



Coral Reef Ecosystem Division Pacific Ocean Acidification Program

Rusty Brainard, Tom Oliver, C Young, M Timmers, R Feely, A Cohen, N Price, J Smith, D Manzello, I Enochs, D Gledhill, and many others



Intergovernmental
Oceanographic
Commission



NOAA OCEAN ACIDIFICATION PROGRAM



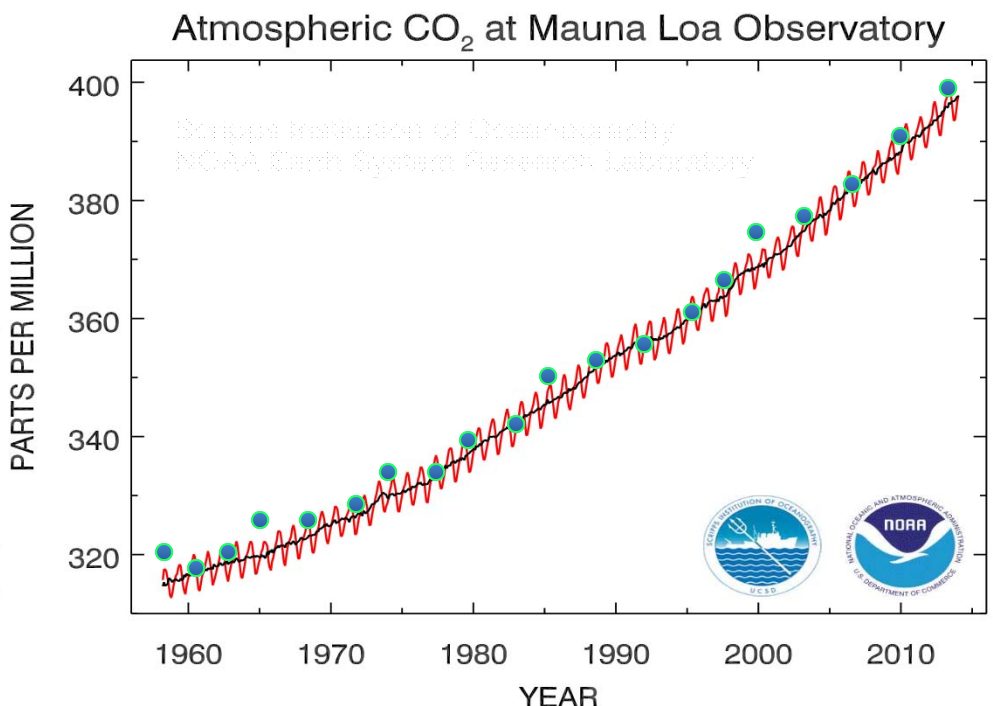
Assessing and Monitoring Ecological Impacts of OA Pacific RAMP

Establish baseline observations to assess and monitor long-term changes of:

Carbonate chemistry DIC, TA, S → pH, Ω

Calcification rates (Coring, CAUs)

Bioerosion rates (BMUs)



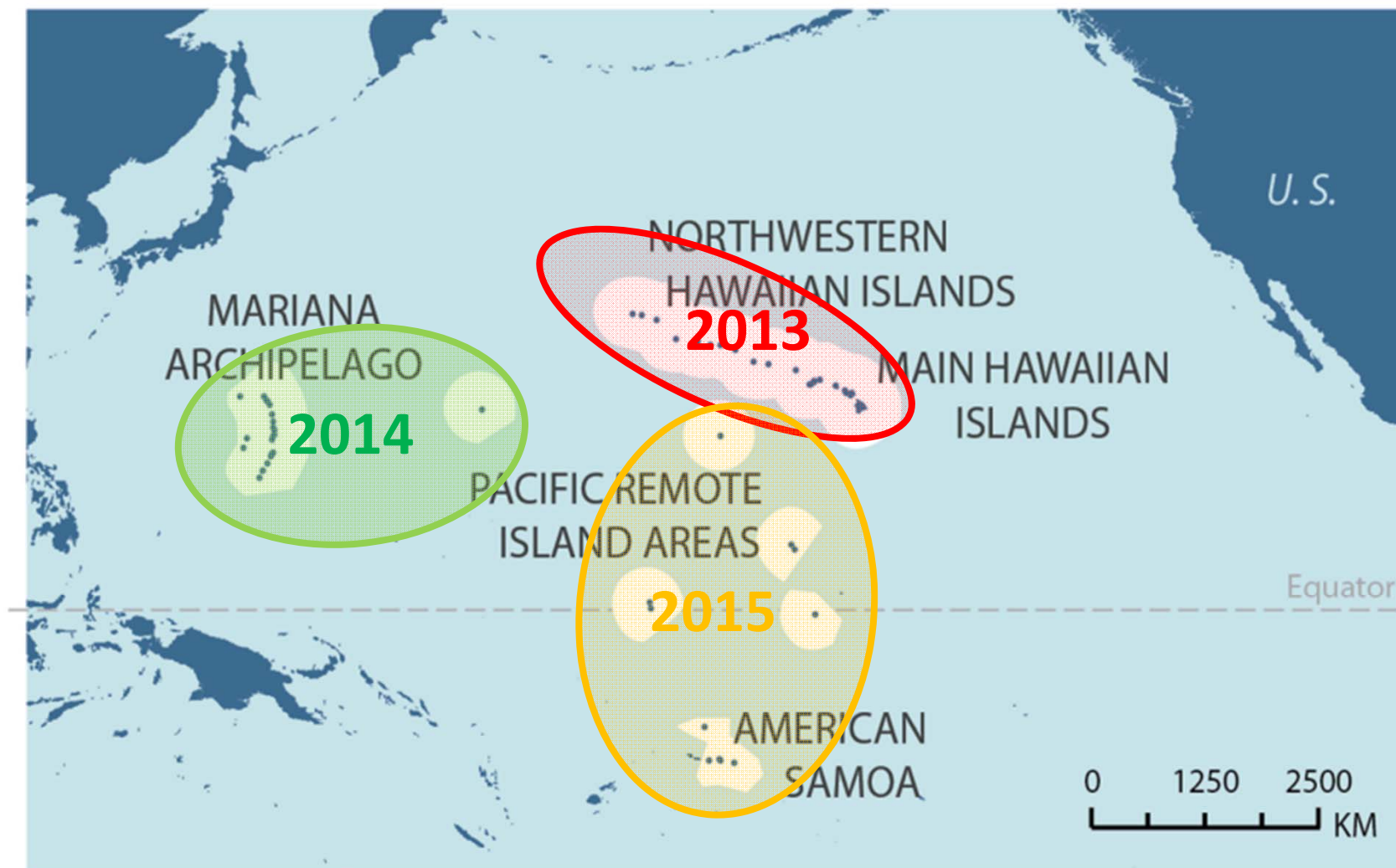
Cryptobiota diversity (ARMS)

Microbial diversity (environmental water sampling)

