Causes and Consequences of Mass Bleaching in Papahānaumokuākea

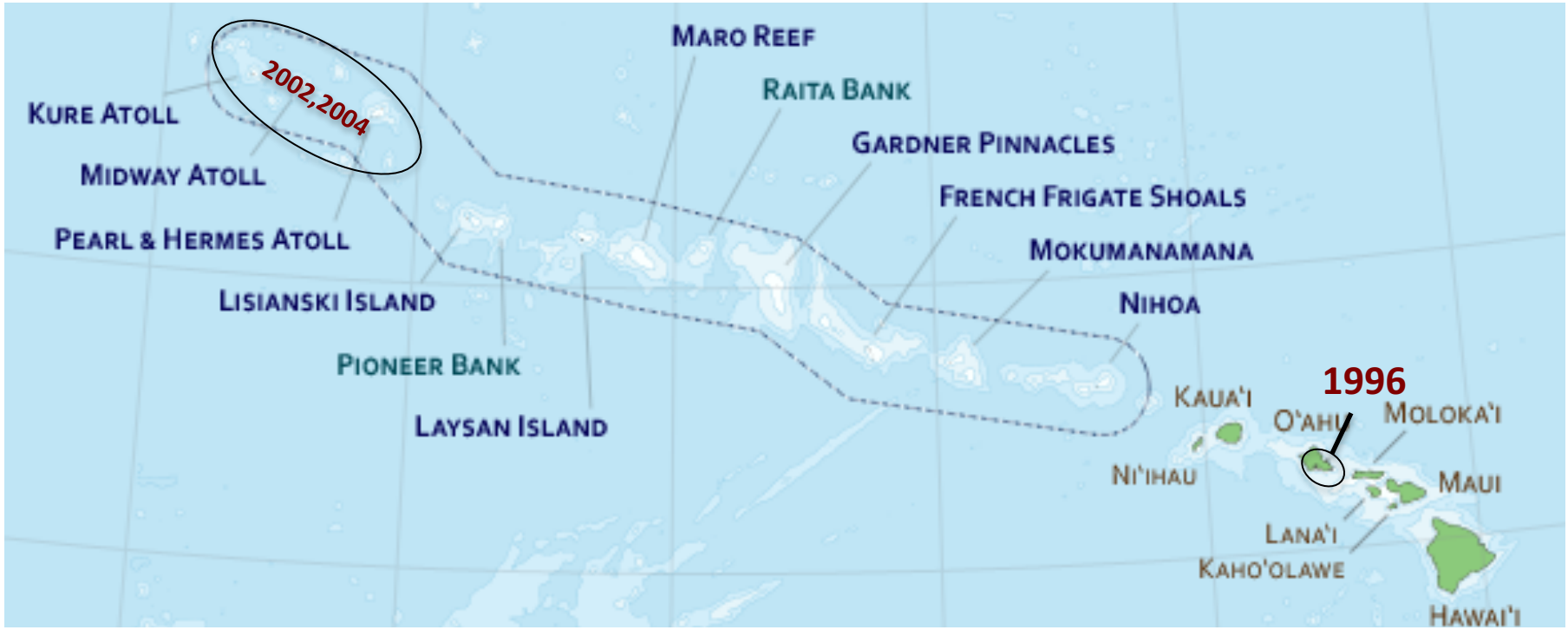
Courtney Couch, **John Burns***, Kanoelani Steward, Tiffany-Nicole Gutlay, Erick Geiger, Mark Eakin, Randall Kosaki

Hawaii Institute of Marine Biology
University of Hawaii at Hilo
NOAA Coral Reef Watch Program
NOAA Papahānaumokuākea

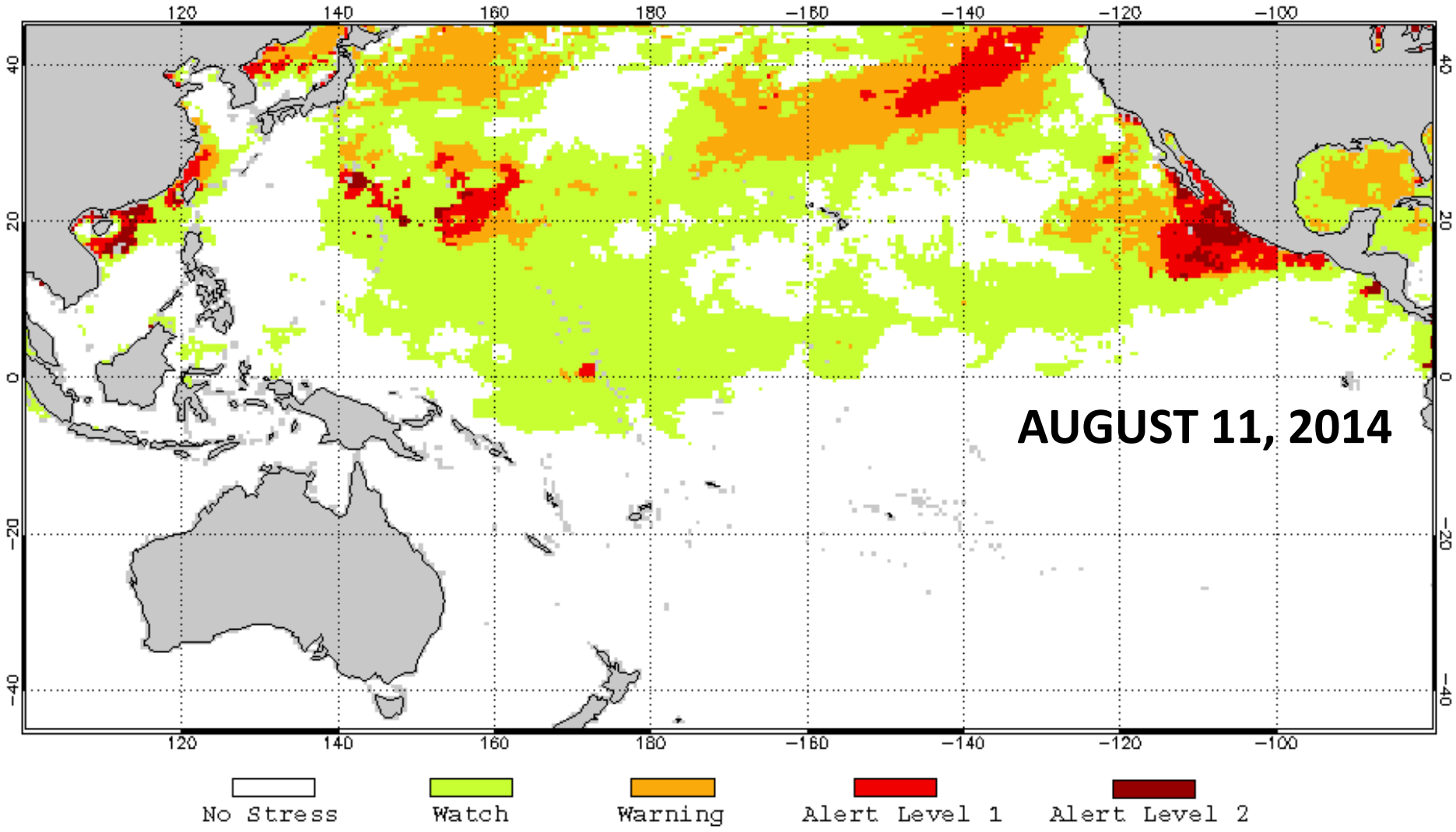
PAPAHĀNAUMOKUĀKEA
Marine National Monument

