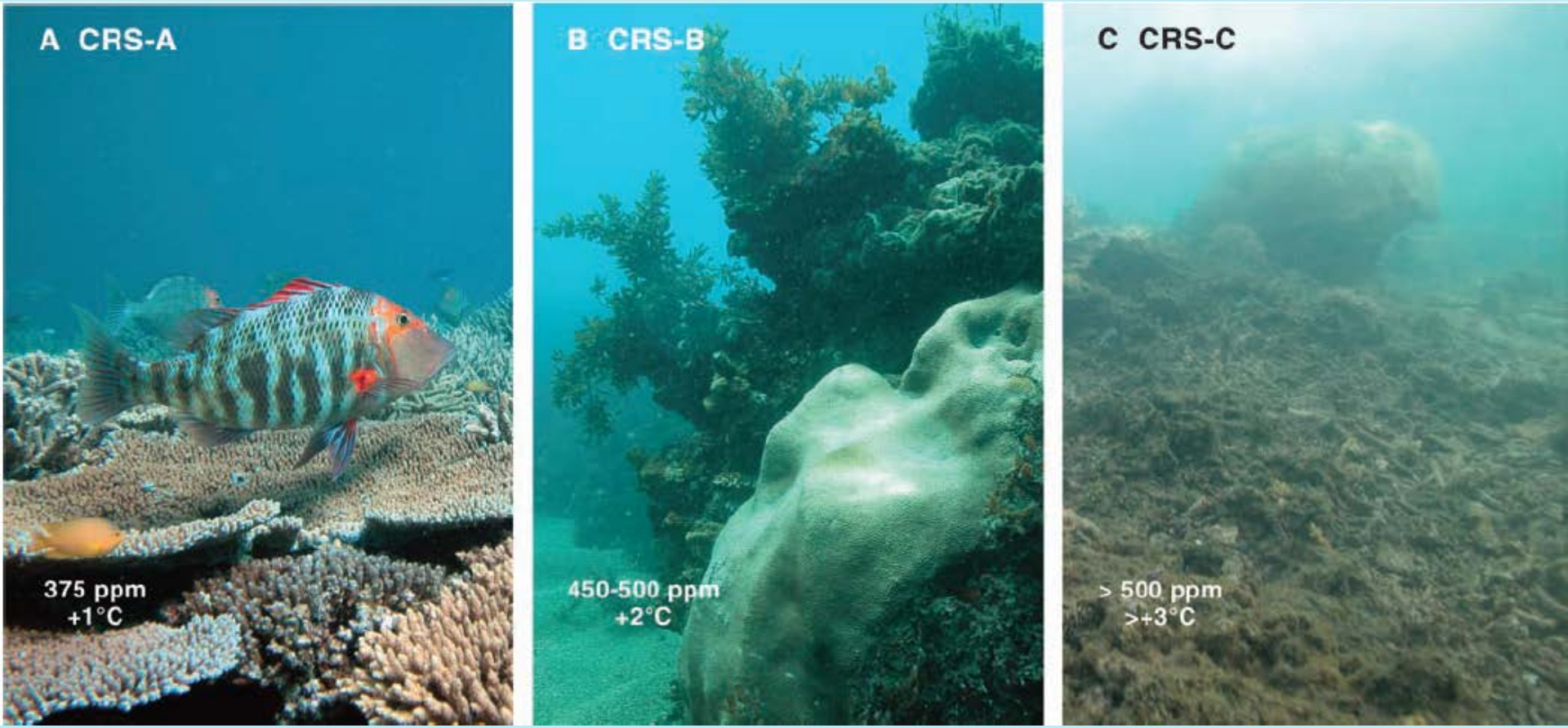


Excess sugars transferred from *Symbiodinium* to coral

Coral Reefs in Peril

- Massive SST anomalies & coral bleaching
- GBR lost ~35% of corals – 2015-2017

Is This Really the Future of Coral Reefs?



Hoegh-Guldberg *et al.* 2007

Why Good Fishes Make Good Reefs

1. Fishes are important herbivores – remove algae and facilitate corals – important for resilience after disturbance

2. Fishes are important sources of nutrients – help corals grow, withstand temperature stress

3. ALL IS NOT LOST! – Local management can help corals survive the Anthropocene

View of Earth centered on Moorea

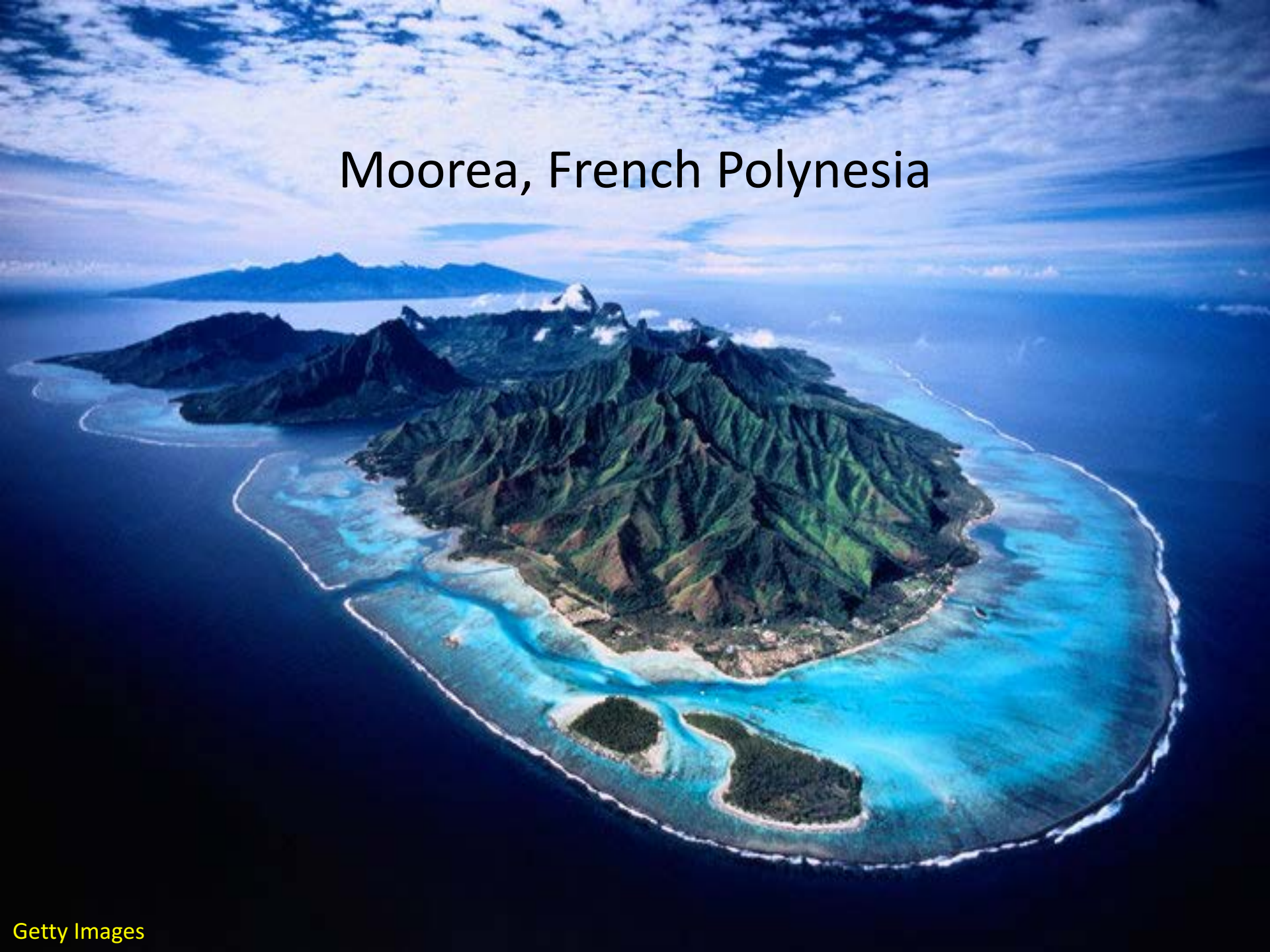
Moorea

French Polynesia
EEZ 5,030,000 km^2

US Dept of State Geographer
© 2016 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google

Imagery Date: 12/13/2015 17°35'11.55" S 149°50'10.72" W eye alt


Moorea, French Polynesia
Getty Images

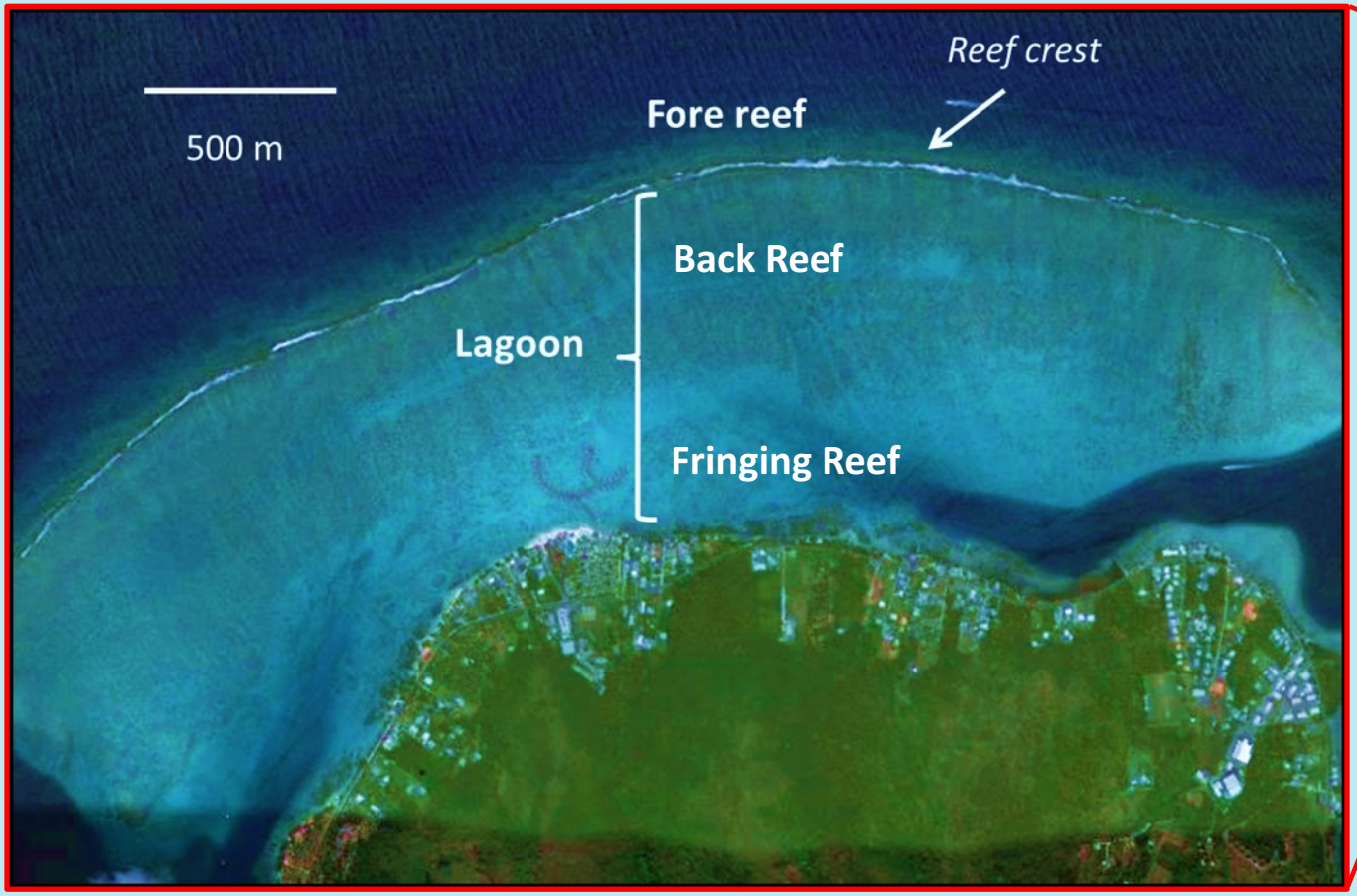
MOOREA CORAL REEF LTER

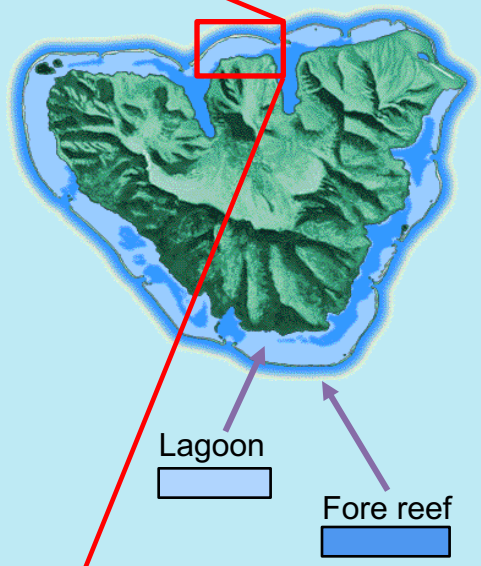
Member of the NSF Long Term Ecological Research Network