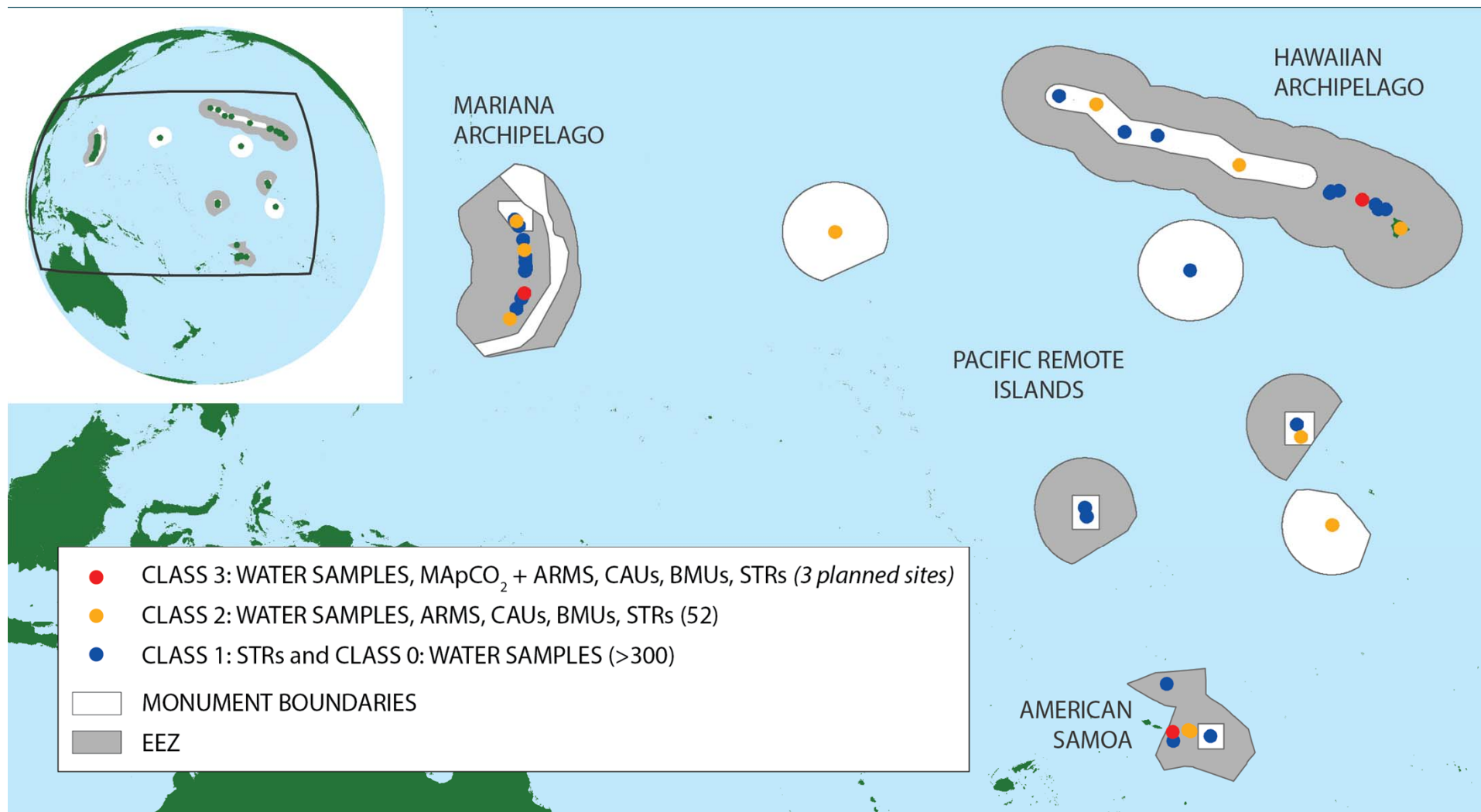
Benthic rugosity

→ Spatially distributed, consistent, repeatable, long-term observations of key indicators to robustly document changes in natural coral reefs attributable to OA

STUDY AREA



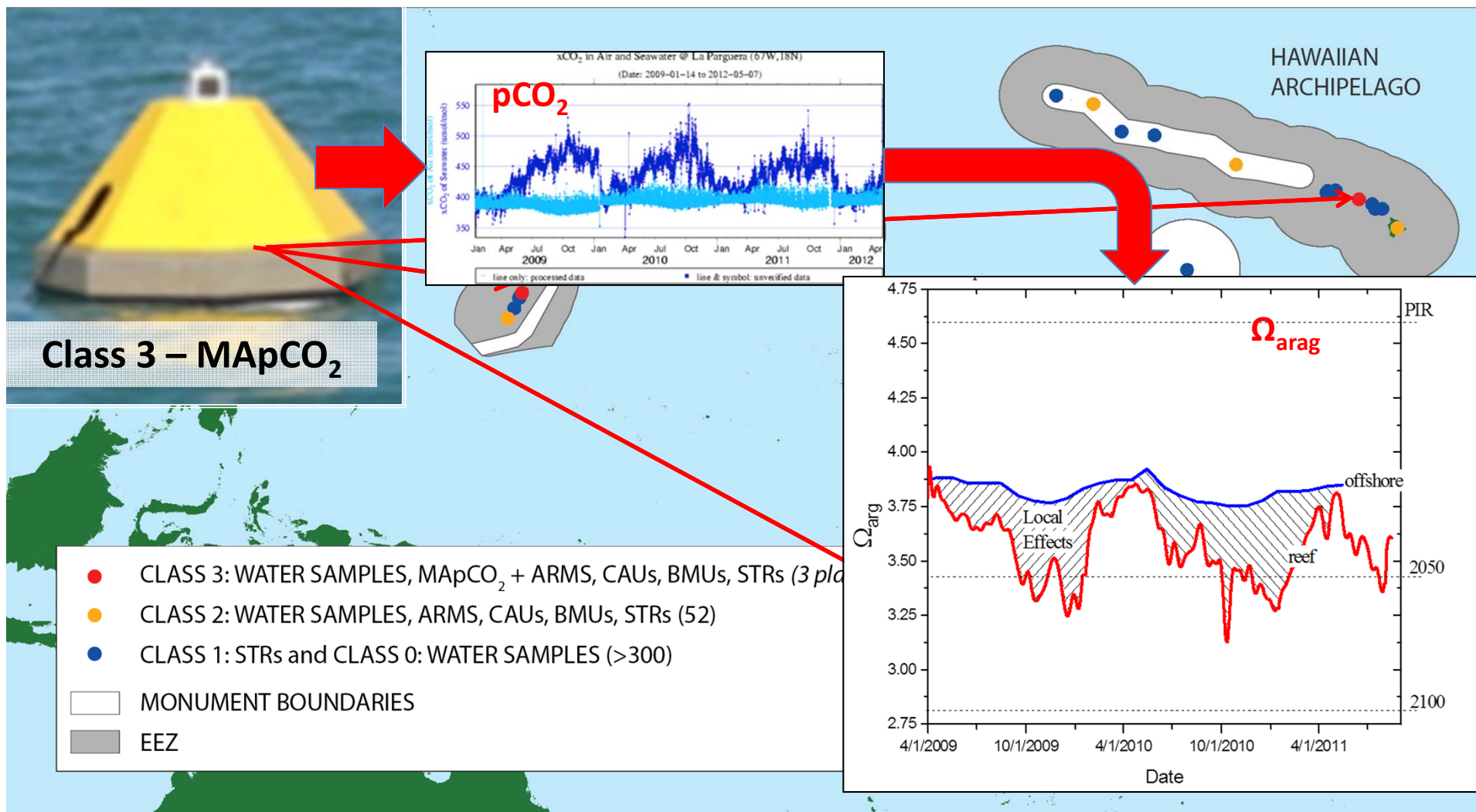
Pacific Ocean Acidification Hierarchical Observing Network



