Fore-C: Forecasting coral disease outbreaks across the tropical Pacific

(a) The two benthic functional groups commonly used to evaluate reef health: hard coral and macroalgae.

Jennifer E. Smith et al. Proc. R. Soc. B 2016;283:20151985

HURRICANES AND CARIBBEAN CORAL REEFS: IMPACTS, RECOVERY PATTERNS, AND ROL...

TOBY A. GARDNER,[1,2] ISABELLE M. C...
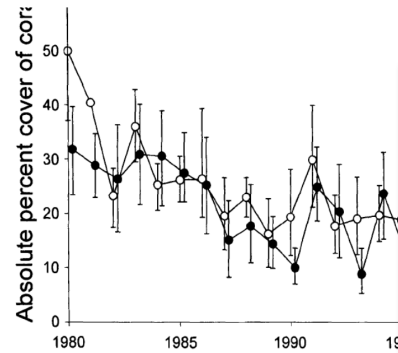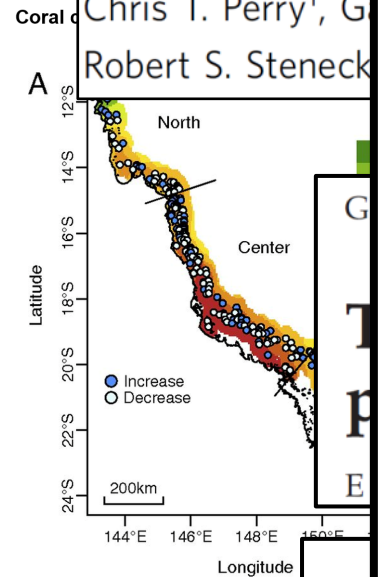AND ANDR...

Absolute percent cover of cor...

FIG. 5. Coral percent cover at impacted... nonimpacted (open circles) sites across the... from 1980 to 2001. Means (with 95% bo... dence intervals) for each year are shown... for clarity. *N* = 1 for 1980 and 1981.
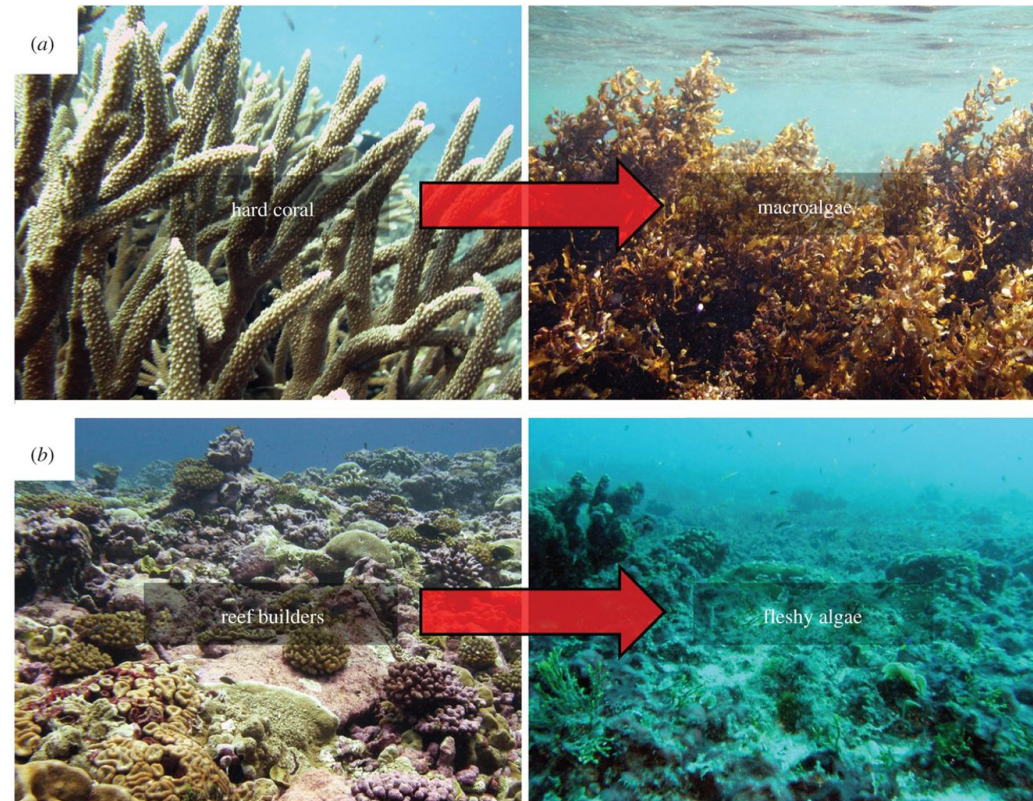
Caribbean-wide decline in carbonate production threaten...

Chris T. Perry[1], G...

Robert S. Steneck...

Coral c...

A

North

Center

Latitude

○ Increase
○ Decrease

200km

Longitude

Glenn De'ath et al. PNAS 2012;109:44:17...

June 2014 - May 2017 Thermal Stress

- Longest global bleaching event ever
- Most widespread bleaching event ever
- Over ½ exposed twice (Guam 4 of 5 years)
- >75% suffered bleaching-level heat stress
- Probably most damaging on record

NOAA Coral Reef Watch 5 km Maximum Satellite Coral Bleaching Alert Area   June 2014 - May 2017
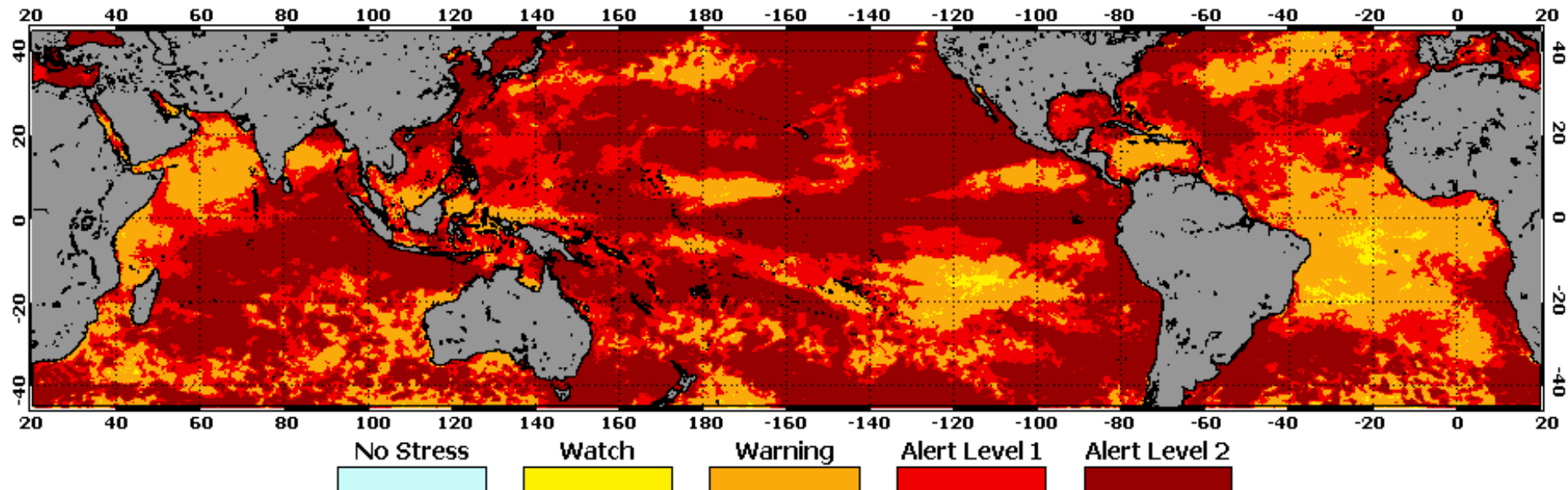
| No Stress | Watch | Warning | Alert Level 1 | Alert Level 2 |