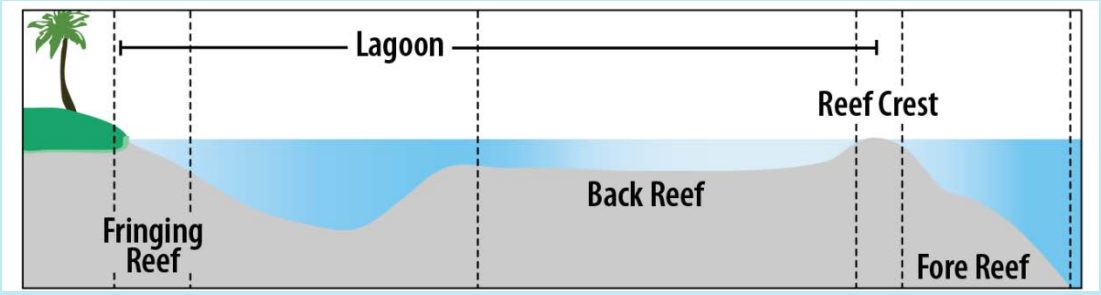
Est. 2004

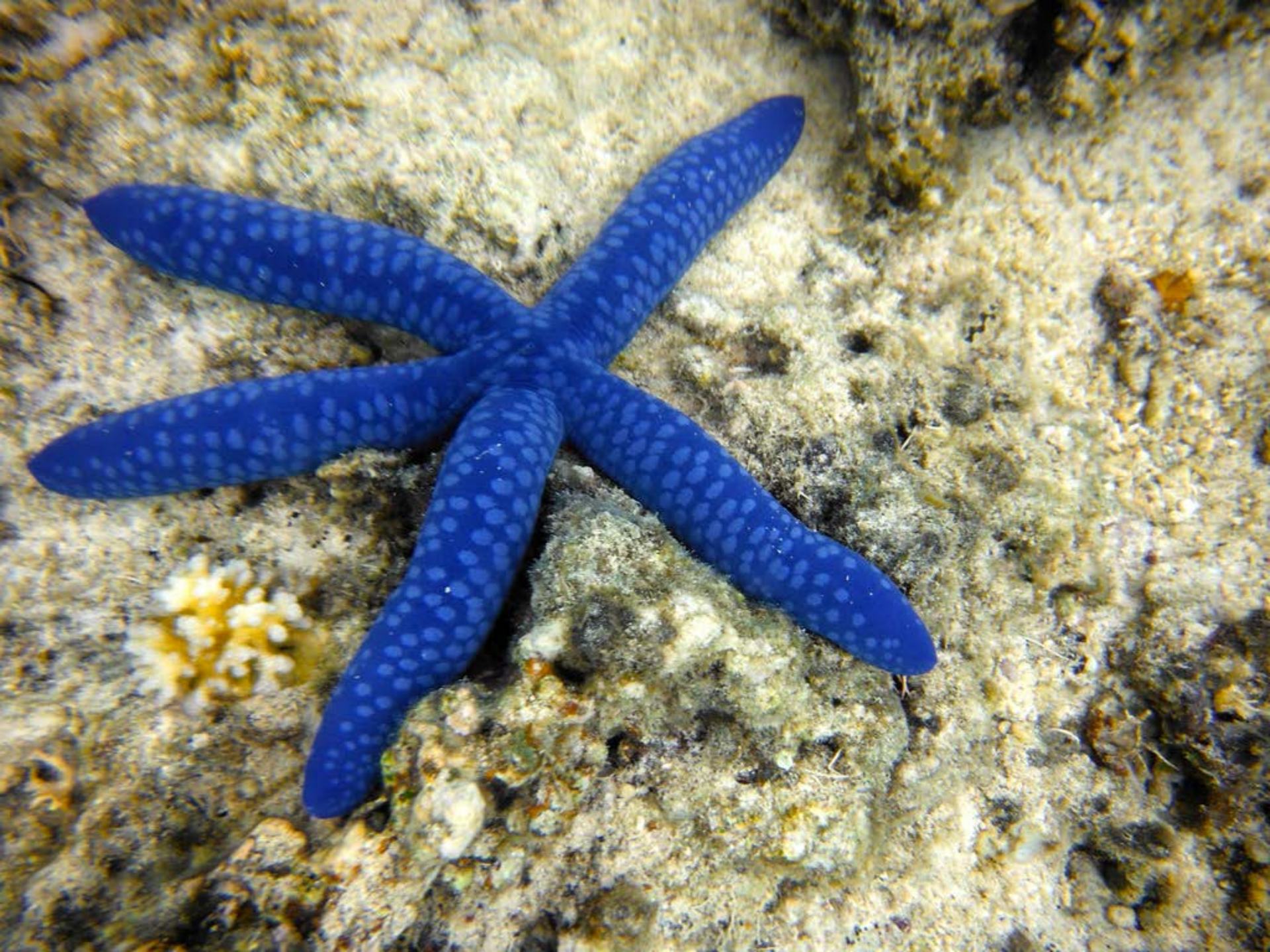
- Principal Investigators from UC Santa Barbara (R. Schmitt, S. Holbrook) & CSUN (R. Carpenter, P. Edmunds)
- 19 Associate Investigators + post-docs, grad students & undergrads from 9 academic institutions
- Field operations based out of UC Berkeley Gump Research Station

Coral Reefs of Moorea

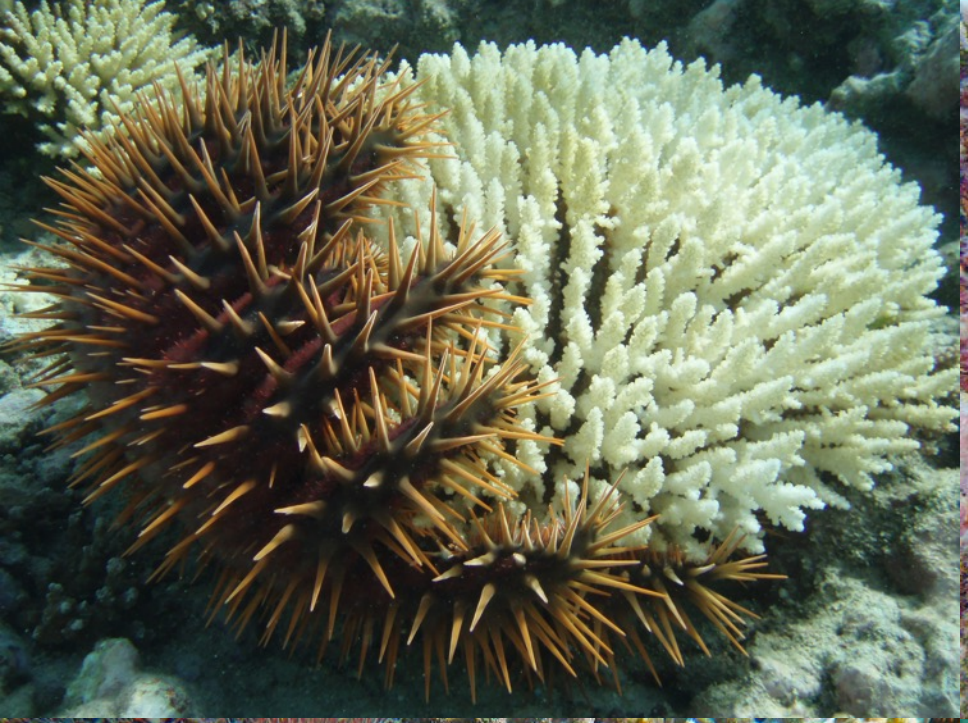
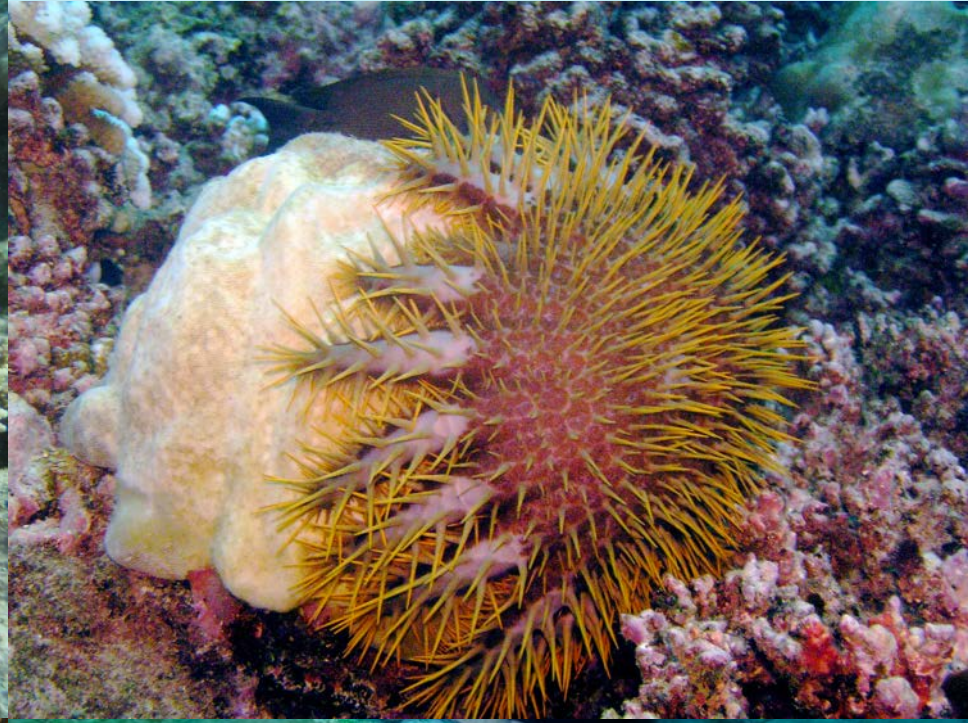
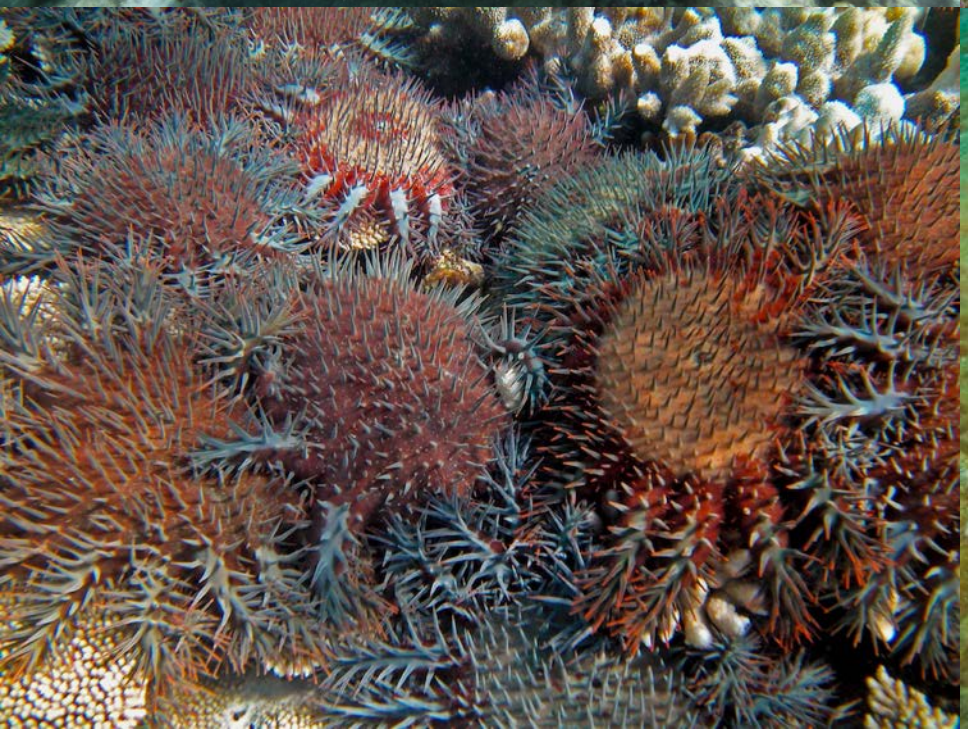