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

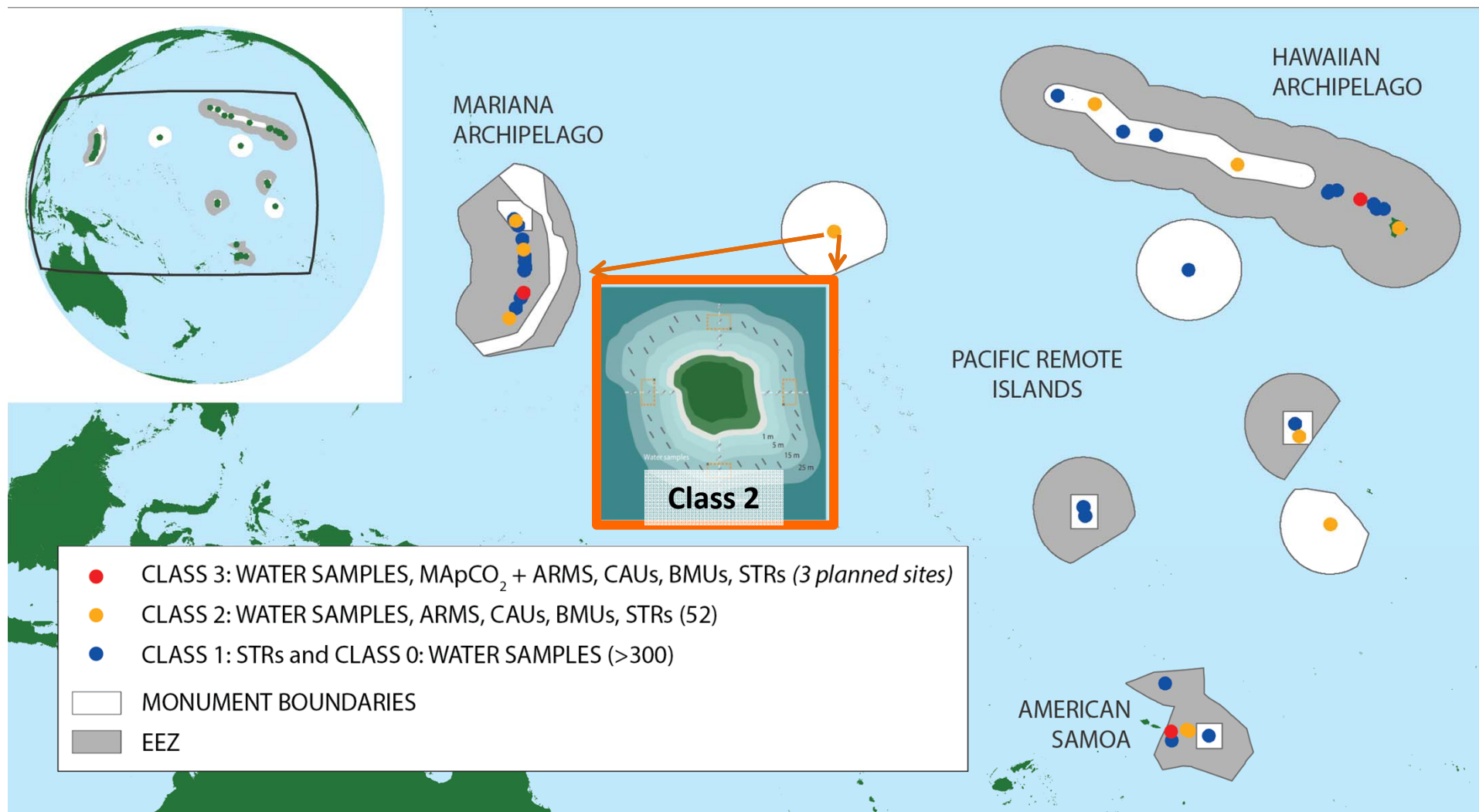
Pacific Ocean Acidification

Class 3 Stations



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

Pacific Ocean Acidification Class 2 Stations

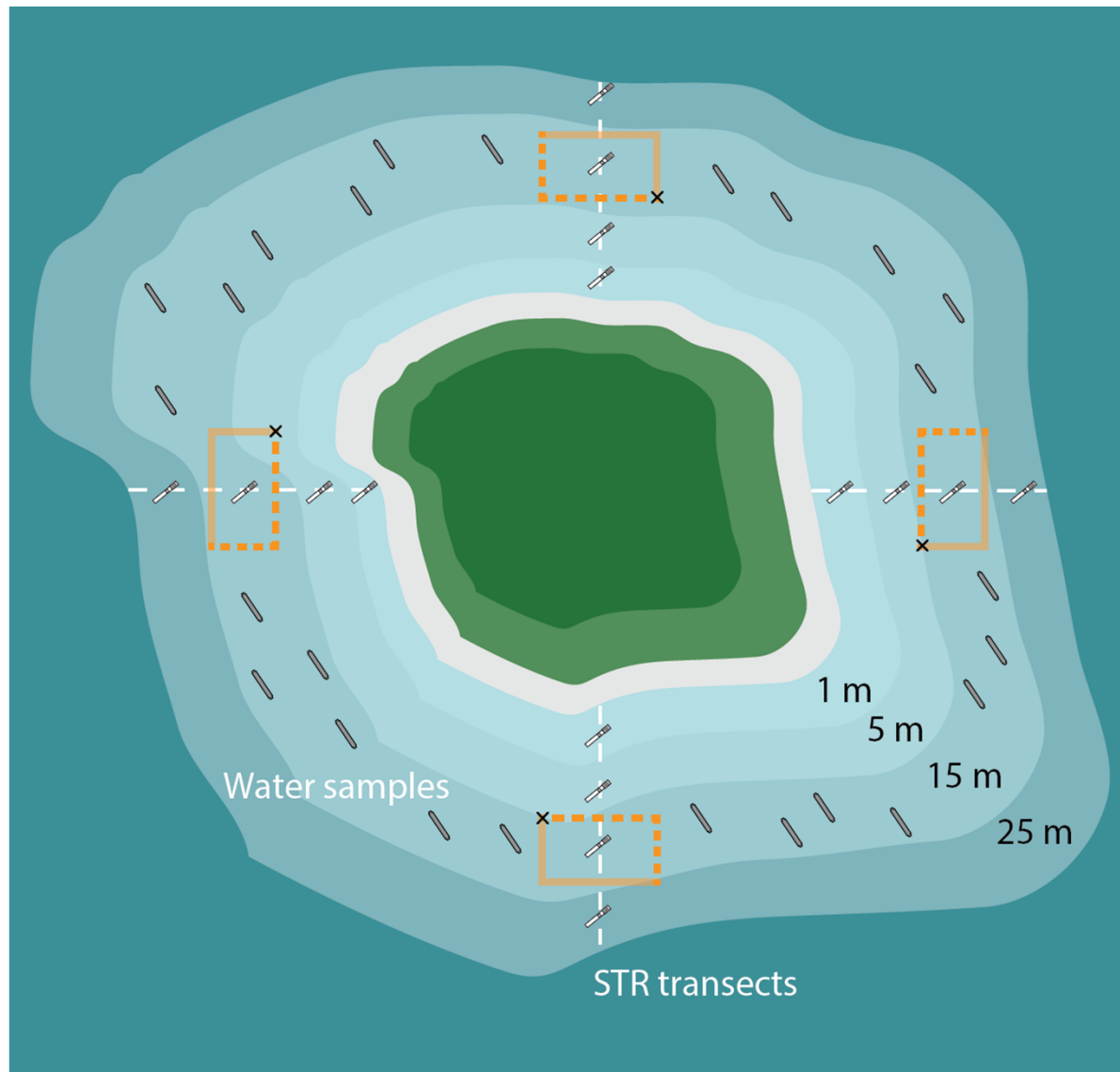


**Observing across gradients of environmental/oceanographic conditions,
biodiversity, human uses and impacts**