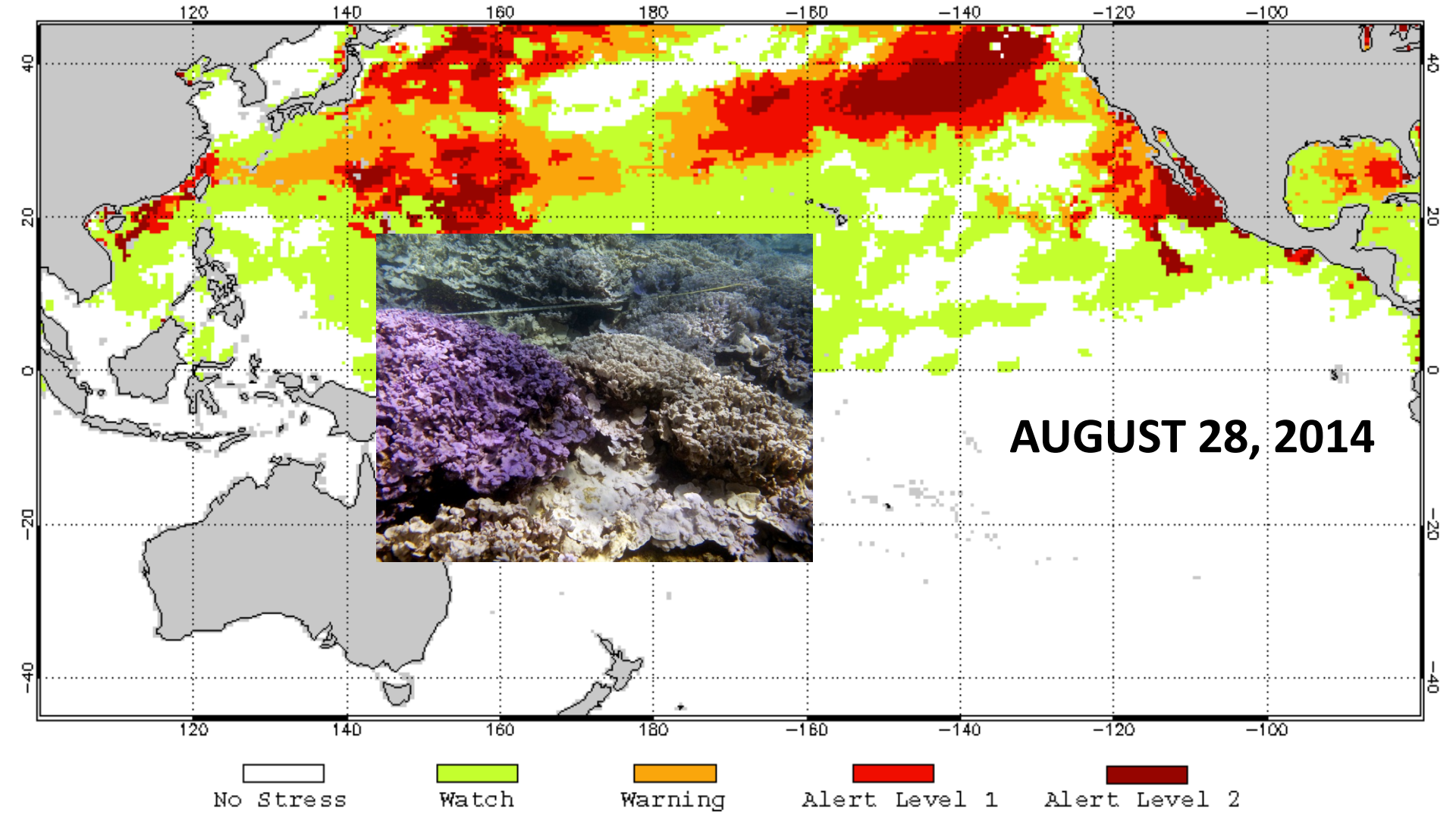
Coral Reef Watch

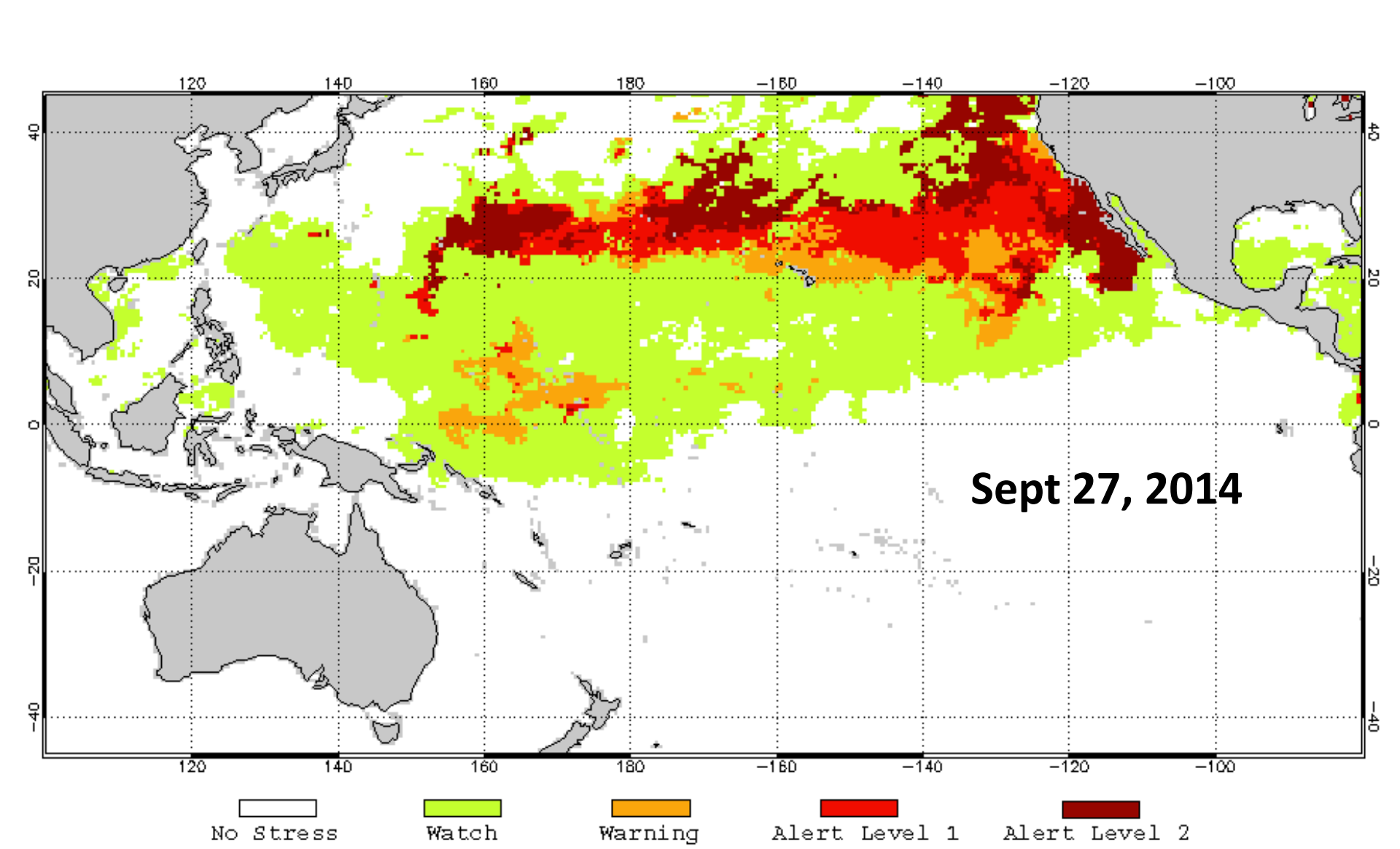
History of Mass Bleaching in Hawaiʻi

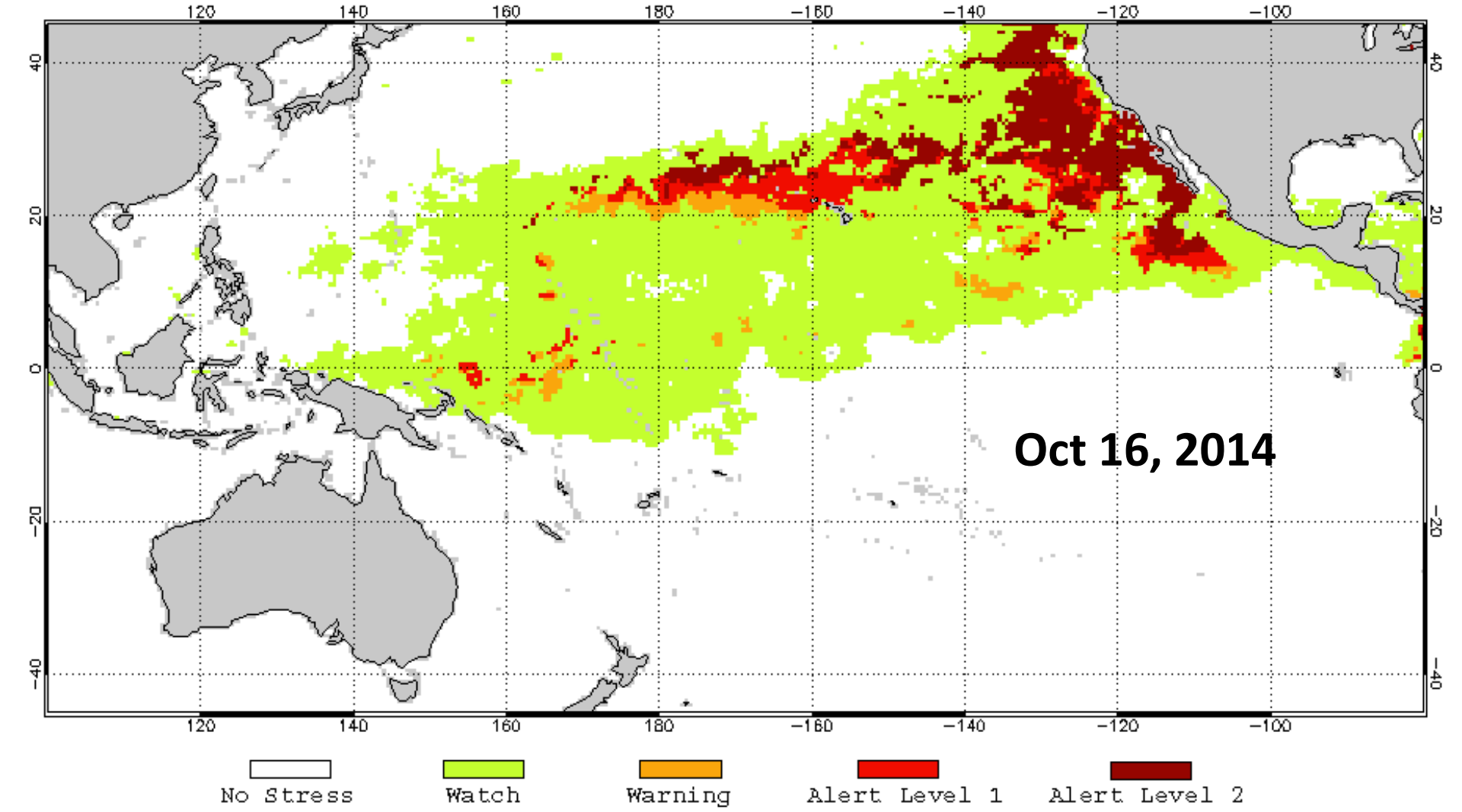


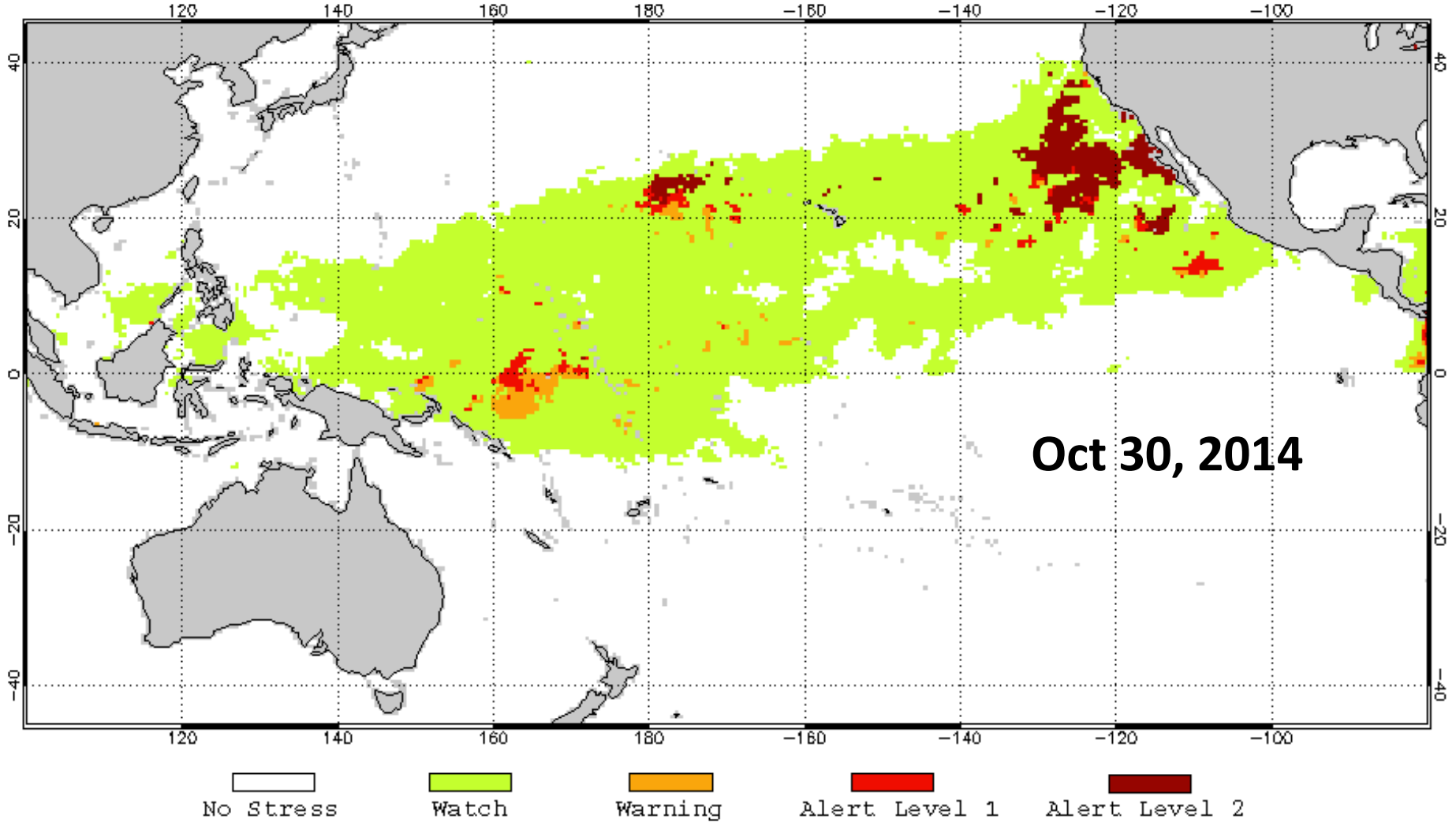
- **1996 Mass Bleaching in Kāneʻohe Bay, Oʻahu** (Jokiel and Brown 2004)
- **2002, 2004 PMNM**(Aeby et al. 2003, Kenyon and Brainard 2006)
  - **Prolonged thermal stress and UV**
  - **2002 more severe; primarily affected *Montipora* in western atolls**
- **2014 & 2015: Hawaii's first back-to-back bleaching event.**

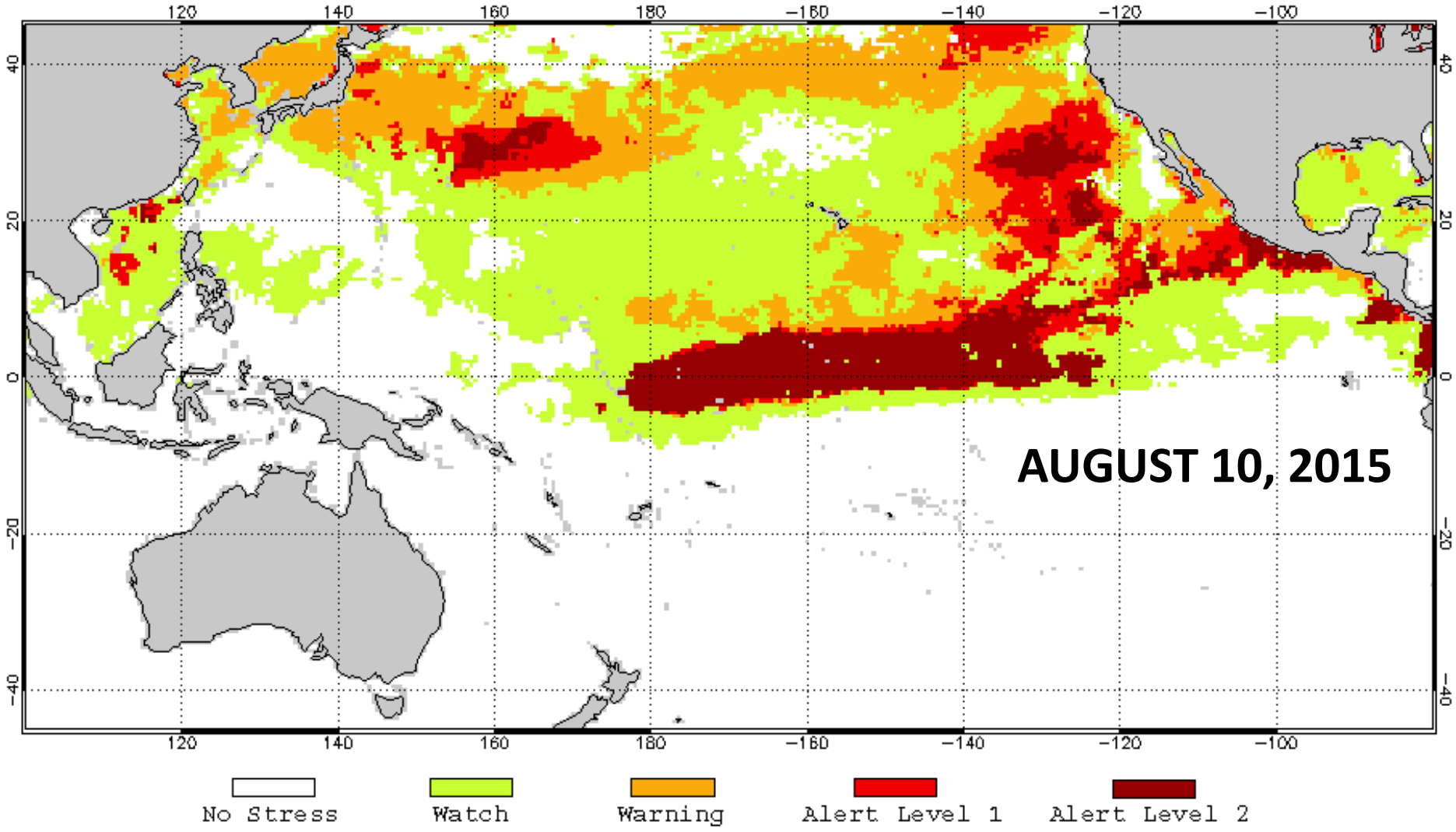

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
AUGUST 11, 2014
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