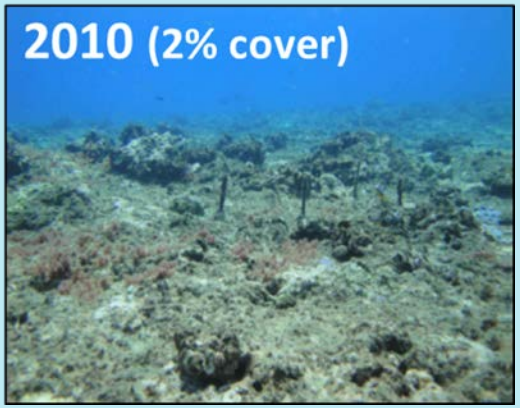


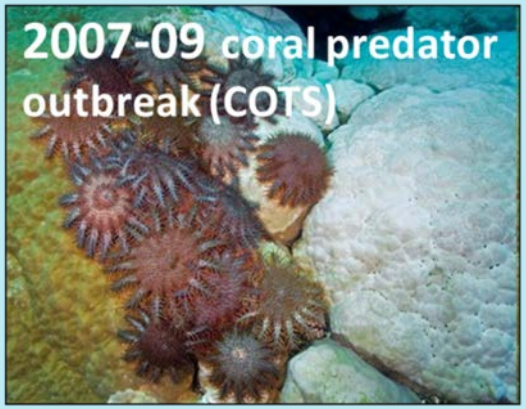


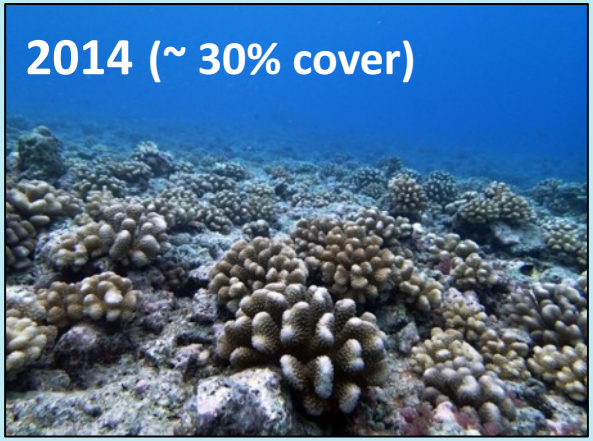

Crown-of-Thorns
Seastar (C.O.T.S.)


Resilience of Corals in Moorea







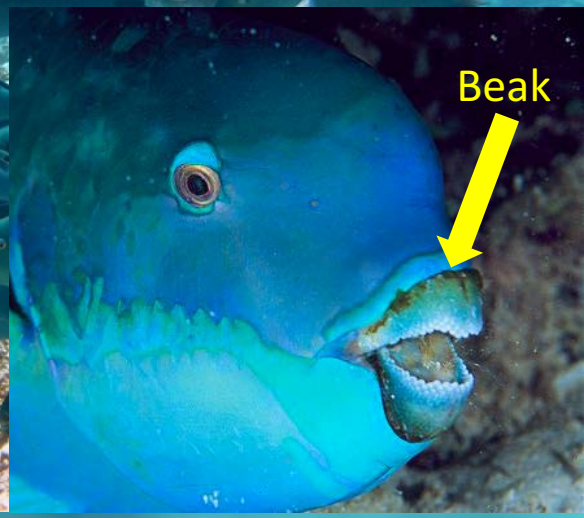
Herbivores Run the Reef!

Parrotfishes

Surgeonfishes

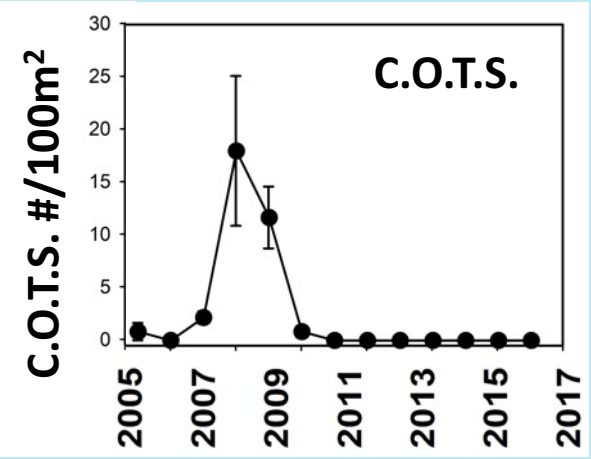
Herbivores Run the Reef!

Parrotfishes

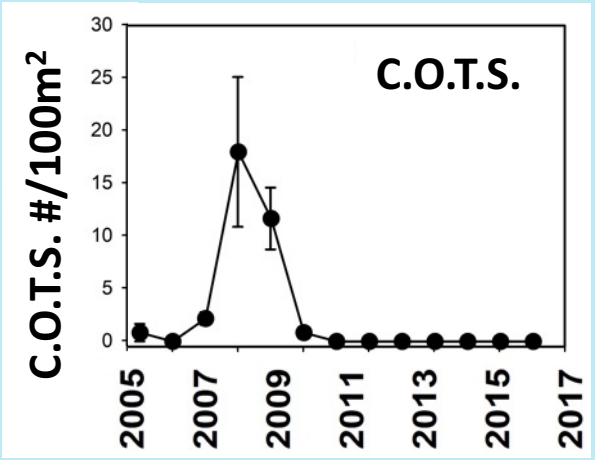


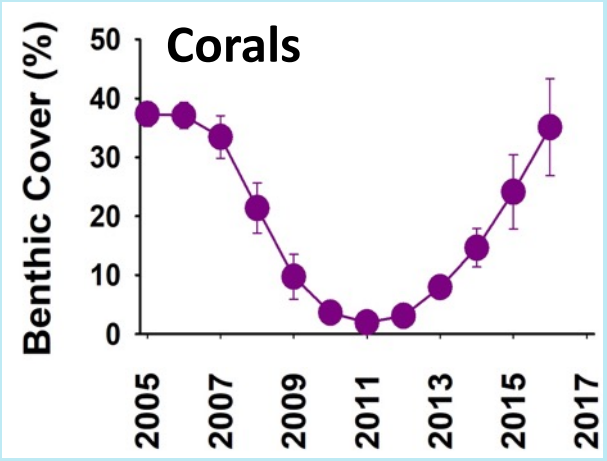
Surgeonfishes

Herbivorous Fishes Drive Resilience of Corals

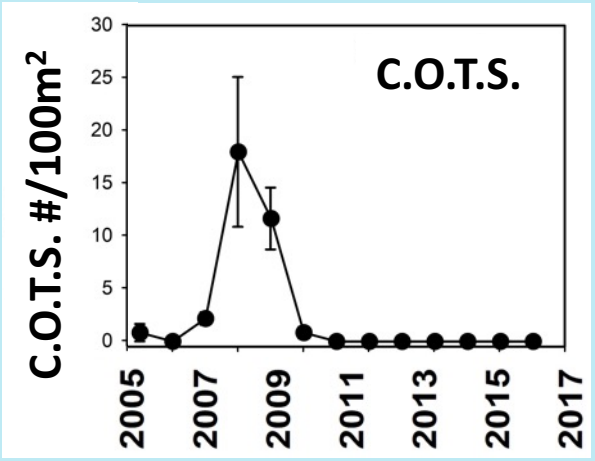


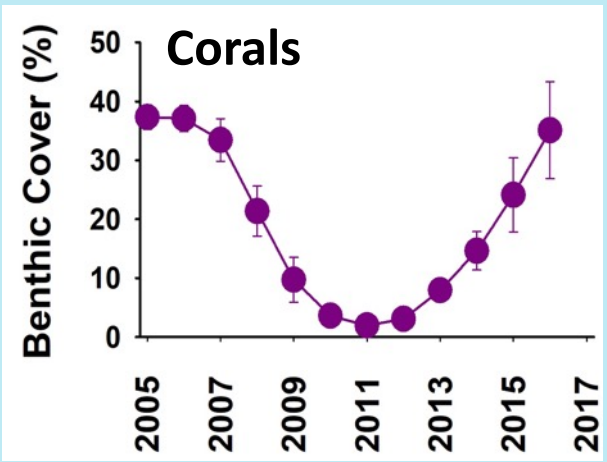
Herbivorous Fishes Drive Resilience of Corals

