

# From top to bottom: Rethinking coral reef community structure after decades of disturbance

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Luke Stoeber, Sarah Rider, Camille White, &  
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Clemson University





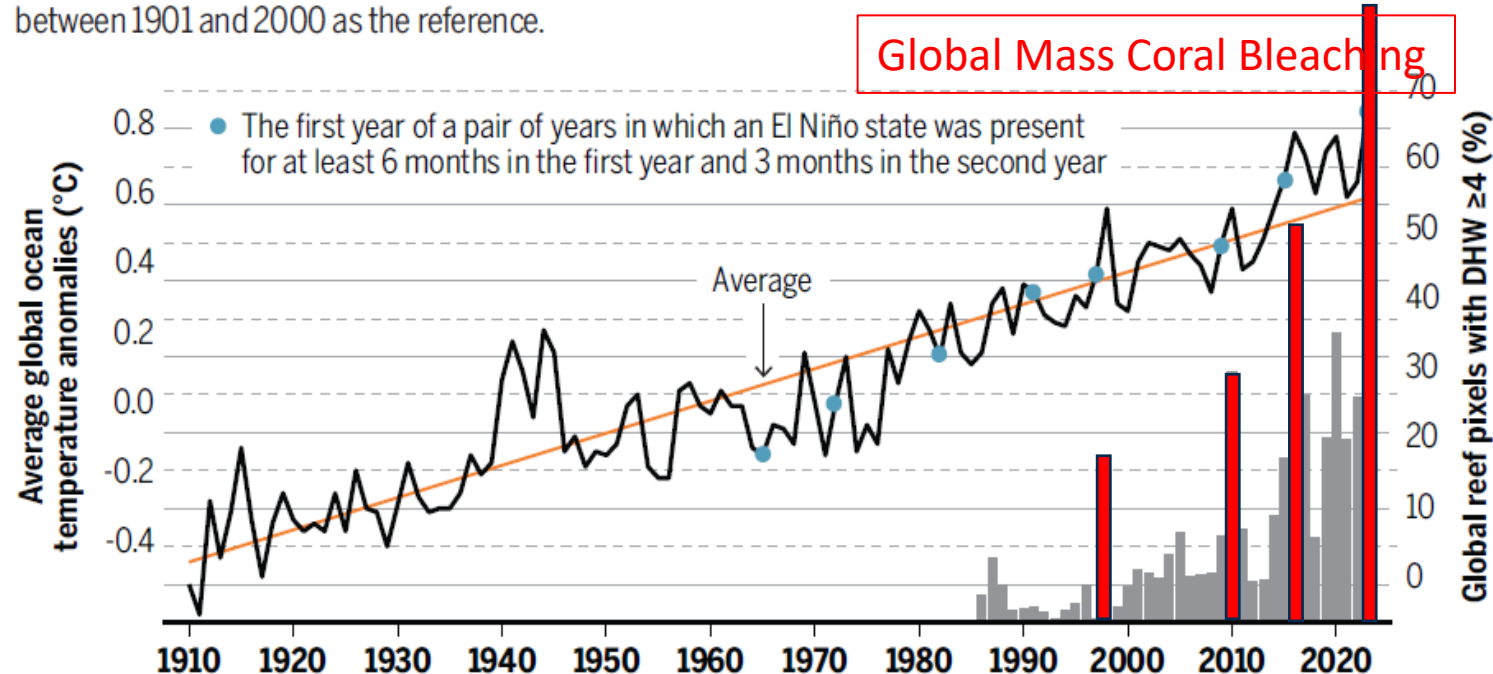




# Have we crossed the coral reef tipping point?

## Coral heat stress

Average global ocean temperature anomalies from February to July each year (1910 to 2023) are increasing. This is coupled with increased periods of degree heating weeks (DHW)  $\geq 4$  (when coral bleaching is likely to occur). Data are from the National Oceanic and Atmospheric Administration (NOAA; [www.ncei.noaa.gov](http://www.ncei.noaa.gov)), using climatology between 1901 and 2000 as the reference.



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NEWS | 12 October 2025

## Coral die-off marks Earth's first climate 'tipping point', scientists say

A surge in global temperatures has caused widespread bleaching and death of warm-water corals around the world.

By [Jeff Tollefson](#)

Global tipping points

### 4.3 Warm-water coral reefs

**Authors:** Paul Pearce-Kelly, Chris Yesson, Melanie McField, Aarón Israel Muñoz-Castillo, Melina Soto, Jesus Ernesto Arias-Gonzalez, Kyle Morgan, Alina Bill-Weilandt, Björn Kjerfve, Christopher E. Cornwall, Lorenzo Alvarez-Filip, Marjana Milkoreit, Tim E. Lenton, Rosa M. Roman-Cuesta.

**Reviewers:** David O. Obura, Chris T. Perry



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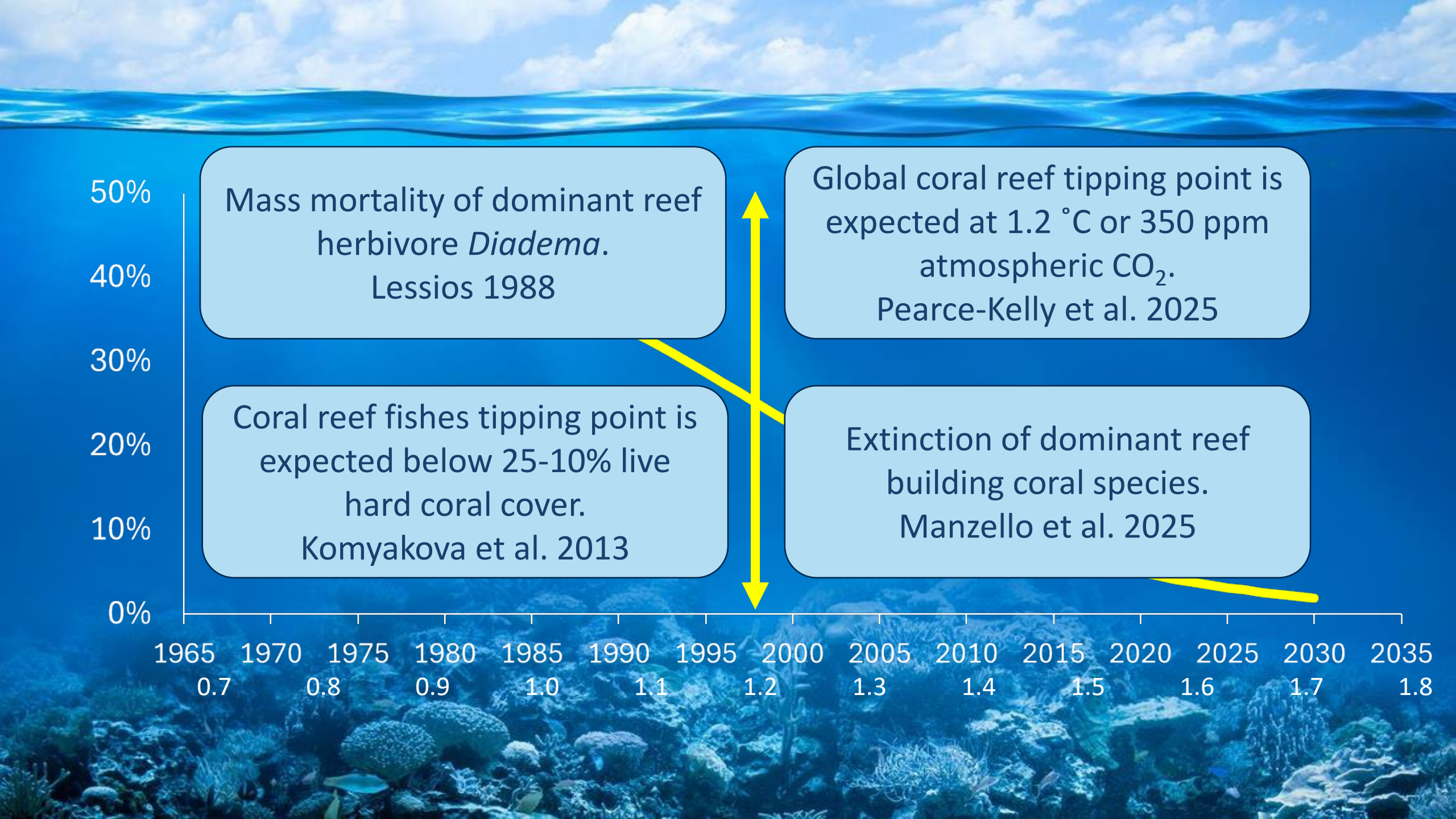
Mass mortality of dominant reef herbivore *Diadema*.  
Lessios 1988

Coral reef fishes tipping point is expected below 25-10% live hard coral cover.  
Komyakova et al. 2013

Global coral reef tipping point is expected at 1.2 °C or 350 ppm atmospheric CO<sub>2</sub>.  
Pearce-Kelly et al. 2025

Extinction of dominant reef building coral species.  
Manzello et al. 2025

1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035  
0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8