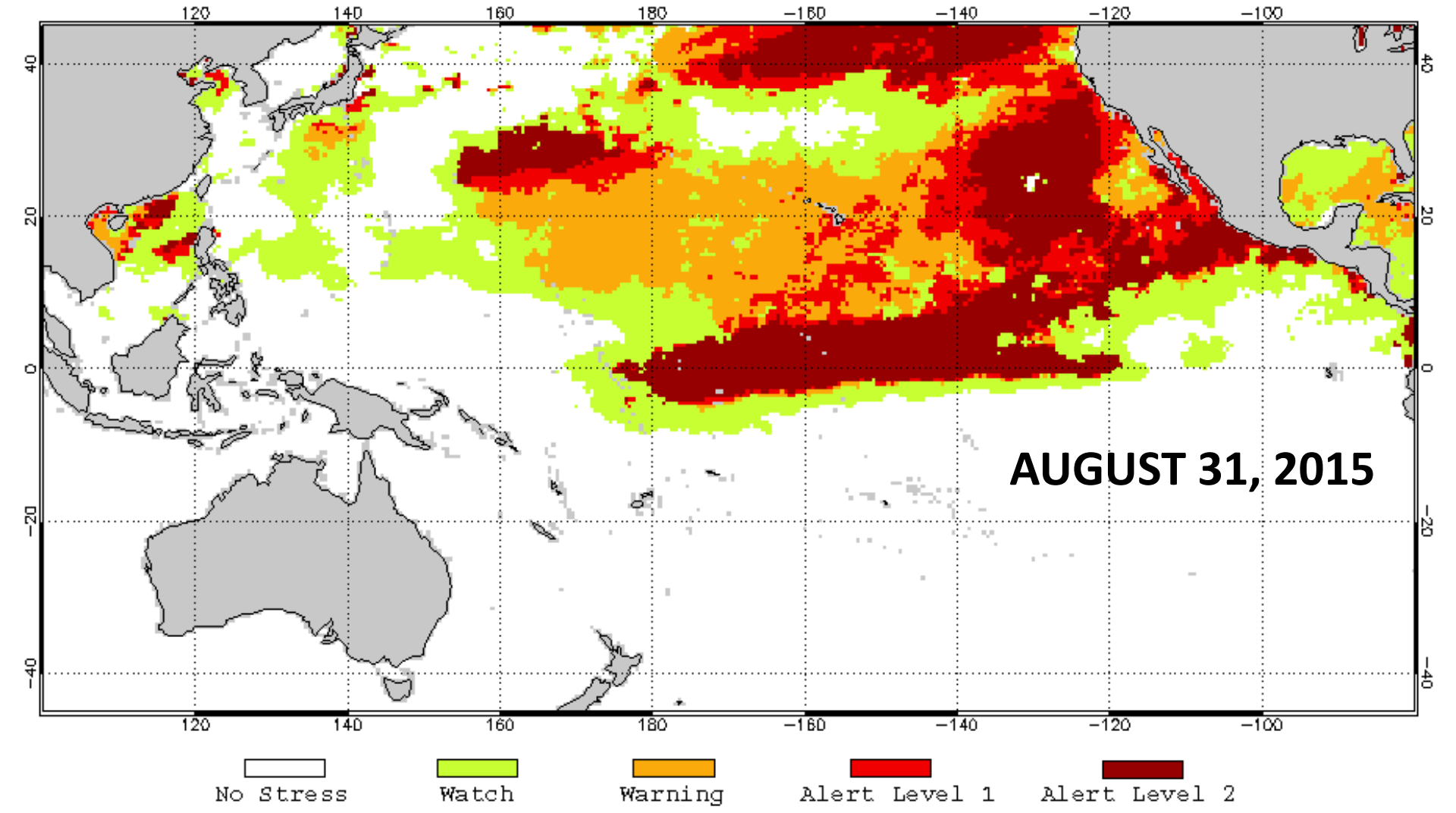

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
AUGUST 28, 2014
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

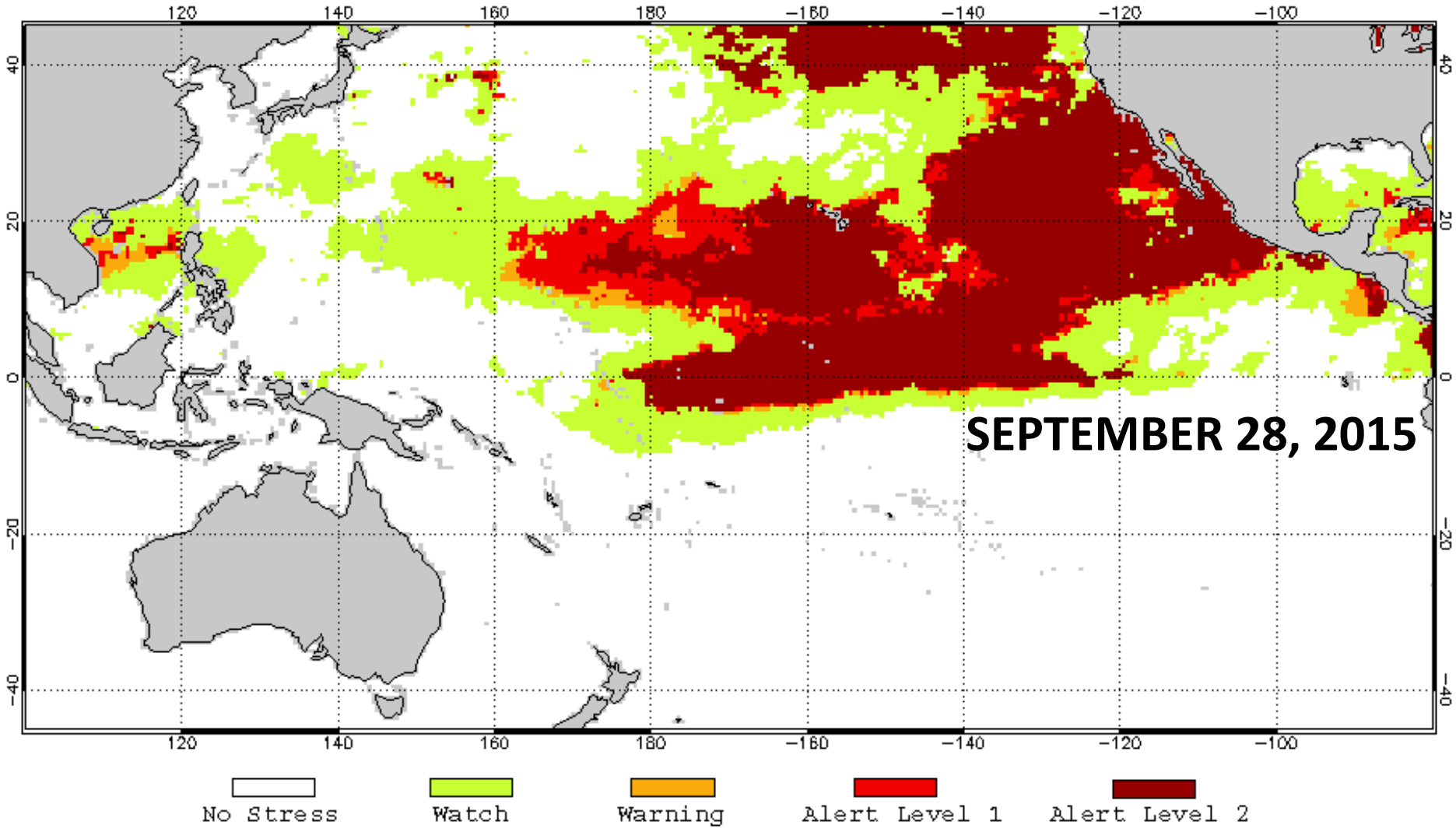

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
Sept 27, 2014
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

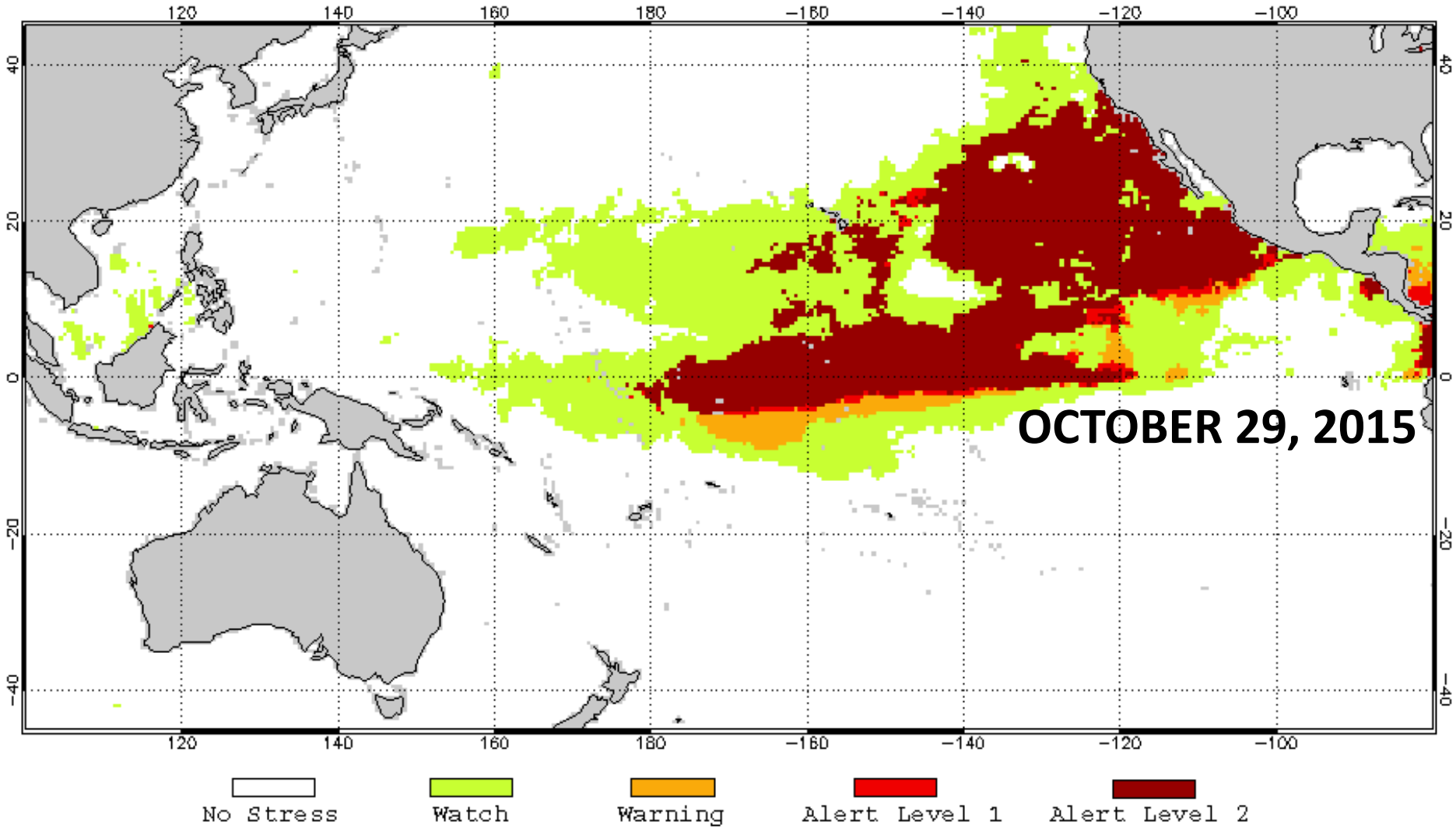

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
Oct 16, 2014
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