Image: Hawaiʻi DAR
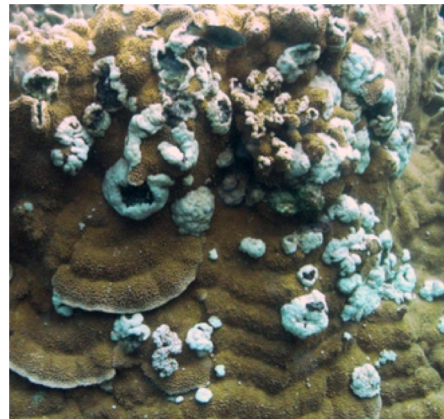
Coral diseases

Bands

Growth anomalies

Discoloration

Tissue loss

Global incidences of coral disease, 1970-2010

Source: World Resources Institute

Source: WRI, *Reefs at Risk Revisited*, 2011.
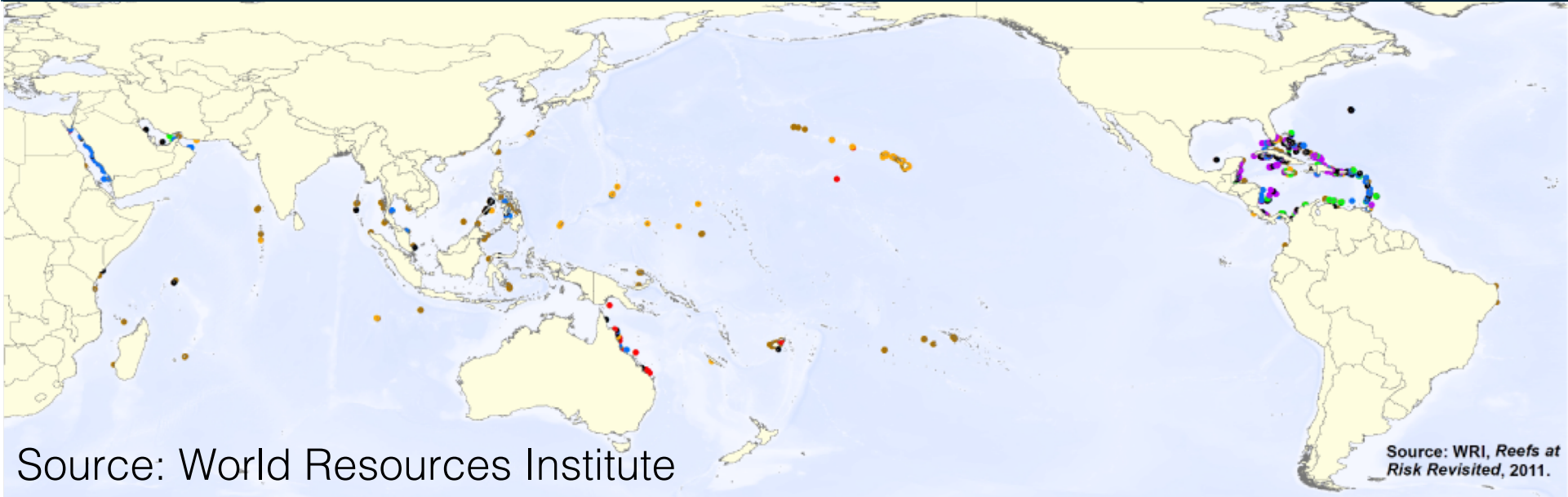
● Black-band disease ● Growth anomalies ● White plague ● White syndrome ● White-band disease ● Yellow band disease ● Other disease

Ward & Lafferty 2004

$r_s=0.63$ $p=0.0002$

$r_s=0.13$ $p=0.4934$

$r_s=0.87$ $p<0.0001$

Disease reports (%)