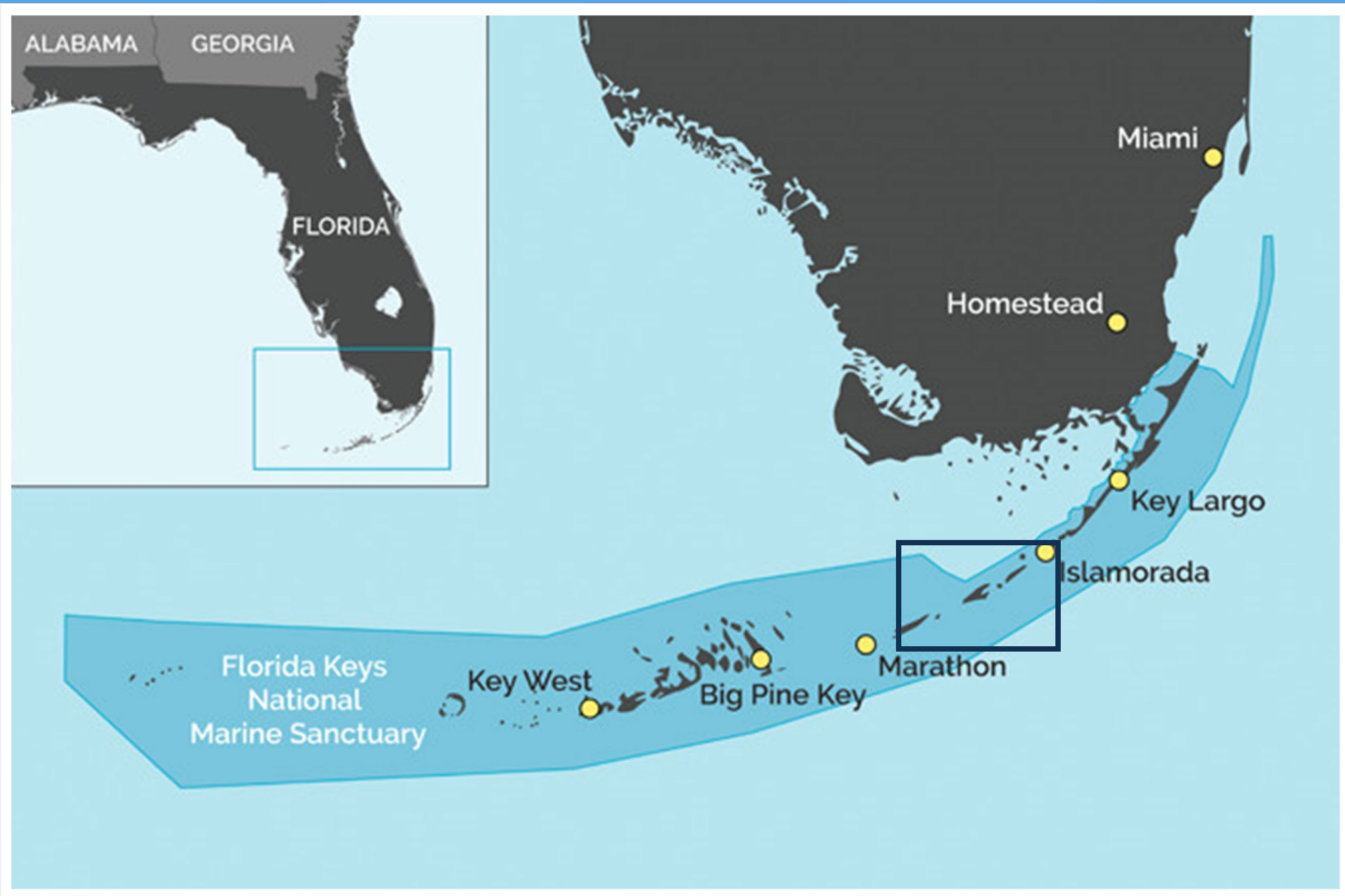




# Questions

- How did coral reef communities of the middle FL Keys respond to the recent marine heat wave?
- Were the impacts greater for chronic heat stress or acute heat stress?
- How long did it take to recover after the last marine heat wave?
- Have we crossed the coral reef tipping point in the FL Keys and, if so, what's next?