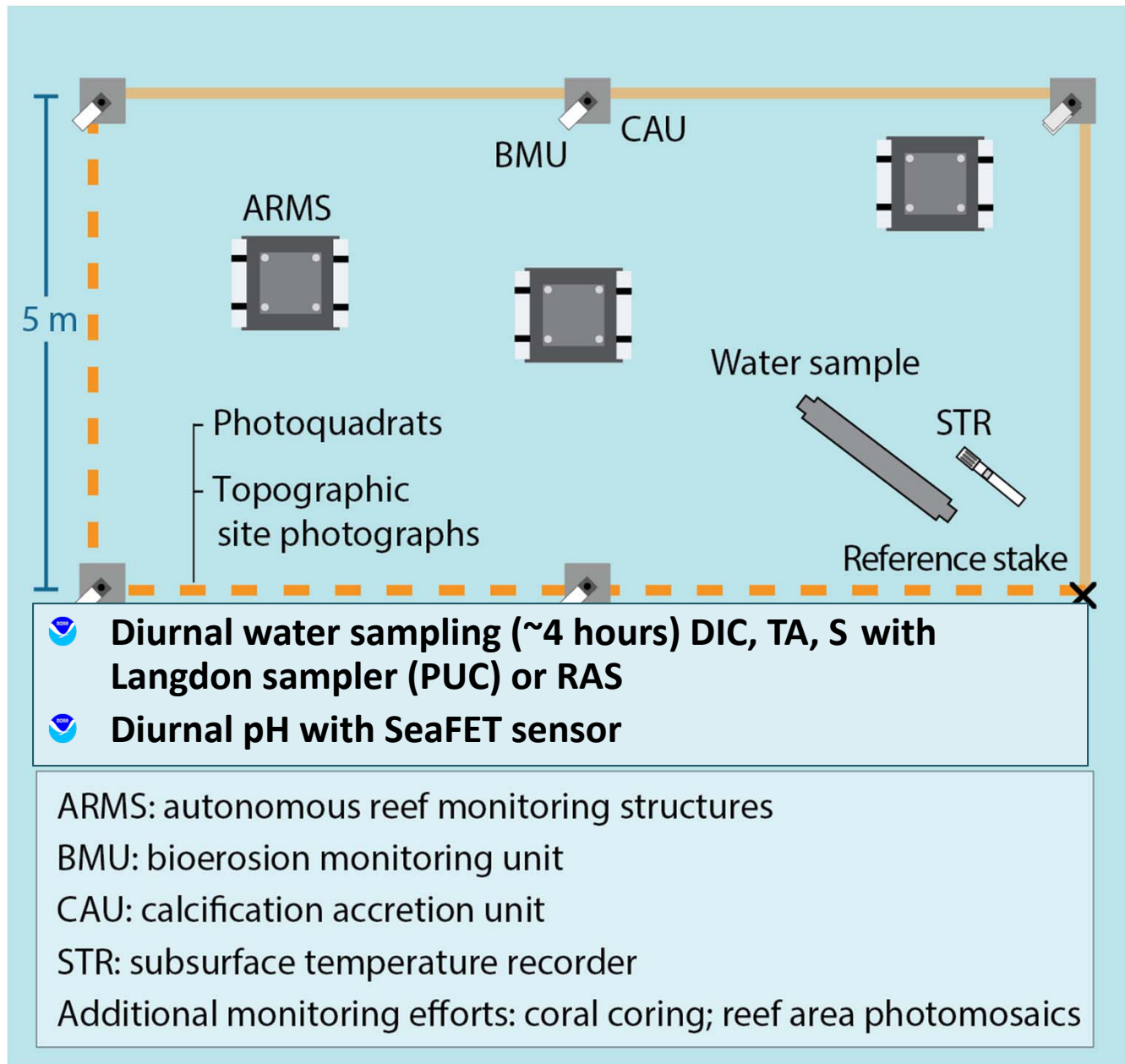
NCRMP – Island-wide Monitoring

Climate Stations positioned on fore reef at 15m depth

Temperature sensor transects: N, S, E, W at 1, 5, 15, 25m depths



NCRMP – Climate Station at 15m Depth





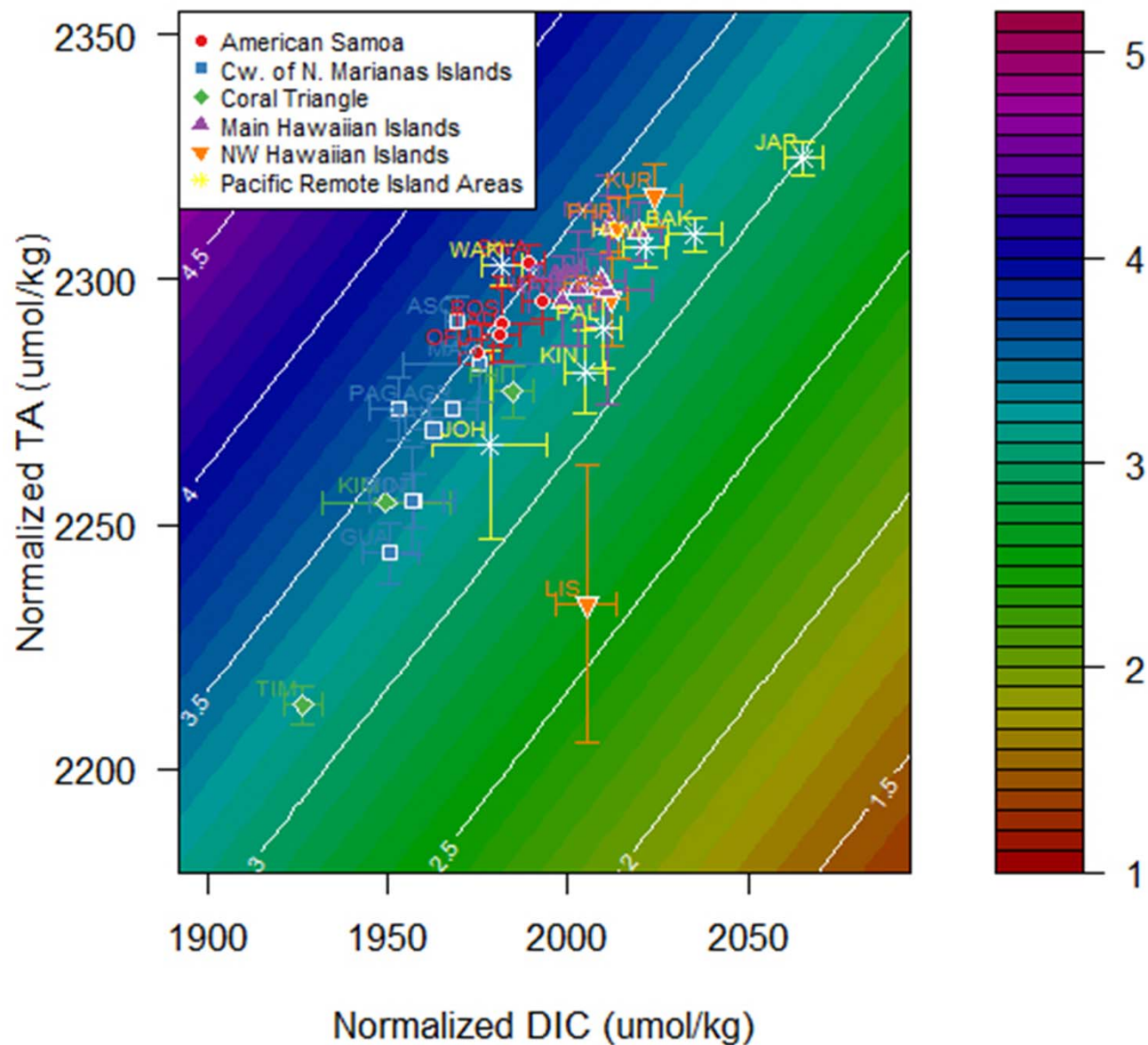
Water Quality Measurements - Carbonate Chemistry

