NOAA Coral Reef Conservation Program Ecosystem Science Evaluation: **Ocean and Climate Change Team in Pacific**

Topical Area: Climate

Presenter: Thomas Oliver
OCC Team: Charles Young, Jeanette Clark, Noah Pomeroy, Molly Timmers, Kerry Reardon, Roberto Venegas

NOAA FISHERIES | PACIFIC ISLANDS FISHERIES SCIENCE CENTER

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Ecosystem Sciences Division: Coral Reef Ecosystem Program*

*The Division Formerly Known As CRED

CREP Ocean and Climate Change Team (OCC)
High-Level Core Questions:

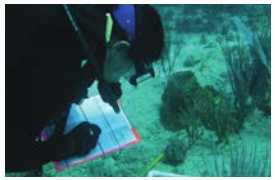
Robustly document *thermal stress*, *carbonate processes, and ecological response* at ~80 sites spanning 1000s km across the US Affiliated Pacific.

1. **How are reefs responding to temperature stresses?**
2. **Are reefs accreting or eroding?**

1. **How will hotter, more acidic reefs affect reef biodiversity?**
2. **How will thermal response, reef accretion, and biodiversity patterns change with changing environments?**

CREP Oceans and Climate Change Team

NCRMP



CREP Oceans and Climate Change Team

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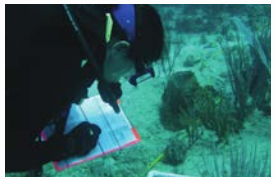
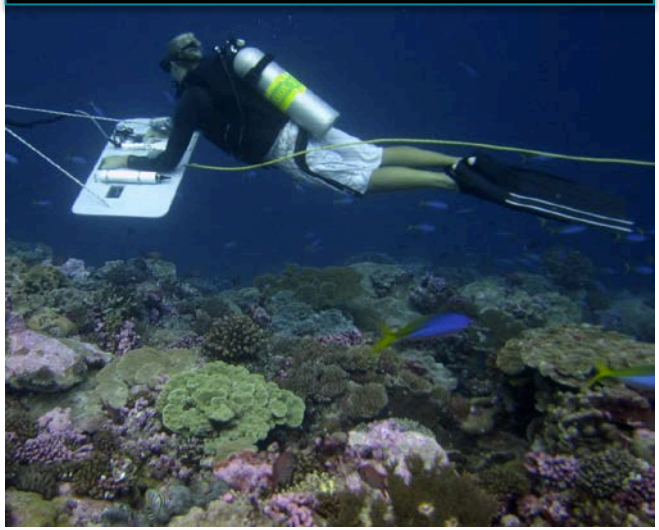


Projects



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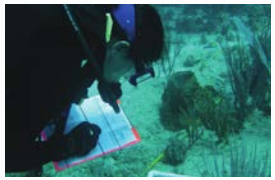

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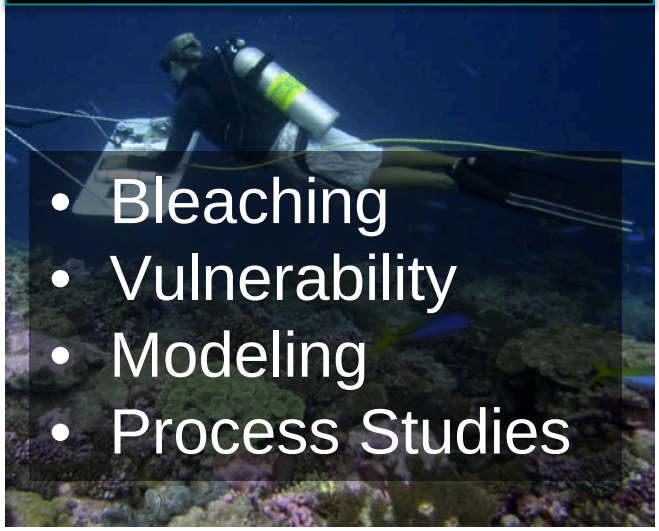

- Bleaching
- Vulnerability
- Modeling
- Process Studies

CREP Oceans and Climate Change Team

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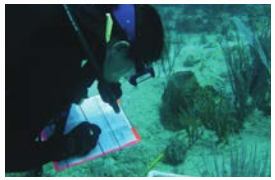

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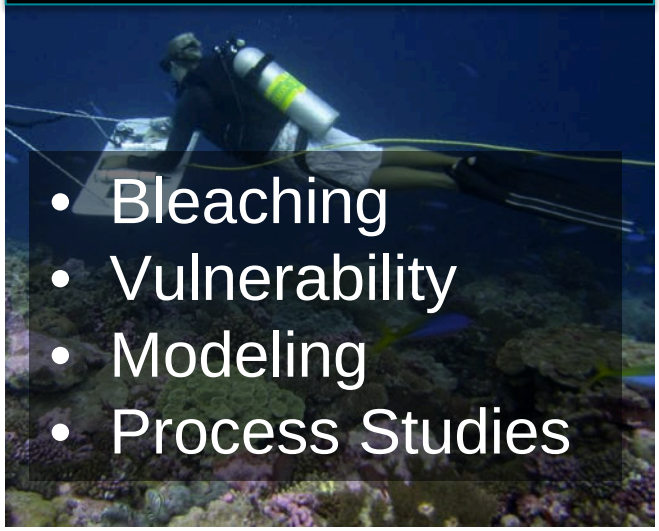

- Bleaching
- Vulnerability
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- Process Studies

International Efforts

CREP OCC Funding Support

NCRMP

- CRCP – NCRMP
- OAP - NCRMP

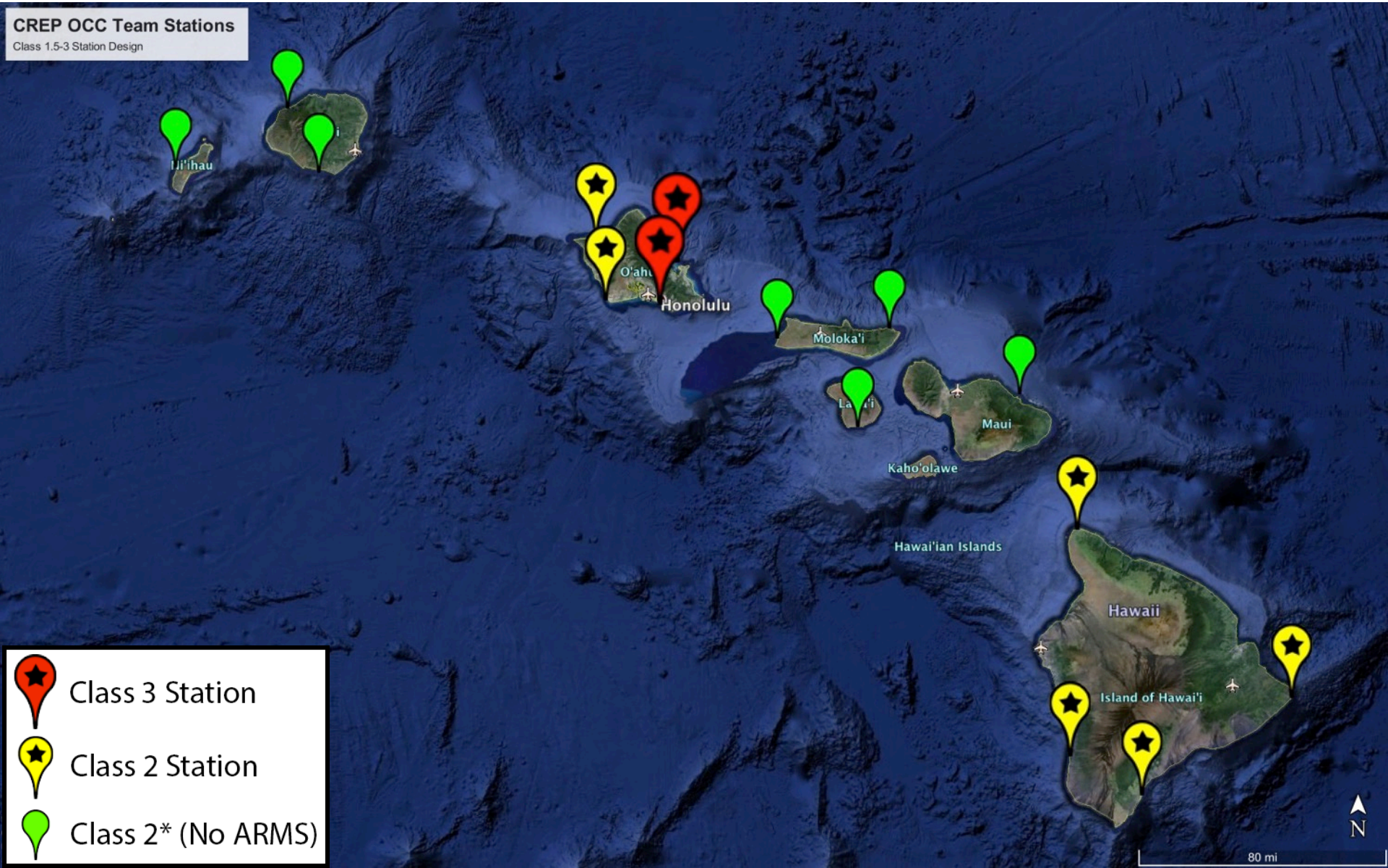
Projects

- CRCP RFP
- OAP
- NSF
- USAID

International Efforts

- USAID
- IOC-Westpac (UN)
- SPREP

Pacific RAMP Climate Stations



Climate

- **Thermal Stress**
  - Temperature/thermal stress
  - Vertical thermal structure
- **Ocean Acidification**
  - Carbonate chemistry
- **Ecological Impacts***
  - Coral growth rate*
  - Bioerosion rate*
  - Community structure* (cryptofauna diversity)

dence on coral reefs

“Class 0 Station”: Carbonate Chemistry

Seawater Sampling for Carbonate Chemistry

- Niskin Samples: 1,903 at 350+ sites
  - TA, DIC, T, S, chl-A, nut., microbes.
- Derive: pH, Aragonite Saturation State

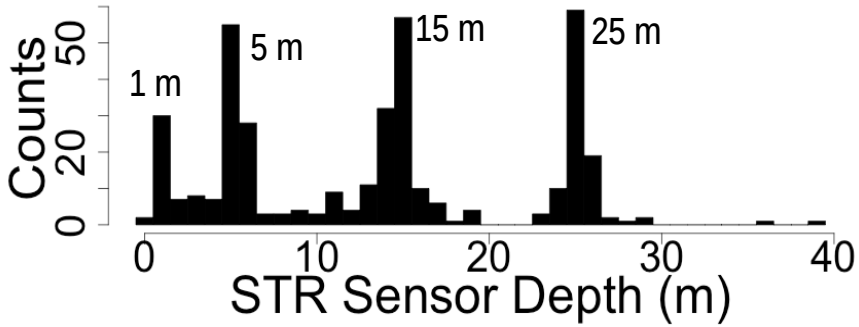
“Class 1 Station”: Temperature/Chemistry