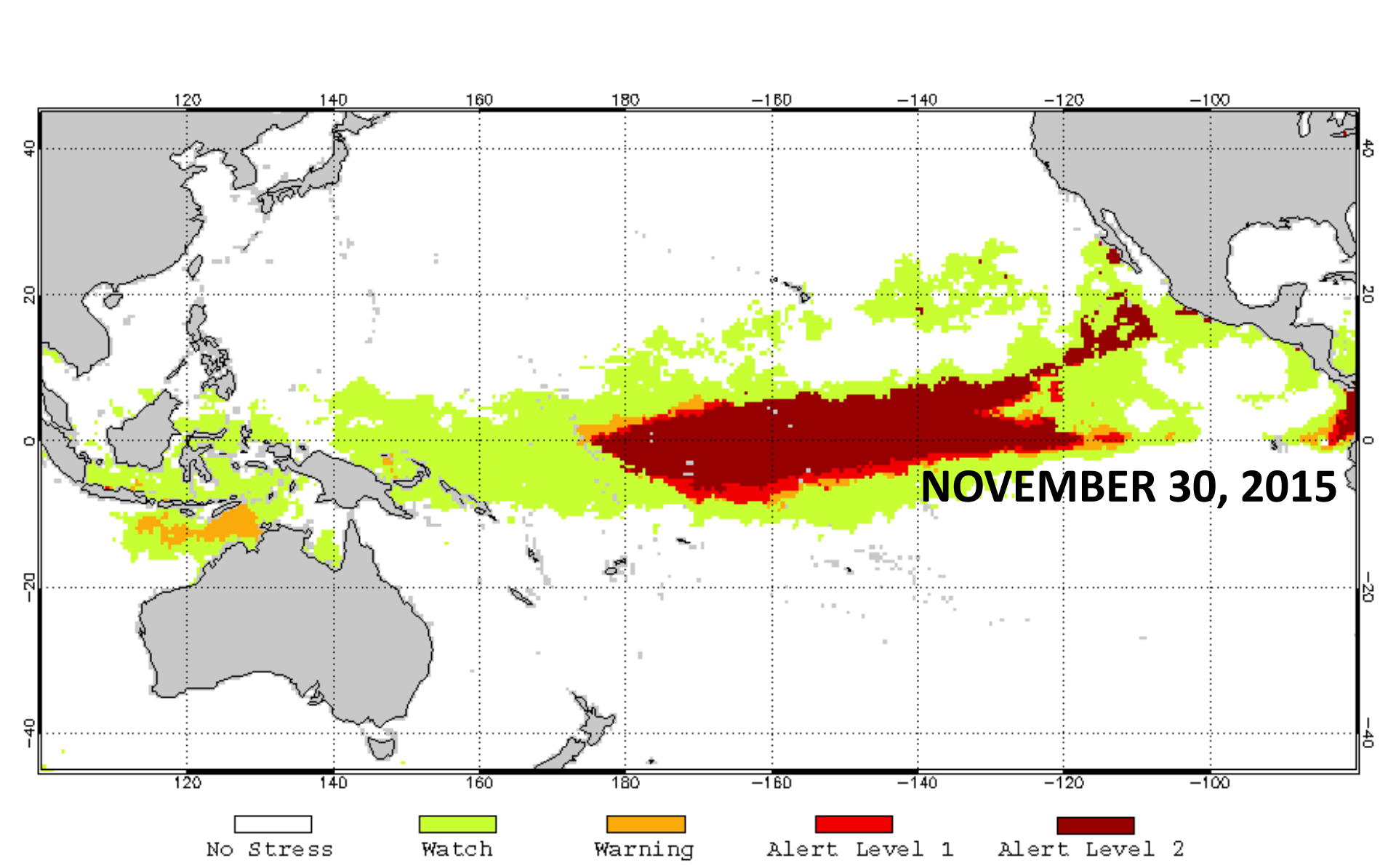

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
Oct 30, 2014
No Stress
Watch
Warning
Alert Level 1
Alert Level 2


120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
AUGUST 10, 2015
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

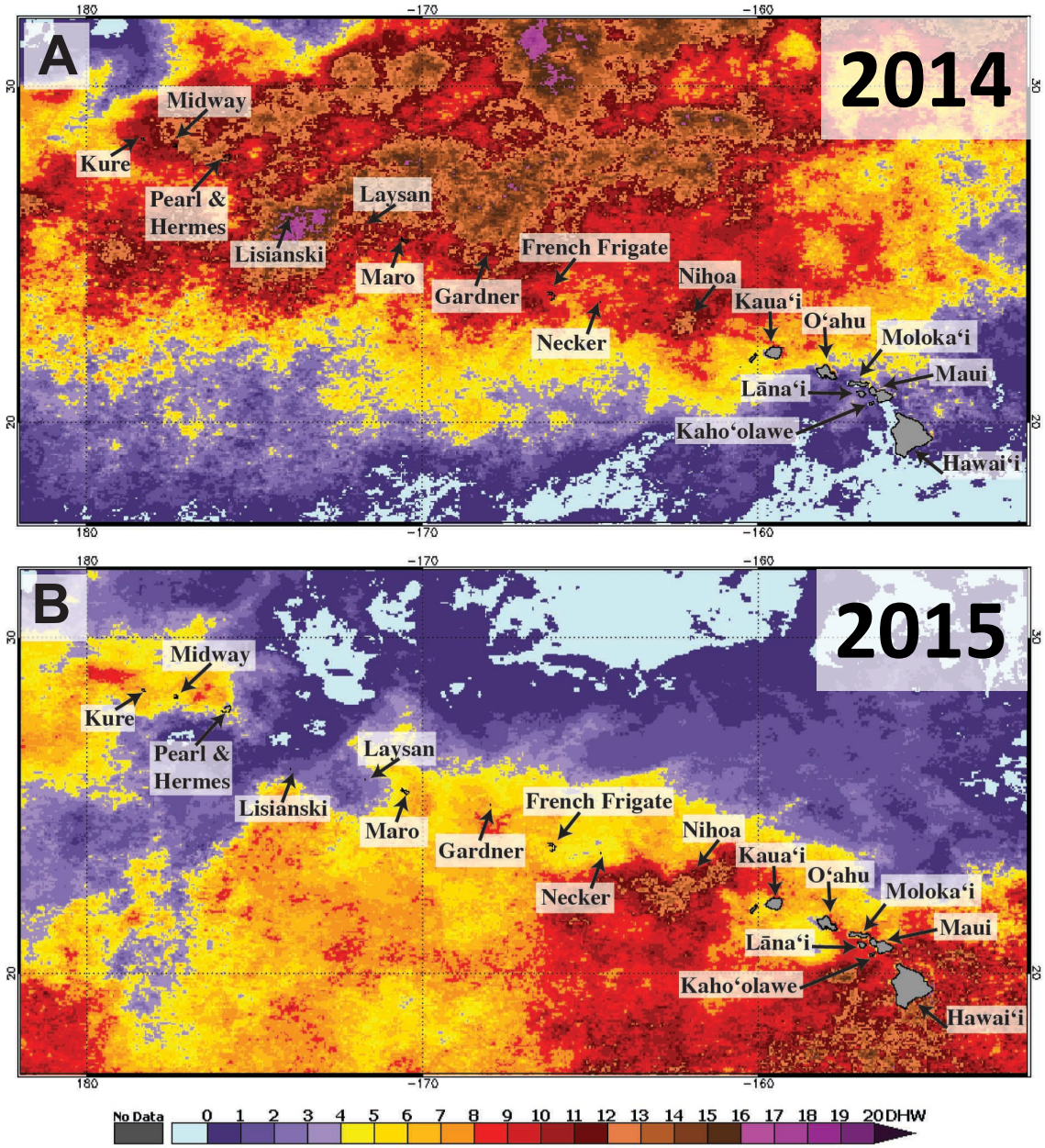

120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
AUGUST 31, 2015
No Stress
Watch
Warning
Alert Level 1
Alert Level 2


120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
SEPTEMBER 28, 2015
No Stress
Watch
Warning
Alert Level 1
Alert Level 2


120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
OCTOBER 29, 2015
No Stress
Watch
Warning
Alert Level 1
Alert Level 2


120
140
160
180
−160
−140
−120
−100
40
20
0
−20
−40
NOVEMBER 30, 2015
No Stress
Watch
Warning
Alert Level 1
Alert Level 2

Maximum Degree Heating Weeks



Couch et al. in prep

Objectives

1. Assess the extent and severity of bleaching event across islands/atolls, habitats and species.

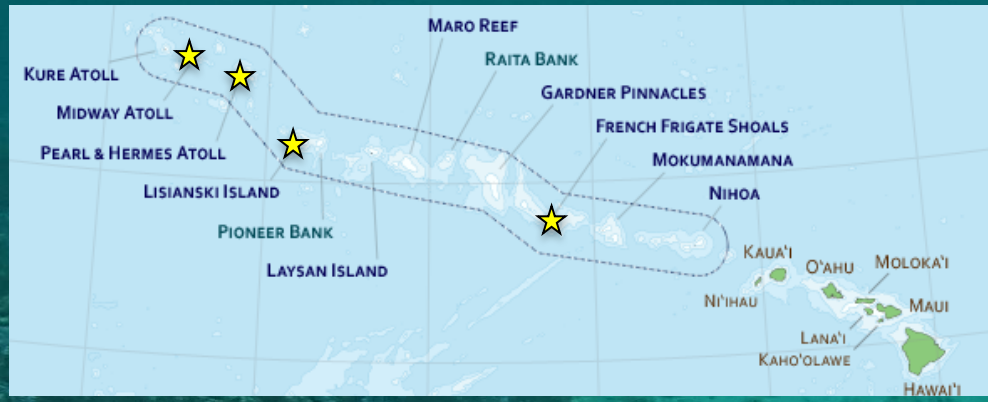
2. Determine how well remotely-sensed thermal stress metrics predicted bleaching levels.

3. Assess the potential long-term consequences on the composition and 3D structure of PMNM coral communities.

Methods

1. Extent and Severity of Bleaching

- **<u>4-8 sites</u> permanent transects** at French Frigate Shoals, Lisianski Island, Pearl and Hermes Atoll, Midway Atoll



- **<u>Habitats:</u>** Forereef, Backreef (shallow: 1-7m; moderate: 8-15m)
- Conducted 3, 10x1-m belt transects
- **Recorded:** species, lesion type and severity of condition.
- **Bleaching Incidence** = % of colonies that were >50% bleached.
- **Survey conducted in**: September 2014 and August 2015.

Methods

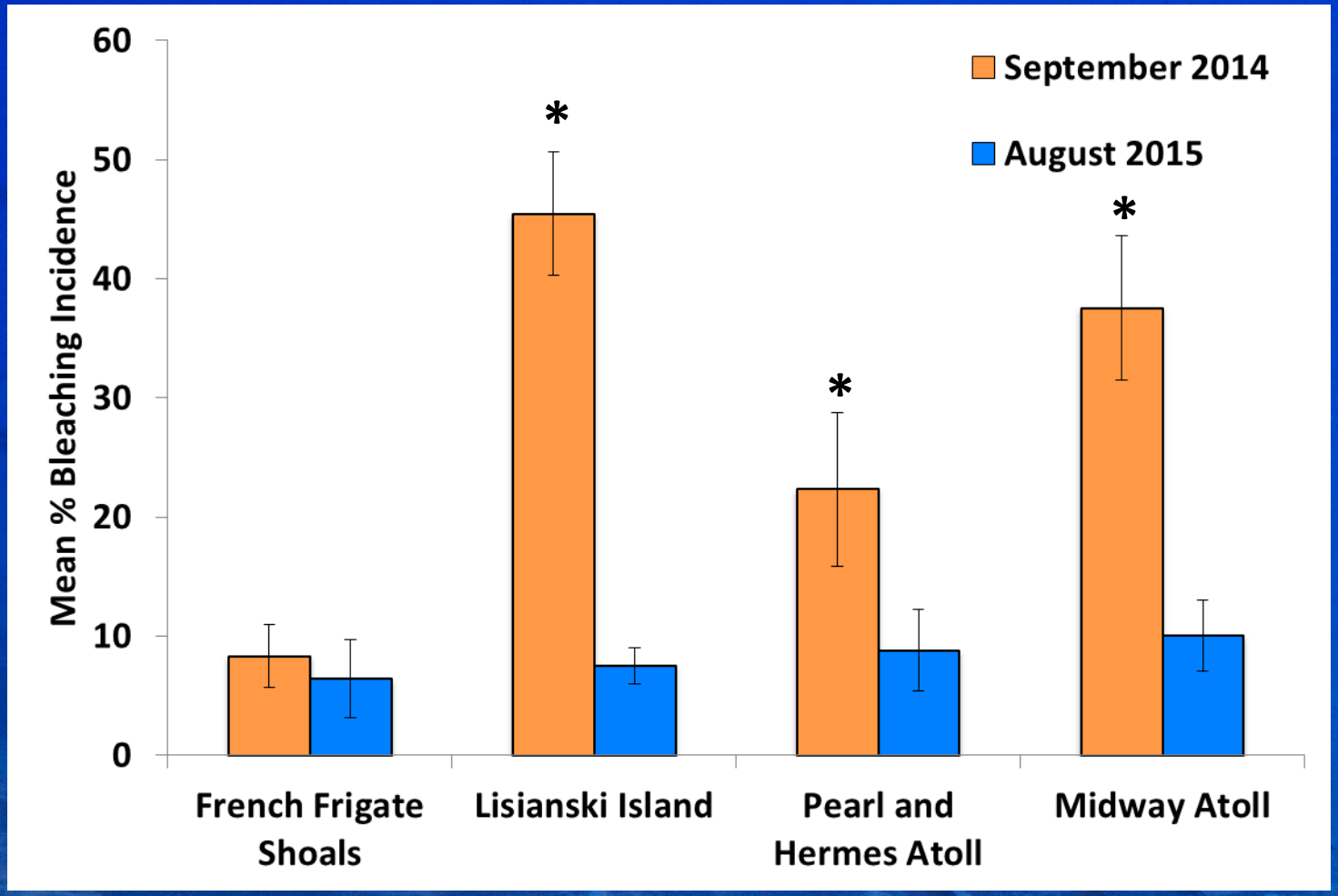
2. Thermal Stress Metrics:

- NOAA Coral Reef Watch Program's 5km night-only degree heating week for each study site at the time of survey.