1972   Year   2001
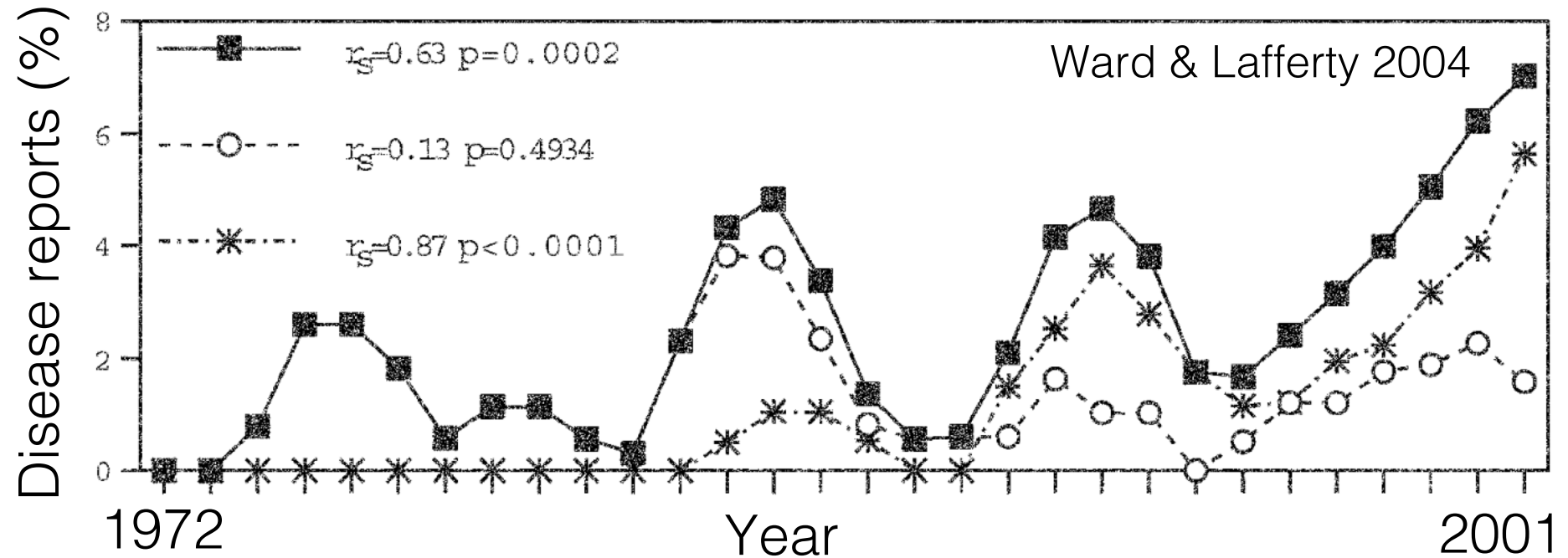
Maynard et al 2015
Nature Climate Change

Increasing disease risk under future climate scenarios

Coral disease may be as likely to cause coral mortality as bleaching in the coming decades
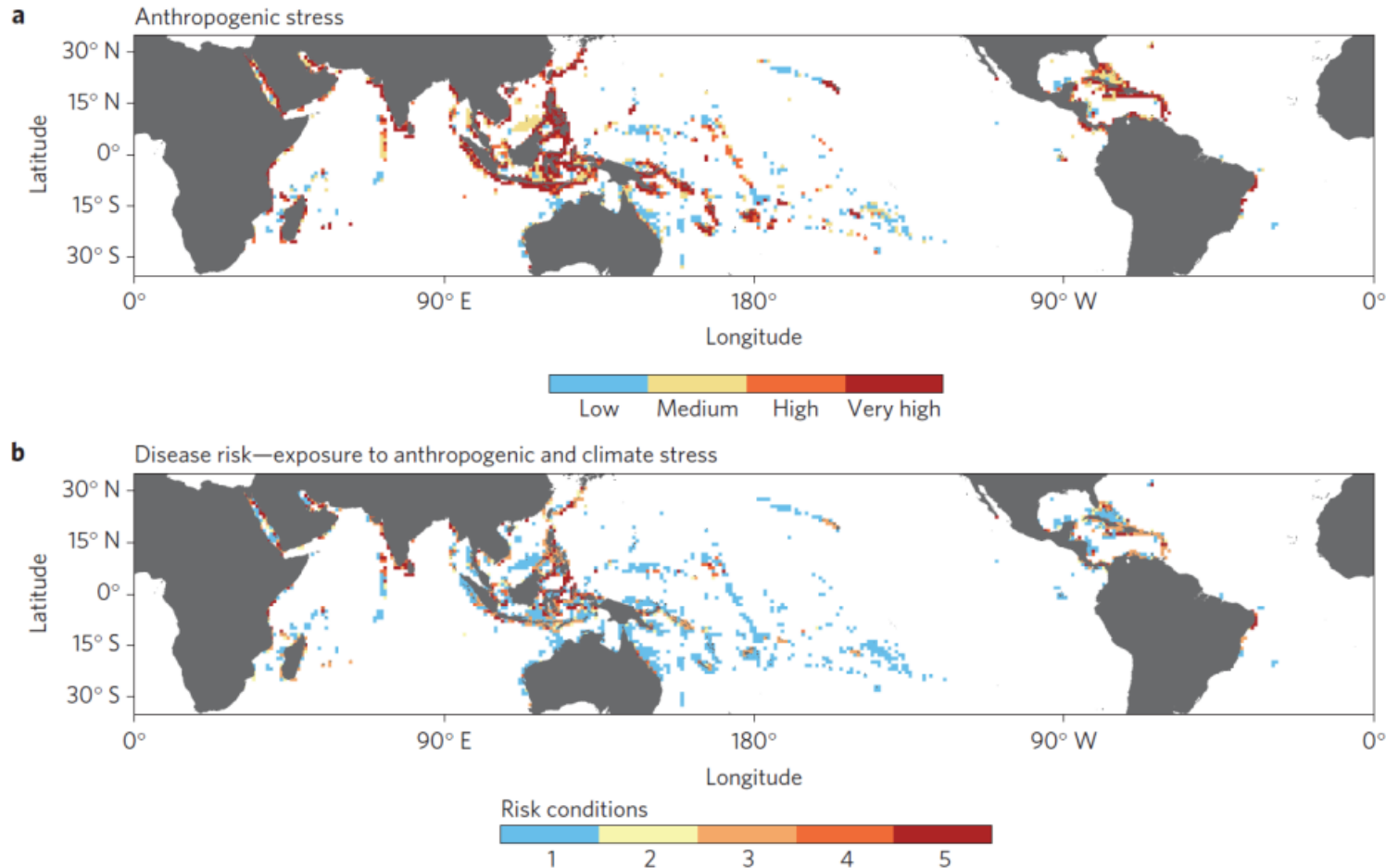
Fore-C: Goal & Objectives

Goal: Increase the resolution and predictive power of forecasts of coral disease outbreaks across the tropical Pacific
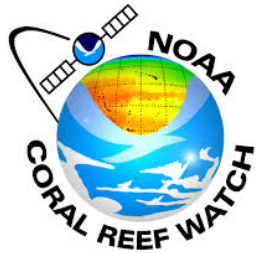
Objective 1: High-resolution satellite products from more regions and diseases

Objective 2: Develop short-term temperature forecasts

Objective 3: Develop satellite-derived water quality indices as coral disease predictors