Seawater Sampling for Carbonate Chemistry

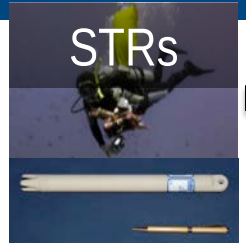
- Niskin Samples: 1,903 at 350+ sites
  - TA, DIC, T, S, chl-A, nut., microbes.
- Derive: pH, Aragonite Saturation State

Subsurface Temperature Recorder (STR)

- Moored Temperature Loggers (382 total)



“Class 2 Station”:



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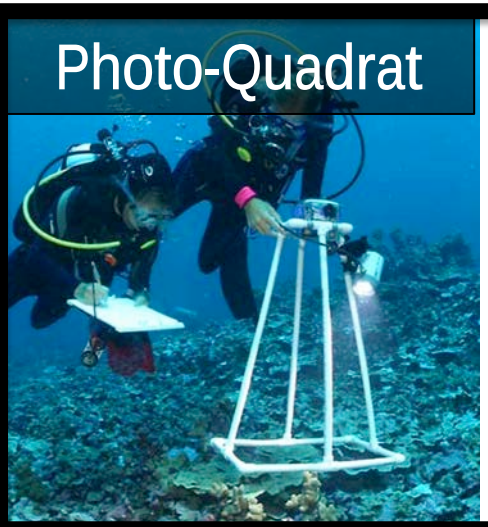

Photo-Quadrat

- Benthic Composition

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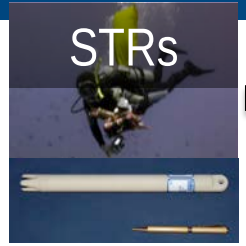

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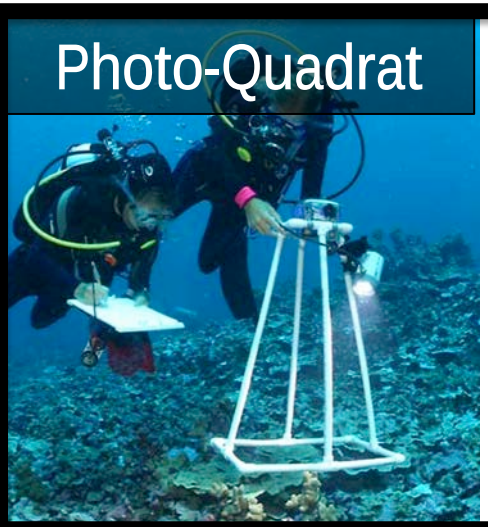

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Calcification Accretion Units & Bio-erosion Monitoring Units

- Net Calcification & Bioerosion

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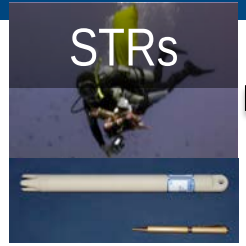

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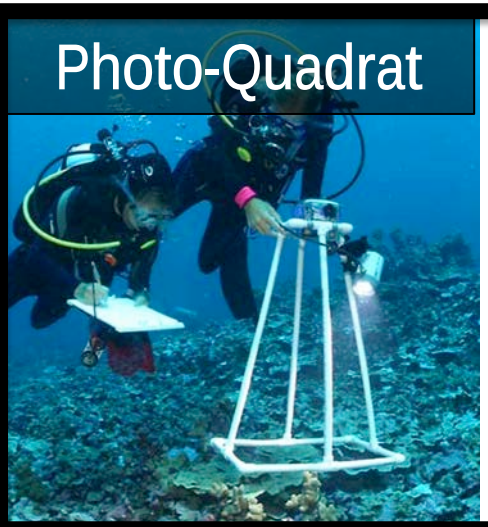

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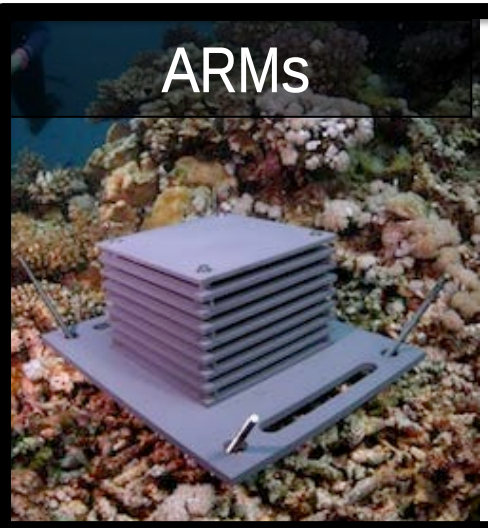

Autonomous Reef Monitoring Structures

- Crypto-biota Diversity

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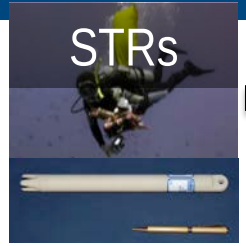

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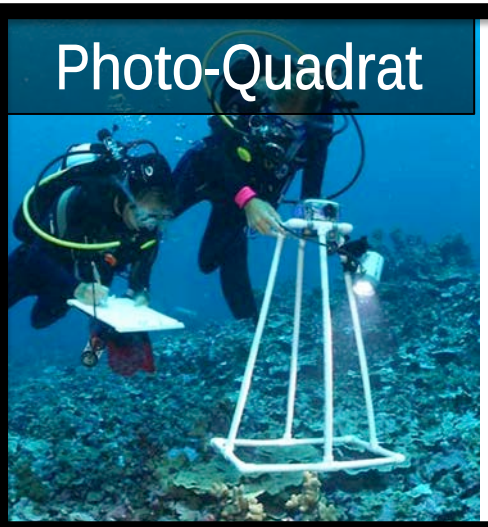

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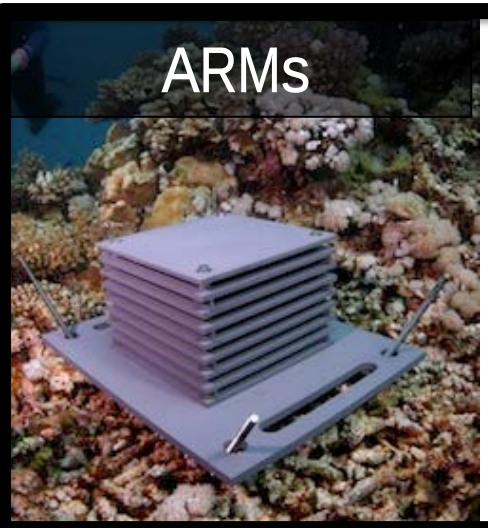

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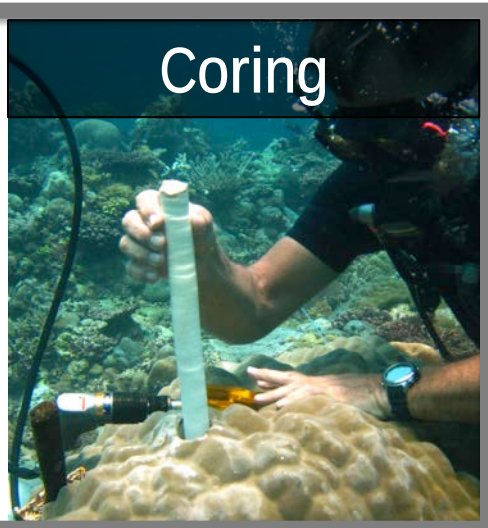
- Crypto-biota Diversity

Coral Coring

- Coral Growth Rates
- In Collaboration with Anne Cohen (WHOI)



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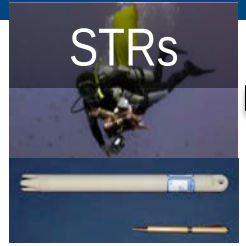

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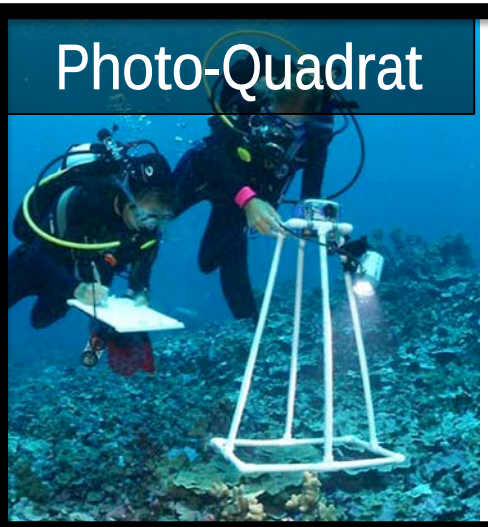
47 Class 2 Stations
+ 32 Stations
w/ all but ARMS



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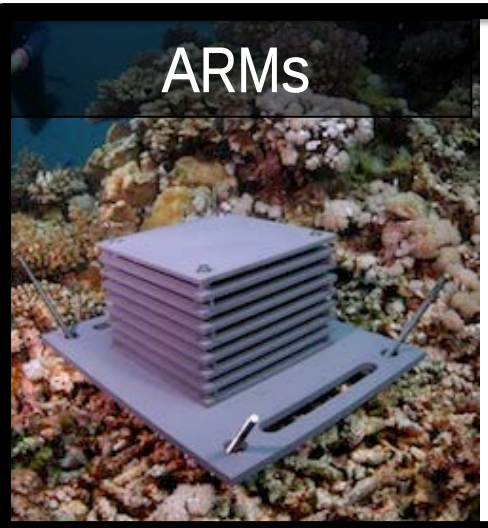

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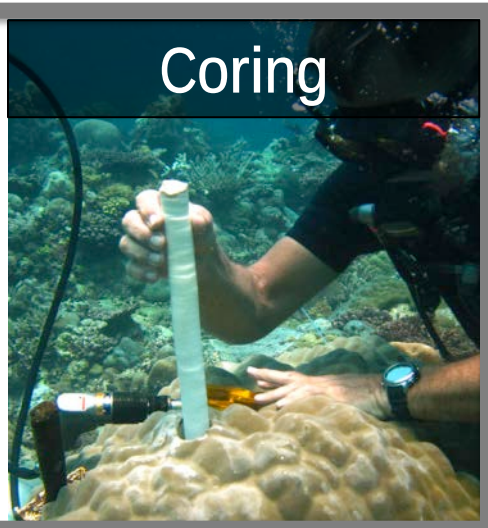
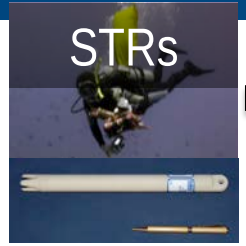


“Class 3 Station”:



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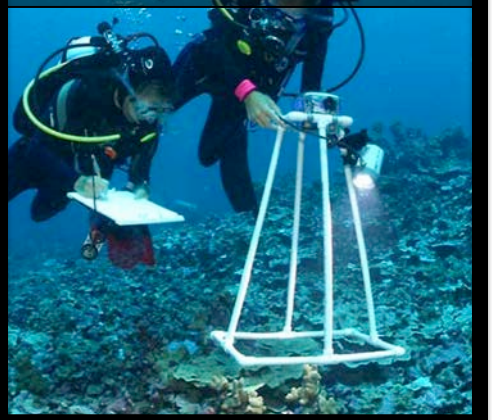
2 Stations in Oahu
1 Funded: Tutuila
1 Proposed: Saipan