- 1. Establish baseline Total Dissolved Inorganic Carbon (C_T) and Total Alkalinity (A_T) measurements**
- 2. Quantify the spatial variability in carbonate chemistry**
 - between surface and reef measurements**
 - between islands**
- 3. Support other ocean acidification (OA) projects within CRED and collaborations**
- 4. Quantify the temporal variability in carbonate chemistry**
 - diurnal signal**
 - annual/decadal trends**

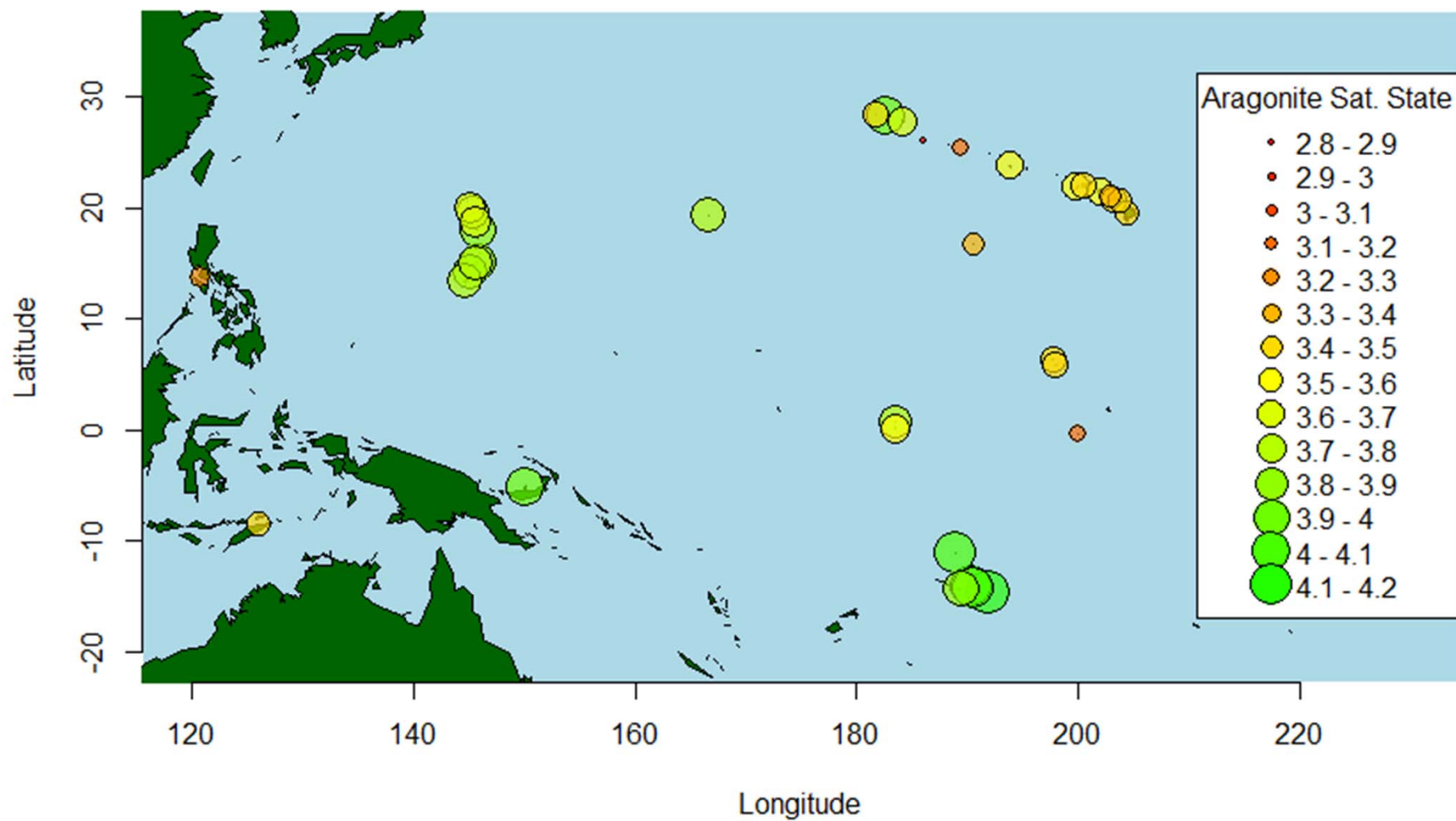


CRED Carbonate Sampling by Region & Island Reef Samples Only, 2011-2013, (T=25, S=35, P=0)