Objective 4: Improve understanding of pre-visible coral stress response

Fore-C Team

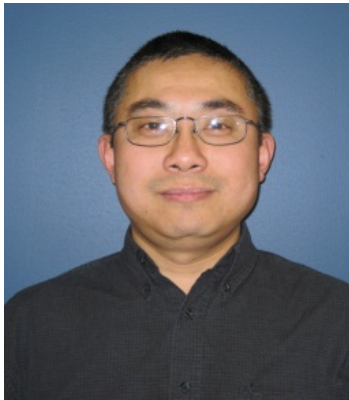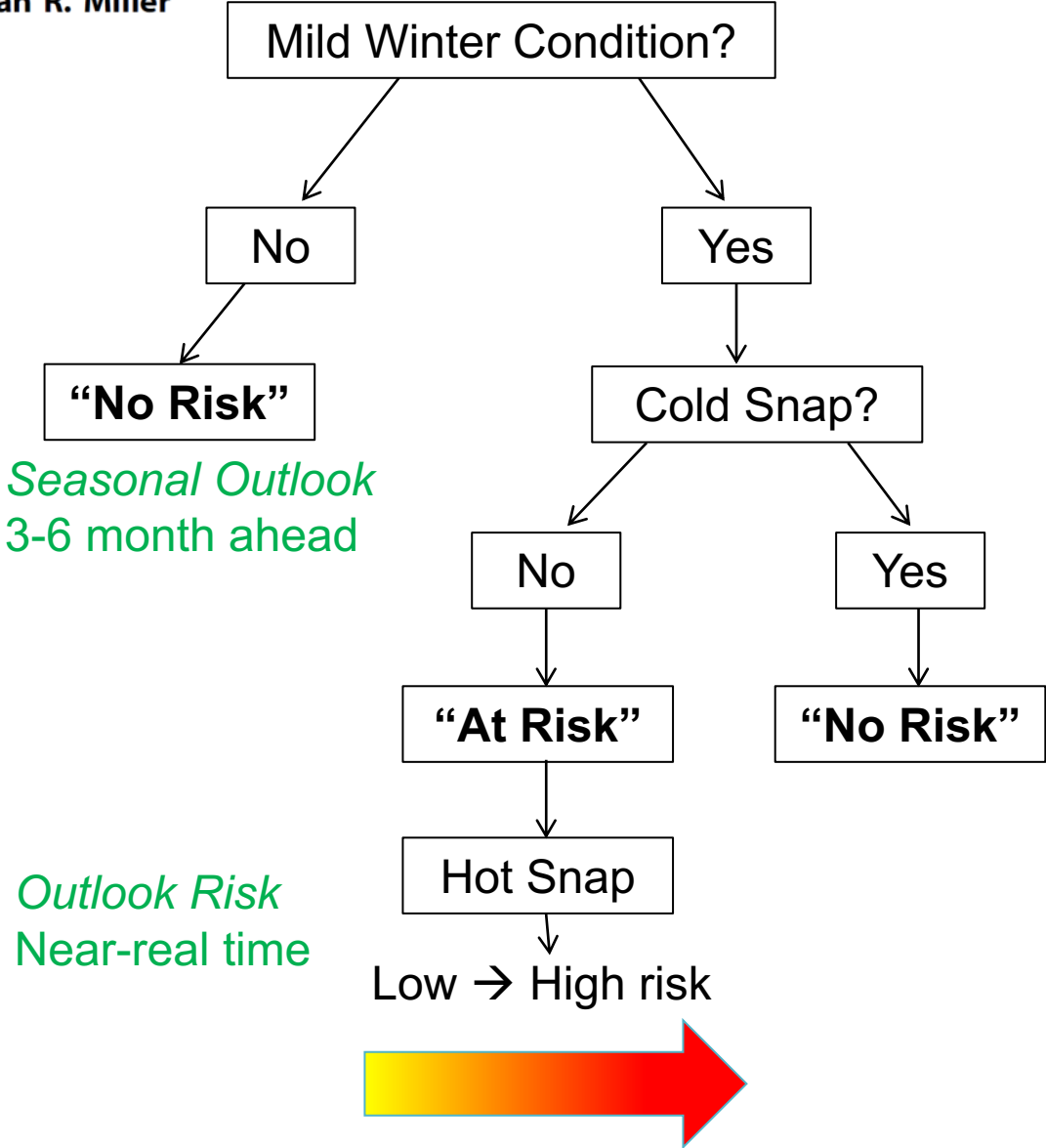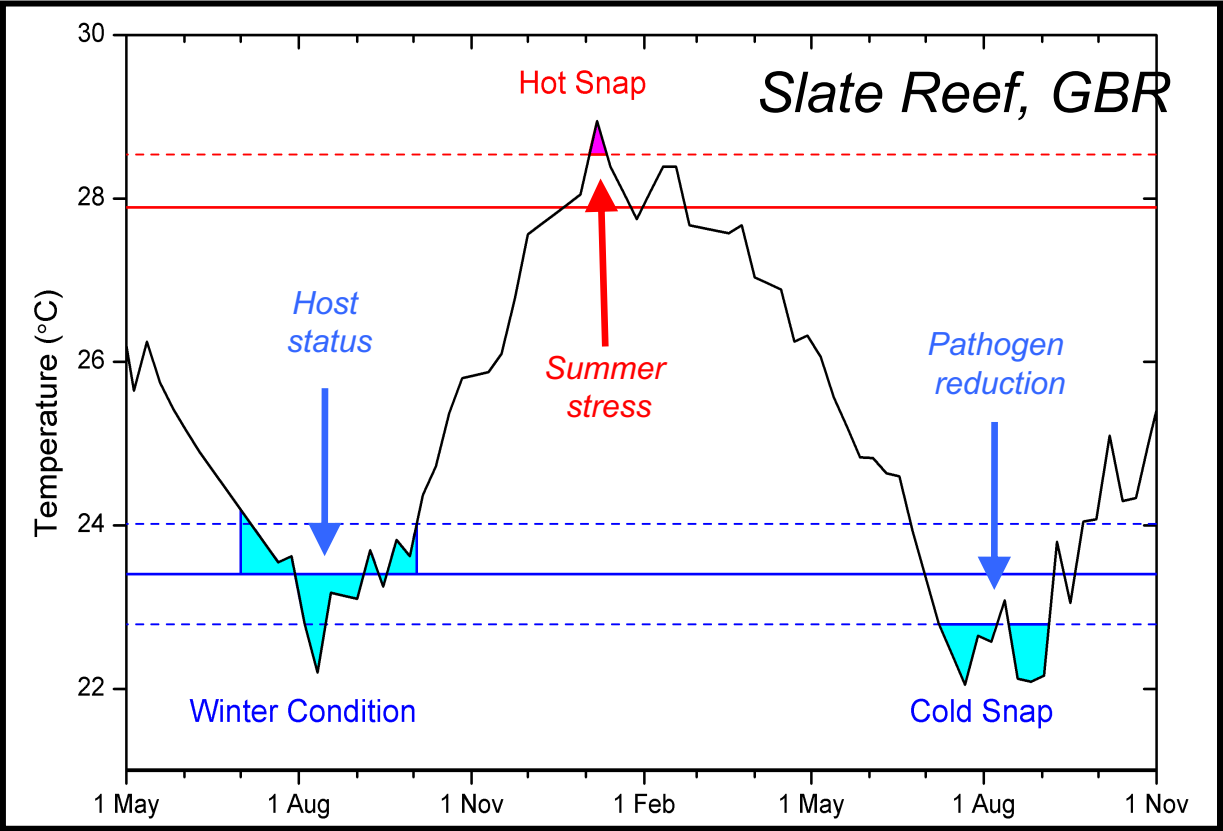# Summer Hot Snaps and Winter Conditions: Modelling White Syndrome Outbreaks on Great Barrier Reef Corals

Scott F. Heron[1,2]*, Bette L. Willis[3], William J. Skirving[2], C. Mark Eakin[4], Cathie A. Page[3], Ian R. Miller[5]

Heron et al. 2010

Satellite SST-Based Coral Disease Outbreak Predictions for the Hawaiian Archipelago

Jamie M. Caldwell [1,*], Scott F. Heron [2,3,4], C. Mark Eakin [2] and Megan J. Donahue [1]
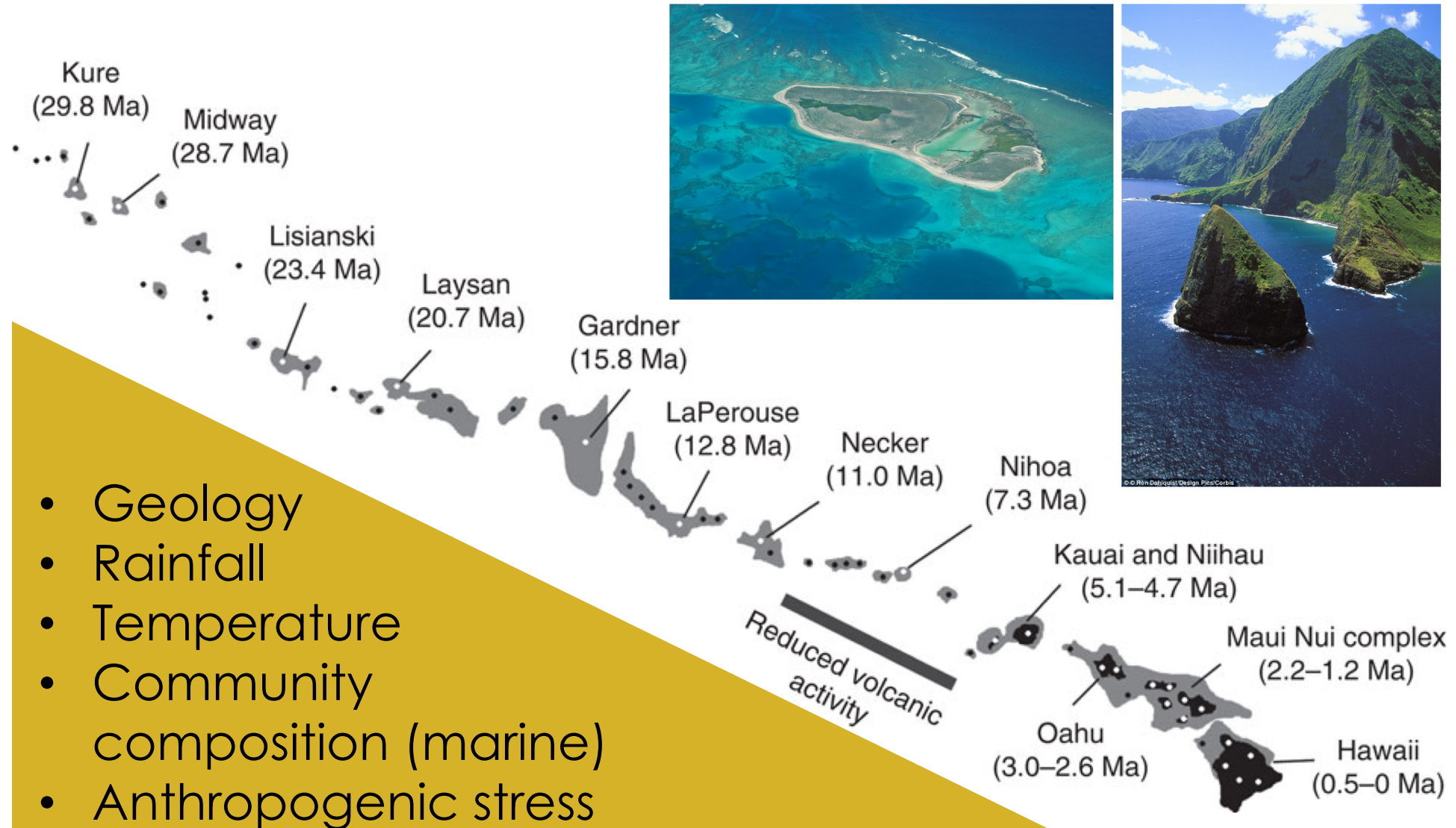
311,320 colonies
651 sites
18 island & atolls
12 years