Photo-Quadrat

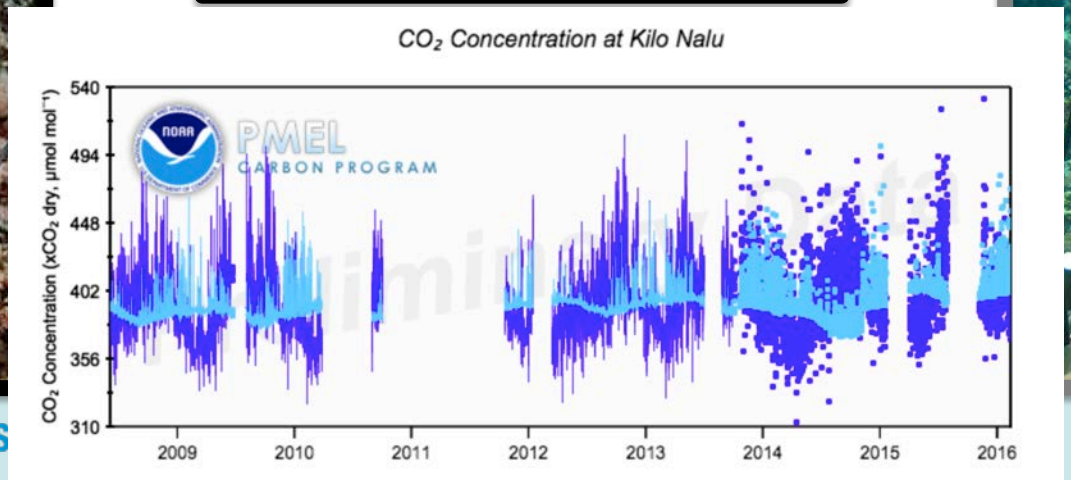


MApCO2 Buoy

- Air/Surface Water pCO2 every 3 hours

CAU / BMU

ARMs



Coring

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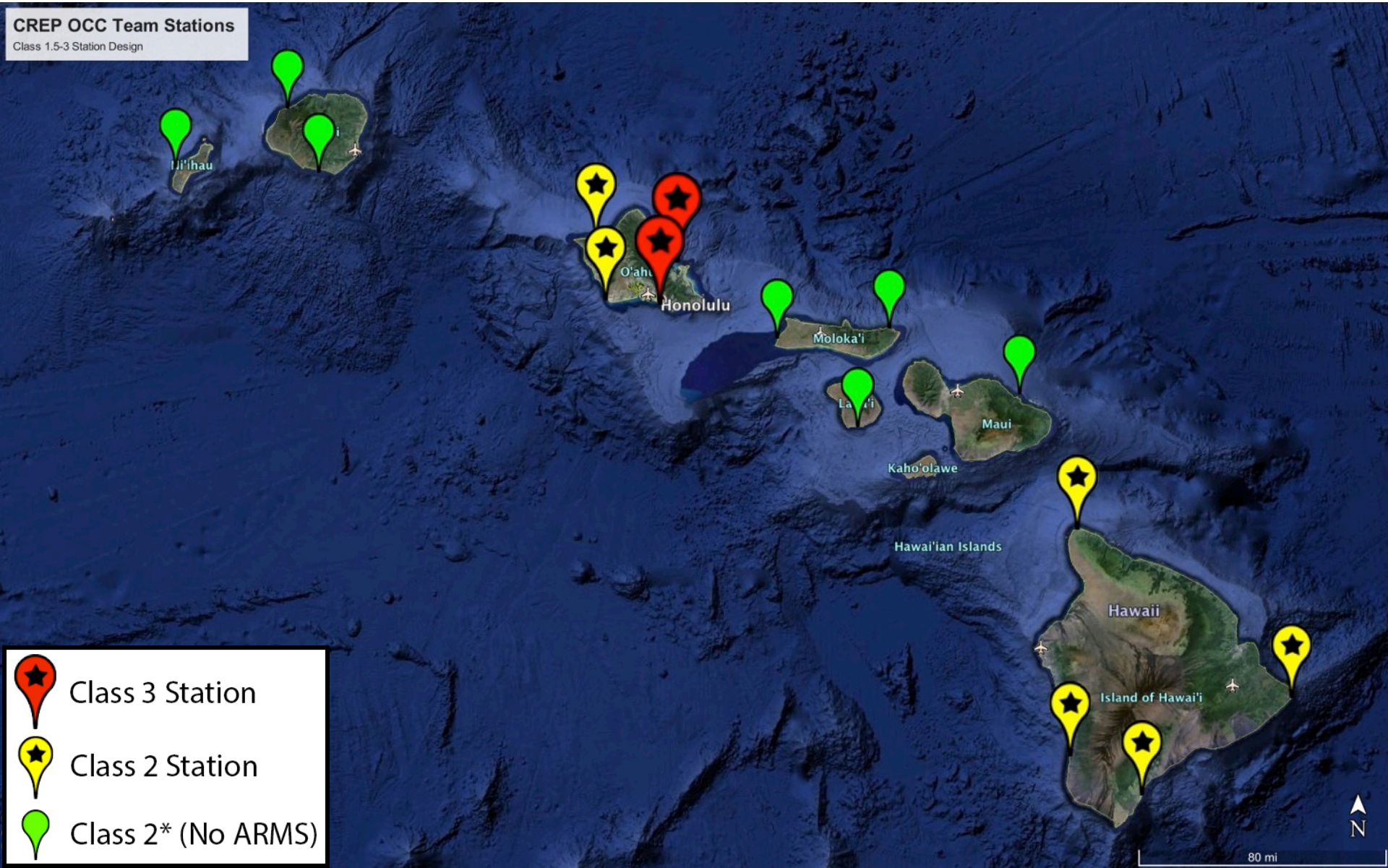
Pacific RAMP Climate Stations