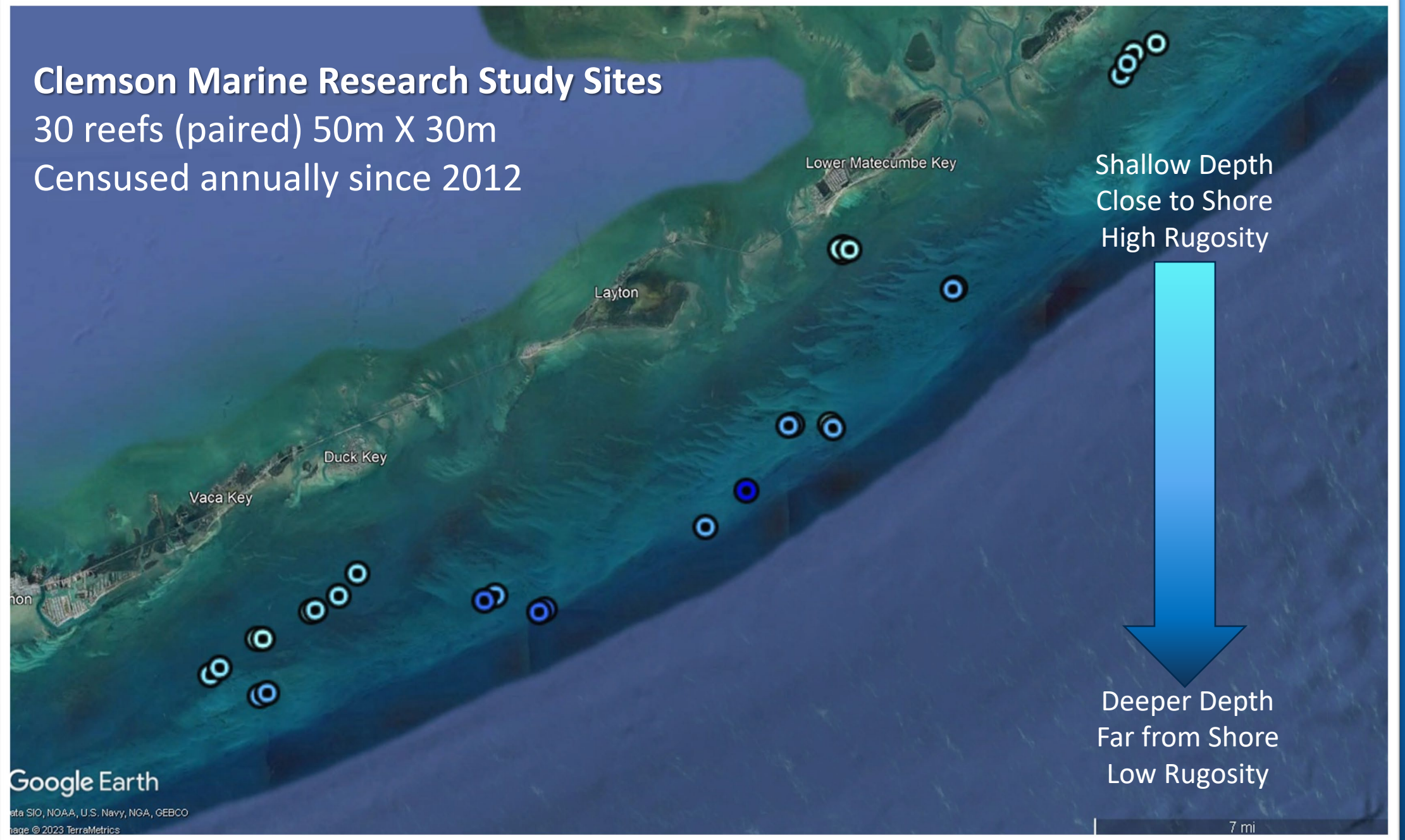




## Clemson Marine Research Study Sites

30 reefs (paired) 50m X 30m

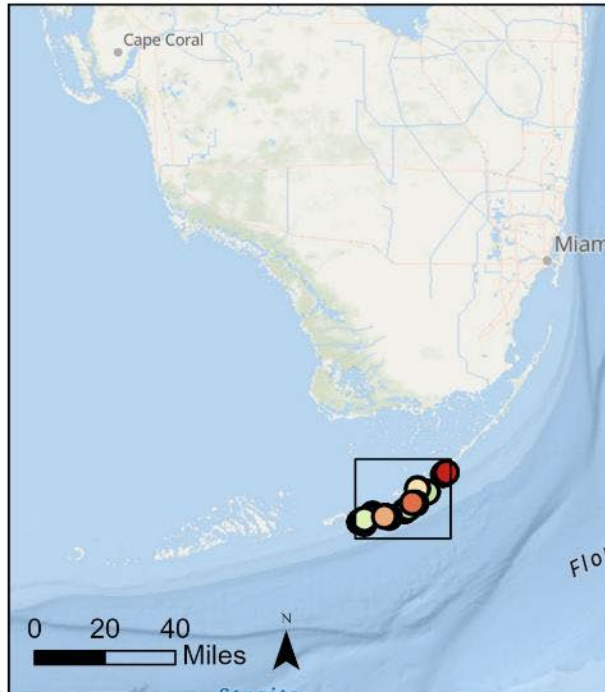
Censused annually since 2012



Map by Michael Childress



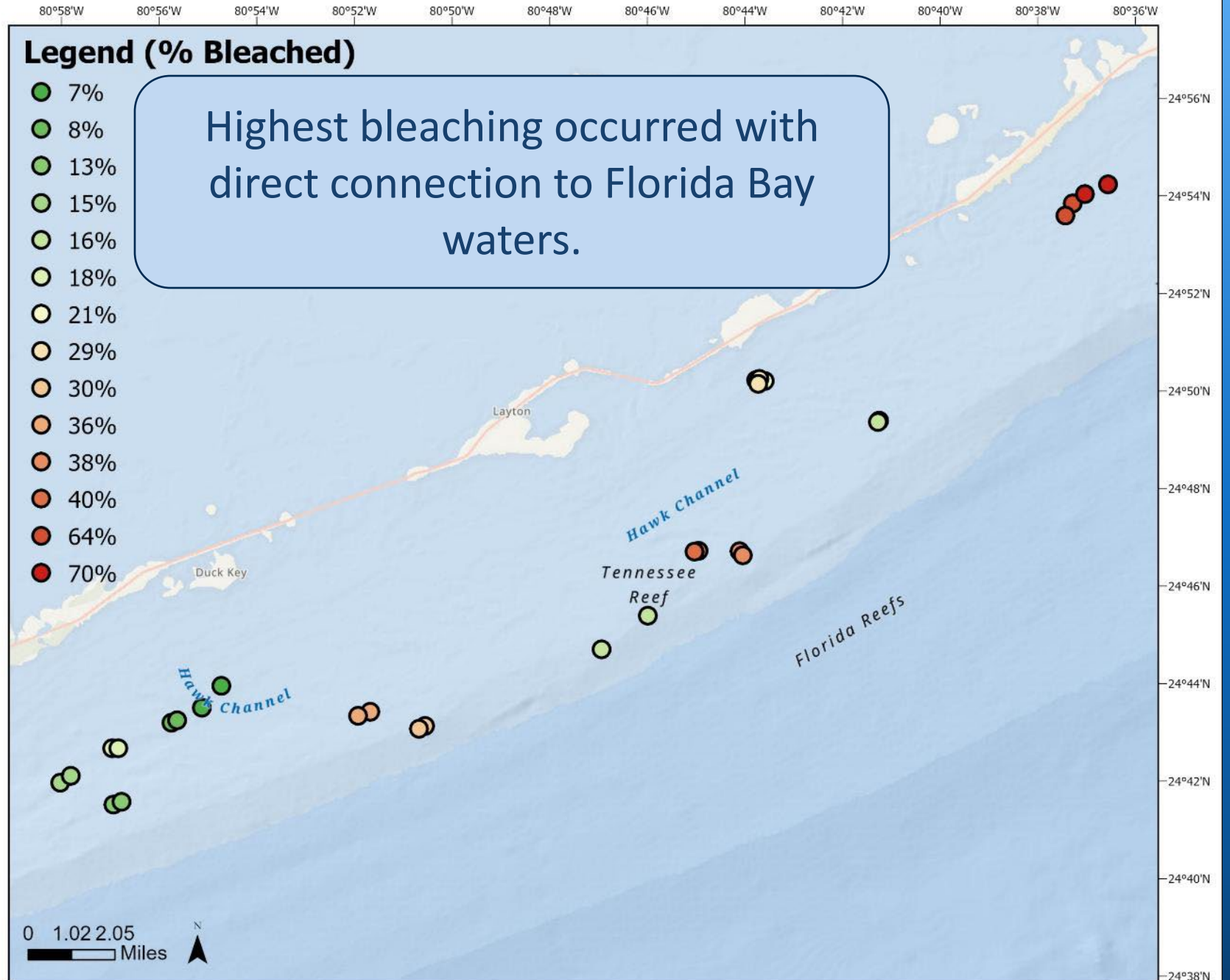




## Legend (% Bleached)

- 7%
- 8%
- 13%
- 15%
- 16%
- 18%
- 21%
- 29%
- 30%
- 36%
- 38%
- 40%
- 64%
- 70%

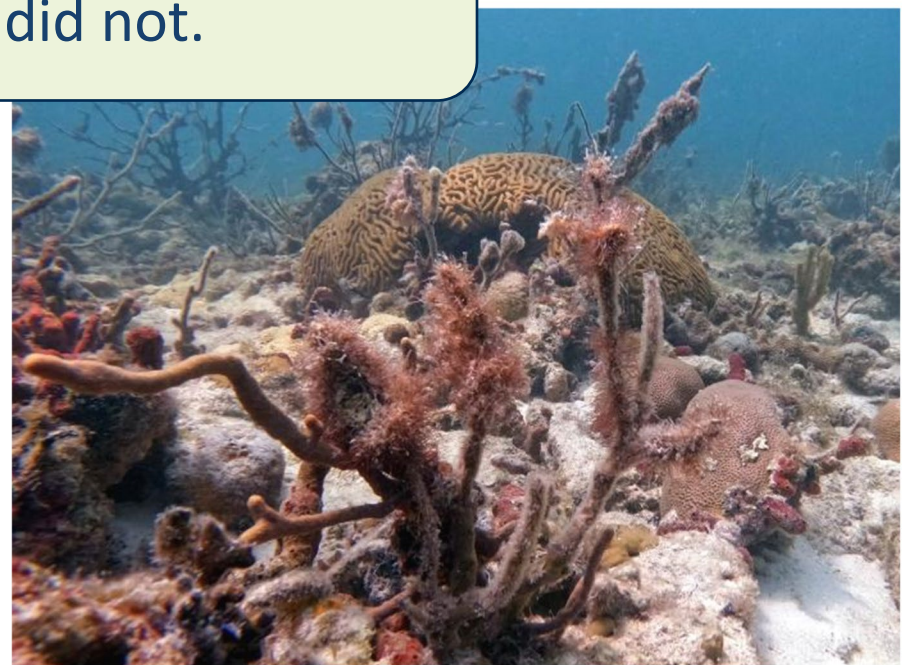
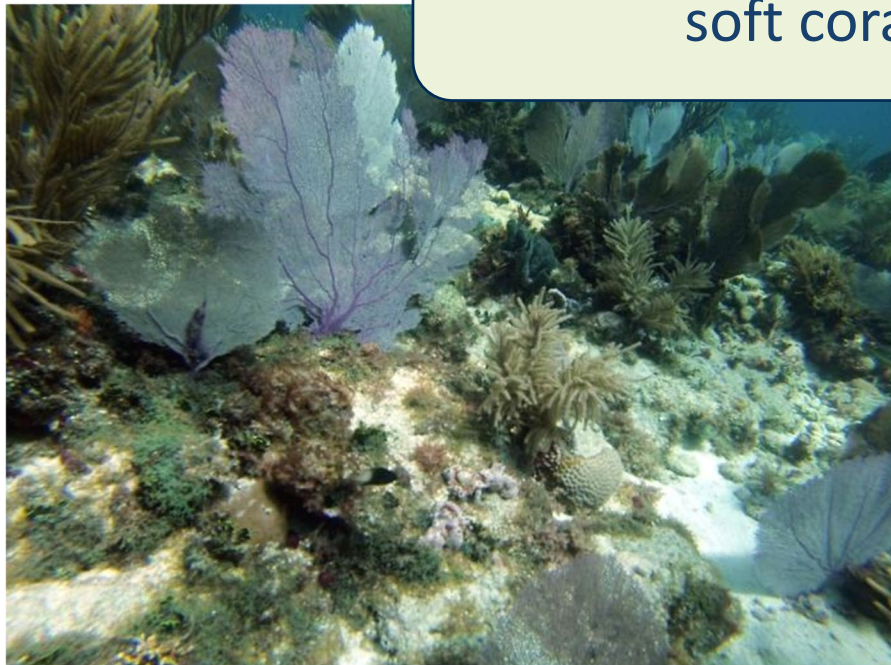
Highest bleaching occurred with direct connection to Florida Bay waters.