Montipora White Syndrome, Porites Growth Anomaly, Porites Tissue Loss

Coral disease in Hawaiʻi

Kure (29.8 Ma)
Midway (28.7 Ma)
Lisianski (23.4 Ma)
Laysan (20.7 Ma)
Gardner (15.8 Ma)
LaPerouse (12.8 Ma)
Necker (11.0 Ma)
Nihoa (7.3 Ma)
Kauai and Niihau (5.1–4.7 Ma)
Maui Nui complex (2.2–1.2 Ma)
Oahu (3.0–2.6 Ma)
Hawaii (0.5–0 Ma)
Reduced volcanic activity

- Geology
- Rainfall
- Temperature
- Community composition (marine)
- Anthropogenic stress

Objective 1: High-resolution satellite products from more regions and diseases
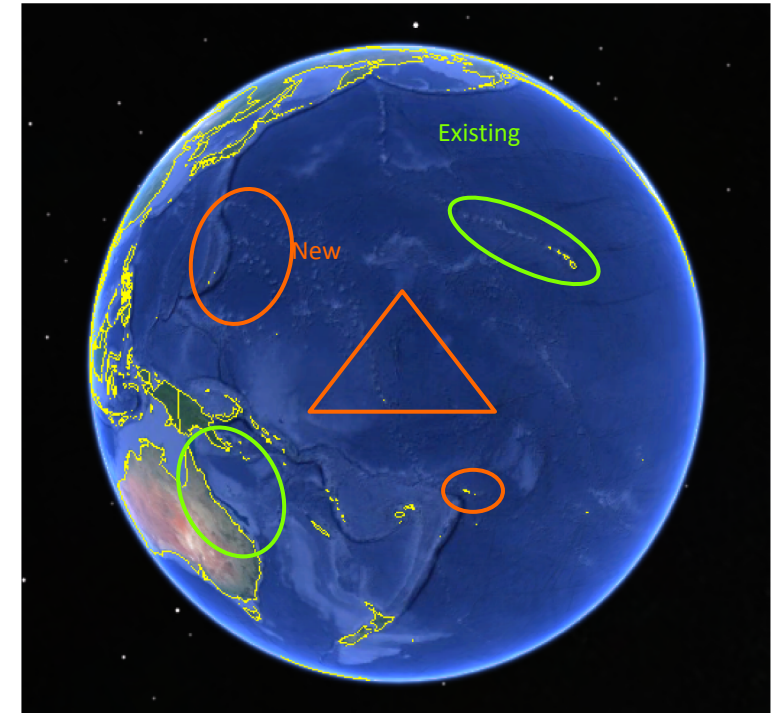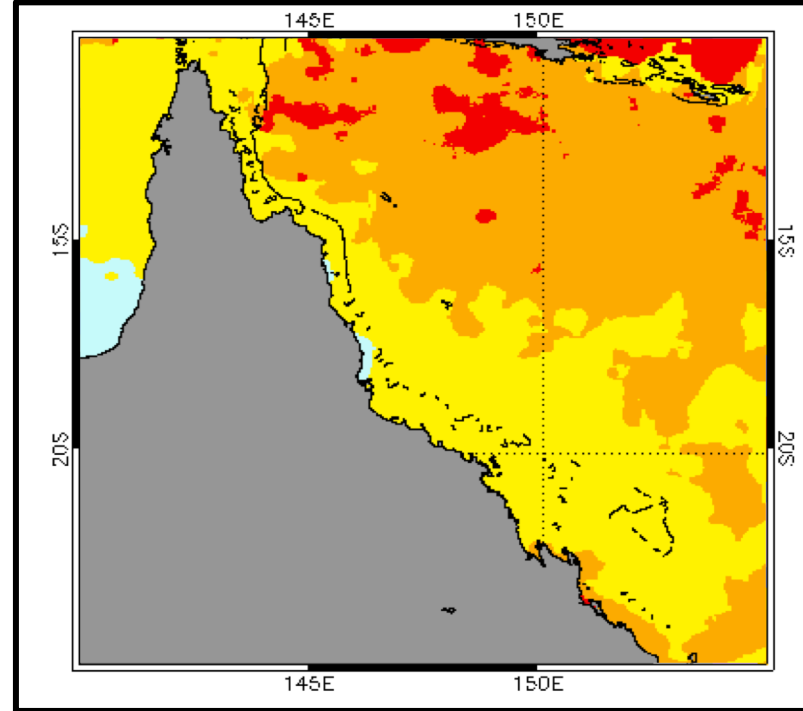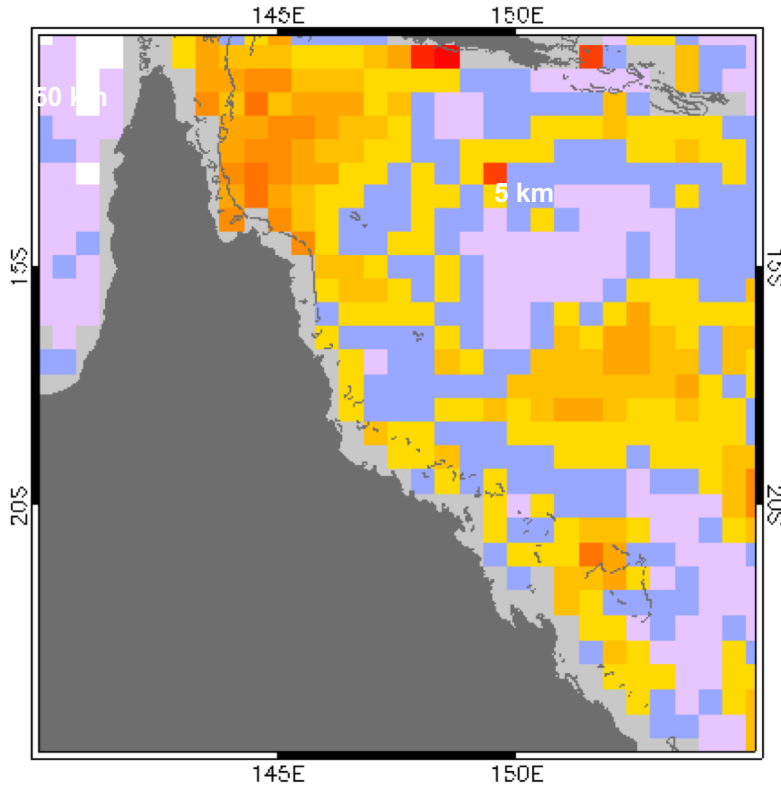