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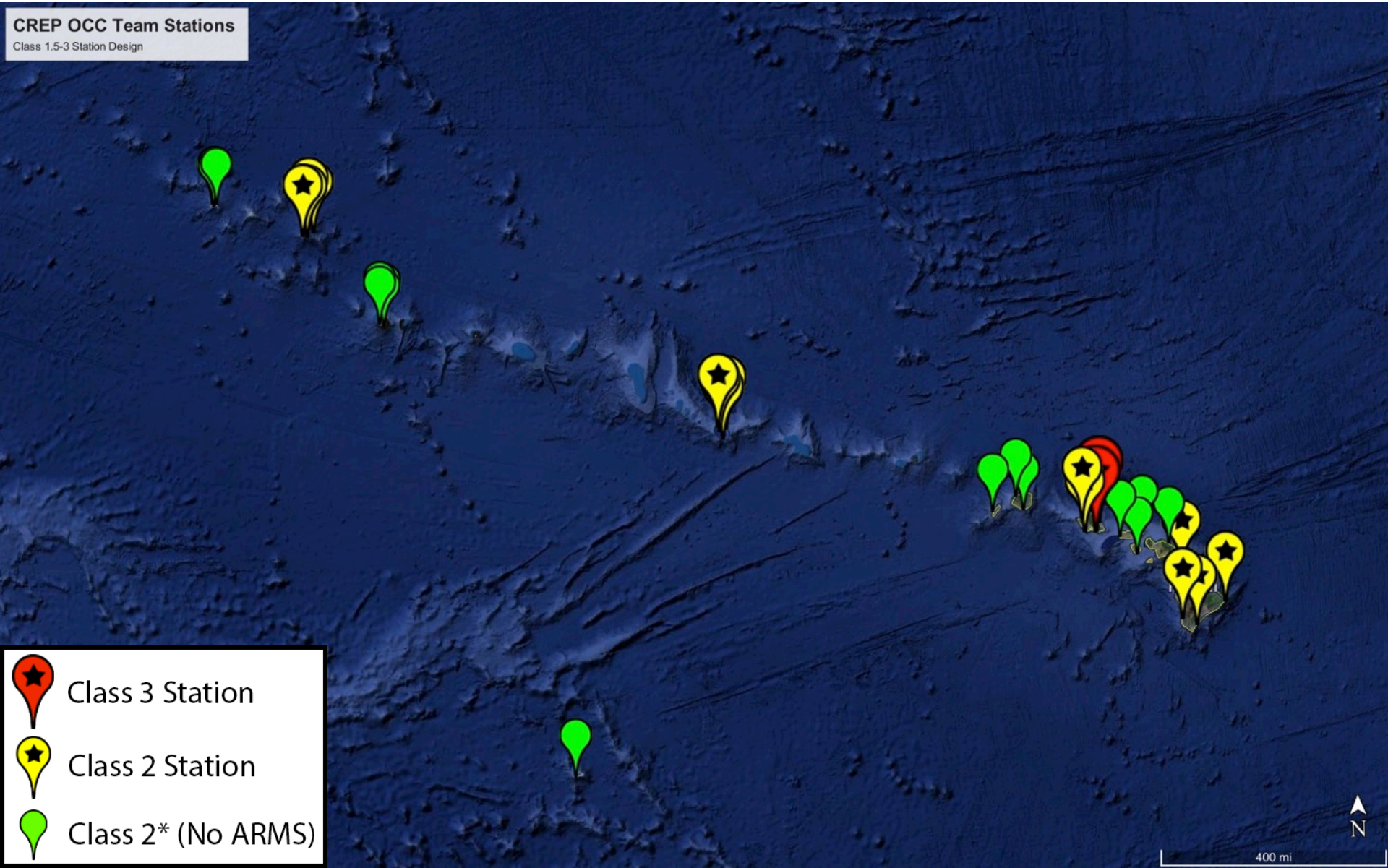
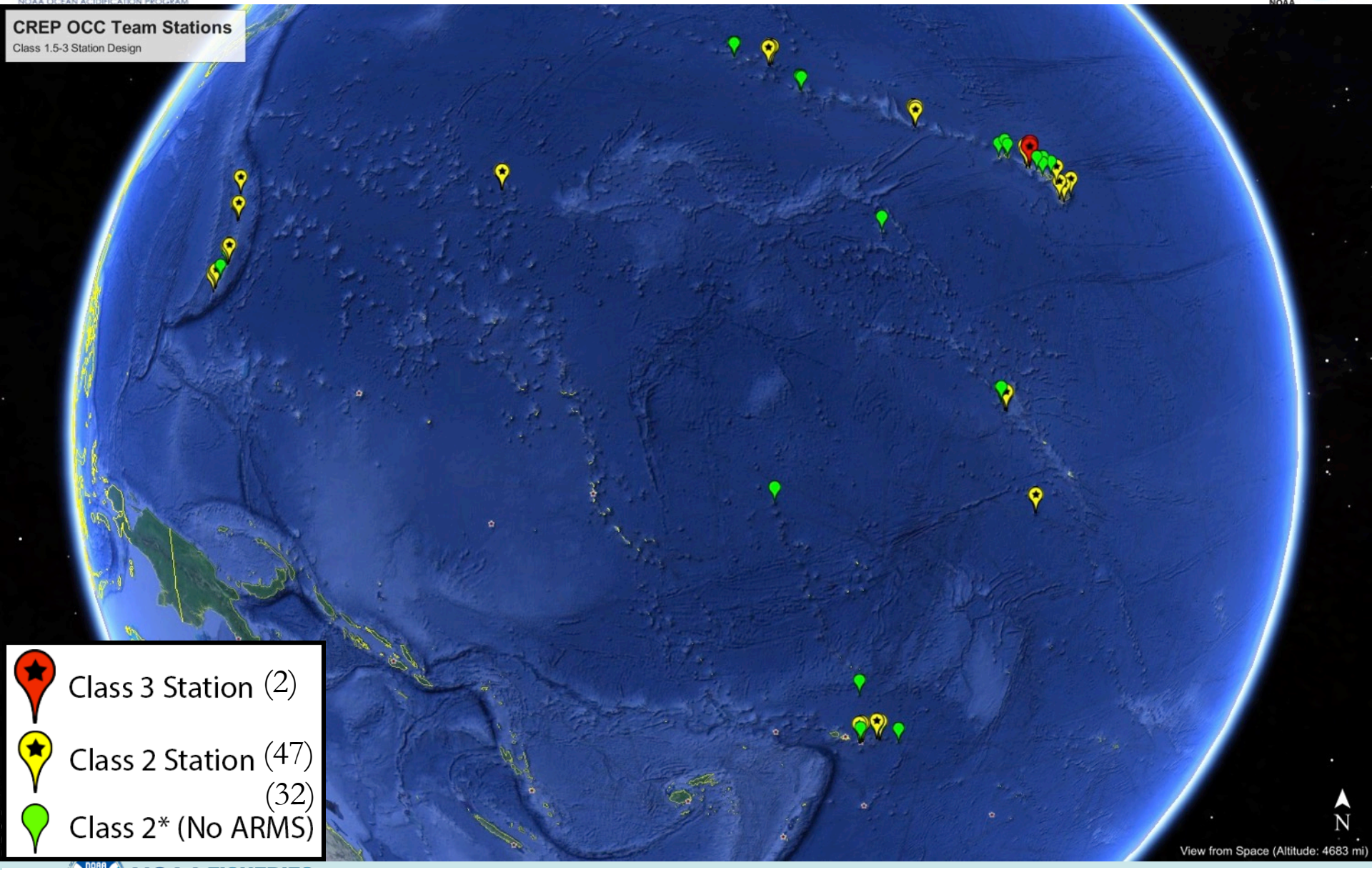
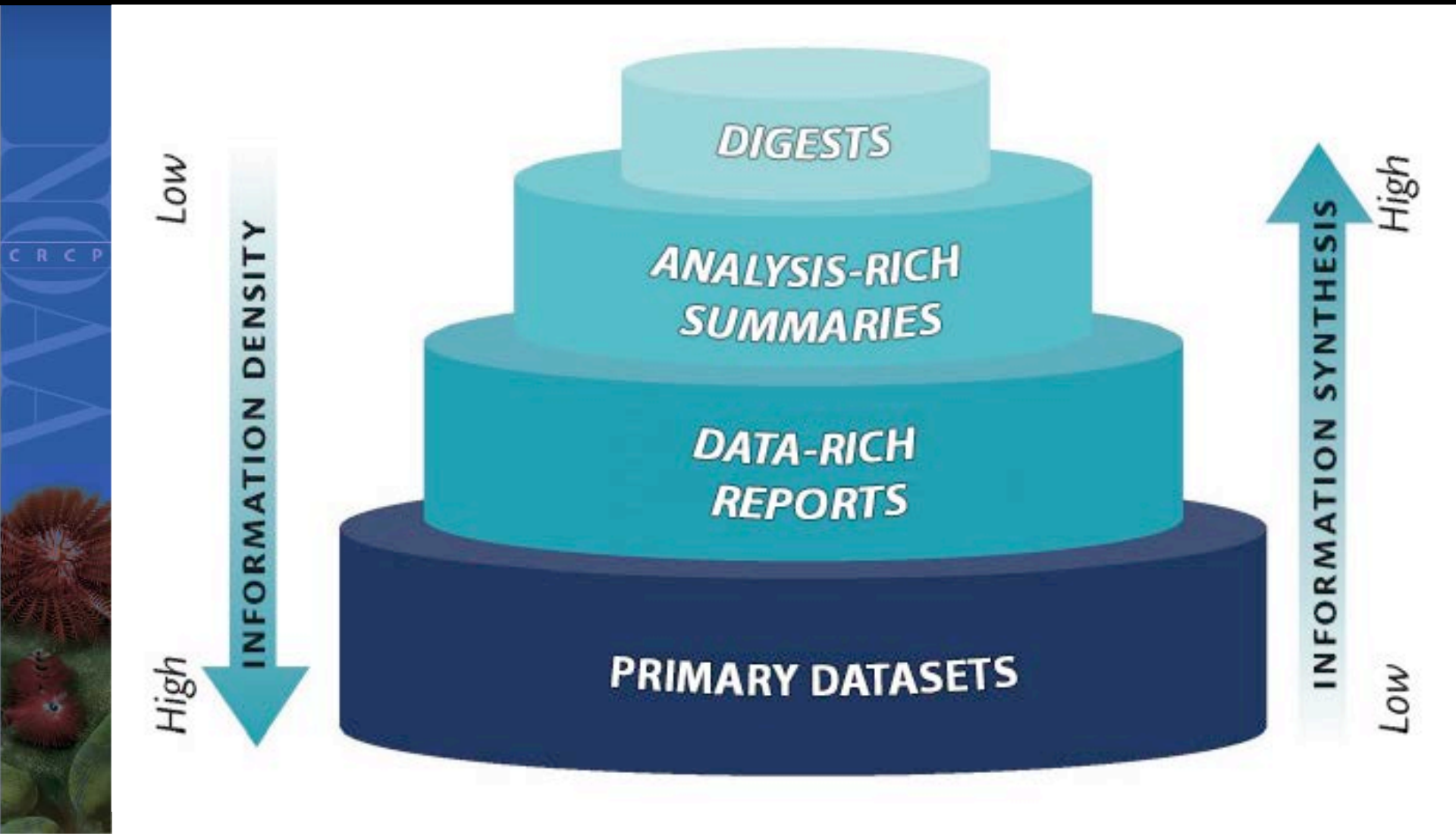


Pacific RAMP Climate Stations



Observing across gradients of environmental/oceanographic conditions, biodiversity, human uses and impacts

Key Outcomes, Dissemination, Users: Reporting "Wedding Cake"



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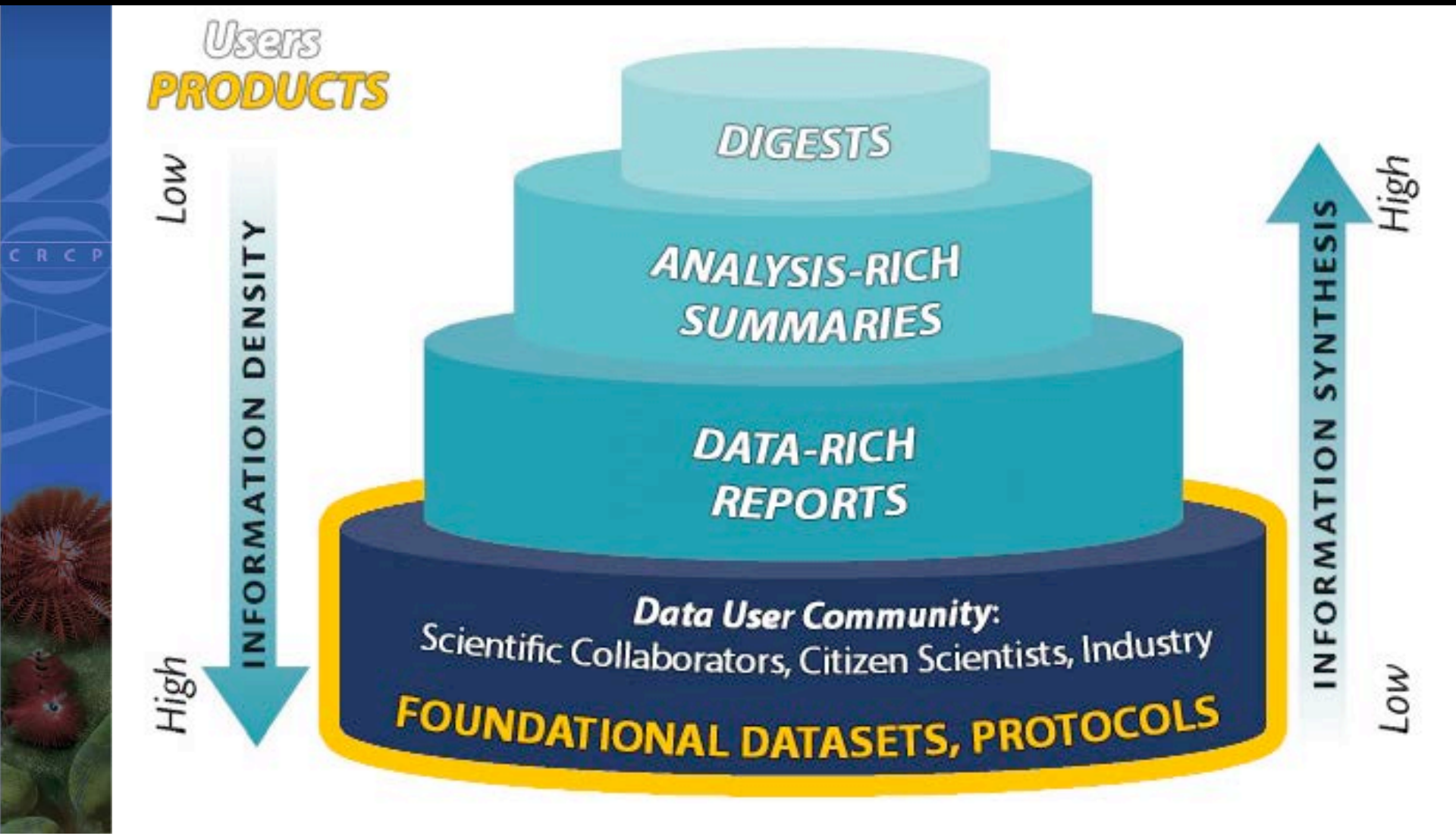
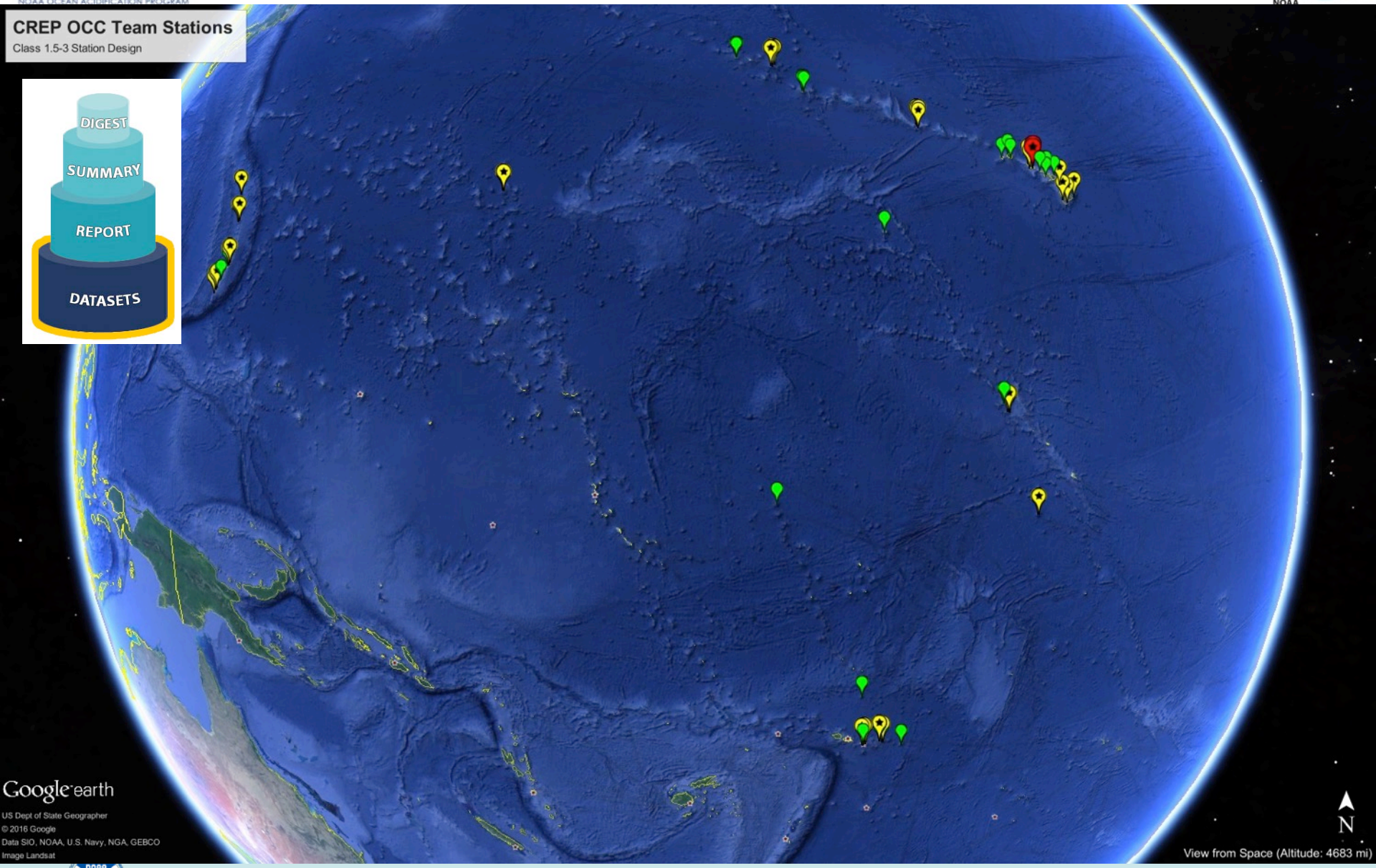