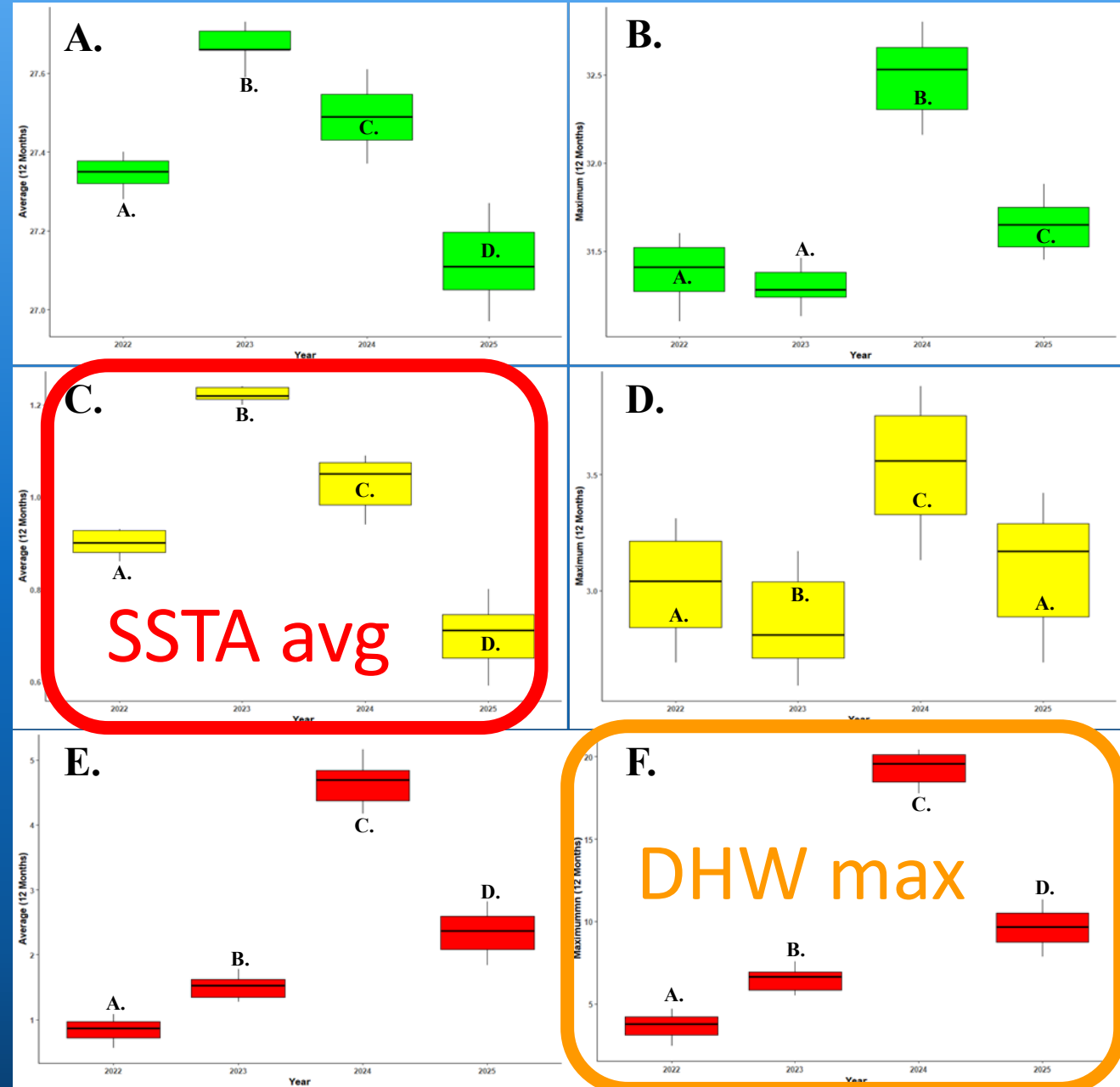
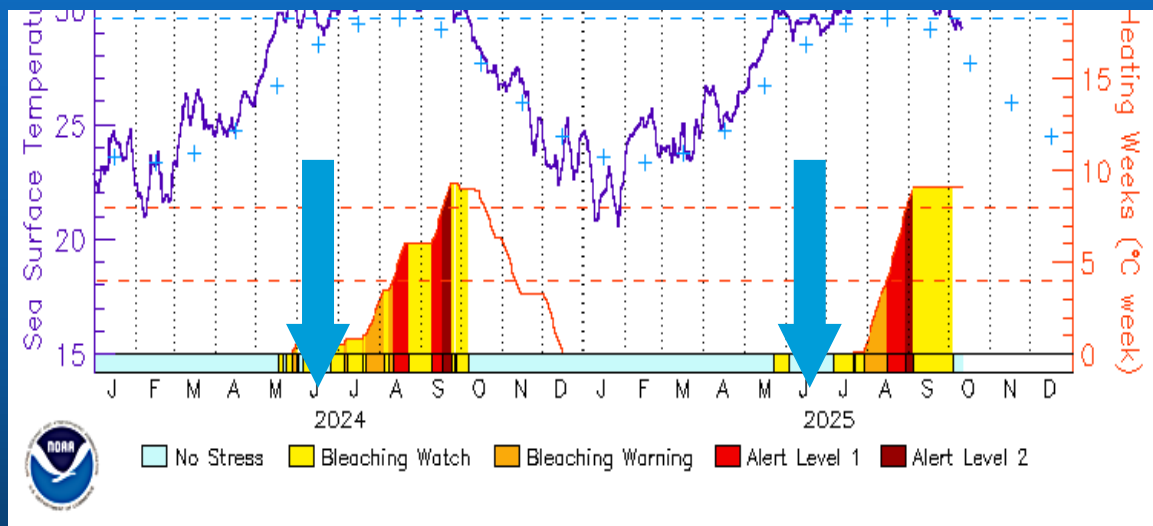
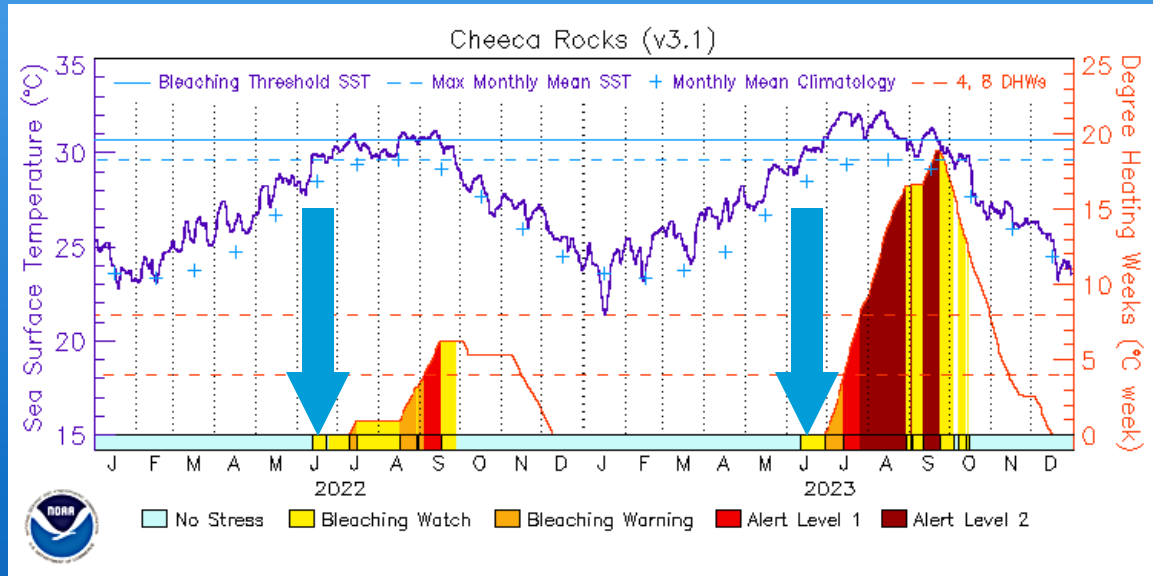


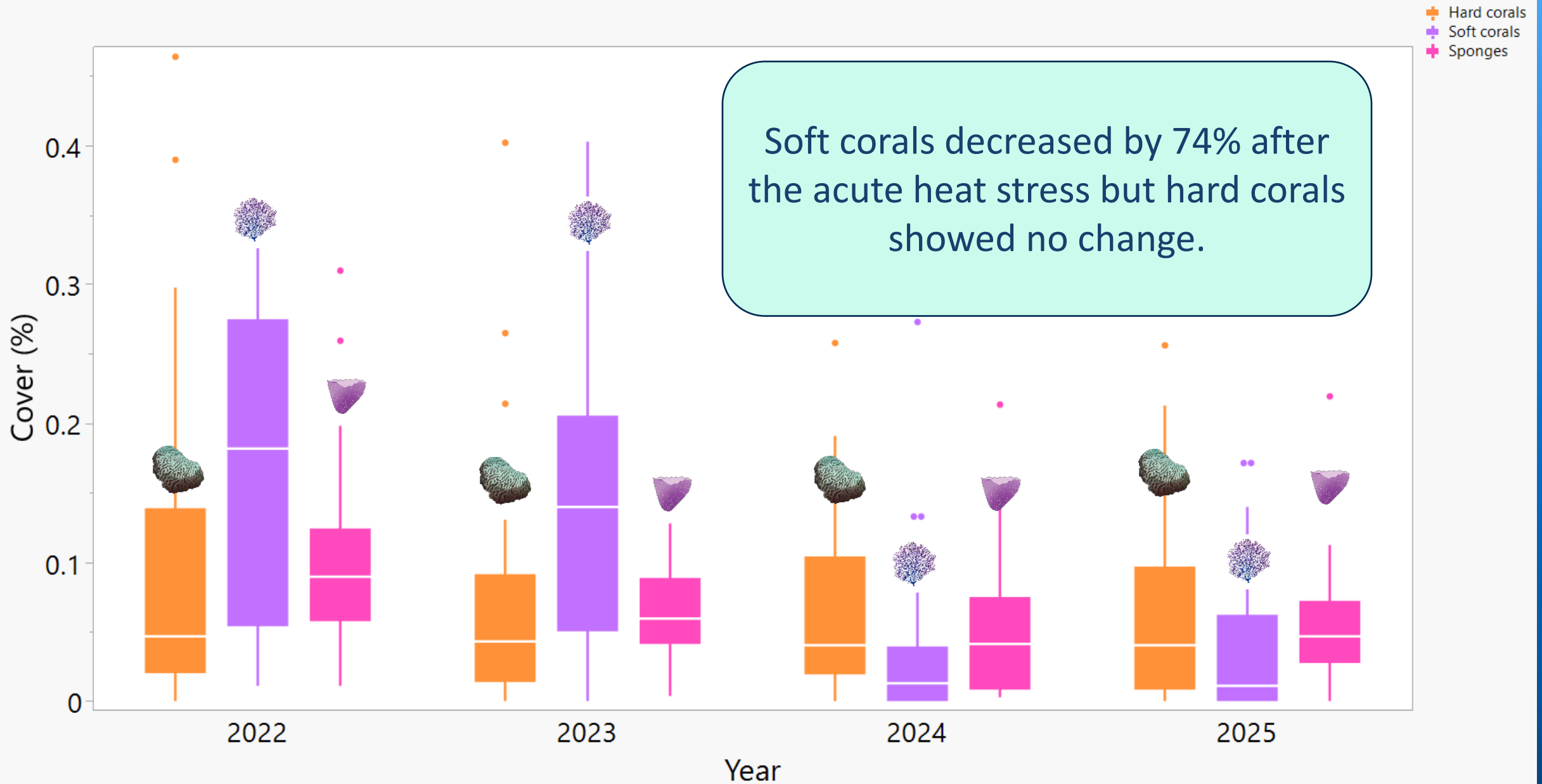
Nearly all hard corals survived but  
soft corals did not.