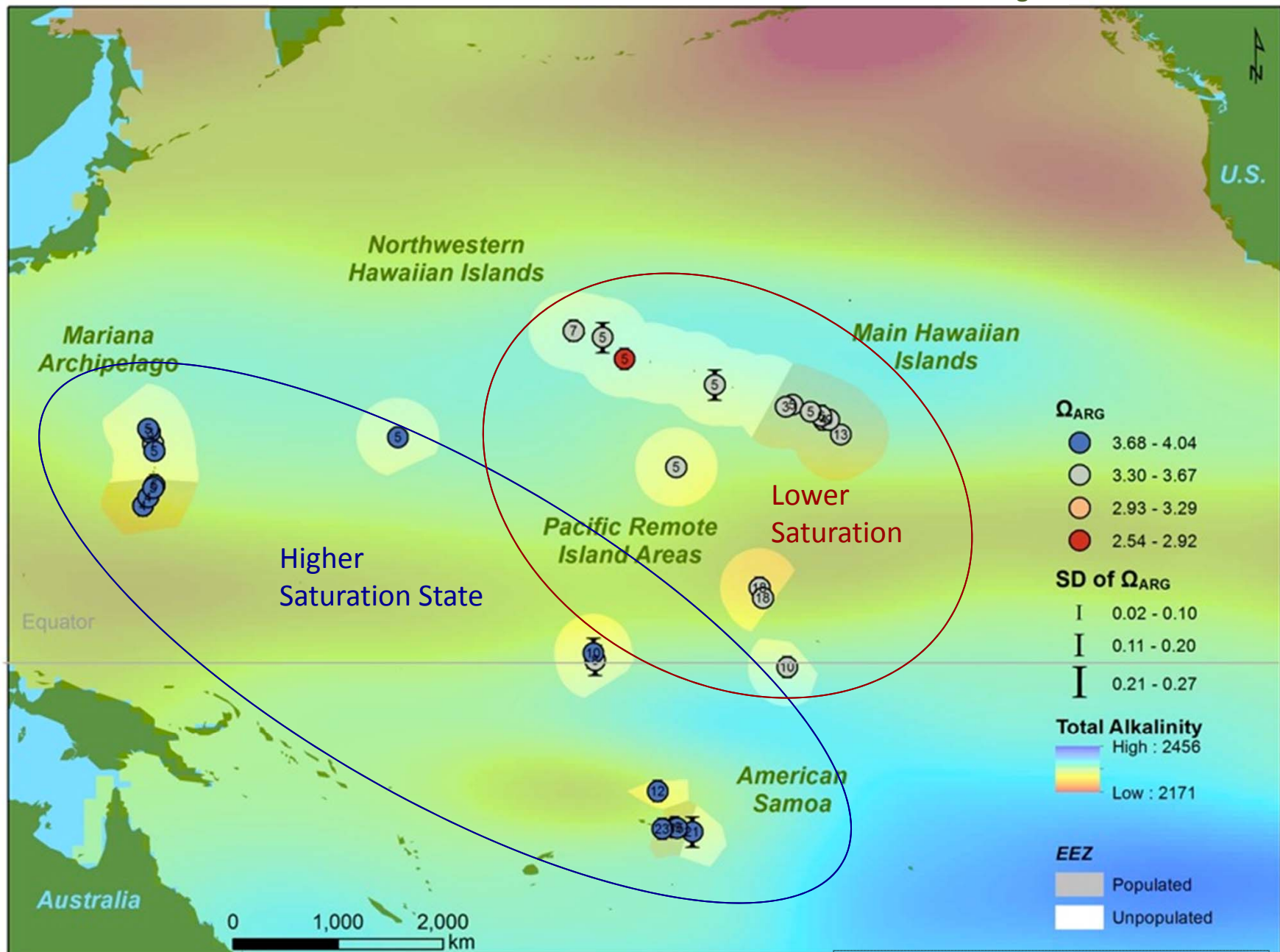
Aragonite
Saturation
State



Cross-Pacific Aragonite Saturation State 2010-2013

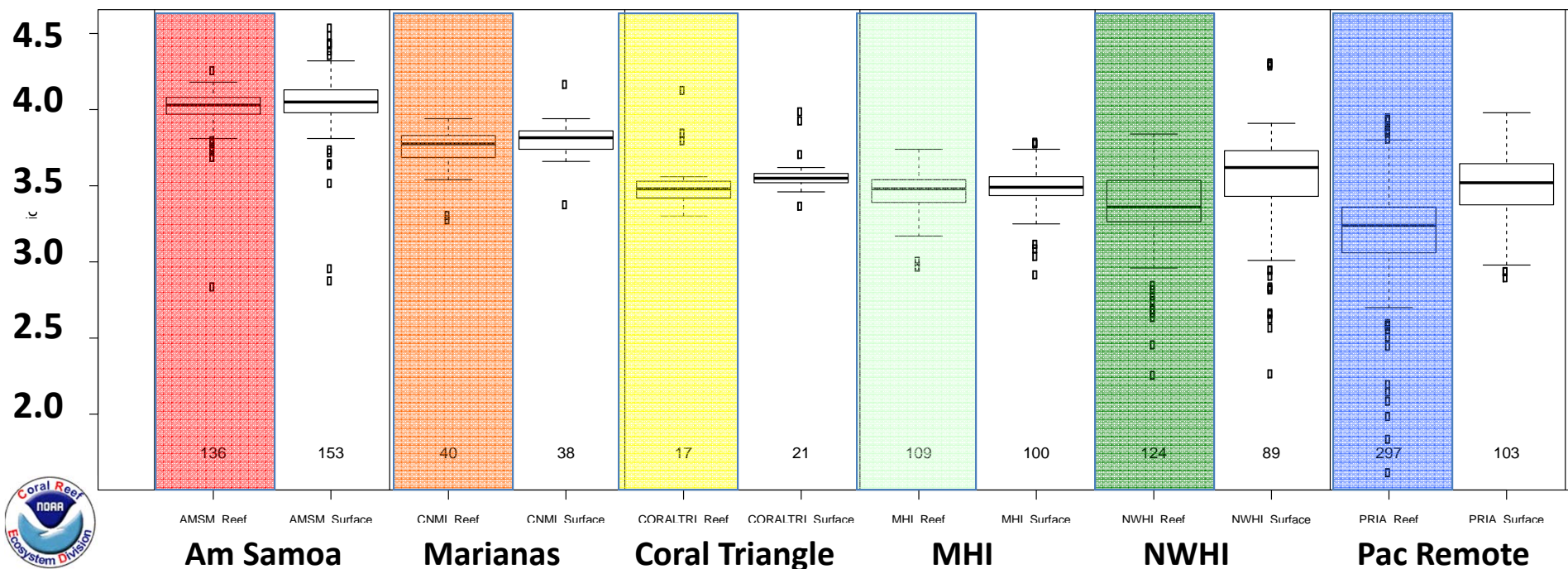
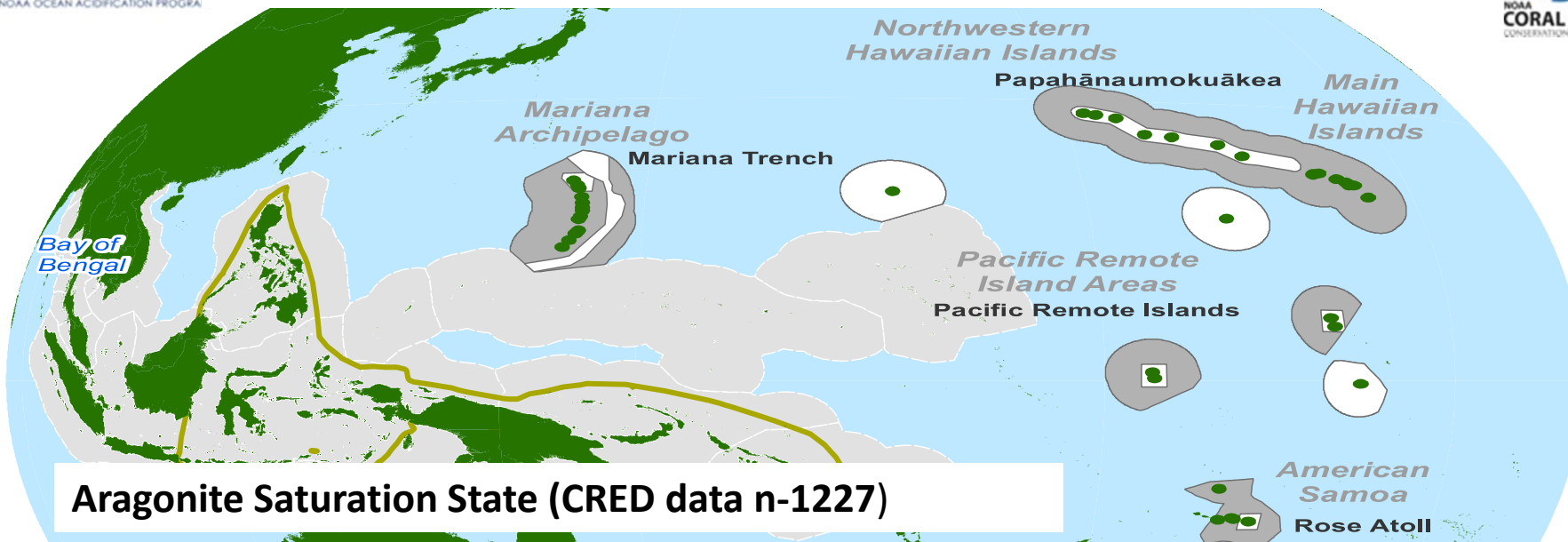


Mean Reef Aragonite Saturation State, Ω_{arg}



Chip Young et al. (in prep)