OCC Datasets



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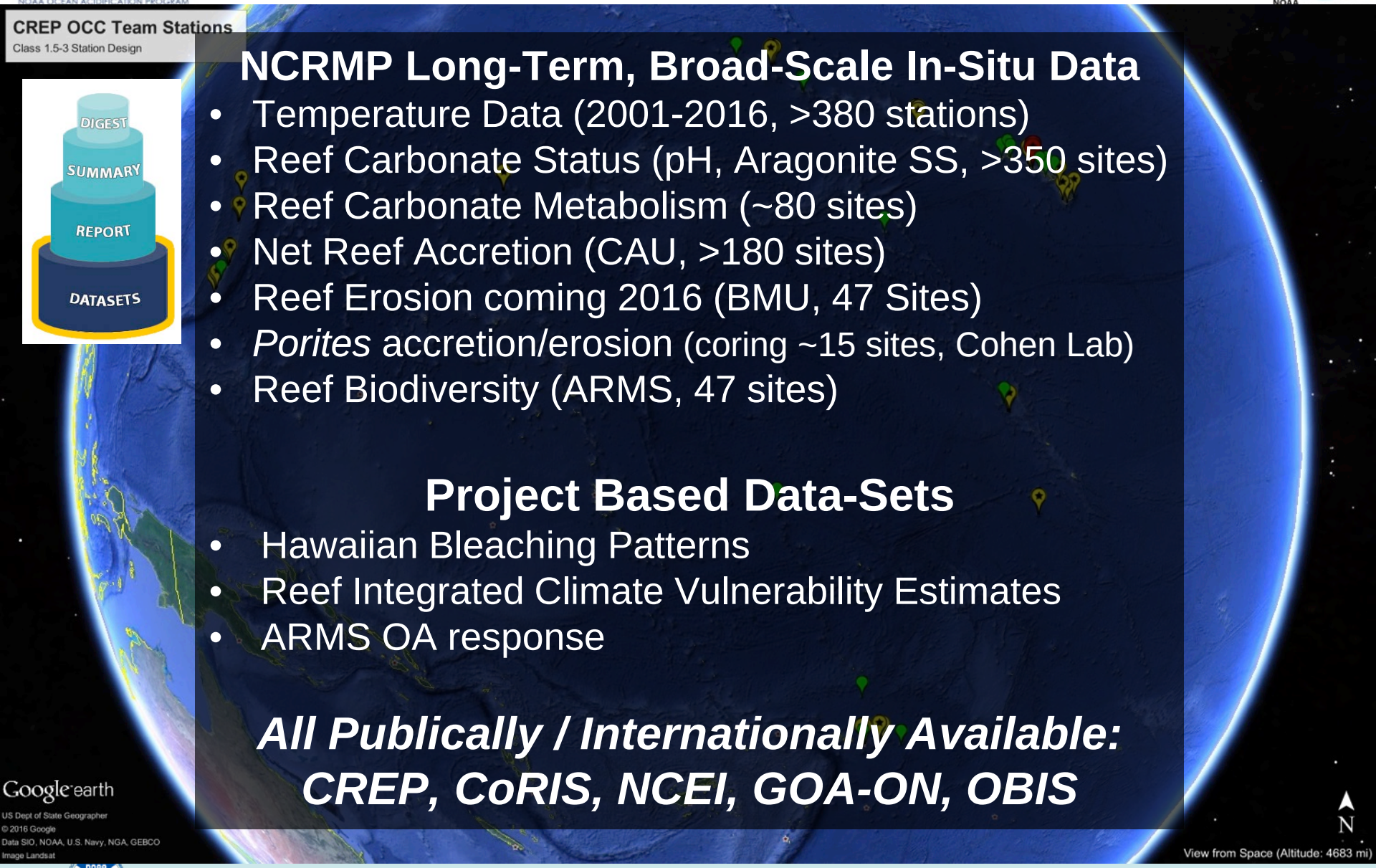

NCRMP Long-Term, Broad-Scale In-Situ Data

- Temperature Data (2001-2016, >380 stations)
- Reef Carbonate Status (pH, Aragonite SS, >350 sites)
- Reef Carbonate Metabolism (~80 sites)
- Net Reef Accretion (CAU, >180 sites)
- Reef Erosion coming 2016 (BMU, 47 Sites)
- *Porites* accretion/erosion (coring ~15 sites, Cohen Lab)
- Reef Biodiversity (ARMS, 47 sites)

Project Based Data-Sets

- Hawaiian Bleaching Patterns
- Reef Integrated Climate Vulnerability Estimates
- ARMS OA response