- *Updated satellite data products for SST at 5 km resolution*
- *Expansion to additional Pacific reef areas*
- *Expansion to additional coral diseases*

Objective 2: Use short-term temperature forecasts to build disease risk projections
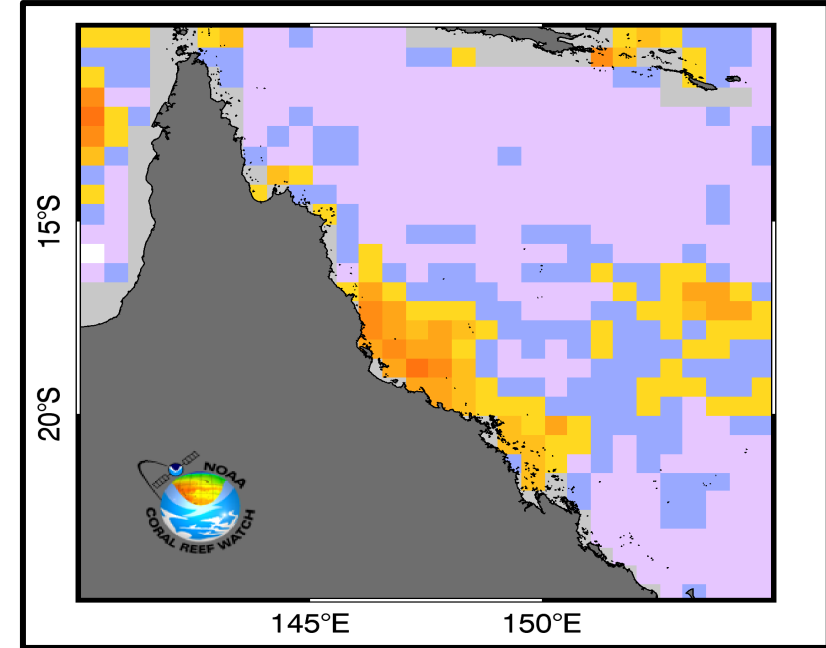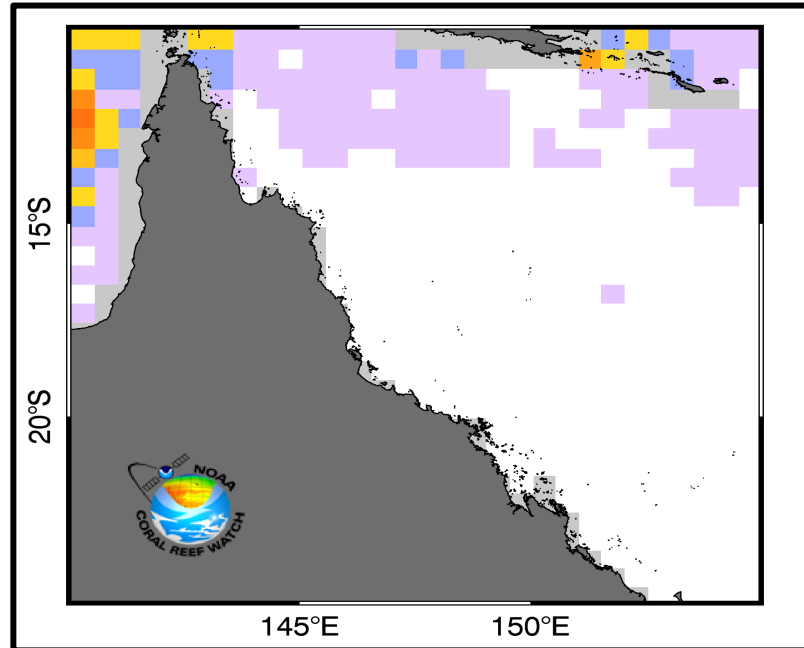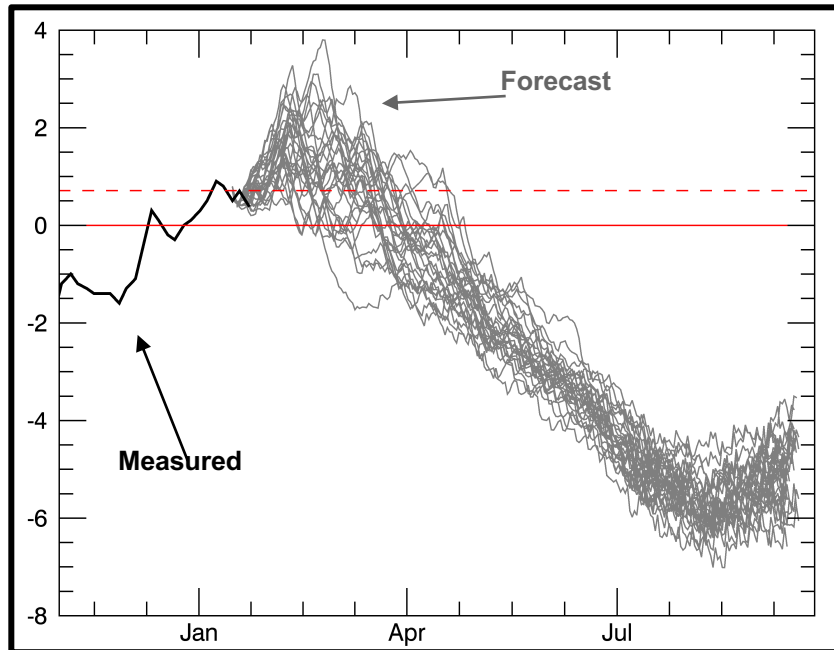

- *Climate models predict SST for the coming months*
- *Forecast disease risk based on relationships between disease and temperature anomalies*
- *Check out Scott's posters presenting initial results for GBR and Hawaii*