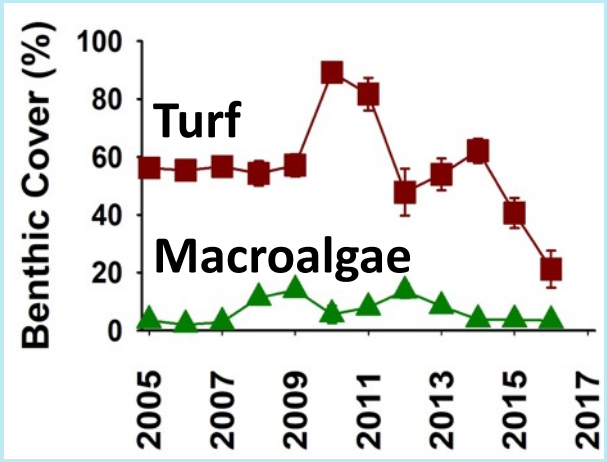


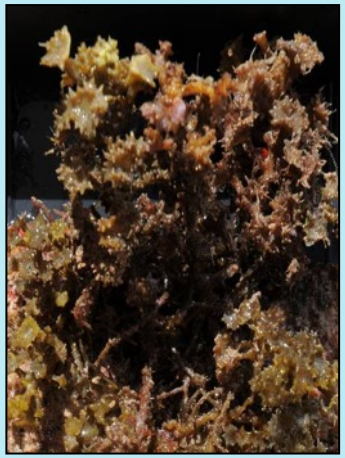


Herbivorous Fishes Drive Resilience of Corals

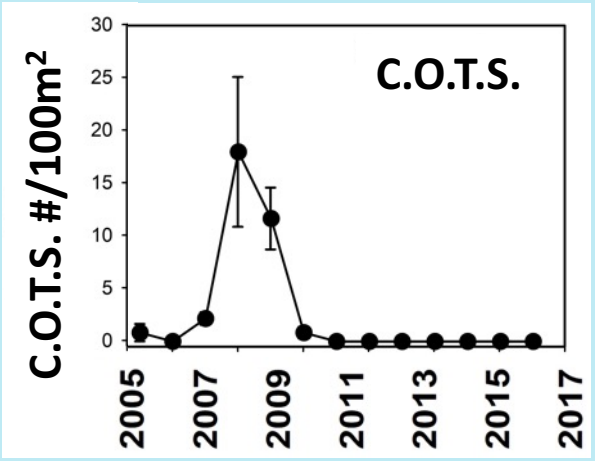


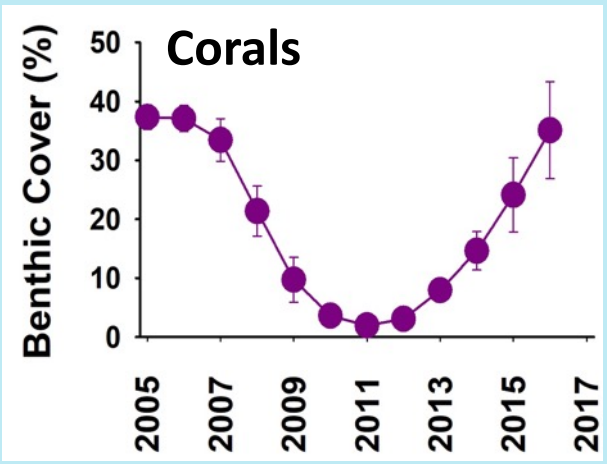


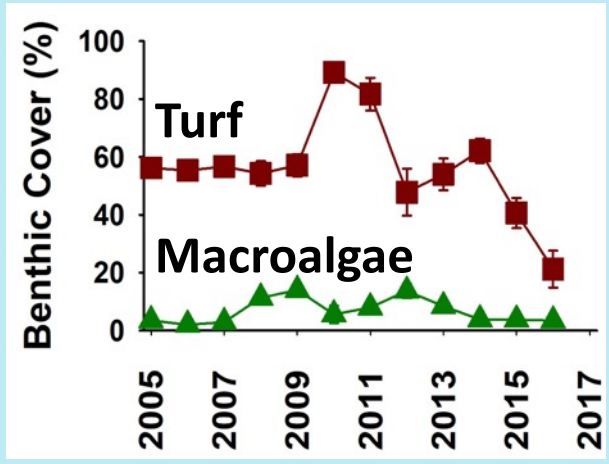


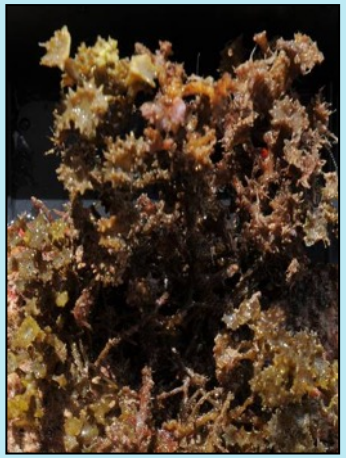


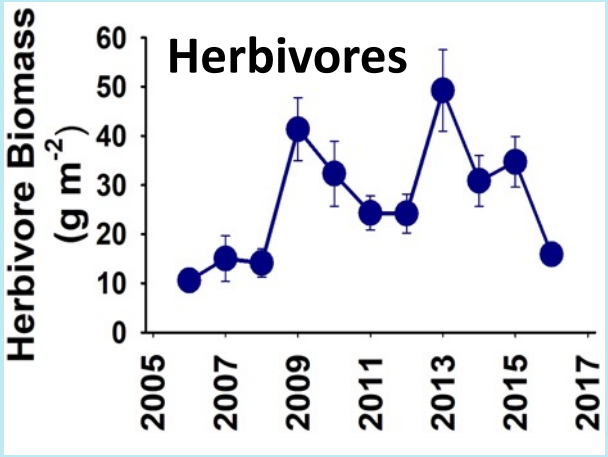
Herbivorous Fishes Drive Resilience of Corals