All Publically / Internationally Available: CREP, CoRIS, NCEI, GOA-ON, OBIS

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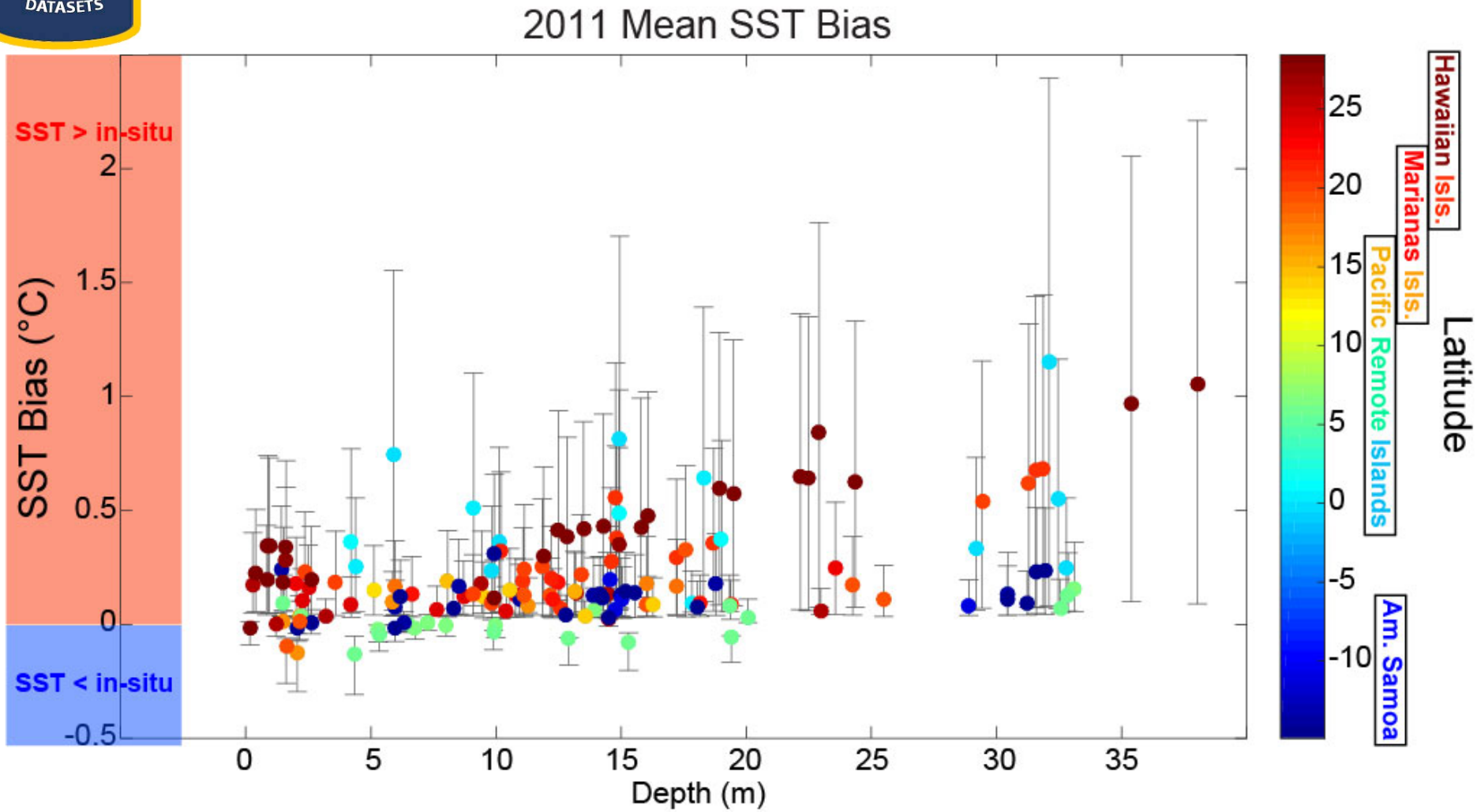
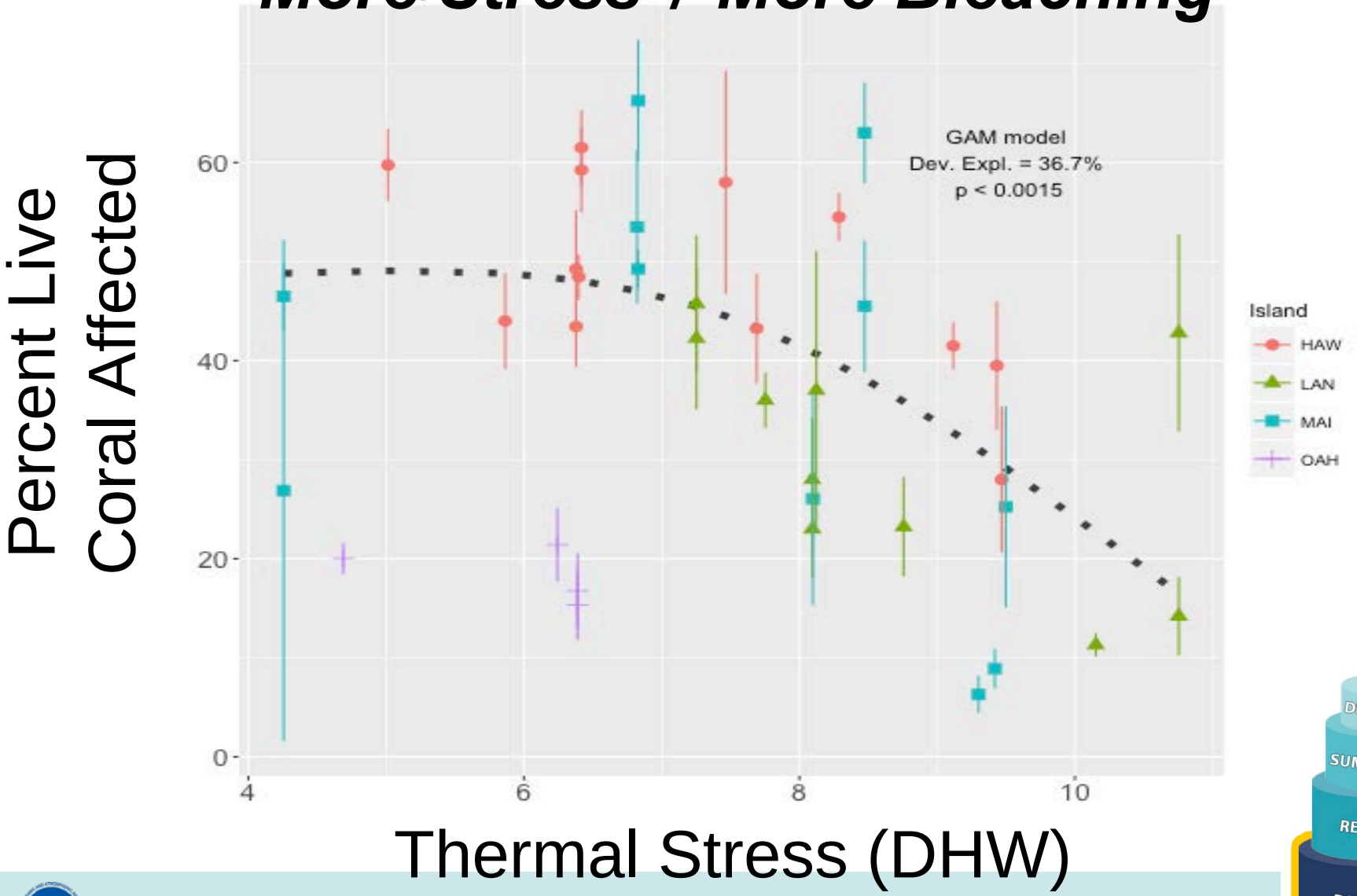
Comparing In-Situ Temperature to Satellite

- ***Satellite Bias Increases with Depth***
- ***Critical in Upwelling/Interval Wave Reefs***



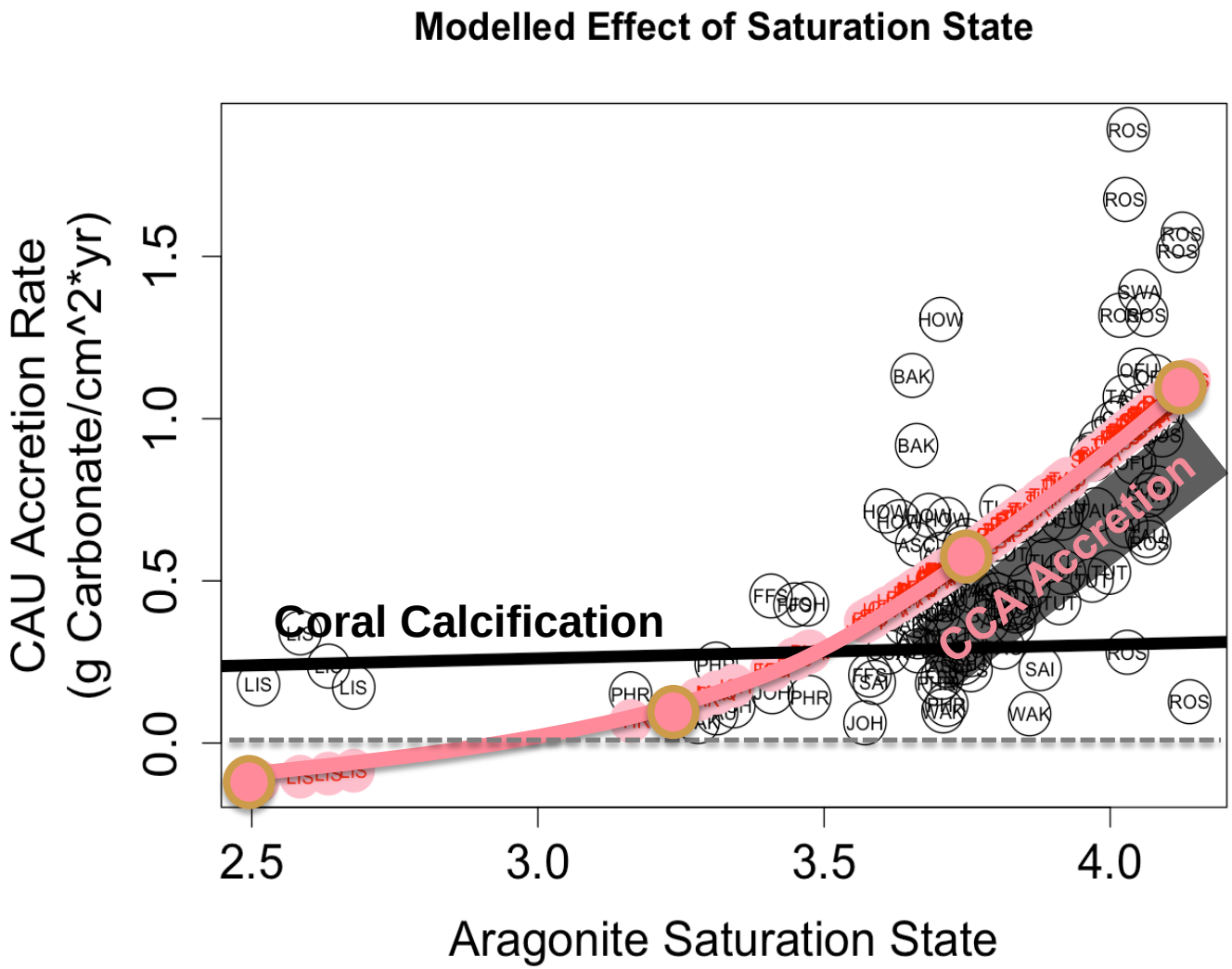
Bleaching *Resistance* As Important As Exposure

- ***More Stress ≠ More Bleaching***



OA Impacts on CCA likely already happening

- ***CCA much more sensitive than corals***
- ***Impacts already happening or soon to occur***