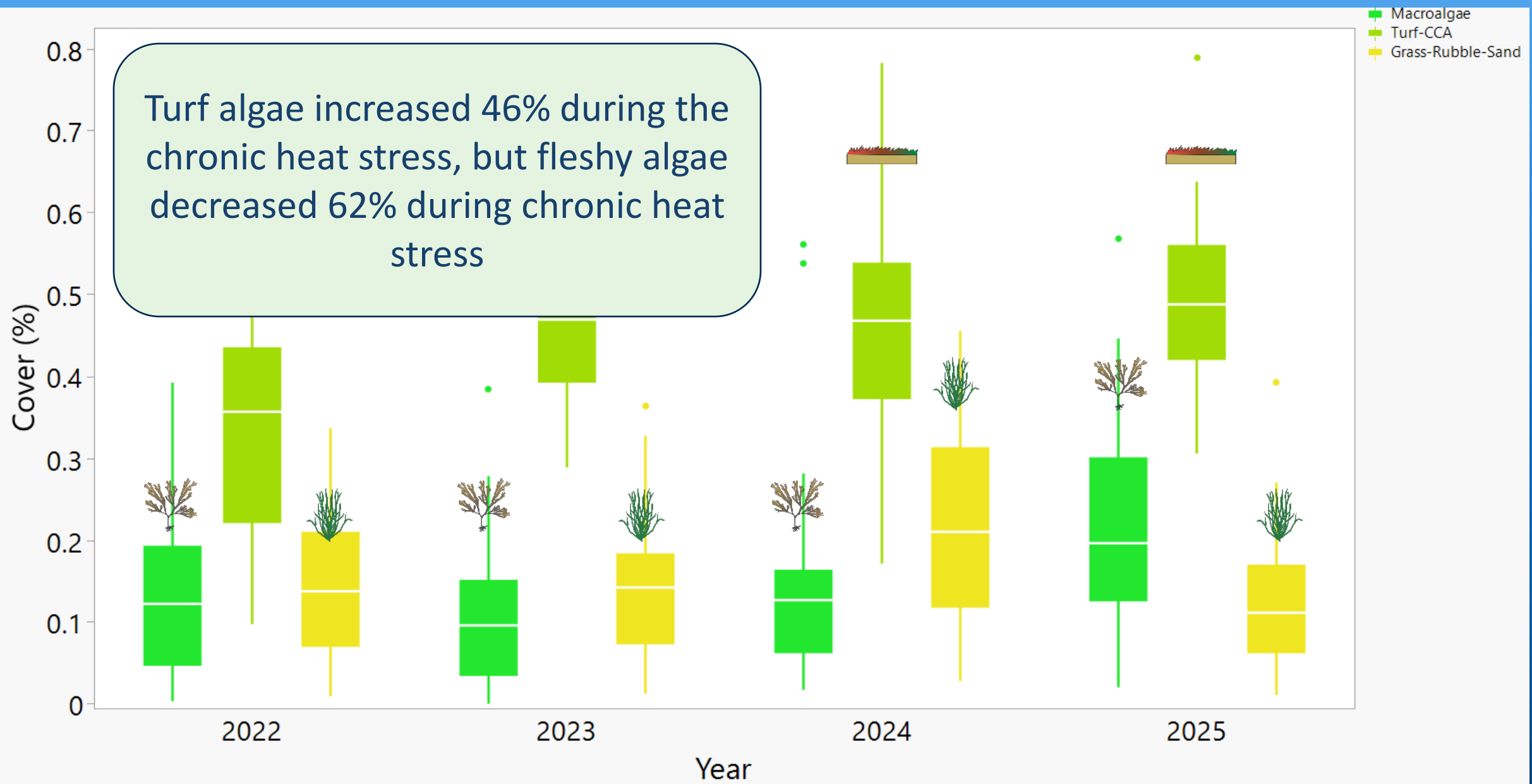


# Measures of Heat Stress

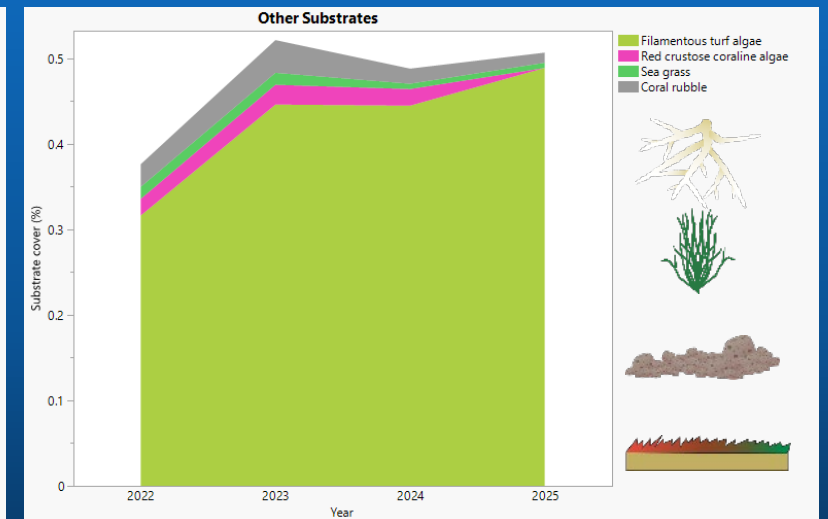
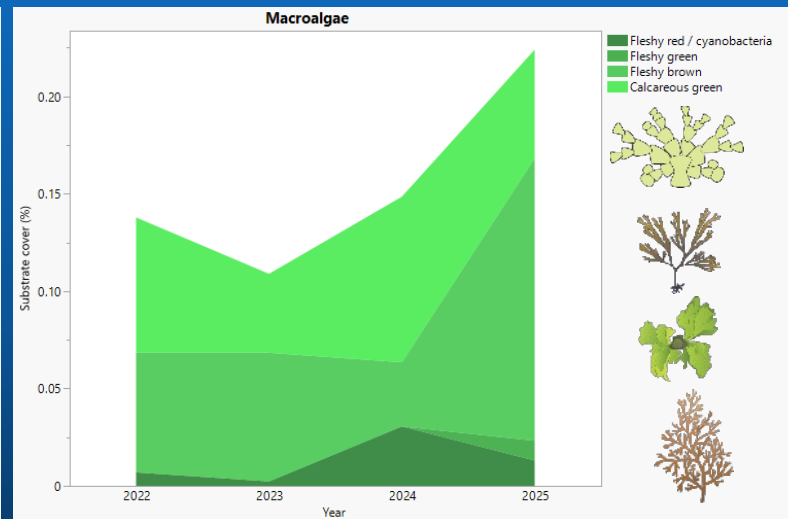
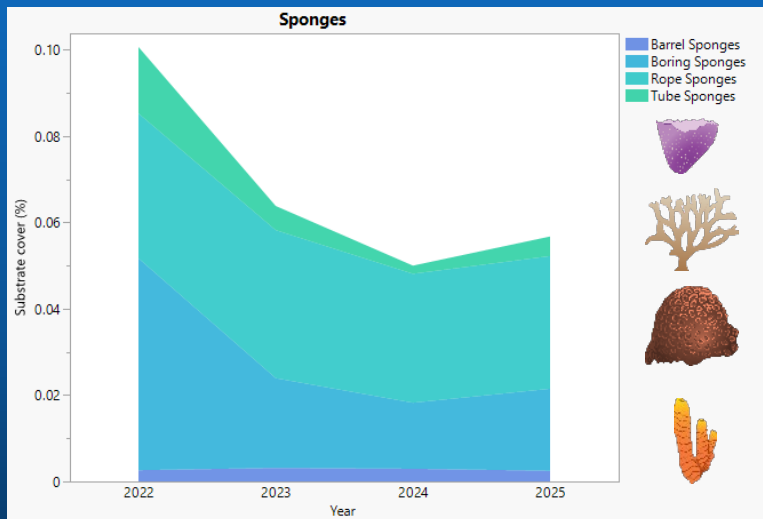
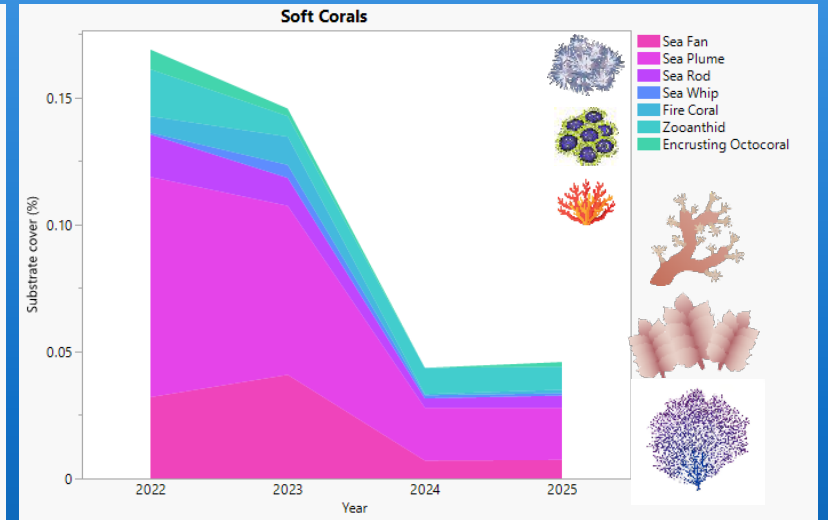
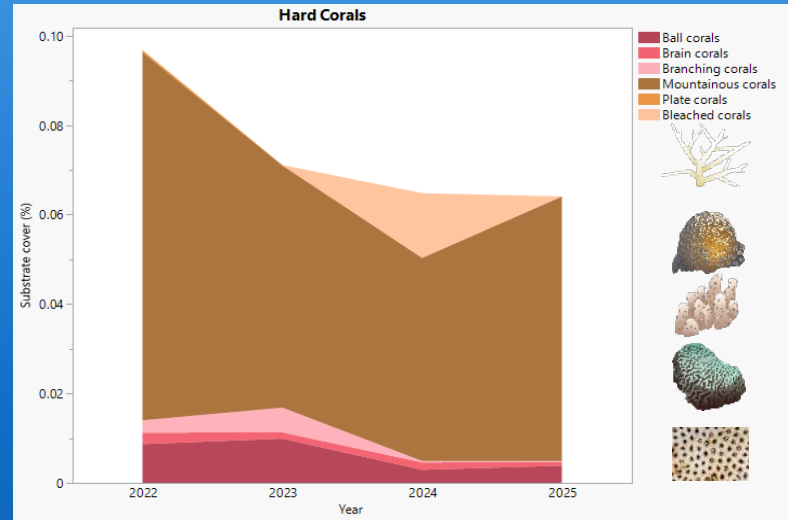
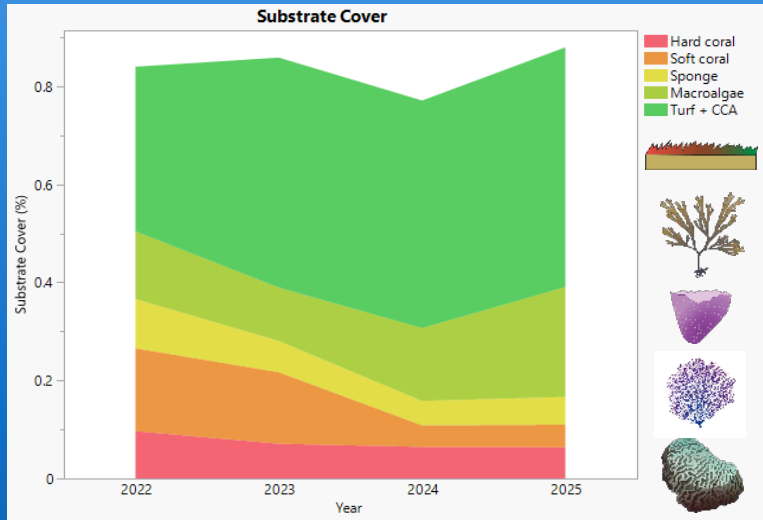