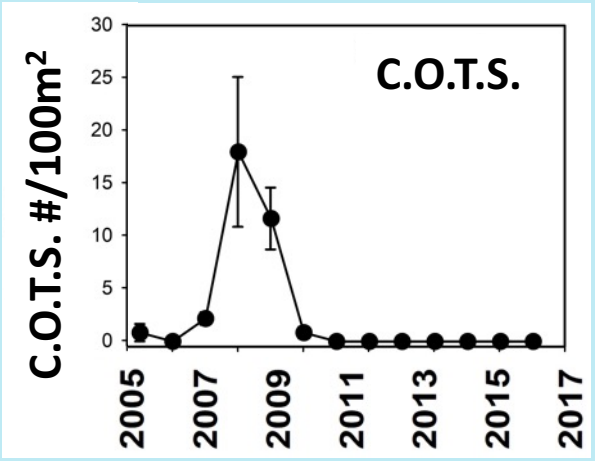


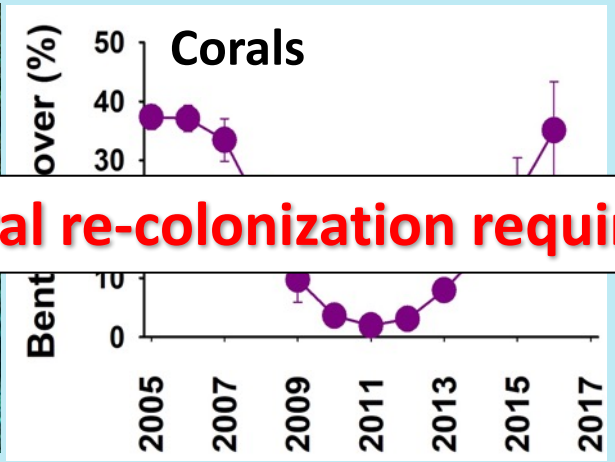


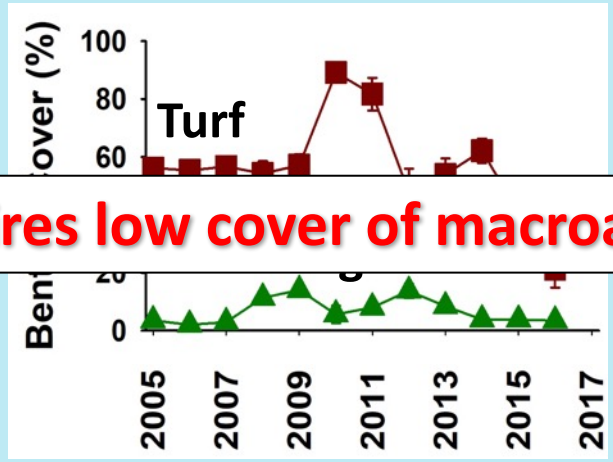


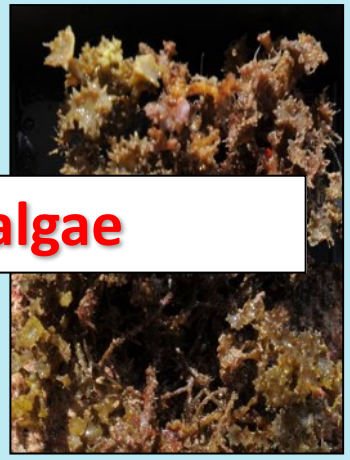


Herbivorous Fishes Drive Resilience of Corals

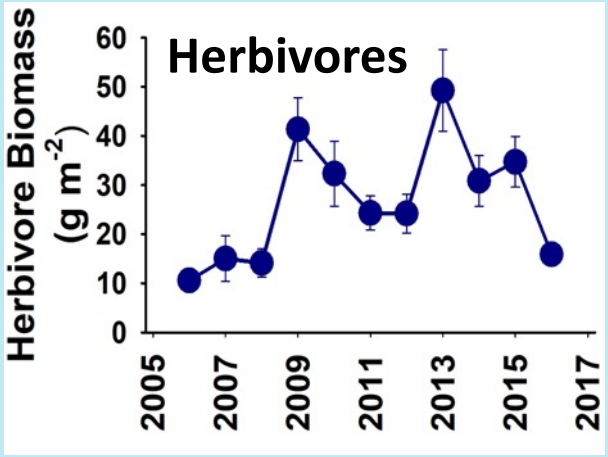




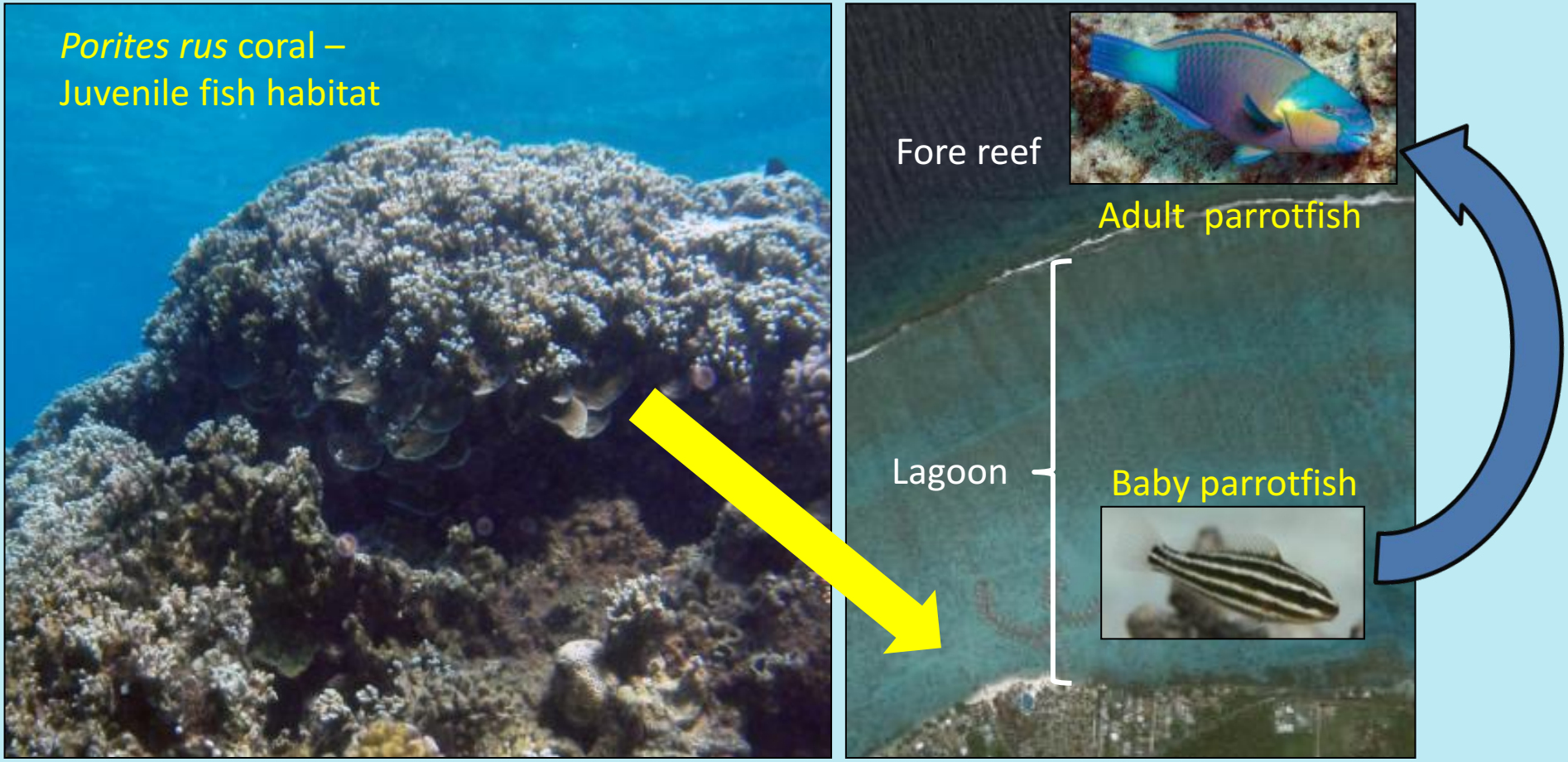




Coral re-colonization requires low cover of macroalgae

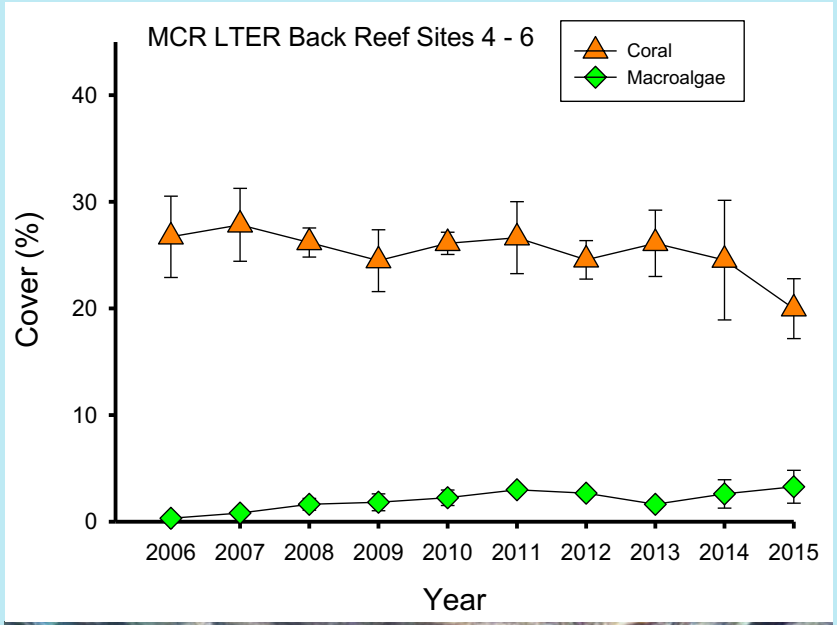


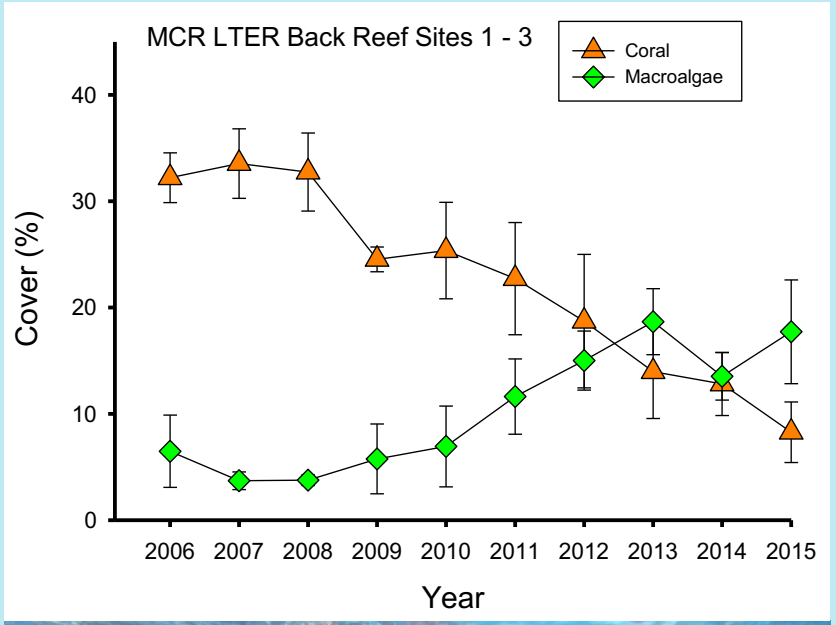
Habitat connectivity critical to resilience



Are Lagoon Dynamics Different?

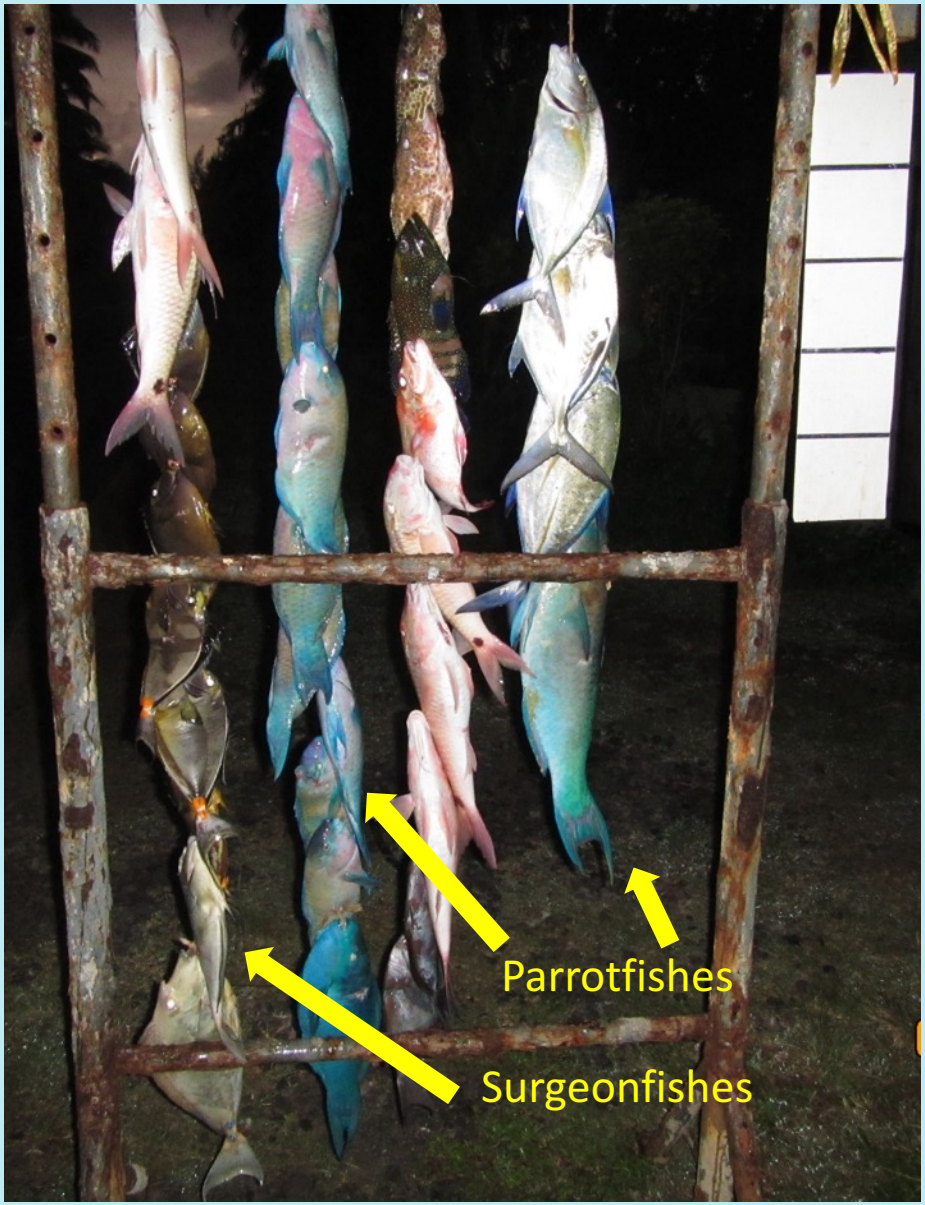
Spatial Heterogeneity in Lagoon Dynamics