3. Coral Cover and 3D Structure:

- Photo quads and CPCe along each transect to assess changes in % coral cover and benthic community structure.
- Structure-from-motion photogrammetry and geospatial software used to quantify 3D changes in habitat complexity

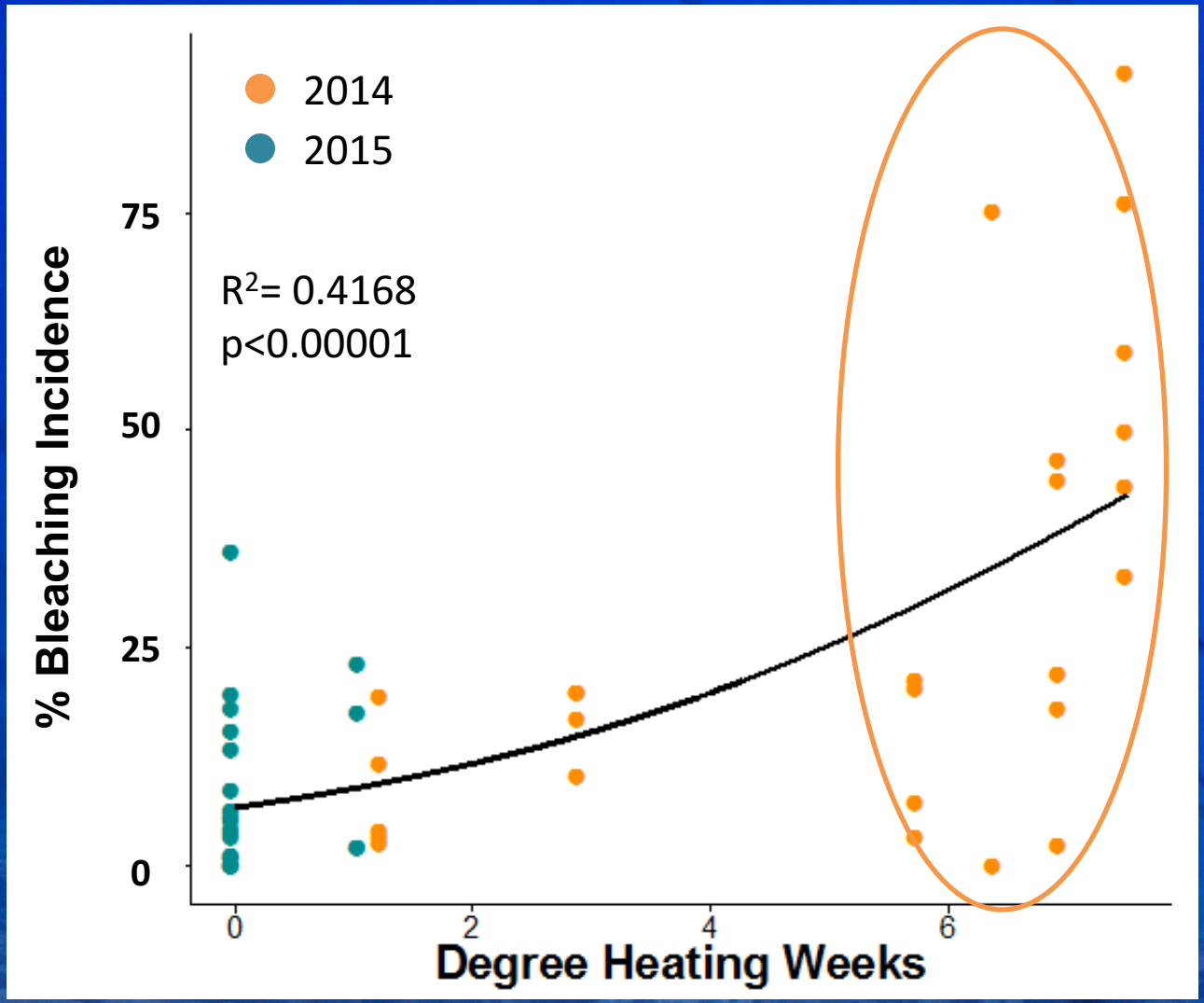
Bleaching Patterns by Atoll/Island



binomial generalized linear model with tukey HSD post hoc test

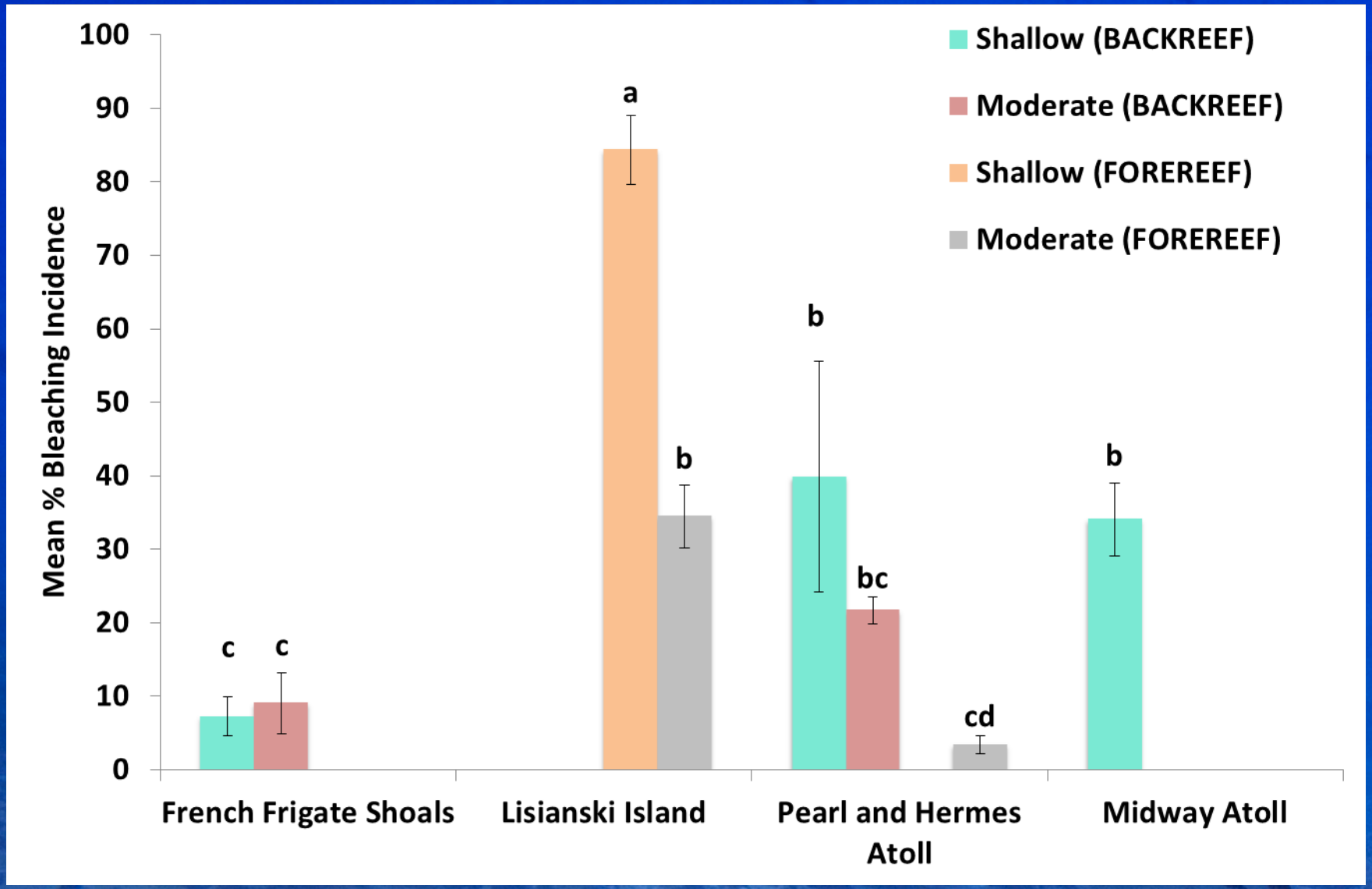
Couch et al. in prep

Did Thermal Stress Predict Bleaching?



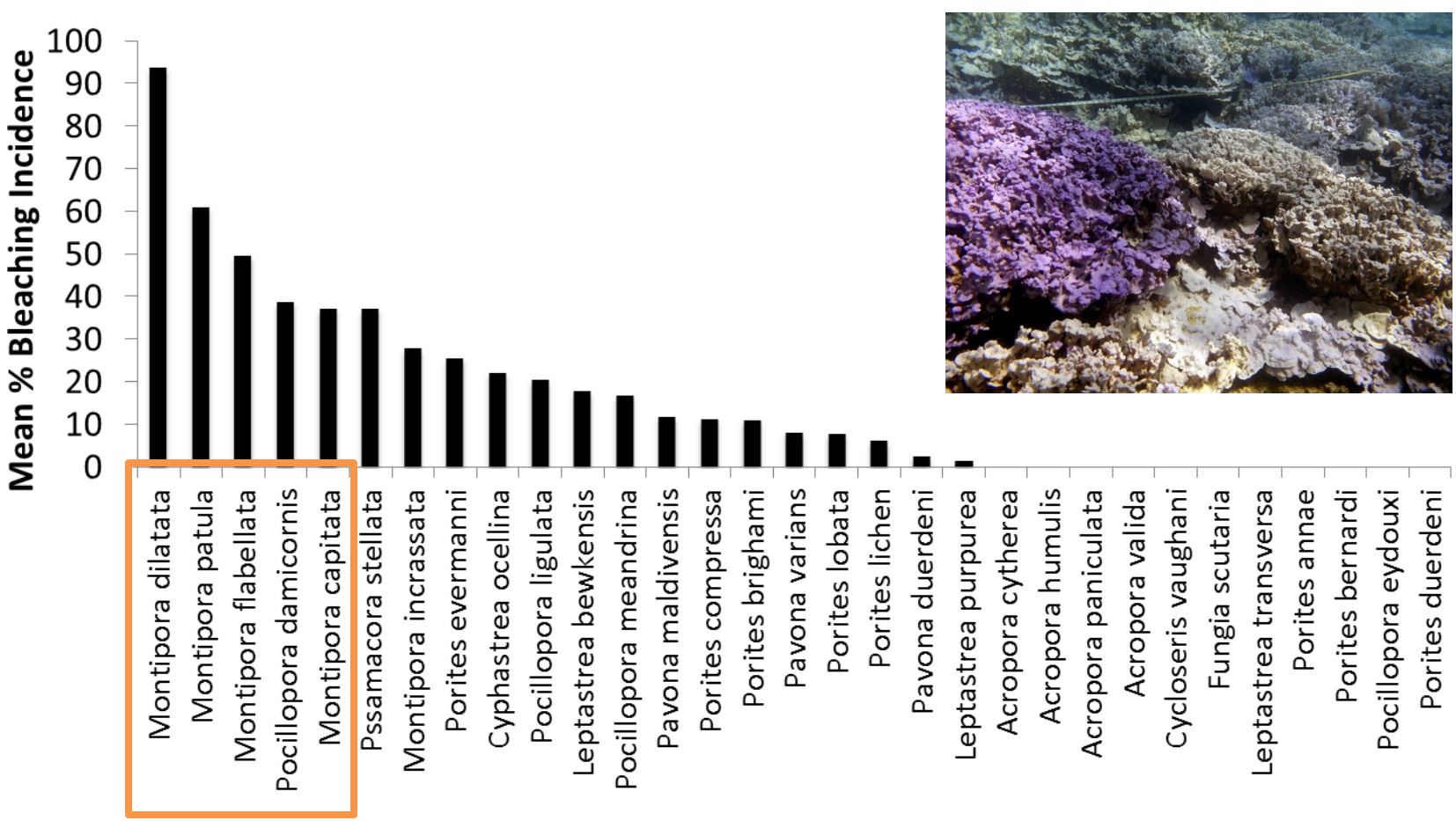
Couch et al. in prep

How Does Bleaching Vary Across Habitats?



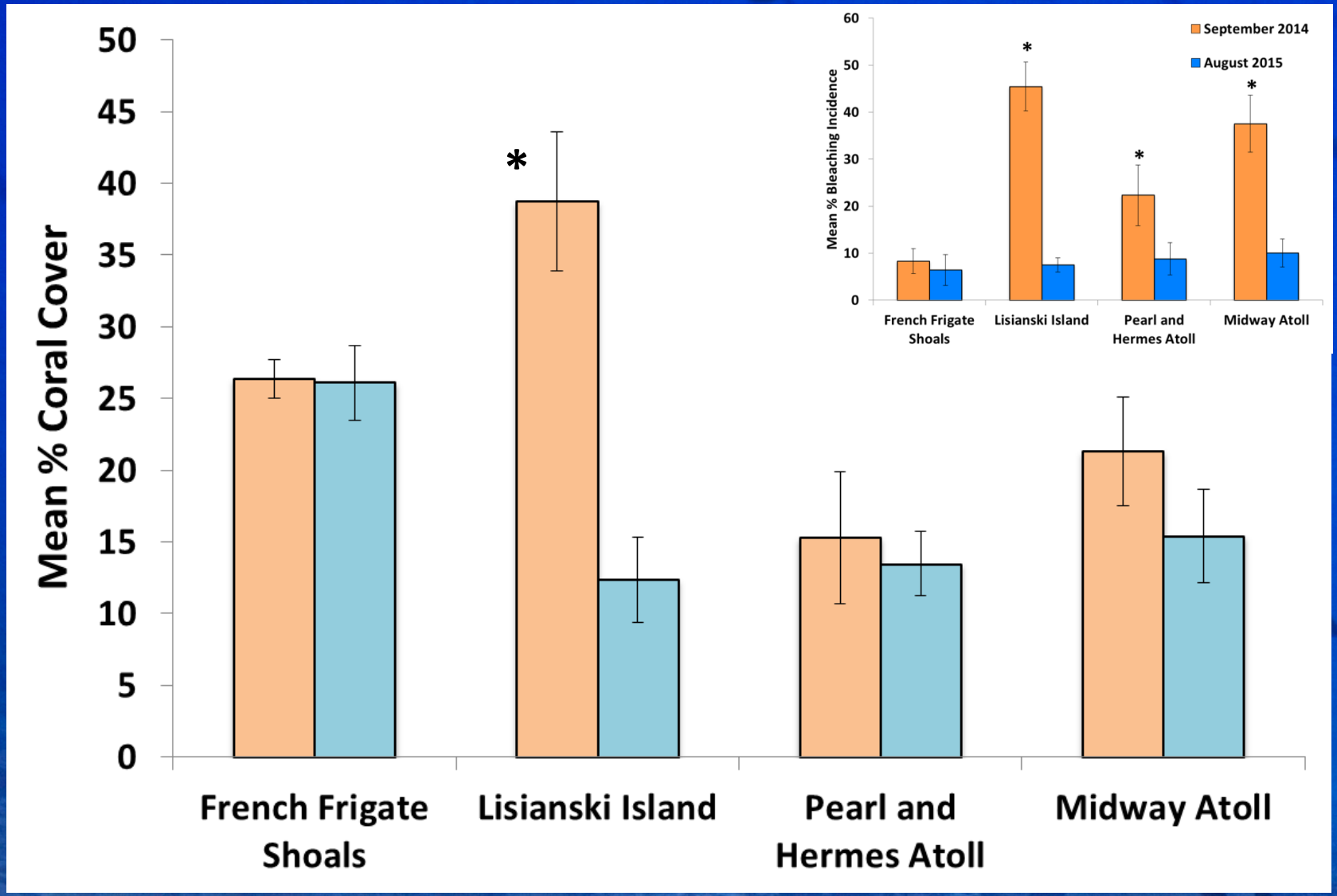
Couch et al. in prep

How Did Corals Vary in their Bleaching Susceptibility?