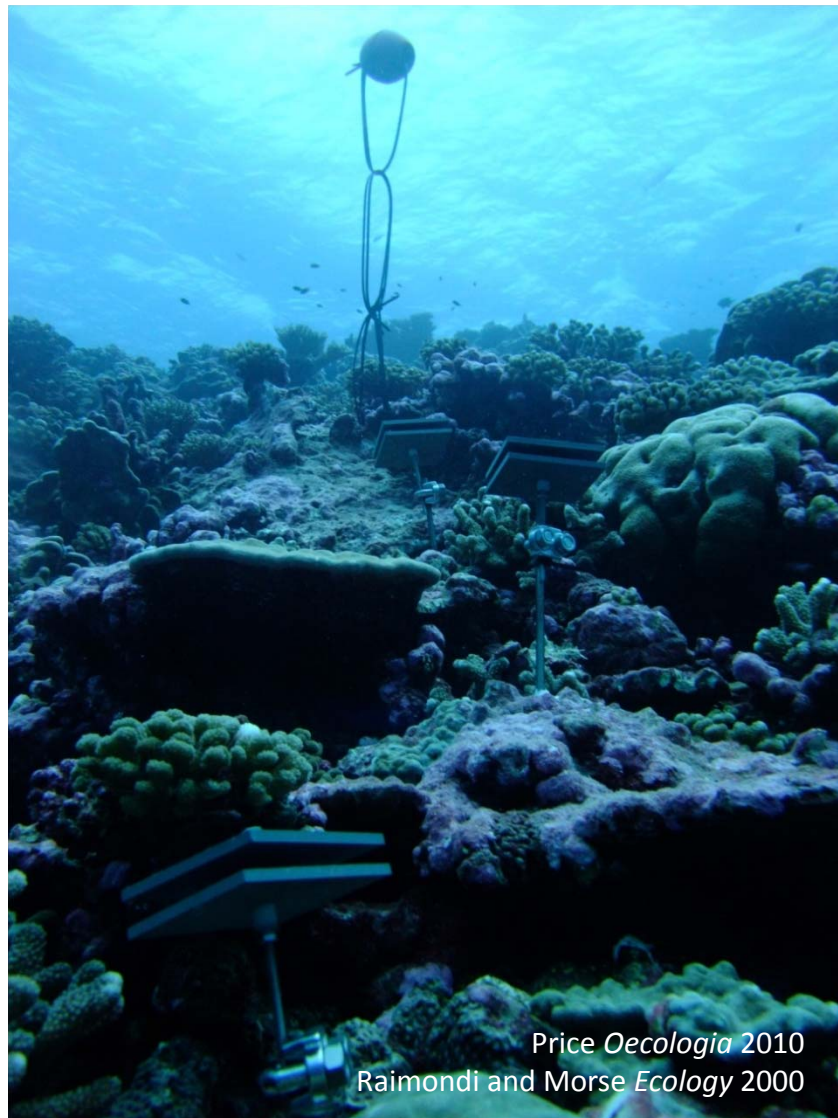
CRED Carbonate Chemistry





Calcification Measurements

Calcification Accretion Units (CAUs)



Products:

Net Calcification ($\text{g CaCO}_3 \text{ m}^{-2} \text{ yr}^{-1}$)

Net Vertical Accretion ($\text{mm CaCO}_3 \text{ yr}^{-1}$)

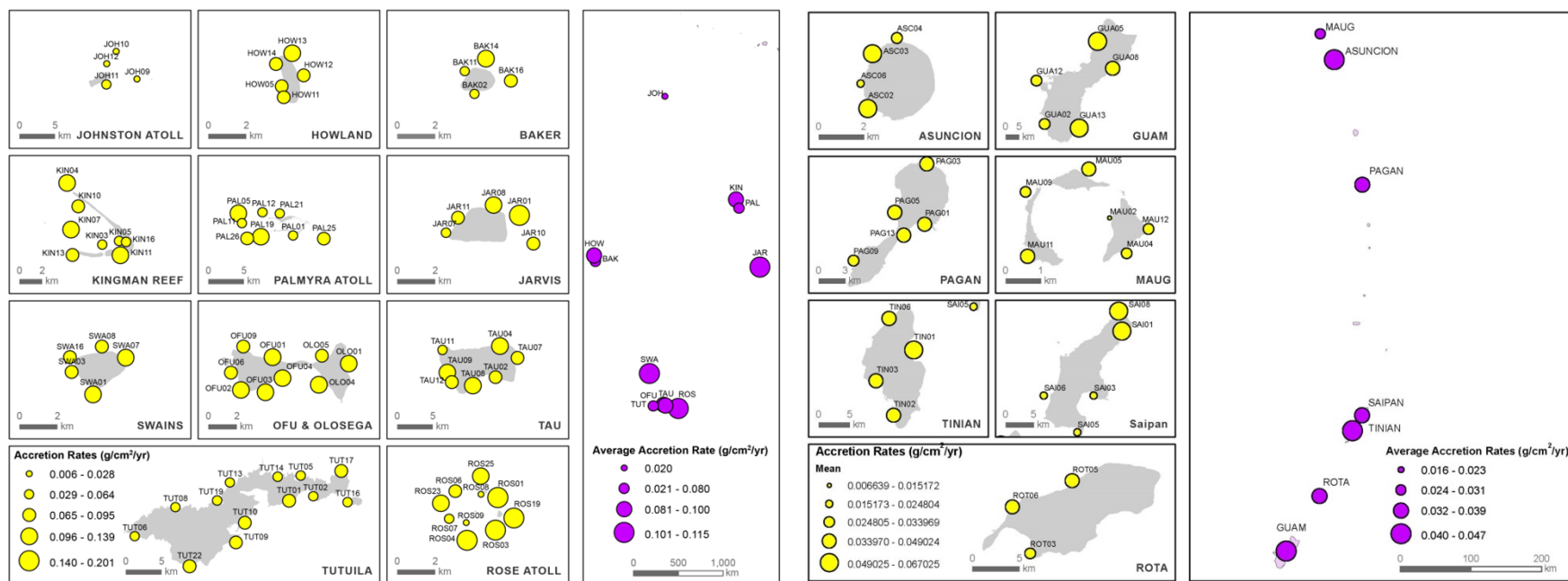
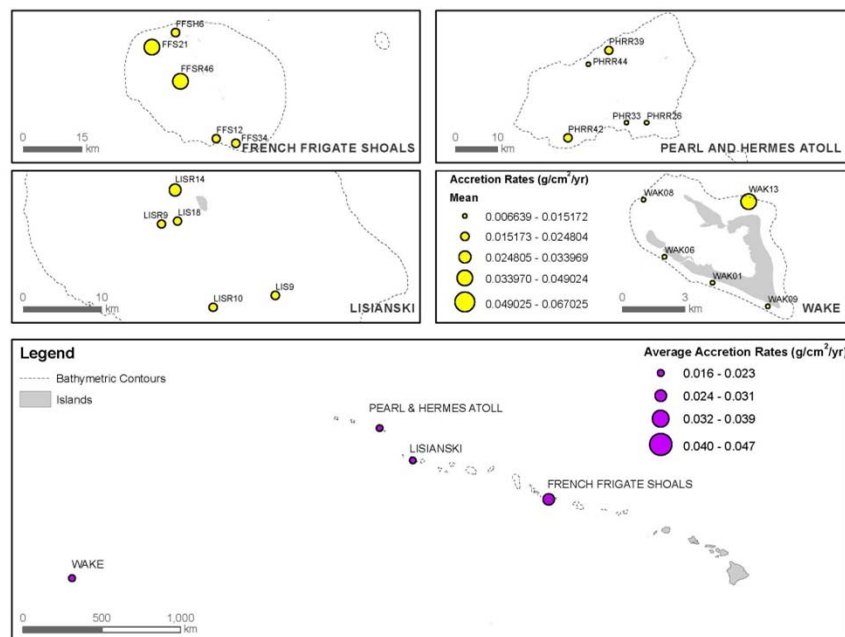
Species specific recruitment rates

Percent cover functional groups (CCA, coral, fleshy algae)