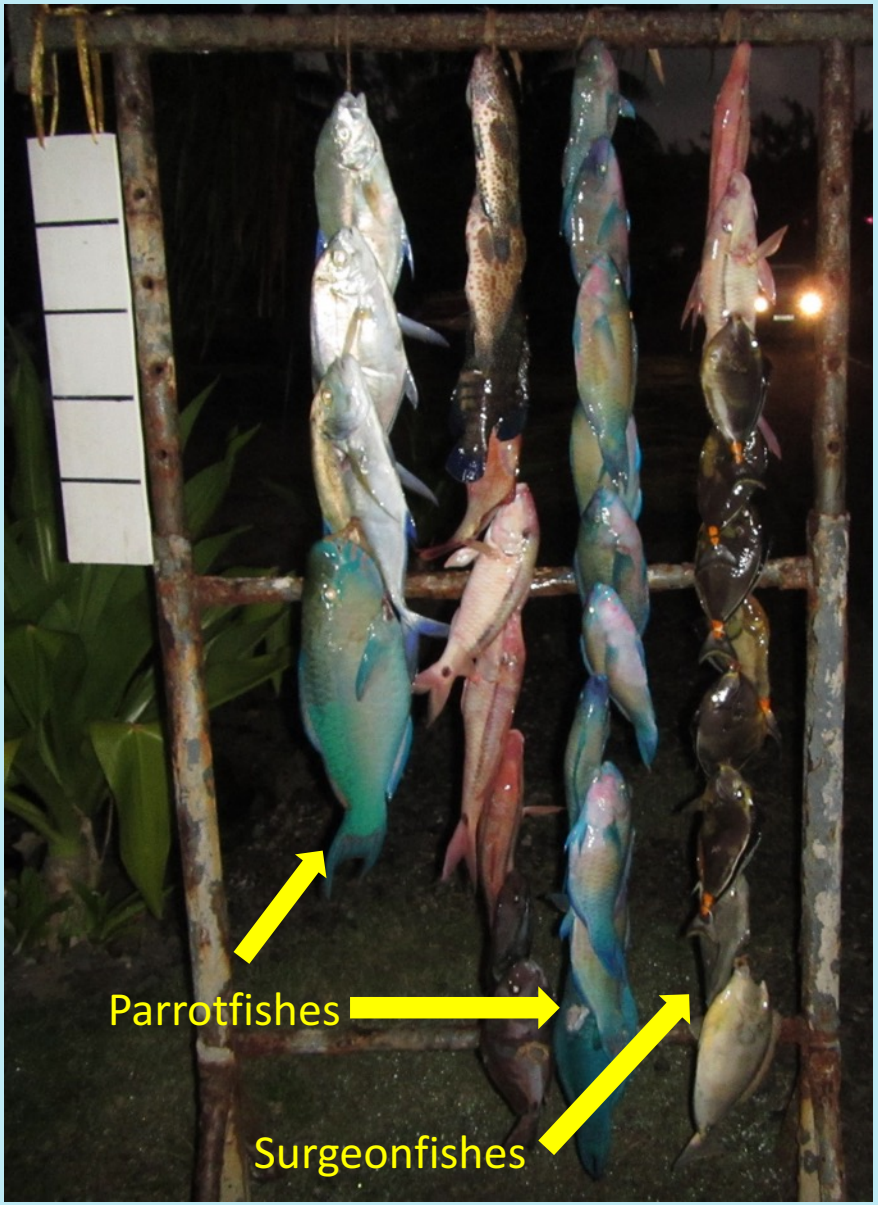


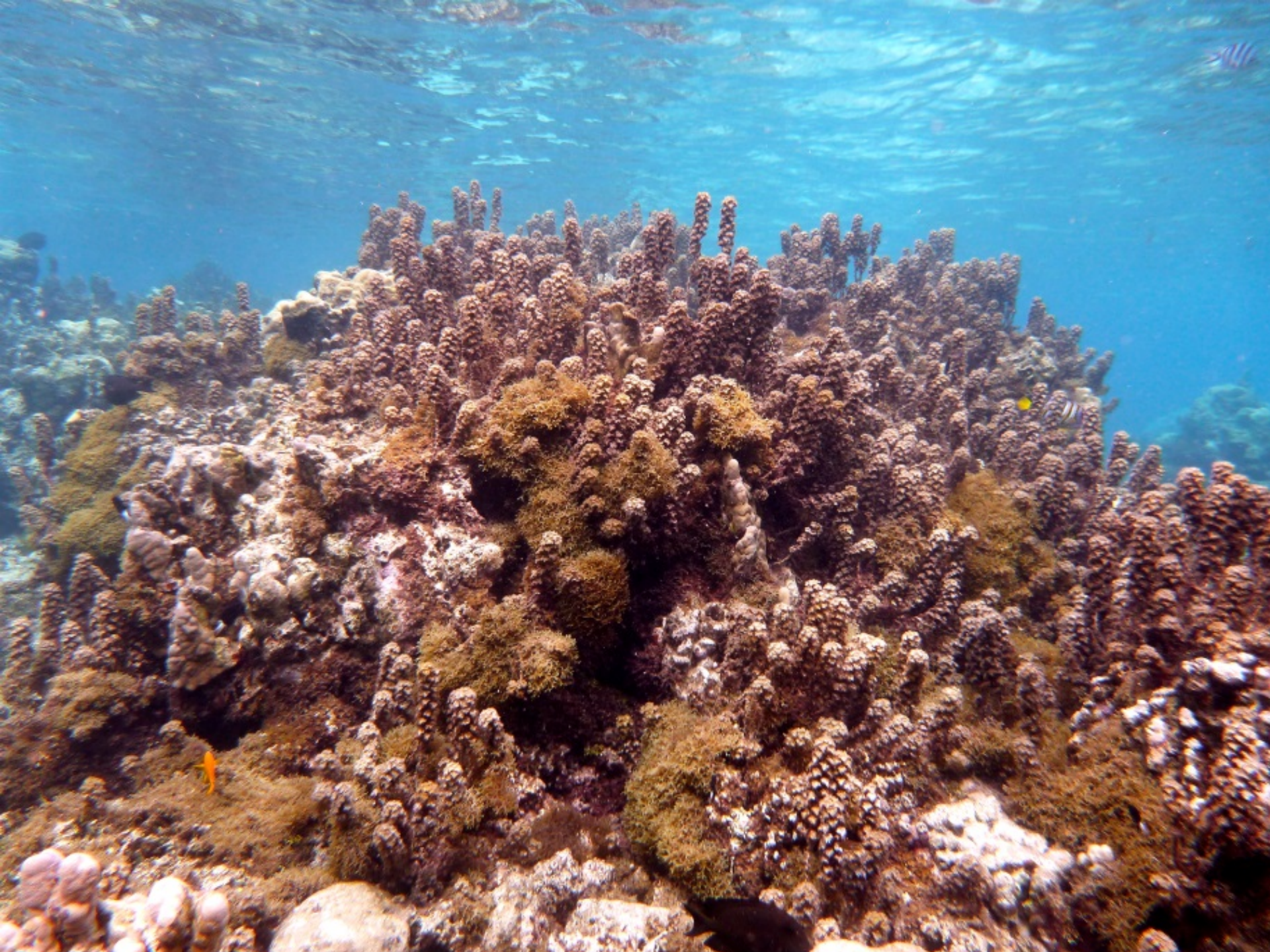


Lagoon Fishery – Herbivores Prize Catches

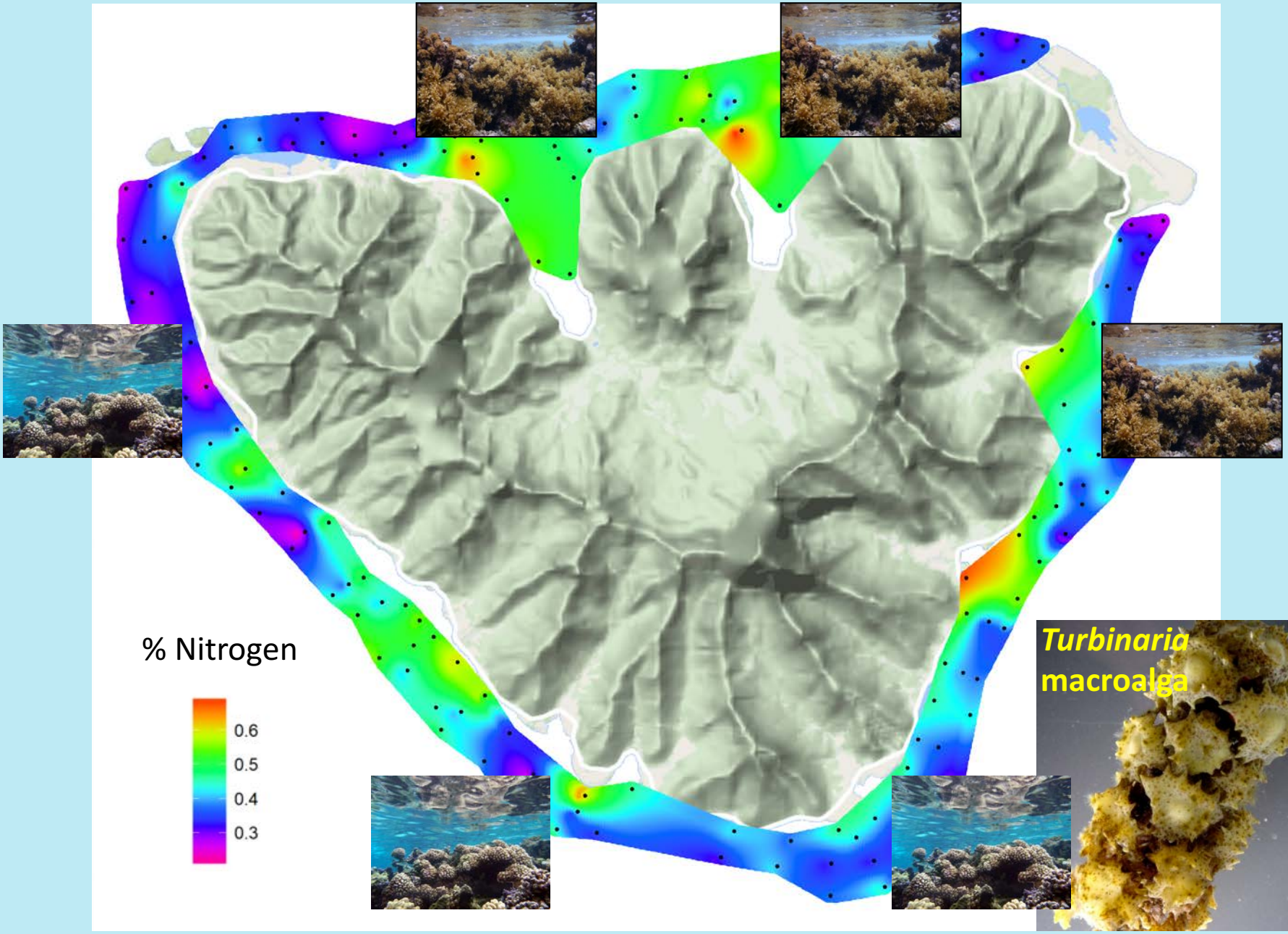
Lagoon Fishery – Herbivores Prize Catches







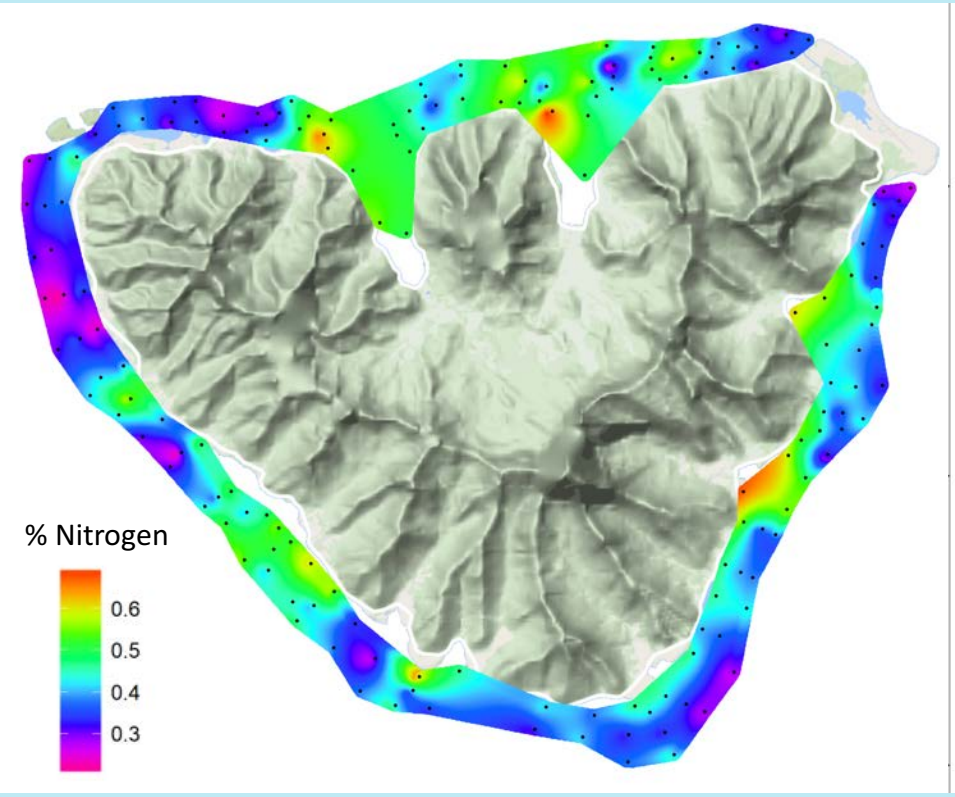
Nutrients and The Rise of Macroalgae

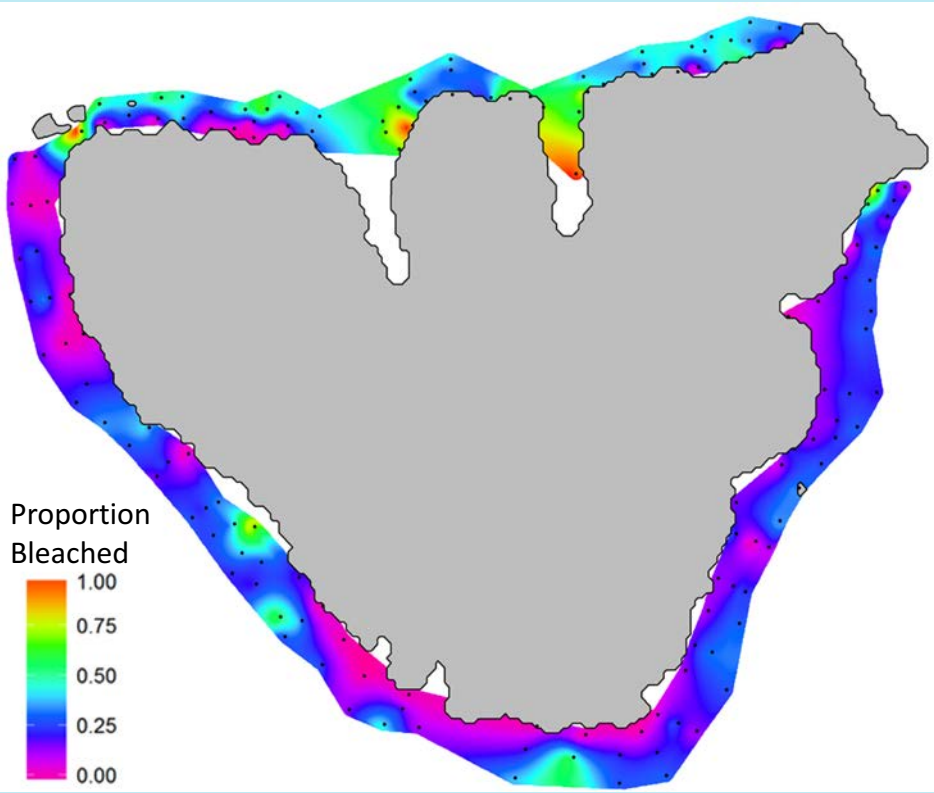


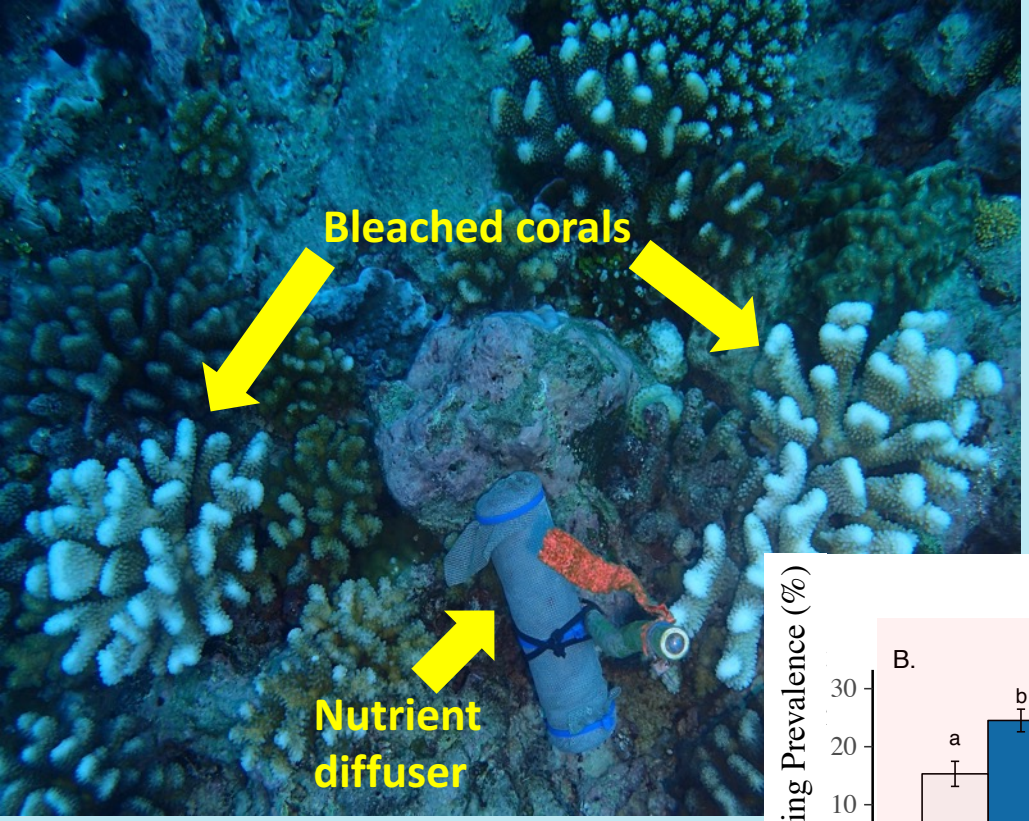
More Nutrients Means More Coral Bleaching