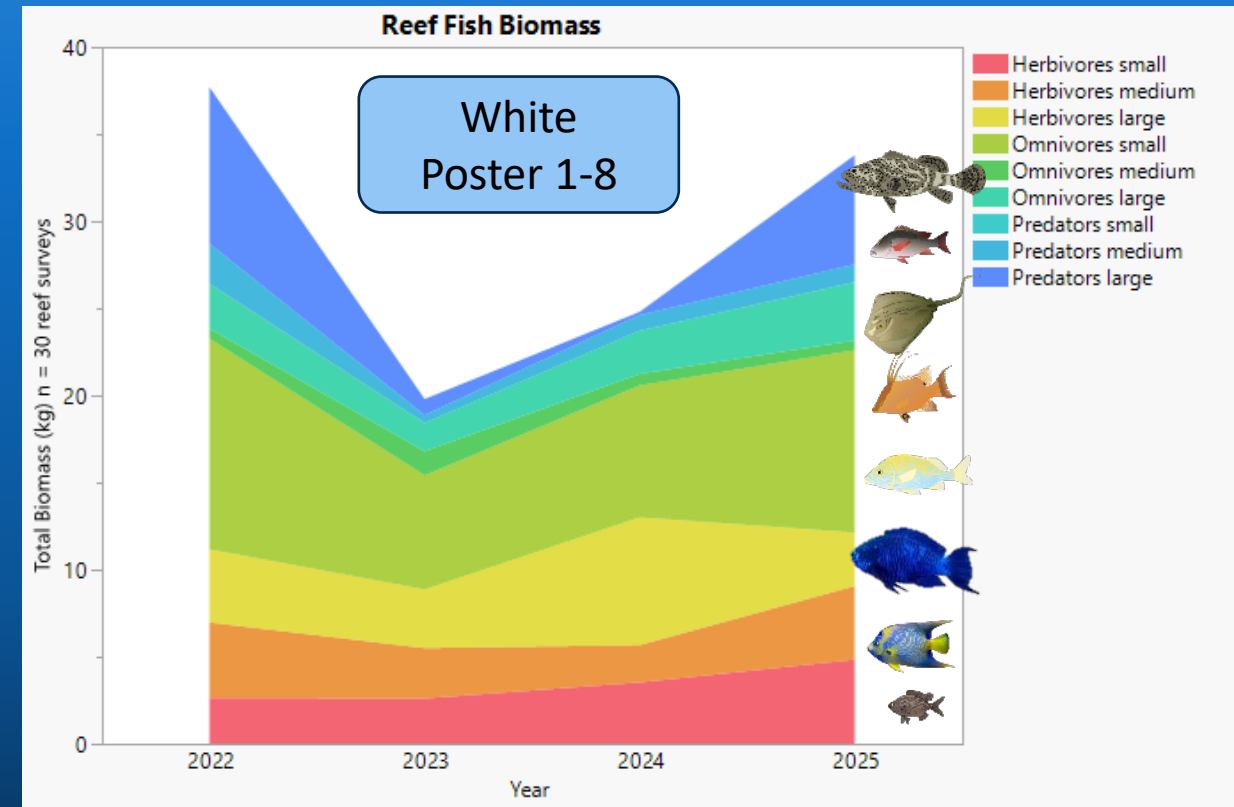
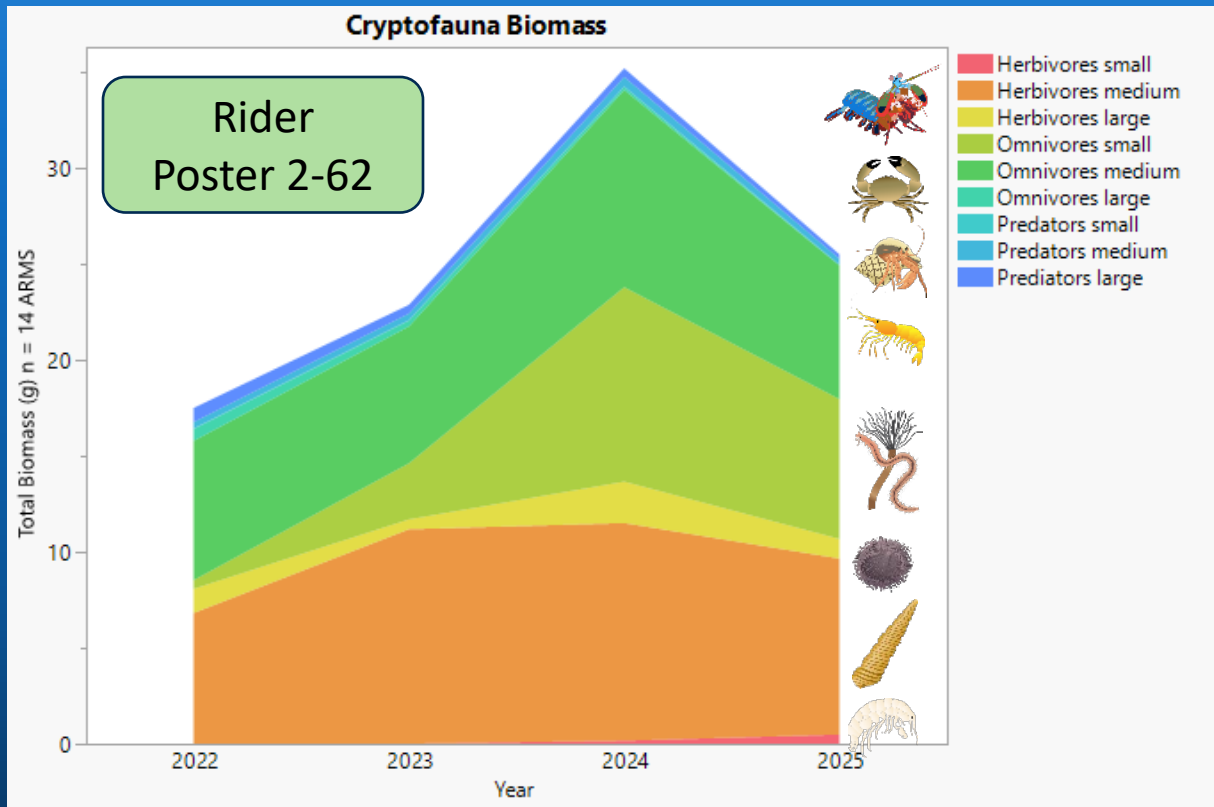
**Losers:** Boring sponges, sea fans, sea plumes, sea rods & sea whips  
**Winners:** turf algae, fleshy red algae, & fleshy brown algae





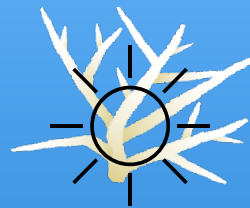
Cryptofauna biomass was positively related to acute heat stress (DHW) with worm taxa showing the greatest increase.

Reef fish biomass was negatively related to chronic heat stress (SSTA) with large predators showing the greatest decrease.