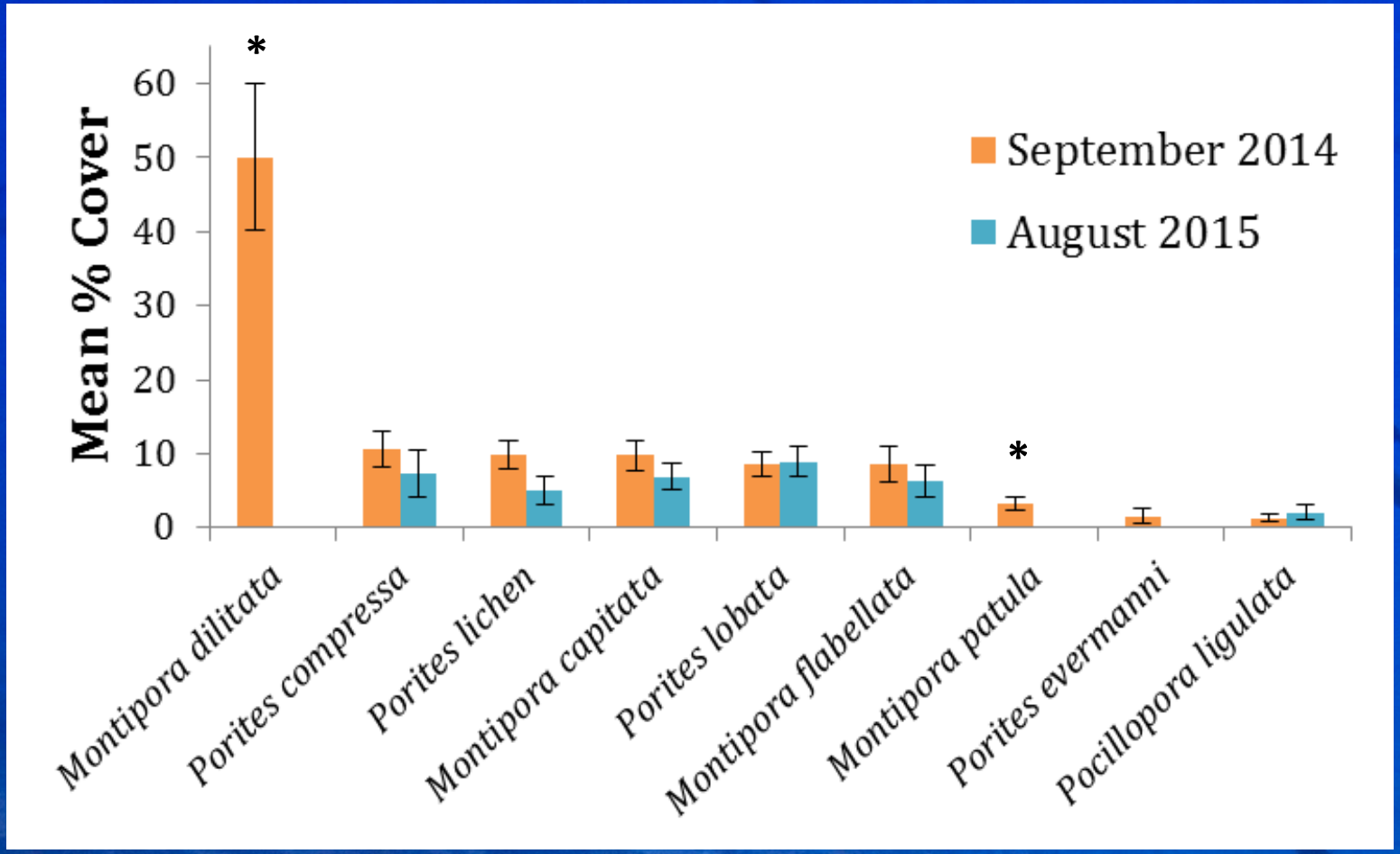
Couch et al. in prep

How Did Coral Cover Change after the Bleaching Event?



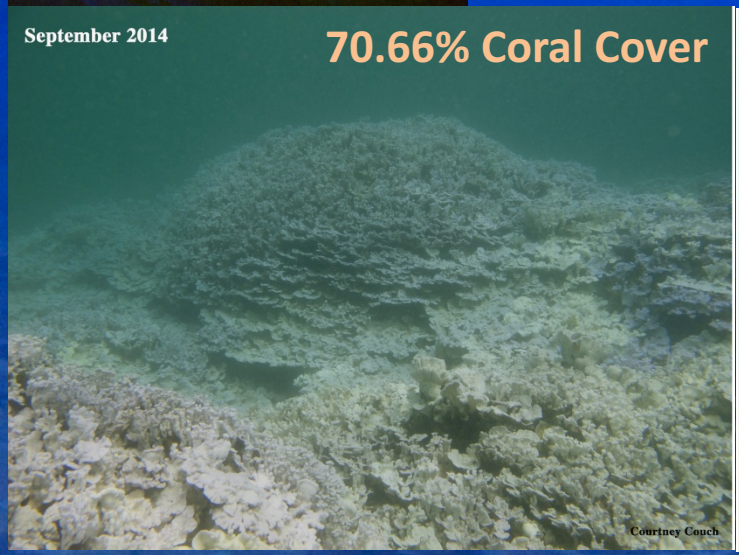
Couch et al. in prep

Coral Cover Change by Species

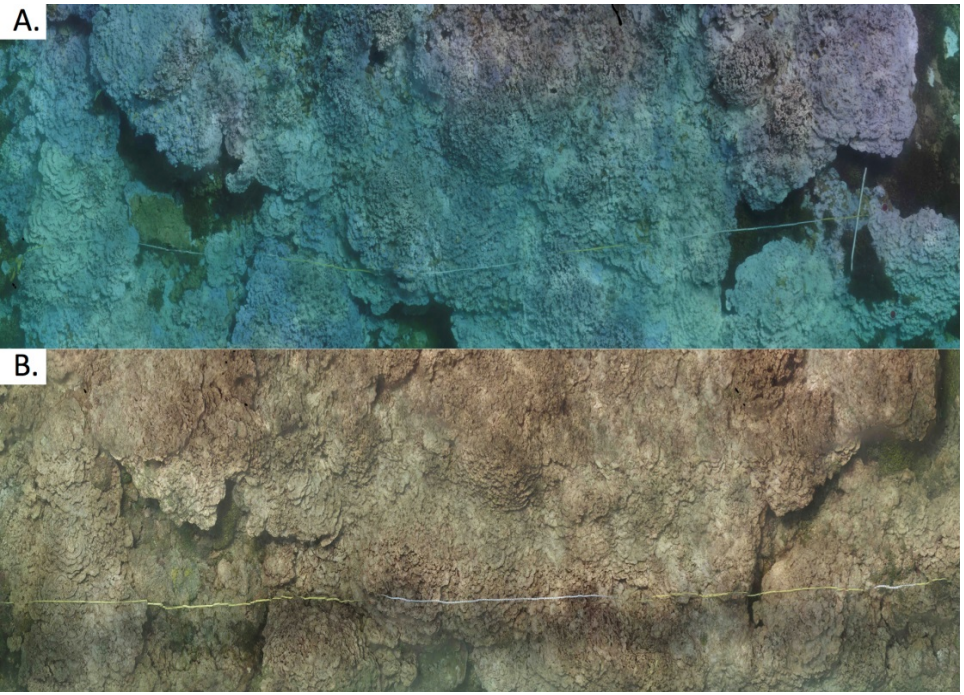


Couch et al. in prep

How Did Coral Cover Change after the Bleaching Event?