Nutrient Availability

Pocillopora coral Bleaching Prevalence

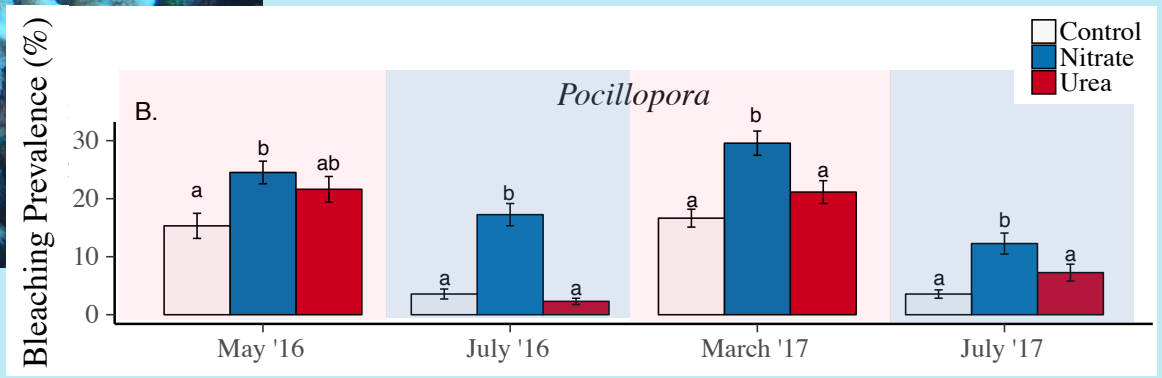


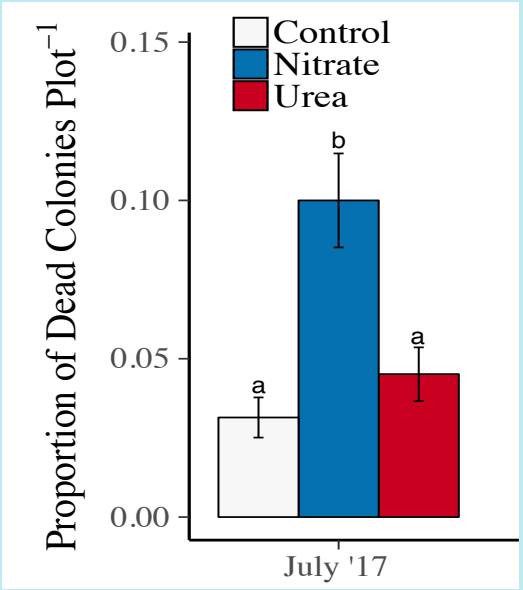




The Type of Nutrient Matters!

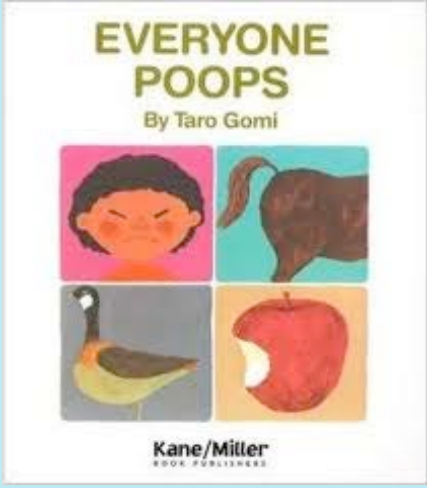
- Nitrate exacerbated bleaching prevalence and duration in both *Acropora* and *Pocillopora*

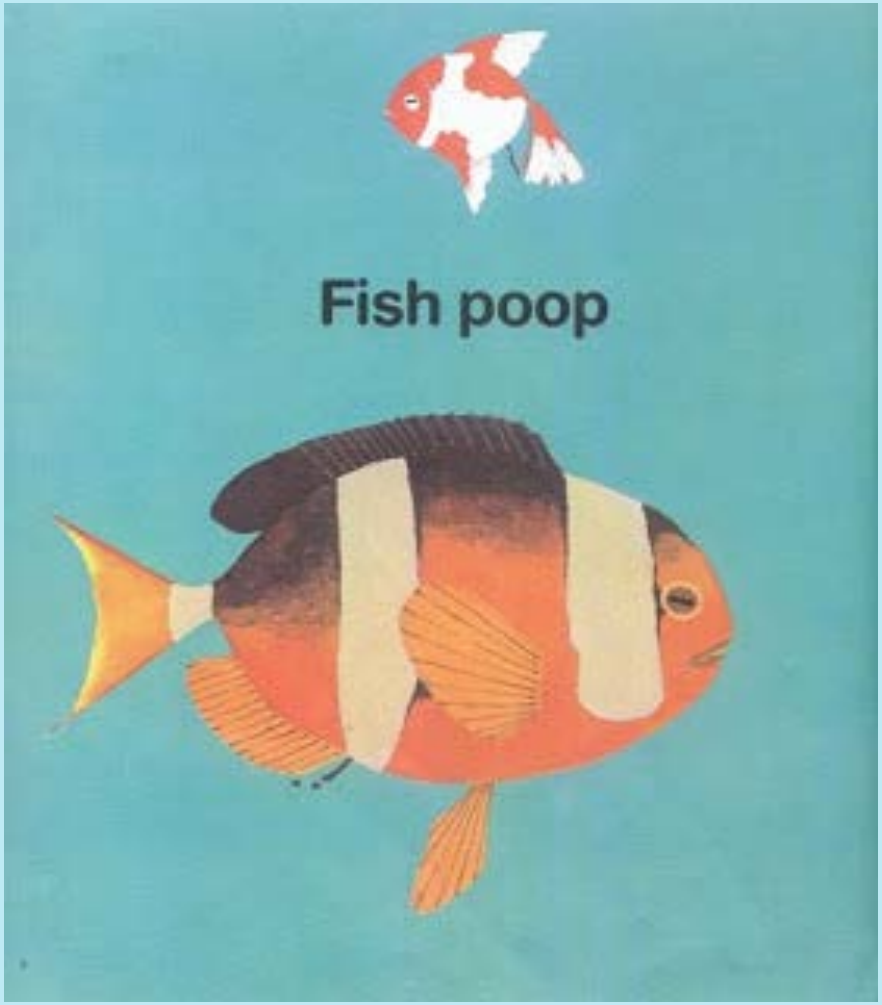




- Nitrate tripled coral mortality in *Pocillopora*
- No effect of urea
- Nitrate = human-derived
  Urea = fish-derived

Everyone poops (and pees)



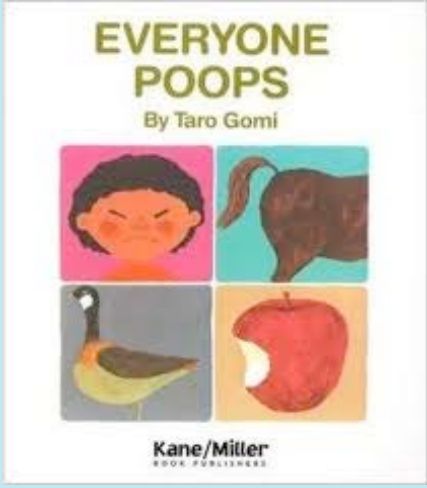


Everyone poops (and pees)

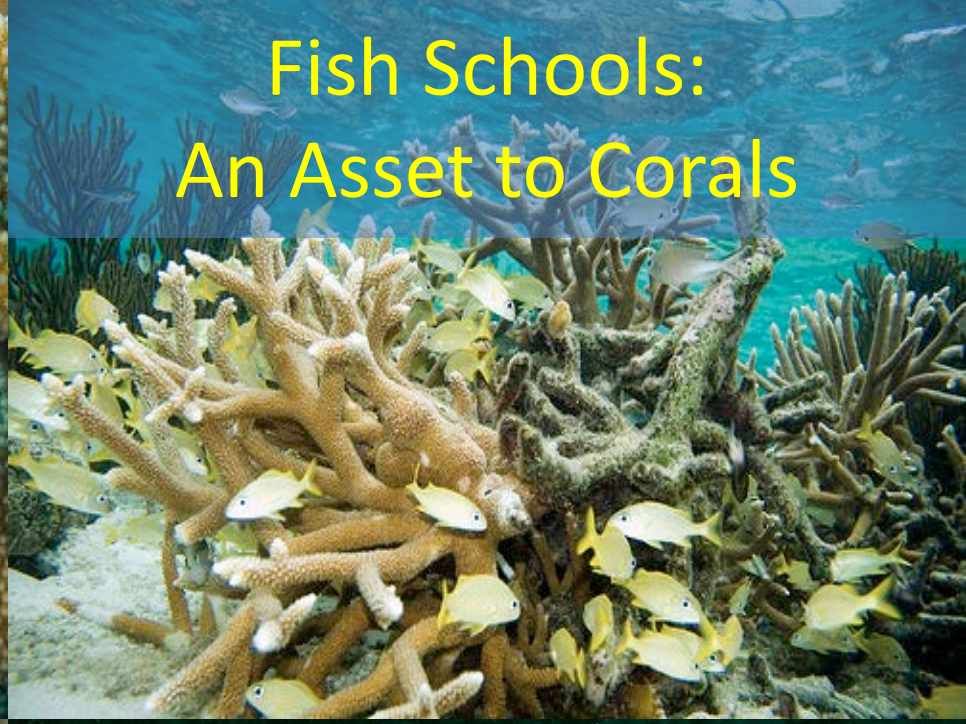
Algae
Coral

Nitrogen

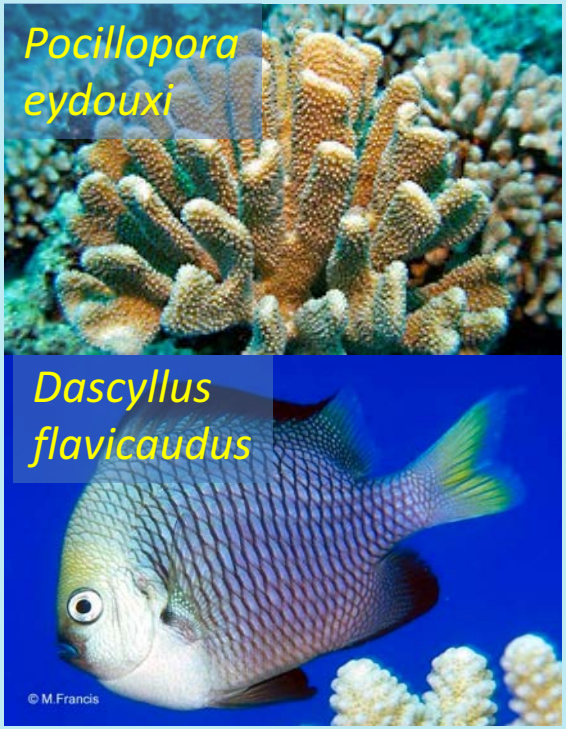
Nitrogen
Phosphorus
POM

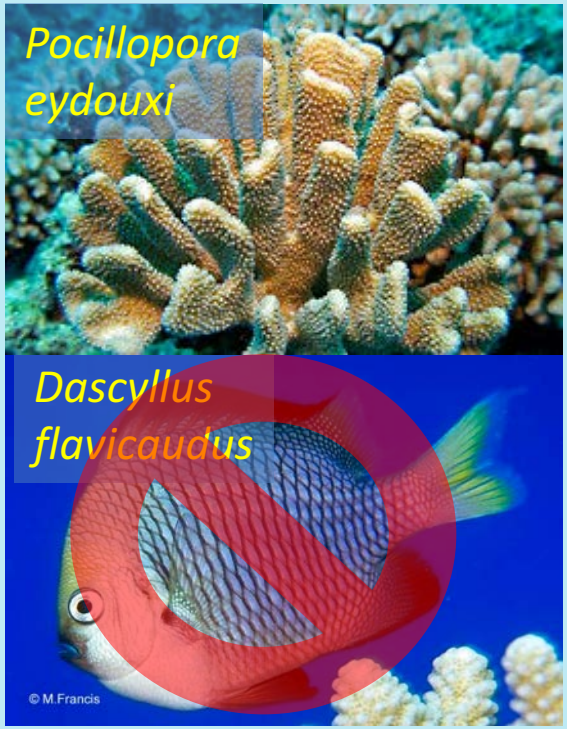


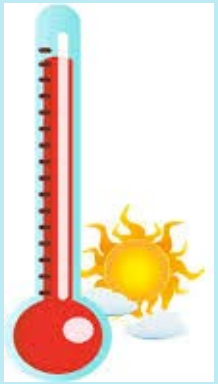
Fish Schools: An Asset to Corals



Can Fishes and Their Nutrients Help Corals Withstand Thermal Stress?