Objective 3: Develop satellite-derived water quality indices as coral disease predictors
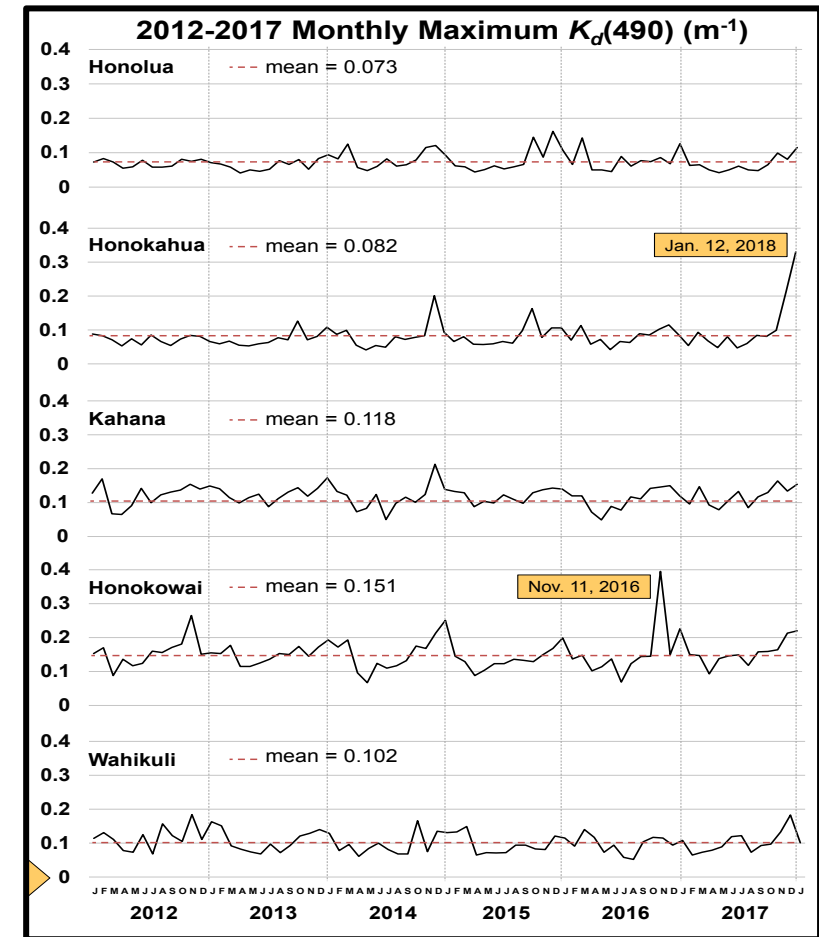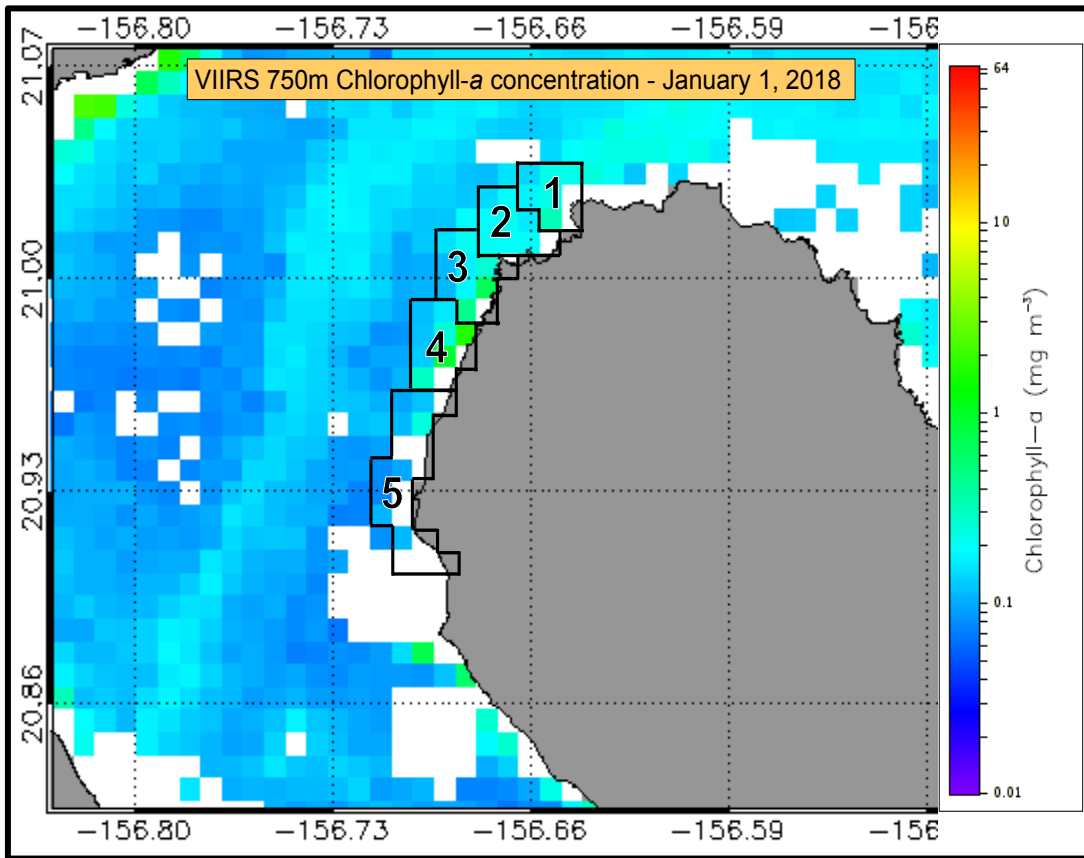
- *Water quality is an important predictor for some coral diseases*
- *Developing tools based on chl-a and diffuse attenuation (turbidity)*

Objective 4: Improve understanding of pre-visible coral stress response
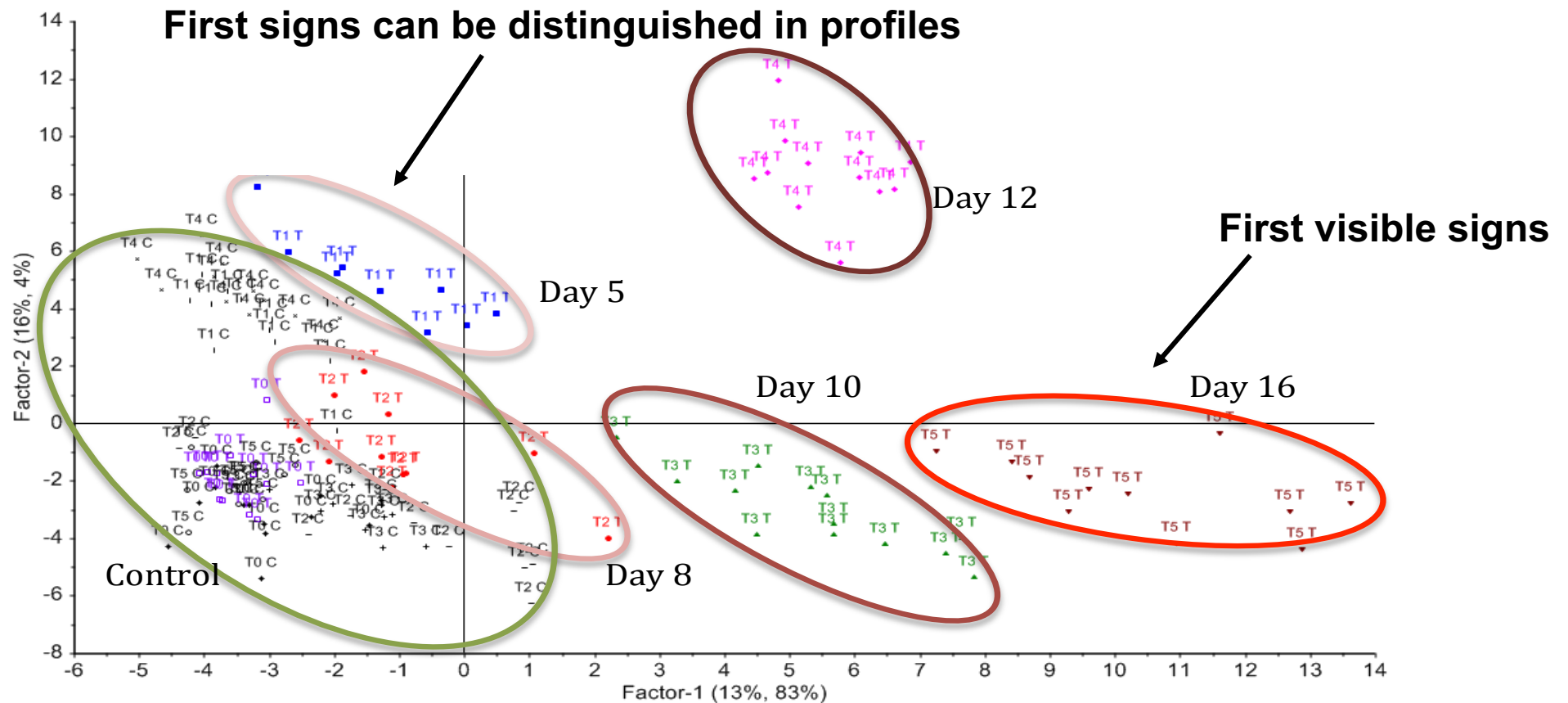
- *Corals respond internally to stress before any visible signs are apparent*
- *Microbial and metabolomic profiling to understanding previsible impacts on corals*