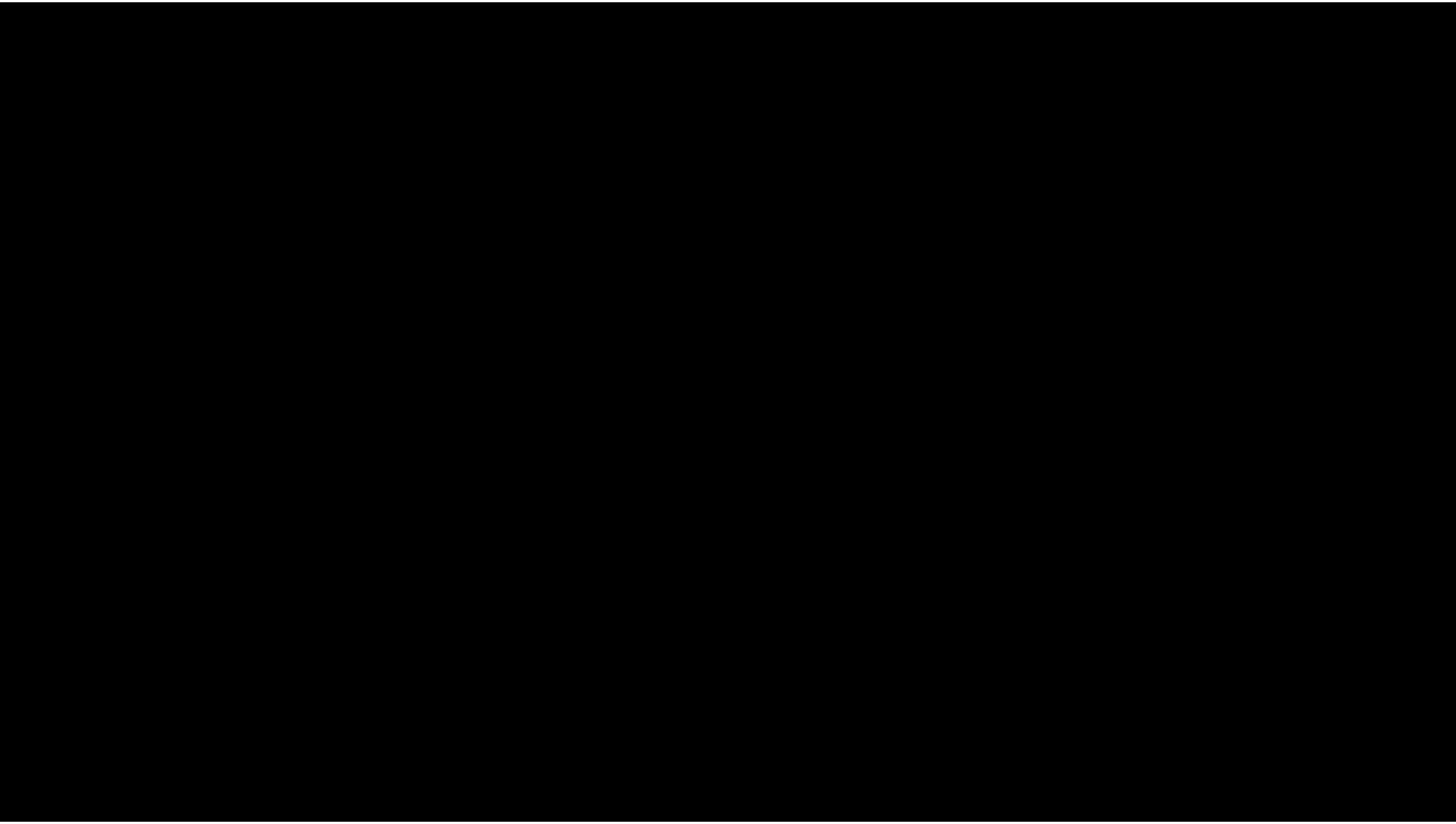


3D analysis of reef structure and composition

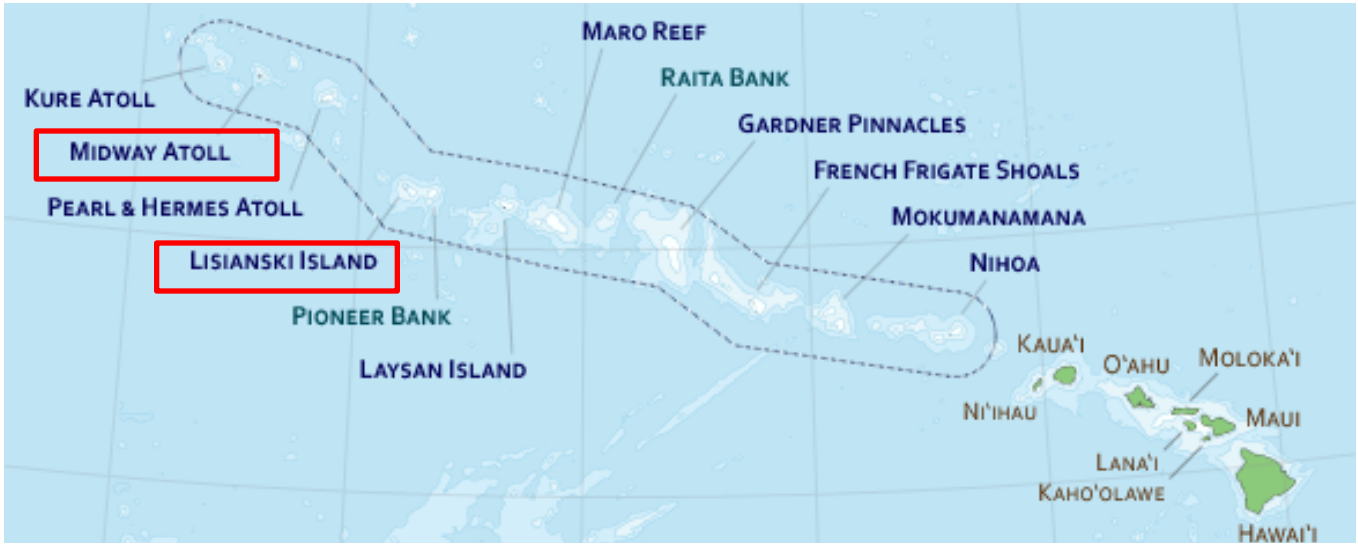


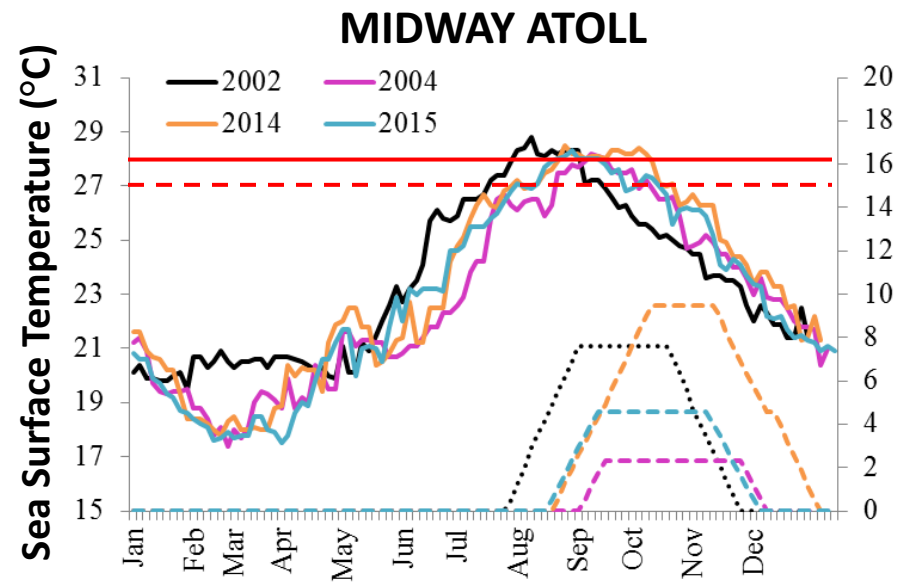
3D analysis of reef structure and composition

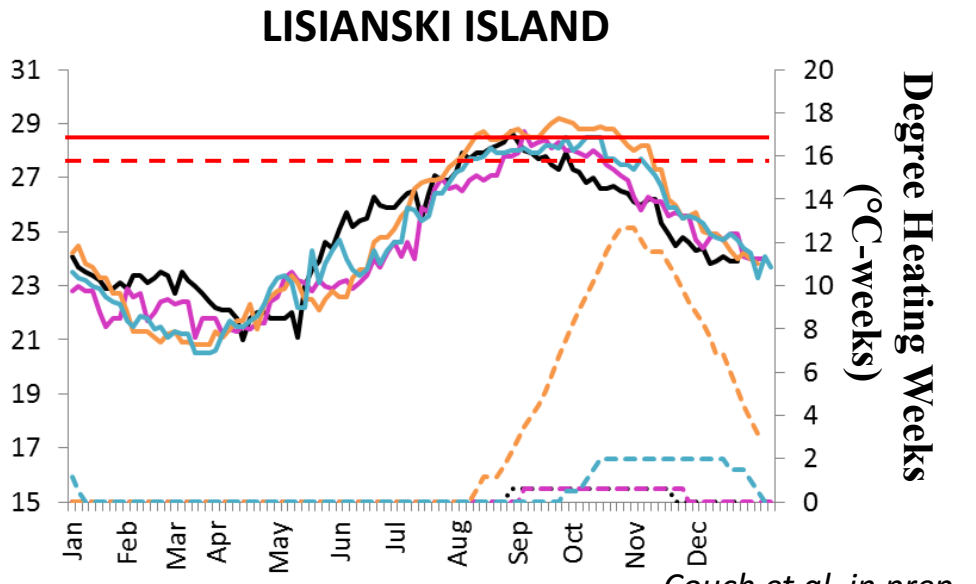
3D analysis of reef structure and composition



How did Thermal Stress Compare to Previous Events?

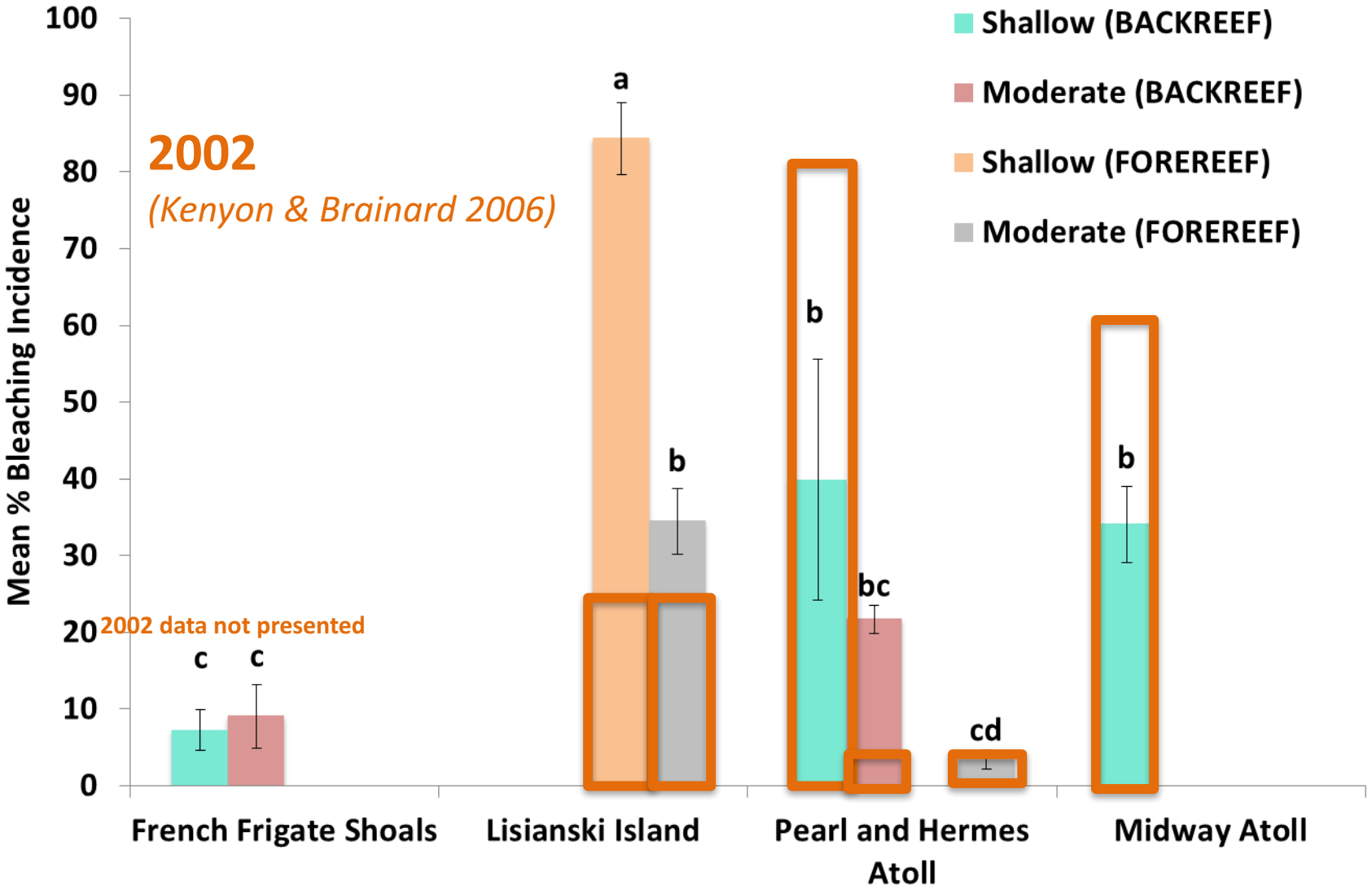






Couch et al. in prep

How did Bleaching Compare to 2002?



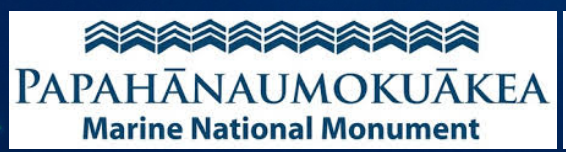
Couch et al. in prep

Conclusions

- In 2014, PMNM experienced the 3rd and most severe mass bleaching.
- The 2014 and 2015 thermal stress events vastly different.
- Lisianski Island experienced the highest thermal stress with 45% of colonies bleached by September 2014.
- Highest bleaching in sheltered shallow habitats dominated by *Montipora*.
- Coral loss was associated with reductions in both habitat complexity .
- MID experienced higher thermal stress in 2014 compared to 2002, but lower bleaching and promising recovery, which highlights importance of bleaching history and possible potential for local acclimation.
- Study highlights need for continued monitoring of bleaching risk, long-term ecosystem impacts and to identify factors important for resilience.

Mahalo!

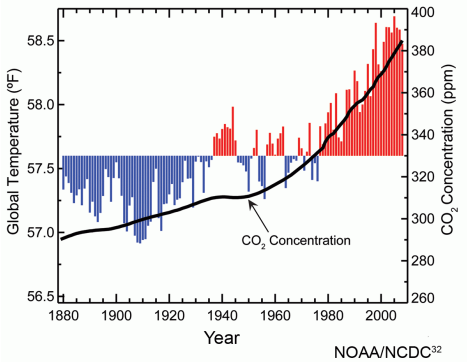
- Field Support
  - Crew of the Hi‘ialakai
- Ruth Gates
- Scott Godwin
- Donahue Lab
- Funding:
  - NOAA/Papahānaumokuākea

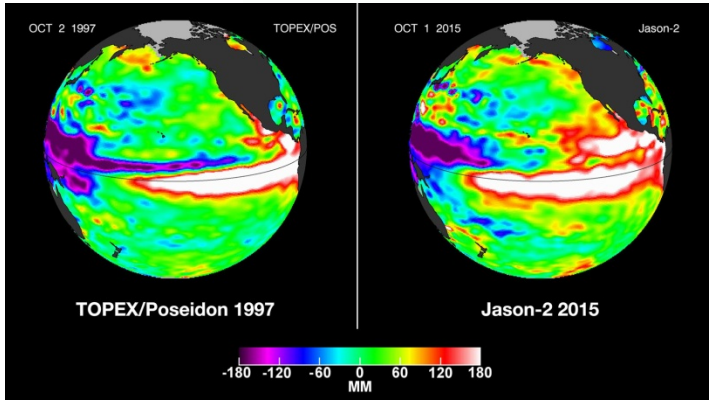


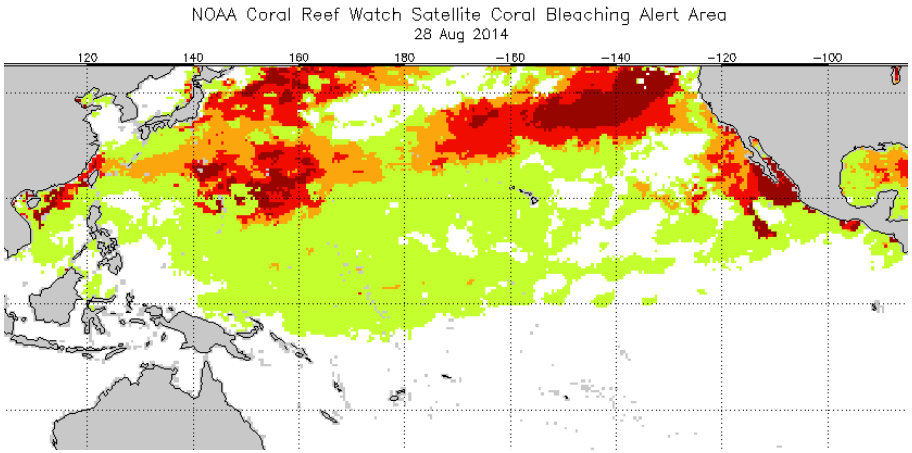
Extra slides

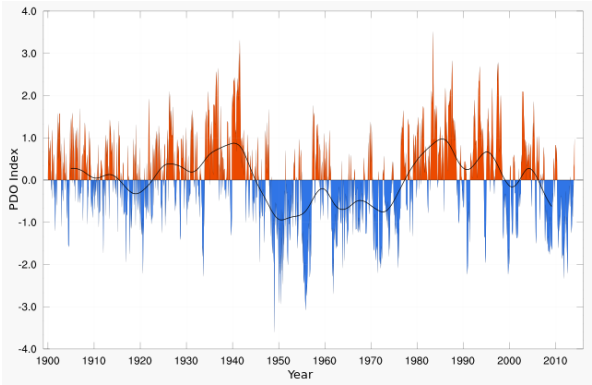
What Climatic Processes are Driving Mass Bleaching in Hawaii?