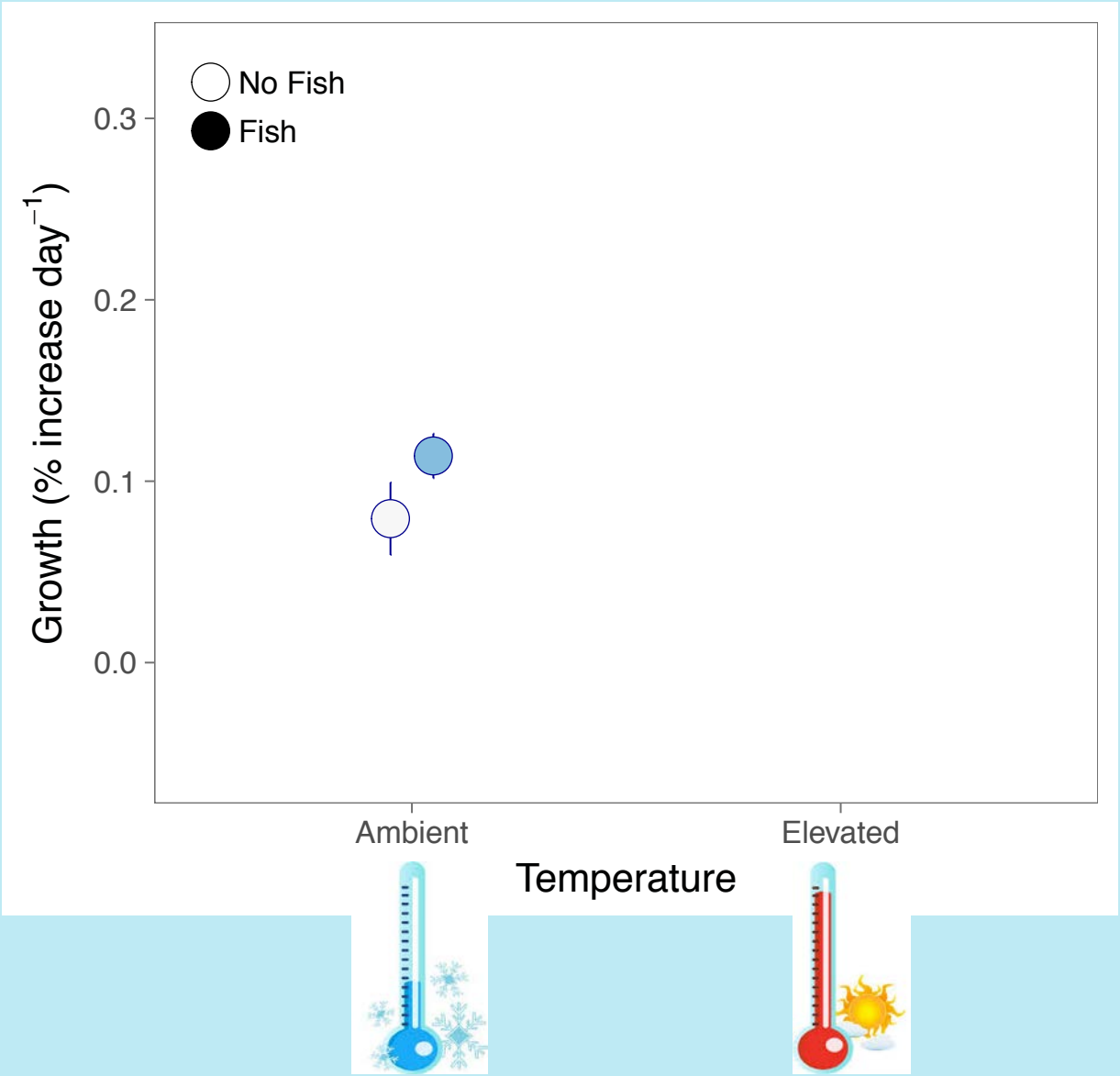






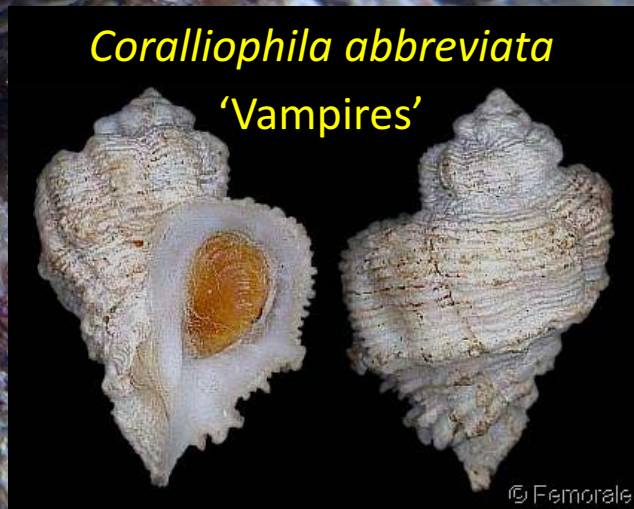
Vs.

Fishes help corals recover after heat stress



- Fish increase coral growth

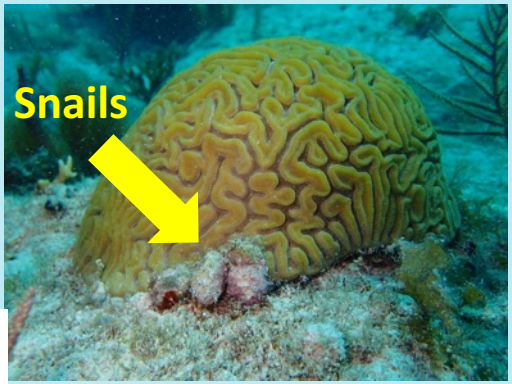
Snails!

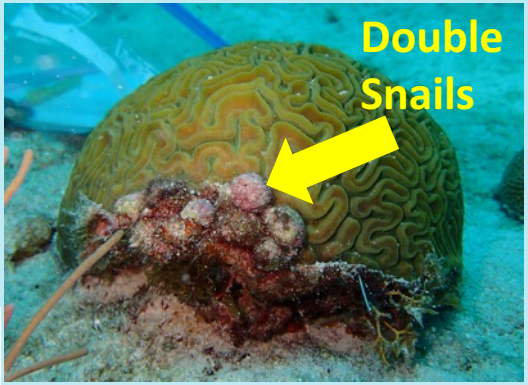


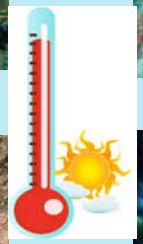
Removals

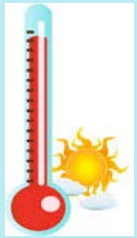
Average Density

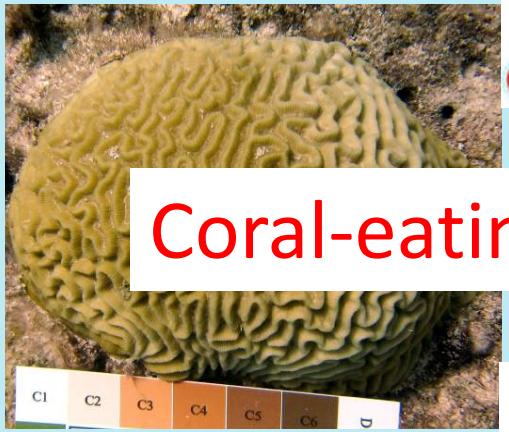
High Density

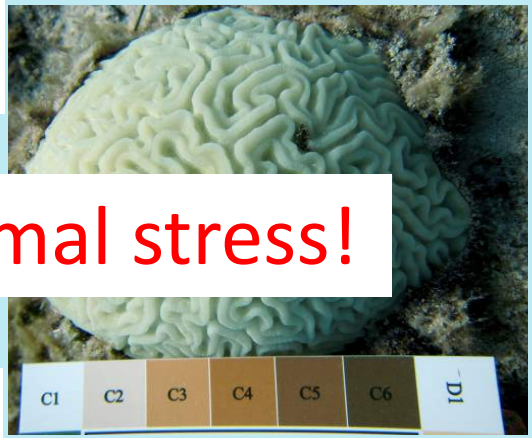






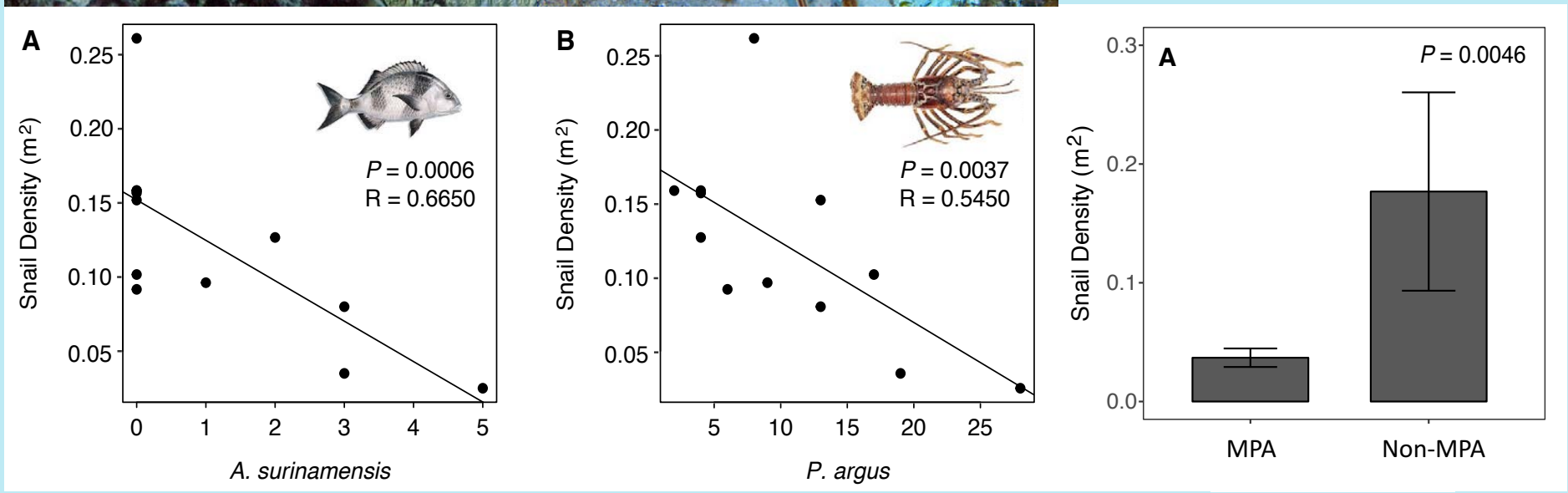






Coral-eating snails magnify thermal stress!

Fishes (& Shellfishes) To The Rescue!



- Can Marine Protected Areas (MPAs) help mitigate coral stress from climate change?

Why Good Fishes Make Good Reefs

1. Fishes are important herbivores – remove algae and facilitate corals – important for resilience after disturbance

2. Fishes are important sources of nutrients – help corals grow, withstand temperature stress

3. ALL IS NOT LOST! – Local management can help corals survive the Anthropocene

This Gives Me Hope Because…

If we slow greenhouse gas emissions…


…then we get to keep these.

Thanks!

NSF Funding Sources

NSF OCE 0417412 - MCR I
NSF OCE 1026851 - MCR IIA
NSF OCE 1236905 - MCR IIB
NSF OCE 1637396 - MCR III
NSF OCE 1619697
NSF OCE 1547952
NSF OCE 1130786
NSF OCE 1056980
NSF OCE 0937852

Gordon and Betty MOORE FOUNDATION

Richard B. Gump South Pacific Research Station
university of california, berkeley
moorea, french polynesia