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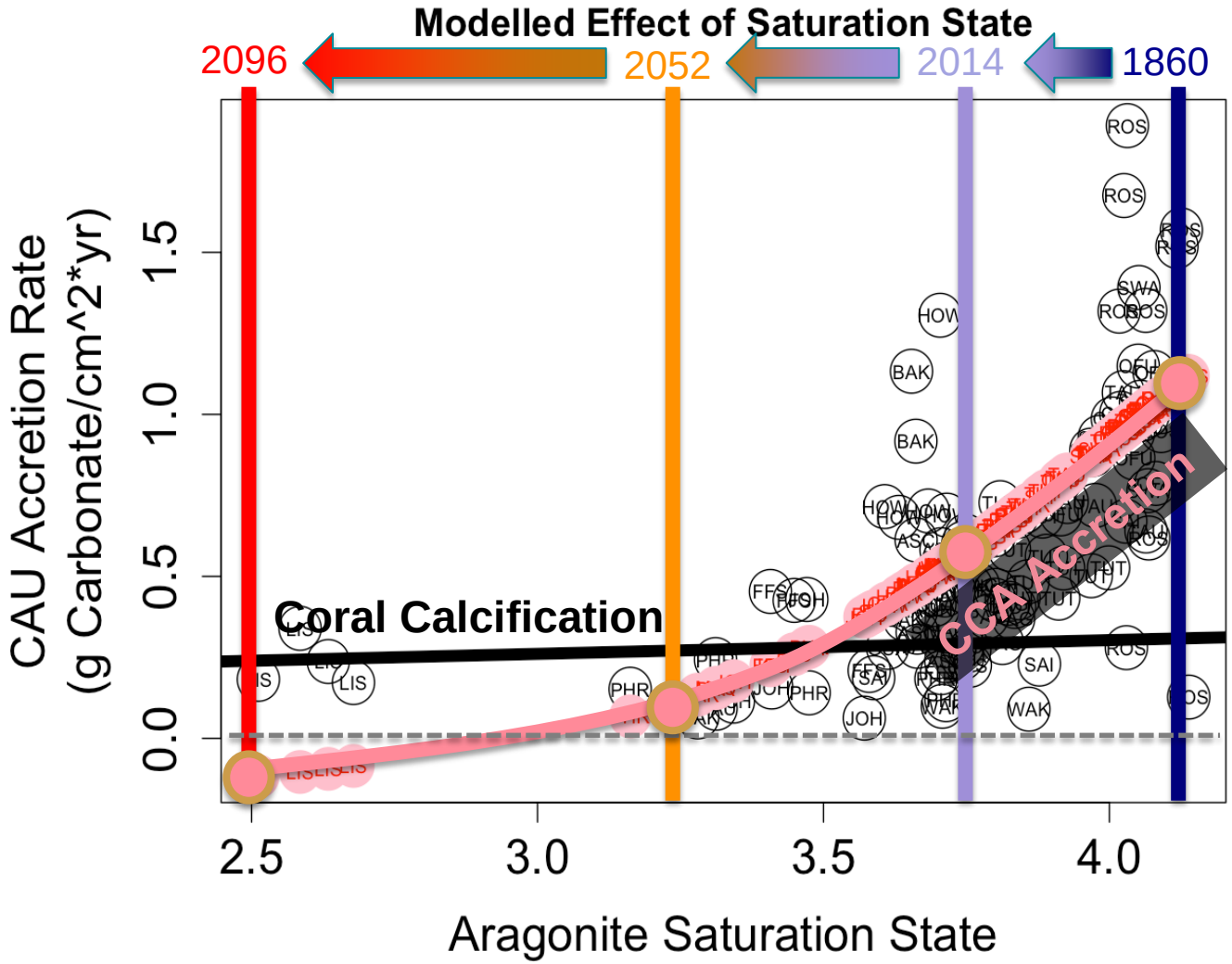
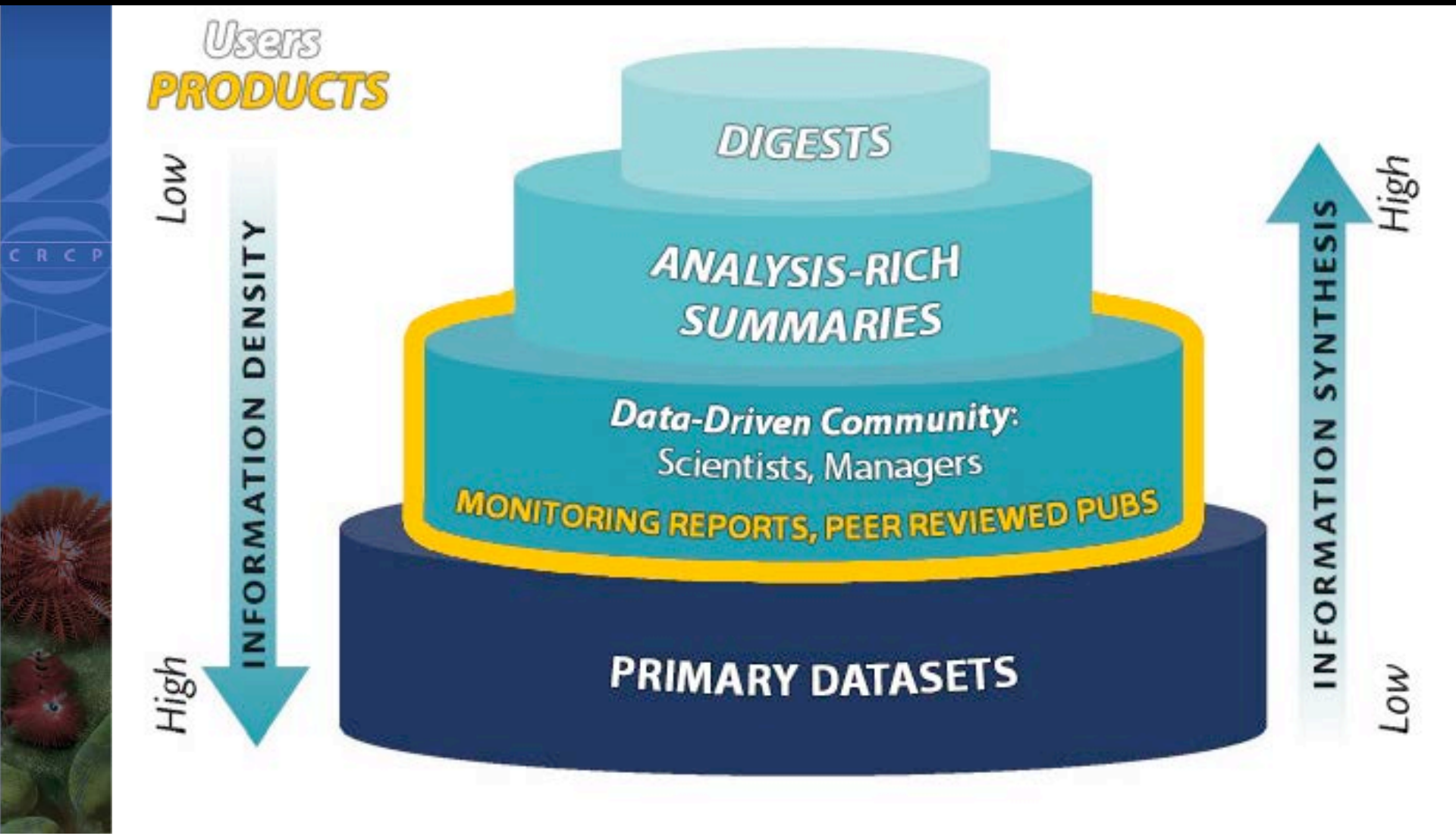
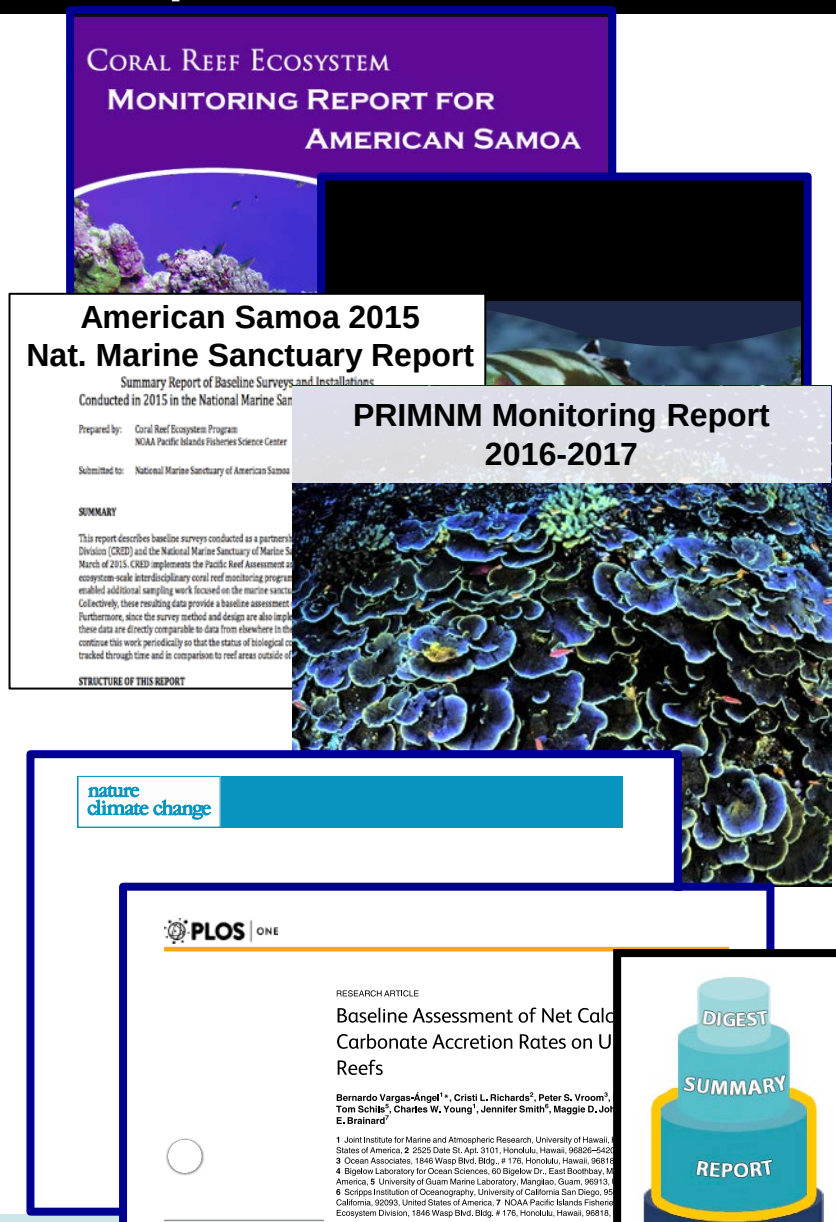


Key Outcomes, Dissemination, Users: Reporting "Wedding Cake"



CREP Data-Rich Reports

- CREP Regional Monitoring Reports
  - In-Depth, Data-Rich Reports
  - 100s of pages
  - Access to Primary Data
  - Manager-Driven, Manager-Used
  - Expensive to Produce, Infrequent
- Peer-Reviewed Publications
  - Highlighting Key Results
  - Maintaining Wider Knowledge of the Dataset's Existence