Metabolomic & Microbial Profiling

- Partners:
  - The Nature Conservancy
  - Division of Aquatic Resources
- West Maui
  - **Coral health** and **water quality** surveyed at **52 sites**
  - **2 coral species** at 20 sites
- Hawai'i
  - **12 sites**
  - *Porites lobata*
  - Long-term water quality data
- Outbreak Response
  - Paired outbreak/nonoutbreak
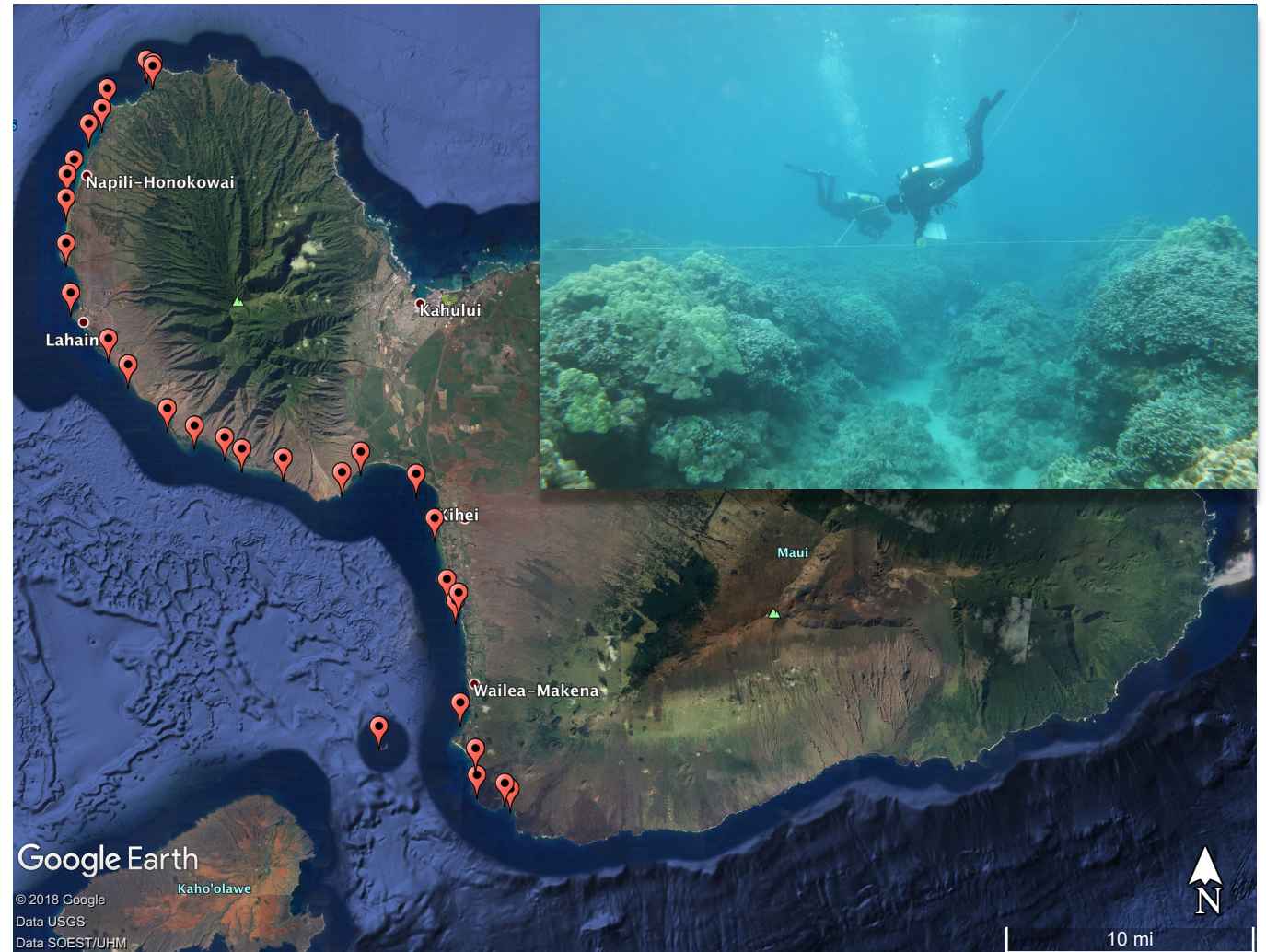
Fore-C Team Meeting

JoLeah Lamb (Cornell University)
Bruce Monger (Cornell University)
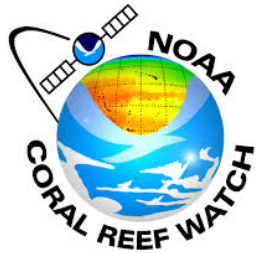Laurie Raymundo (U Guam)
Courtney Couch (U Hawai'i → NOAA Ecosys Sciences

Fore-C Focus Group

- >30 participants from The Nature Conservancy, Hawai'i DAR/DLNR, NOAA, Maui Ocean Center, US-FWS, PMNM, NPS, GBRMA
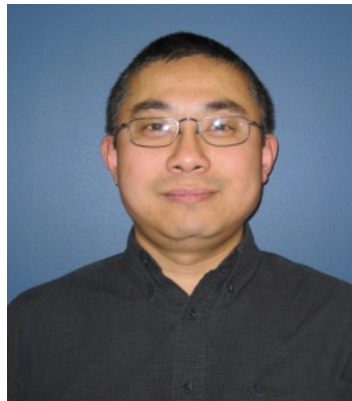- Hawai'i, American Samoa, Guam, GBR

Fore-C Team