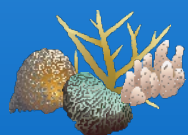




Chronic Heat ( $SSTA_{avg}$ )



Acute Heat ( $DHW_{max}$ )



Hard coral



Soft coral



Sponges



Macroalgae



Turf + CCA

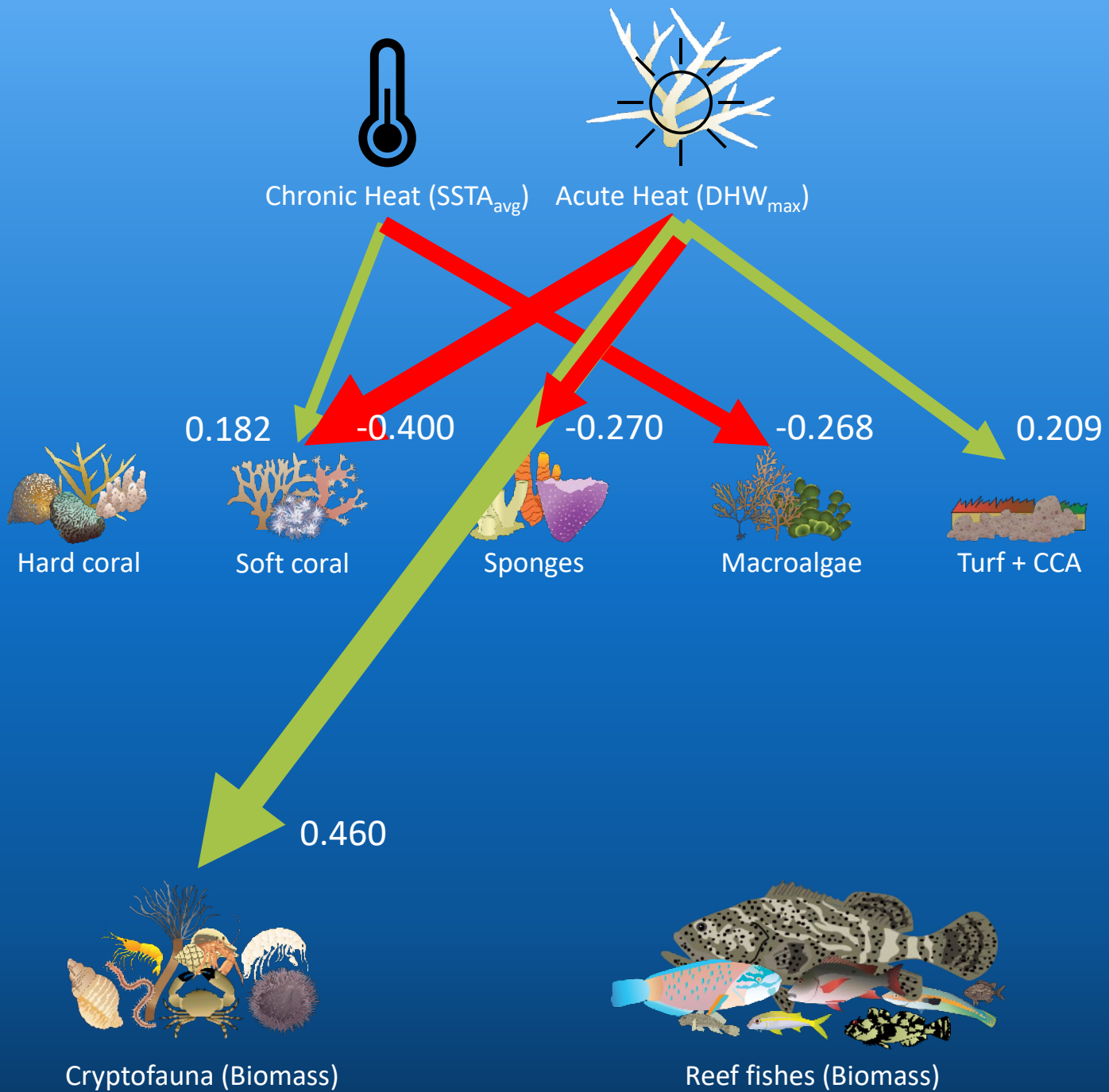


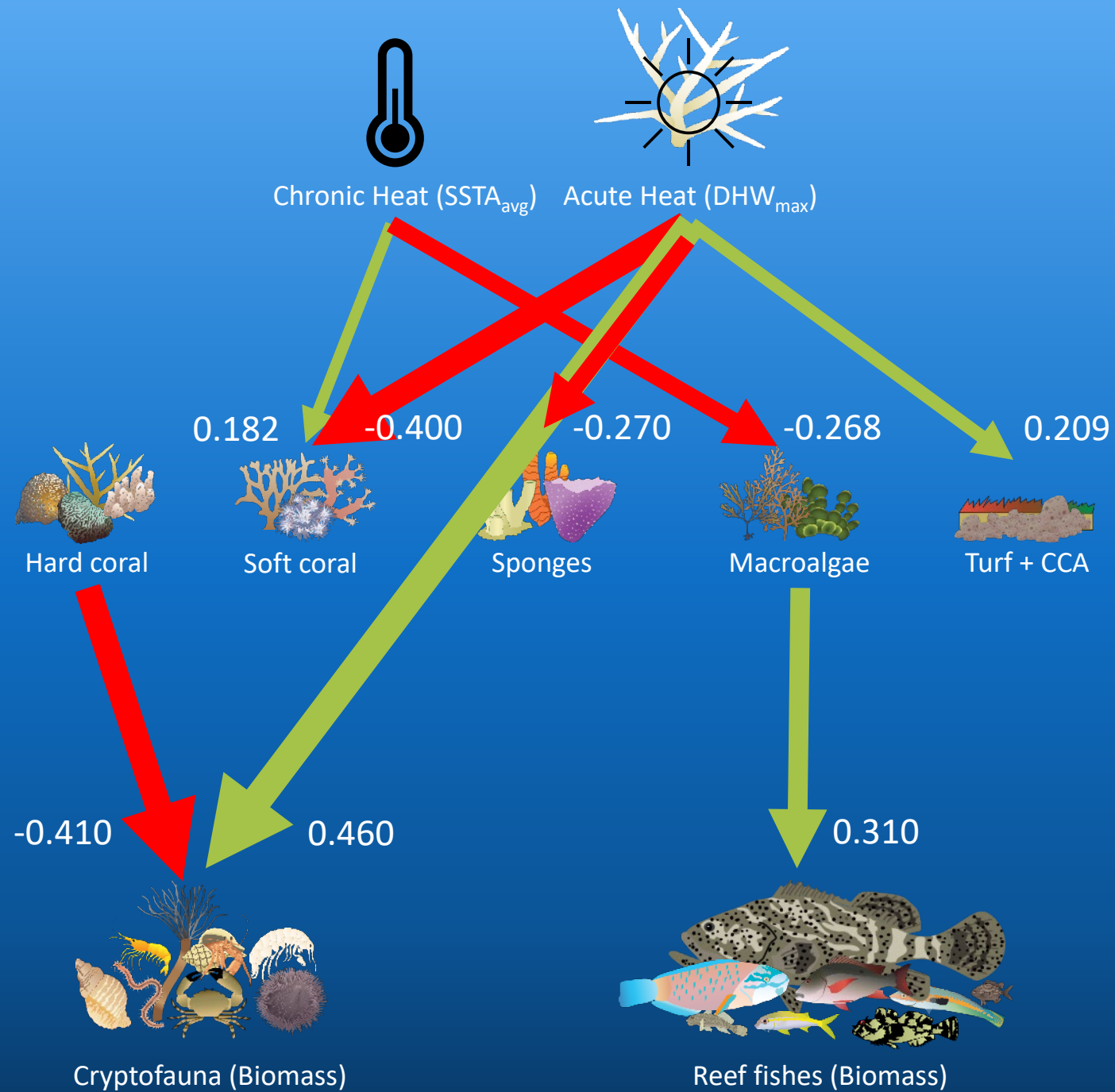
Cryptofauna (Biomass)



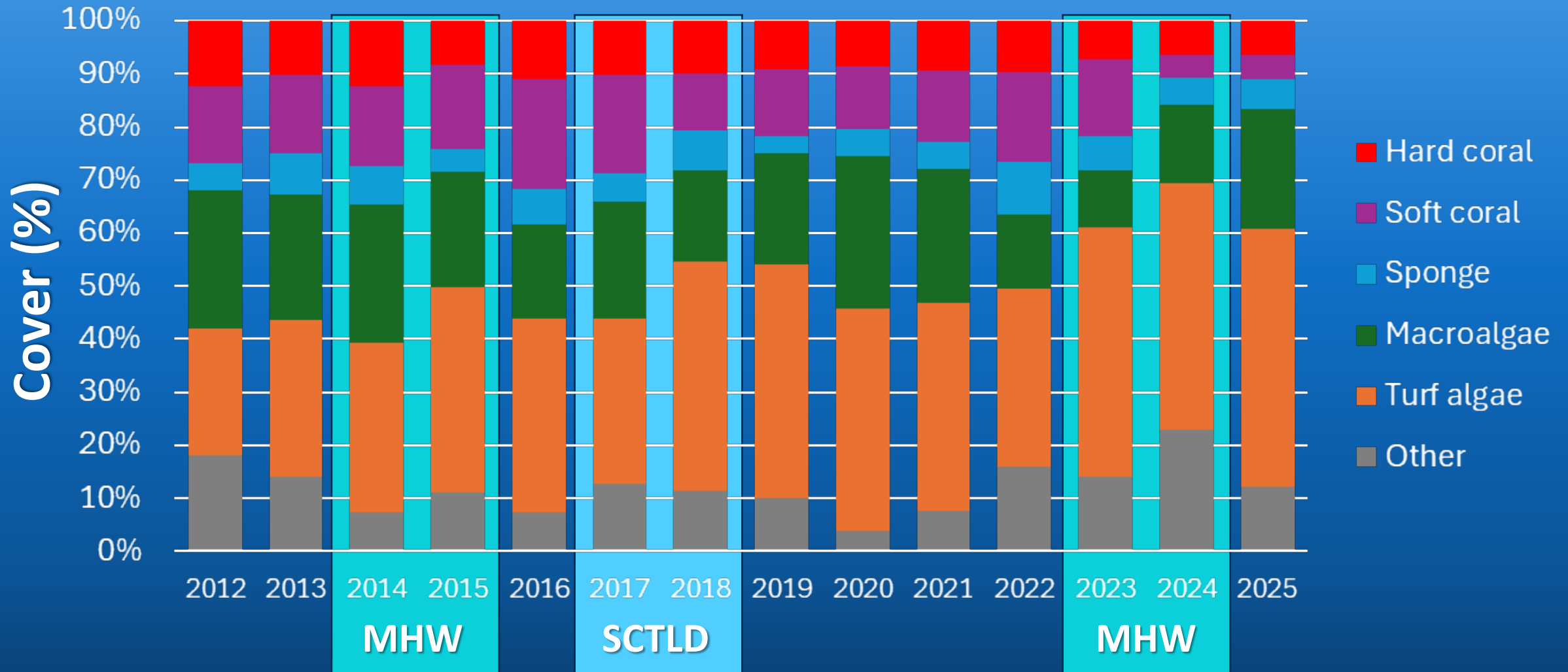
Reef fishes (Biomass)