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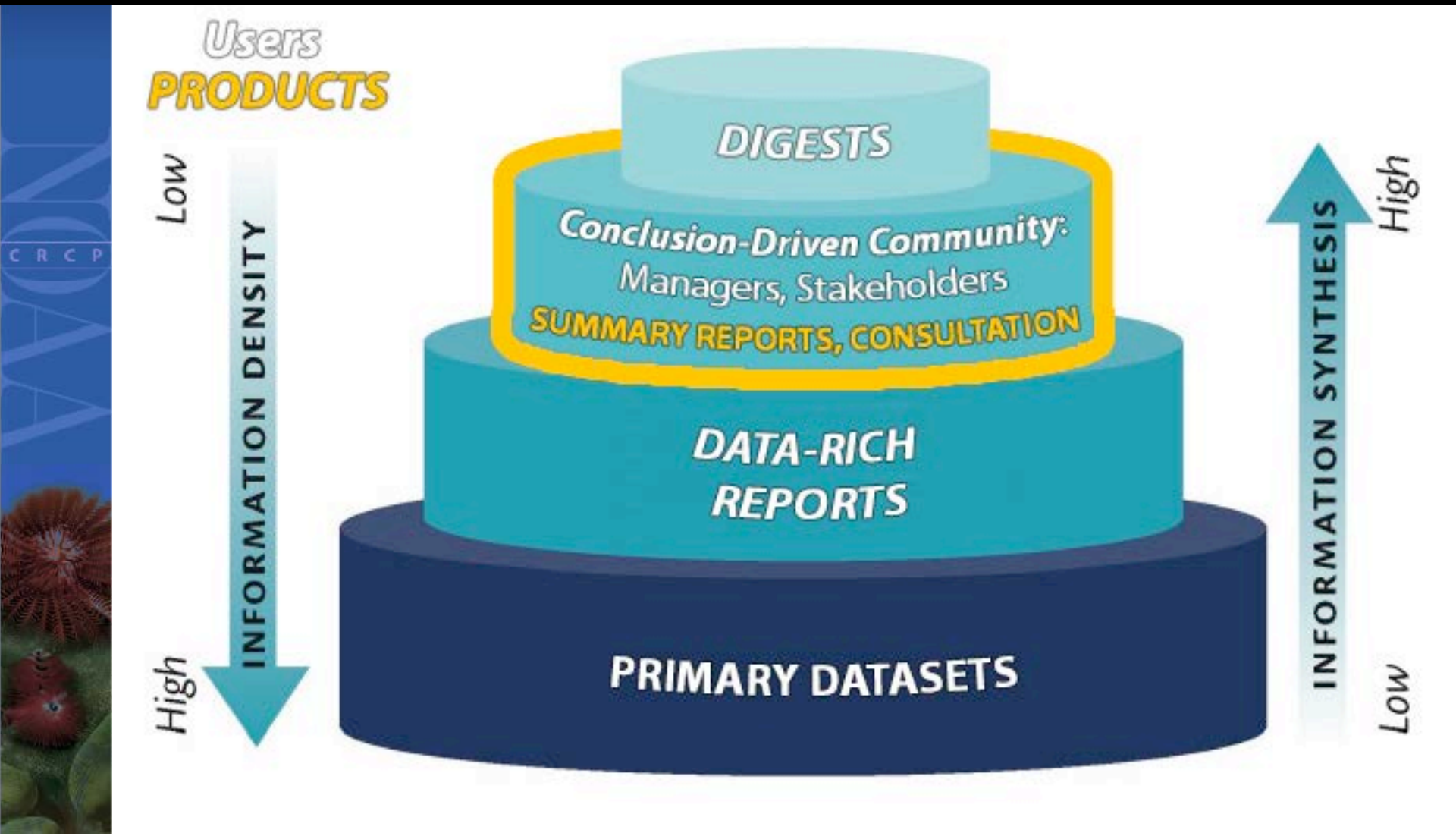
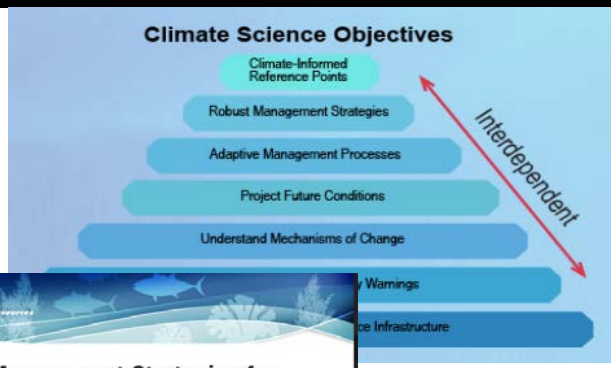


Analysis-Rich Summary: Briefer Booklets

- Briefer Booklets Presenting Digested Data
- Targeted at regional managers and more engaged public/policymakers

Inter-Agency Consultation

- NOAA Pacific Islands Regional Climate Action Plan
- Hawaii DAR Bleaching Recovery Steering Crew / Workshops
- West-Pac Fishery Management Council – Climate Plan Team
- International Oceanographic Commission – OA Workshops



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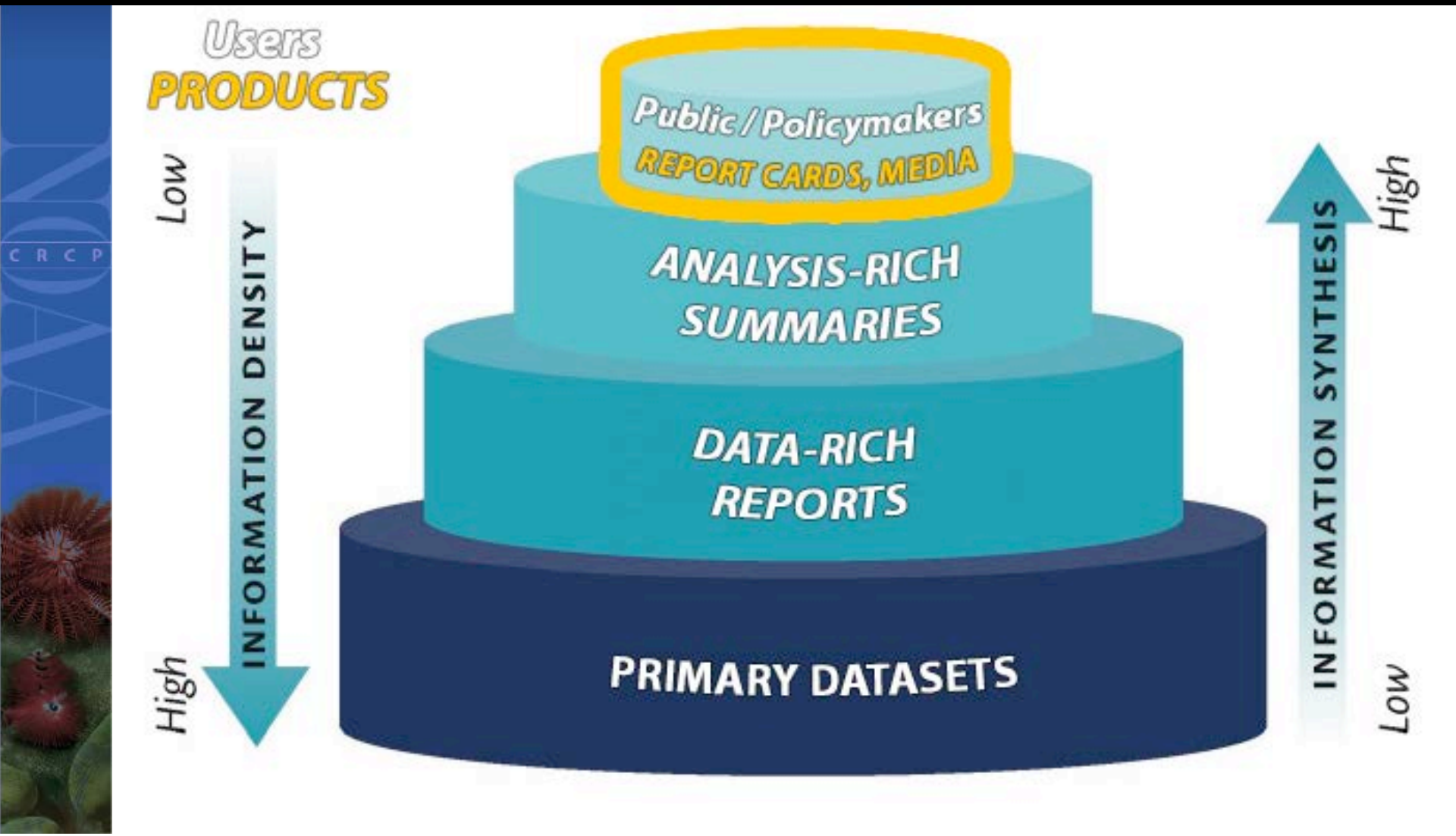
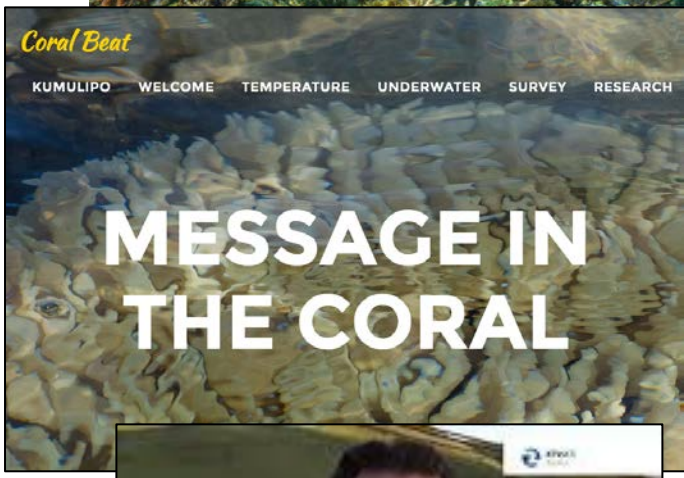


Highly Digested Summary

- Report Card Effort
  - Targeted at public/policymakers
- Web Highlights
  - E.g. Coral Beat: coralbeat.org
    - *2016 Global Space Apps Challenge Nominee*
- Media Interviews



Key Challenges:

Analysis-Collection Balance

- CREP is a well-oiled in-situ data collection machine.
- High-level analysis depends on skilled staff, time to produce synthesis.
- *Thus far, we've been supplementing core NCRMP to produce analytical products.*

Episodic Monitoring

- NCRMP Provides stable, long-term monitoring
- Bleaching events occur outside monitoring window
- *This last time, RFP process fit into bleaching event. Next time?*

Future Directions

- Refine data-management, data-dissemination, and public access to machine-readable data.
  - Better engage collaborators
- Modifying/adding methods to directly address higher-level questions (e.g. NCC, Carbonate Budgets)
- Leveraging opportunities for data-rich reporting: PRIMNM Monitoring report
- Continuing to push all of the above “wedding-cake” reporting

Recent Peer-reviewed OCC Publications

- **Gove, Jamison** M., Gareth J. Williams, Margaret A. McManus, Scott F. Heron, Stuart A. Sandin, **Oliver J. Vetter**, and David G. Foley. "Quantifying climatological ranges and anomalies for Pacific coral reef ecosystems." *PloS one* 8, no. 4 (2013): e61974.
- Vargas-Angel, B, CL Richards, PS Vroom, NN Price, T Schils, **CW Young**, M Johnson, **RE Brainard** (2015). Baseline assessment of net calcium carbonate deposition rates for U.S. Pacific reefs. *PLoS One*
- DeCarlo TM, Cohen AL, Barkley HC, Cobban Q, **Young C**, Shamberger KE, **Brainard** RE, Golbuu Y (2015) Coral macrobioerosion is accelerated by ocean acidification and nutrients. Geology 43 (1): 7-10, doi: 10.1130/G36147.1
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- **Venegas, R., Oliver, T., Brainard, R.**, Geronimo, R., Wongbusarakum, S., Santos, M., *Coral Triangle Fisheries Vulnerability In A Changing Climate: Skipjack Tuna Thermal Spawning Habitats* (Internal Review; to be submitted to *Fisheries Oceanography*)
- **Oliver, T**, NN Price, **RE Brainard**; Environmental drivers of net carbonate accretion rates across the Pacific Basin; (in prep, submission winter-2016)
- **Clark S**, Heron S, **Oliver T**, Eakin M, Brainard RE; A comparison of in-situ and satellite temperature methods to estimate bleaching-relevant high temperature anomalies. (in prep, submission winter-2016)
- **Pomeroy N, Oliver T, Brainard R**; Spatial Variation in Coral Bleaching in the 2015 Bleaching across the Main Hawaiian Islands. (in prep, submission winter-2016)
- Oliver T, Young C, Brainard R; Reef accretion/erosion balance as inferred from onshore-offshore gradients across the Pacific Basin; (in prep, submission mid-2017)