- Climate change
- El Niño
- Pacific Decadal Oscillation
- “The Blob”

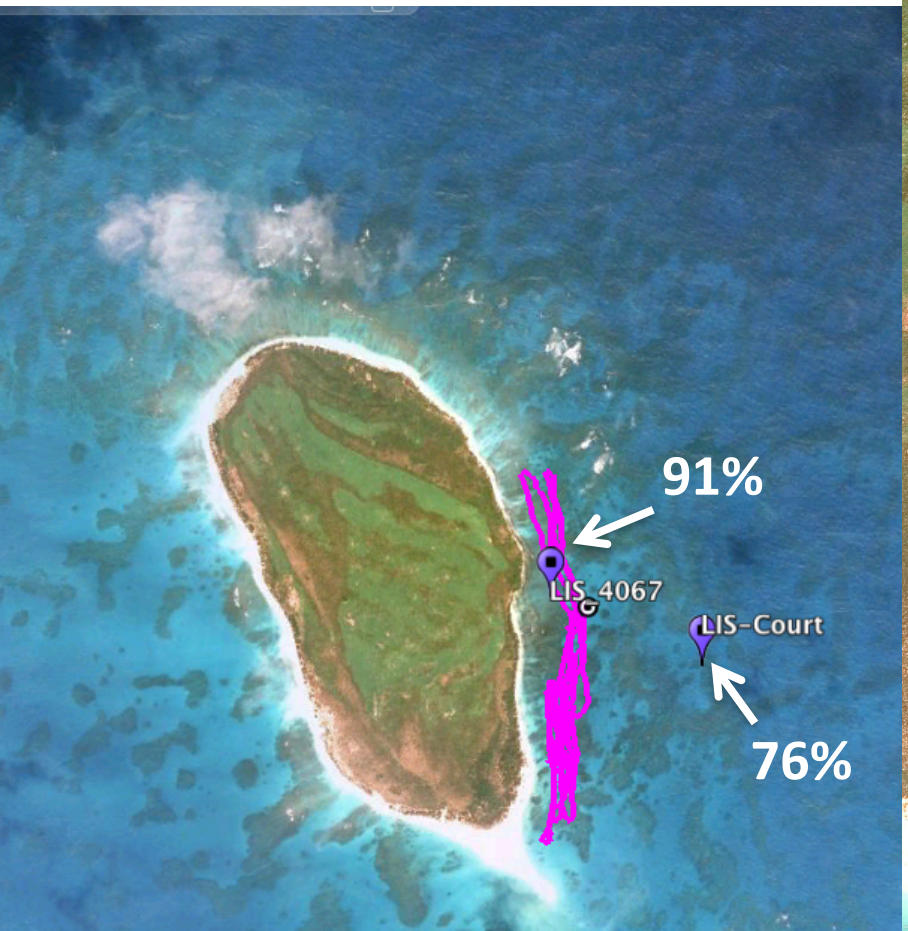


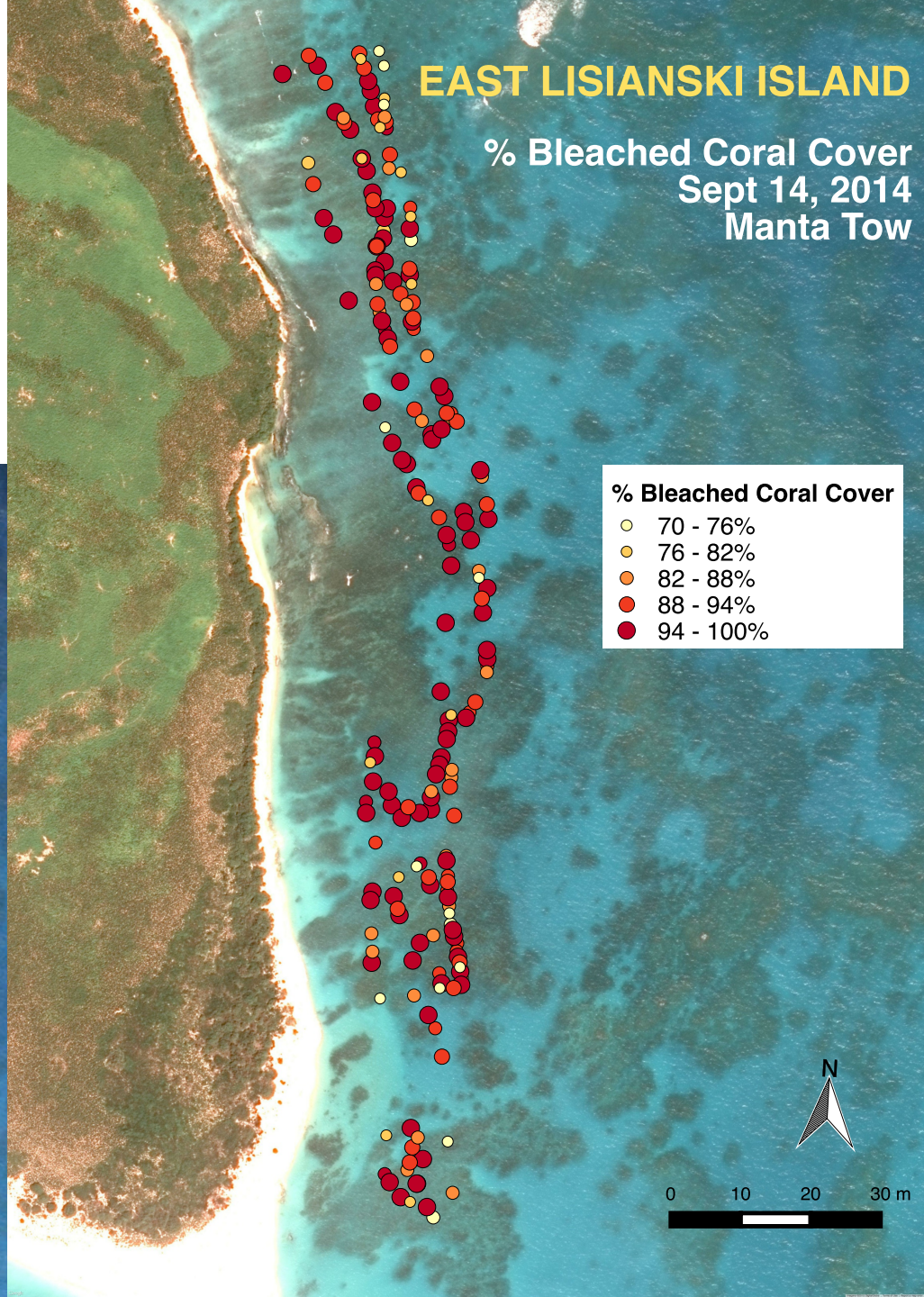






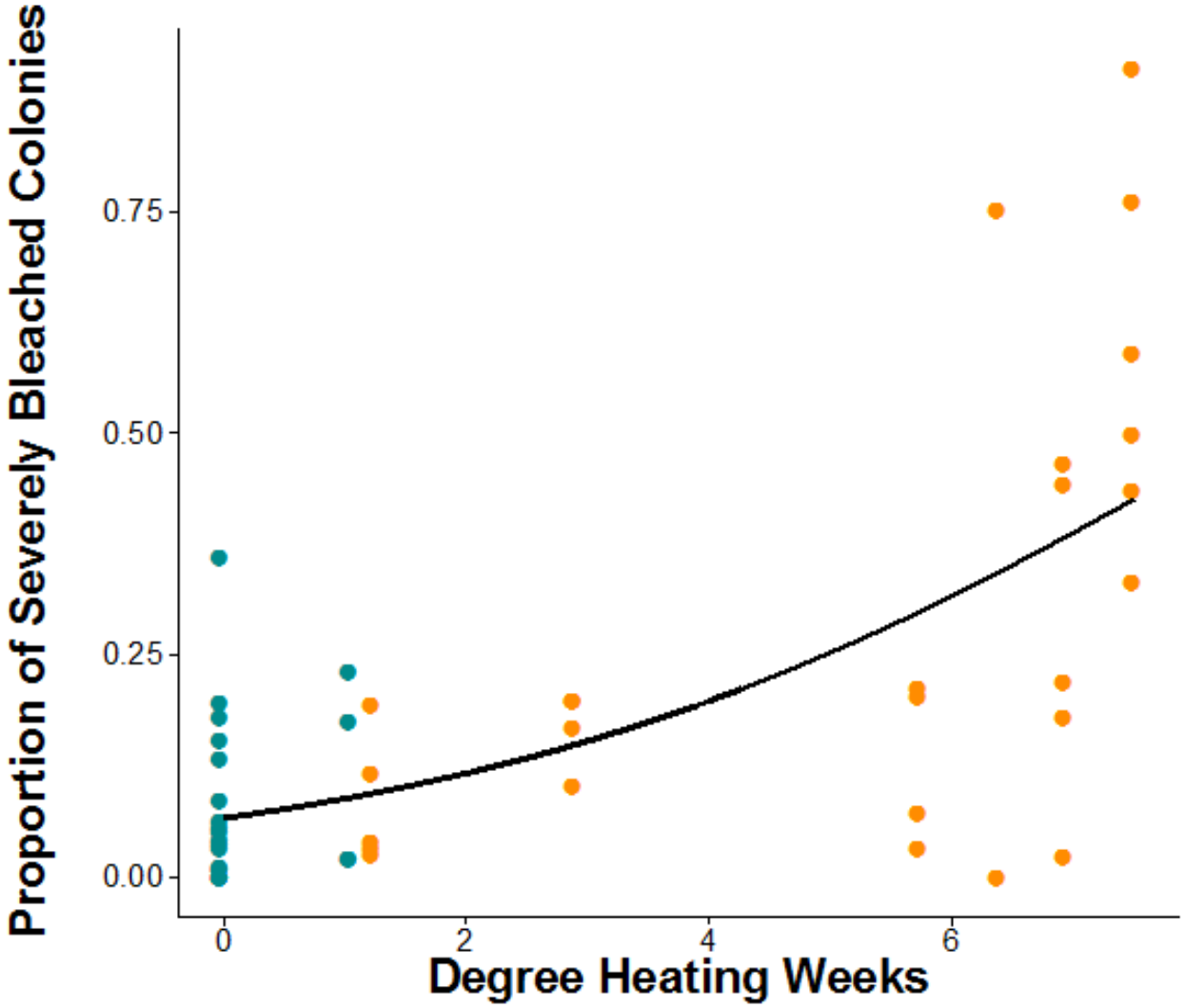
How extensive was mass bleaching on Eastern Lisianski Island?





% cover change by species and region

Region	Species	2014 % Cover	2015 % Cover	p value
FFS	*Porites lobata*	12.44 (2.11)	15.22 (3.70)	0.5745
	Porites lichen	6.77 (2.40)	4.24 (2.51)	0.3065
	Porites compressa	3.88 (1.66)	4.84 (1.97)	0.834
	Porites evermanni	1.59 (1.05)	0.09 (0.09)	0.1038
	Montipora capitata	1.36 (0.31)	0.75 (0.19)	0.1412
	Pocillopora damicornis	1.22 (0.05)	0.31 (0)	0.2207
LIS	***Montipora dilitata***	**50.02 (9.92)**	**0 (0)**	**0.00227***
	Porites compressa	17.17 (1.07)	9.94 (6.26)	0.1508
	Porites lobata	10.515 (1.99)	8.88 (1.71)	0.8408
	Montipora capitata	6.74 (1.40)	4.44 (1.35)	0.2973
	Montipora patula	**3.89 (1.06)**	**0.14 (0.07)**	**0.0019***
	Pocillopora meandrina	1.05 (0.21)	0 (0)	0.0636
PHR	*Montipora capitata*	19.53 (5.87)	18.18 (4.70)	0.9372
	Montipora flabellata	3.06 (0.83)	0 (0)	0.0217
	Pocillopora ligulata	2.05 (0.73)	3.49 (0.77)	0.4
	Porites lobata	10.31 (5.38)	9.00 (4.35)	0.9453
MID	*Montipora flabellata*	14.31 (3.74)	12.68 (2.84)	0.7738
	Montipora capitata	12.34 (3.75)	3.46 (1.30)	0.0943


Proportion of Severely Bleached Colonies
0.75
0.50
0.25
0.00
0
2
4
6
Degree Heating Weeks