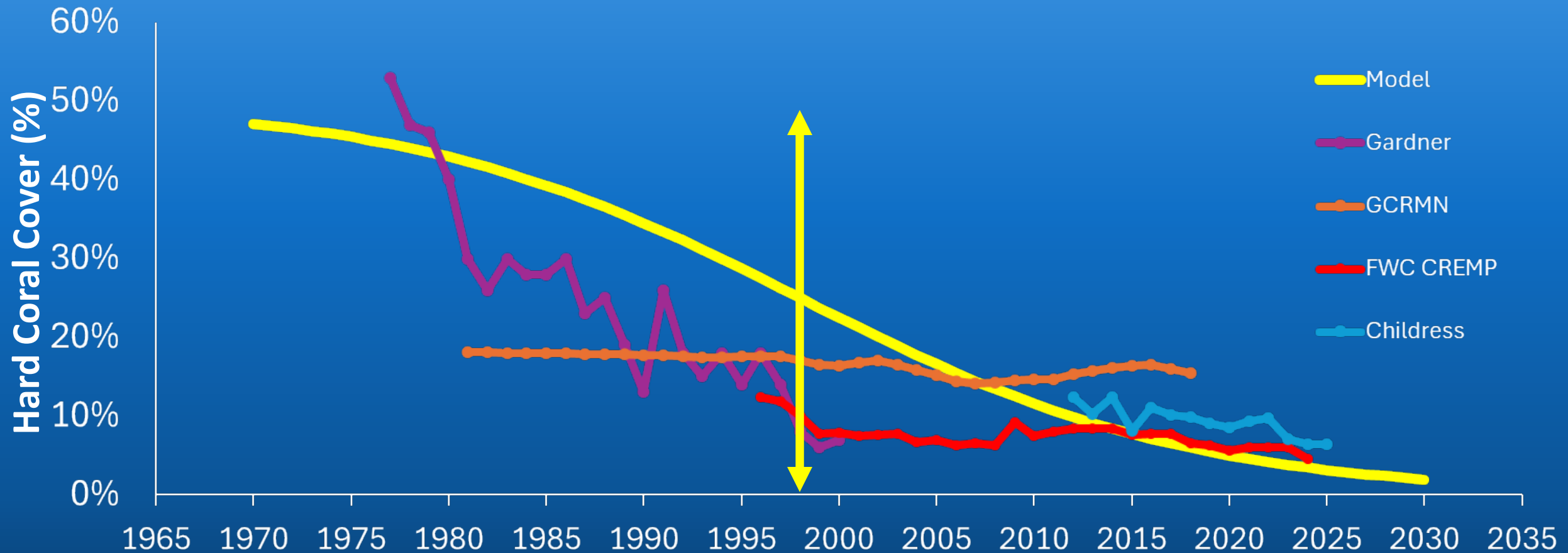


# Previous Response and Recovery





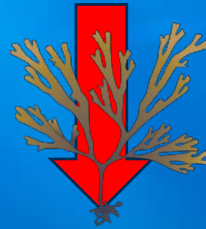
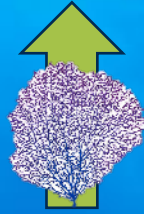
# Why haven't Caribbean coral reefs gone extinct?



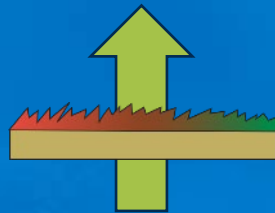
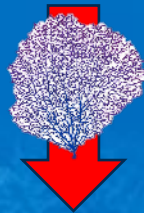
# Summary



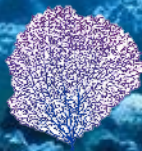
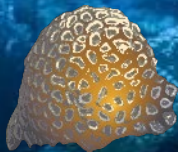
Chronic Heat ( $SSTA_{avg}$ )



Acute Heat ( $DHW_{max}$ )

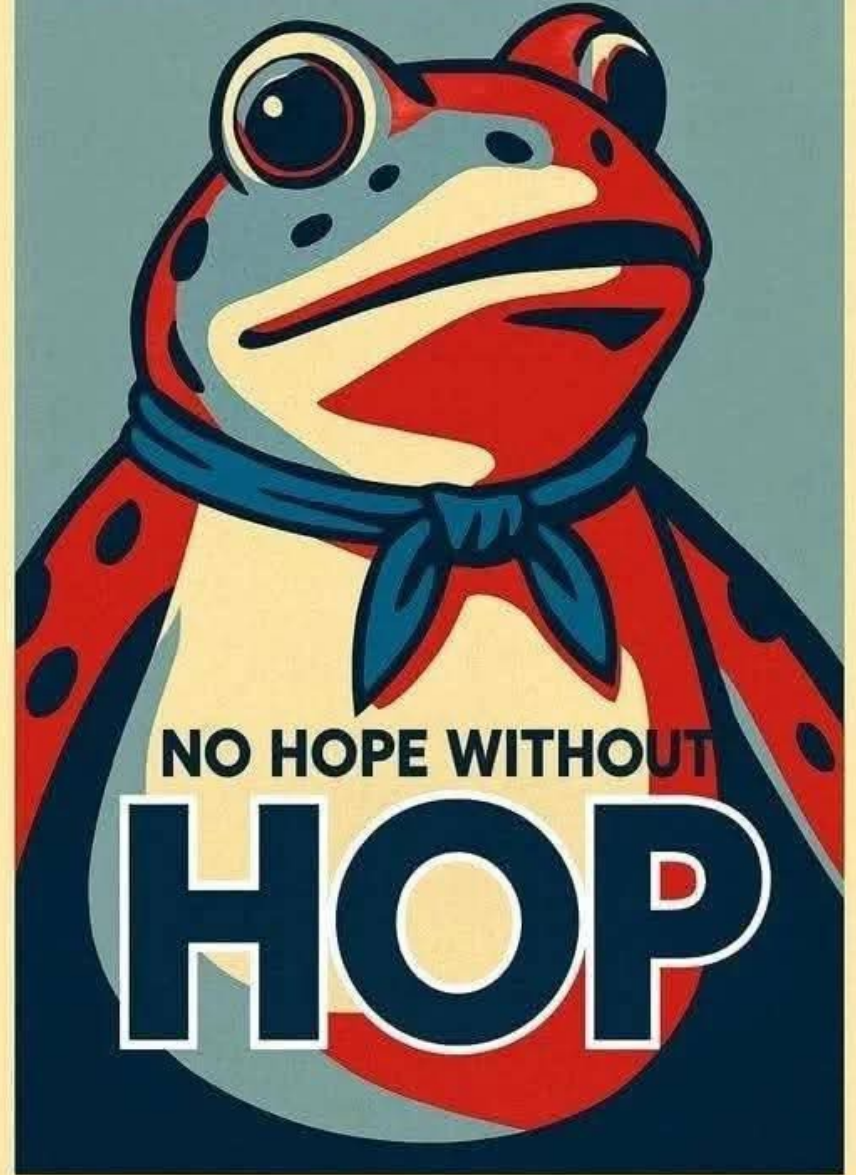


High Resilience



Low Resilience

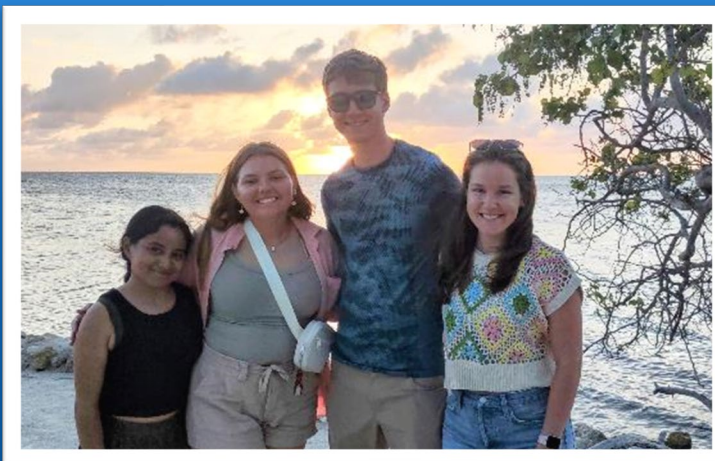
RIBBIT. RESIST. REPEAT.



NO HOPE WITHOUT

**HOP**





NSF-23-47805



FKNMS-17-032

FKNMS-18-119

FKNMS-20-187

FKNMS-22-093



SAL-17-1071

SAL-22-2481

SAL-24-2677

SAL-25-2709



CLEMSON  
CREATIVE  
INQUIRY

#21

#1152

#2595





-2 log likelihood = -484.2  
# parameters = 31  
AICc = -399.6  
AICc weight = 1.000  
BICc = -92.0  
ChiSquare = 18.107  
Df = 23  
P = 0.7516  
CFI = 1.000  
RMSEA = 0.000