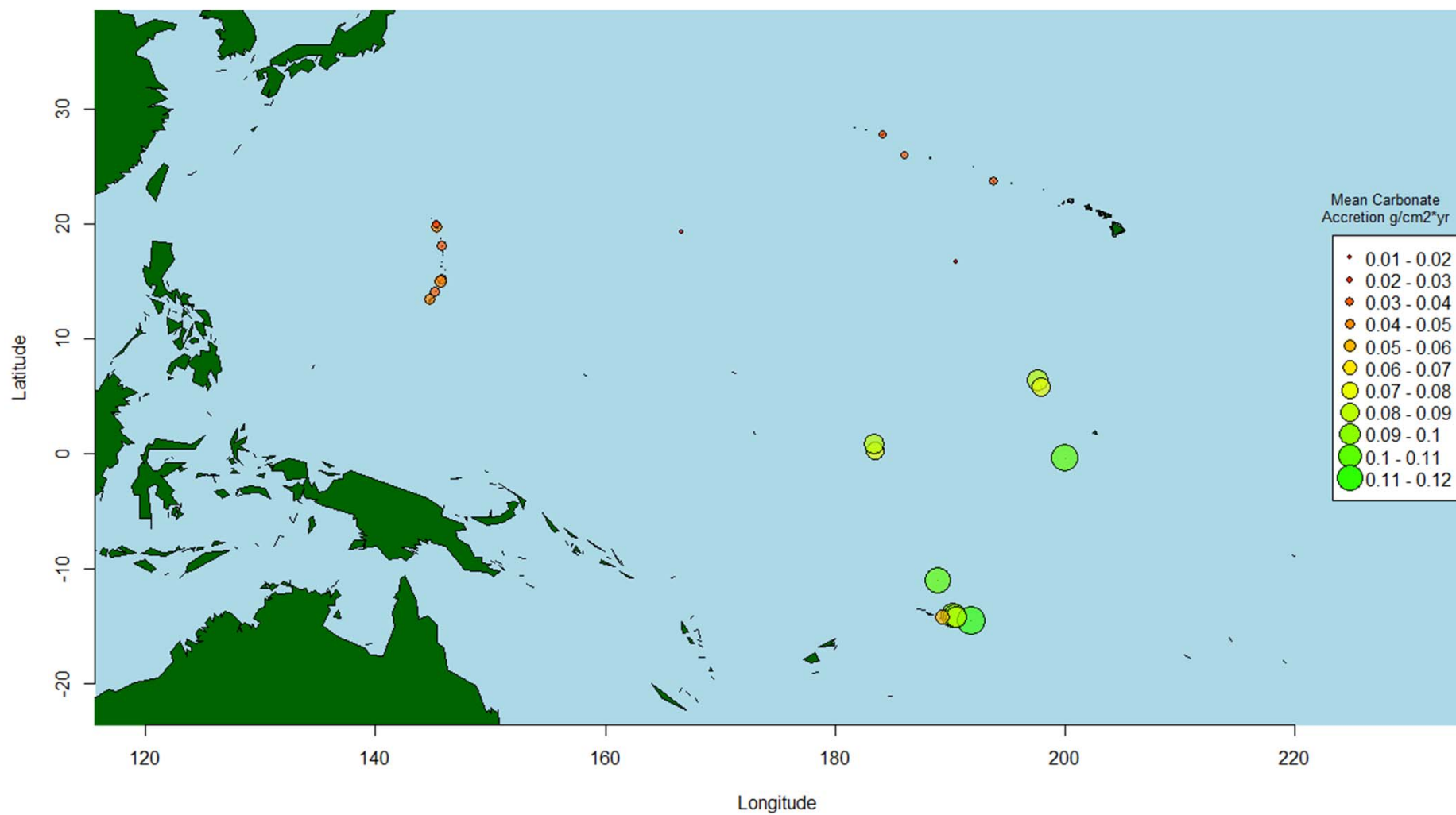




Pacific-wide Carbonate Accretion Rates Calcification Accretion Units (CAUs)

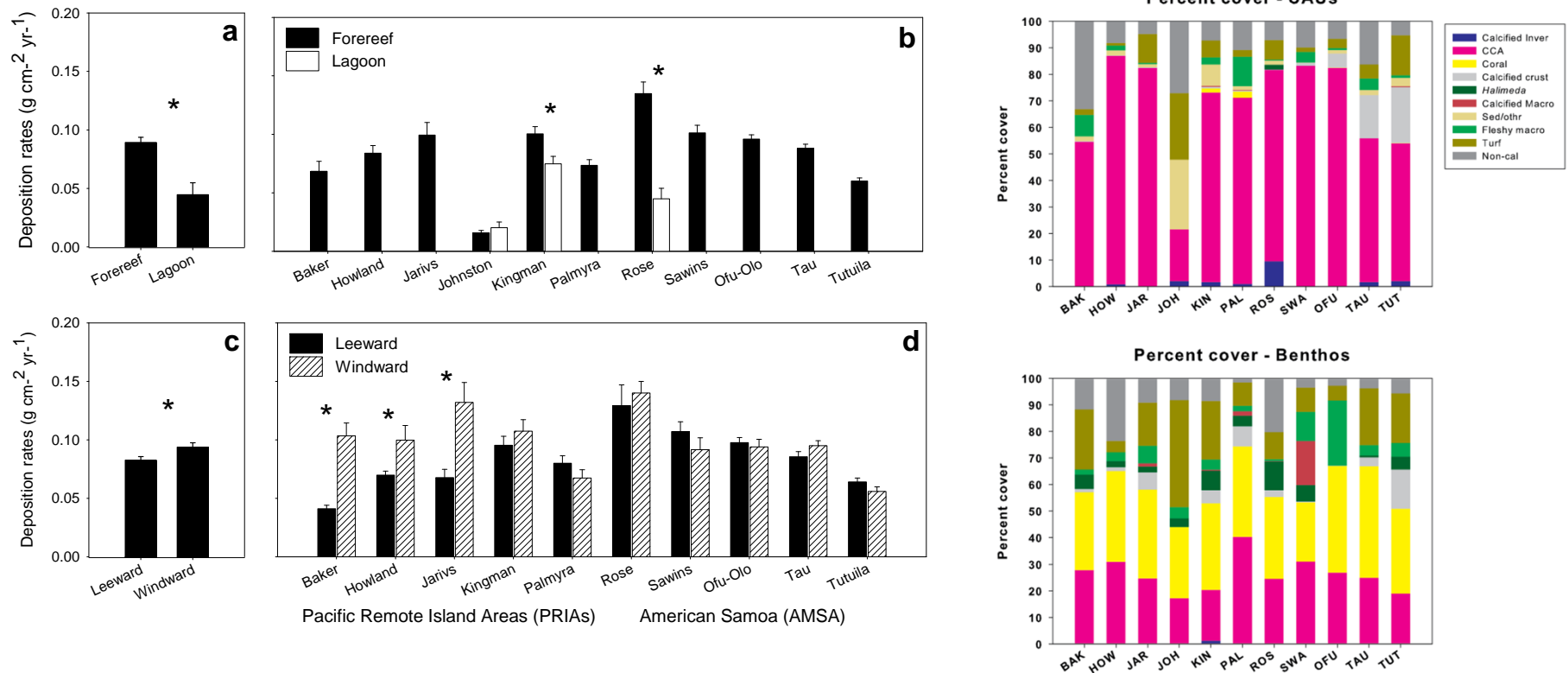


Cross-Pacific Carbonate Accretion (CAU) 2010-2013



Carbonate Accretion Rates Calcification Accretion Units (CAUs)

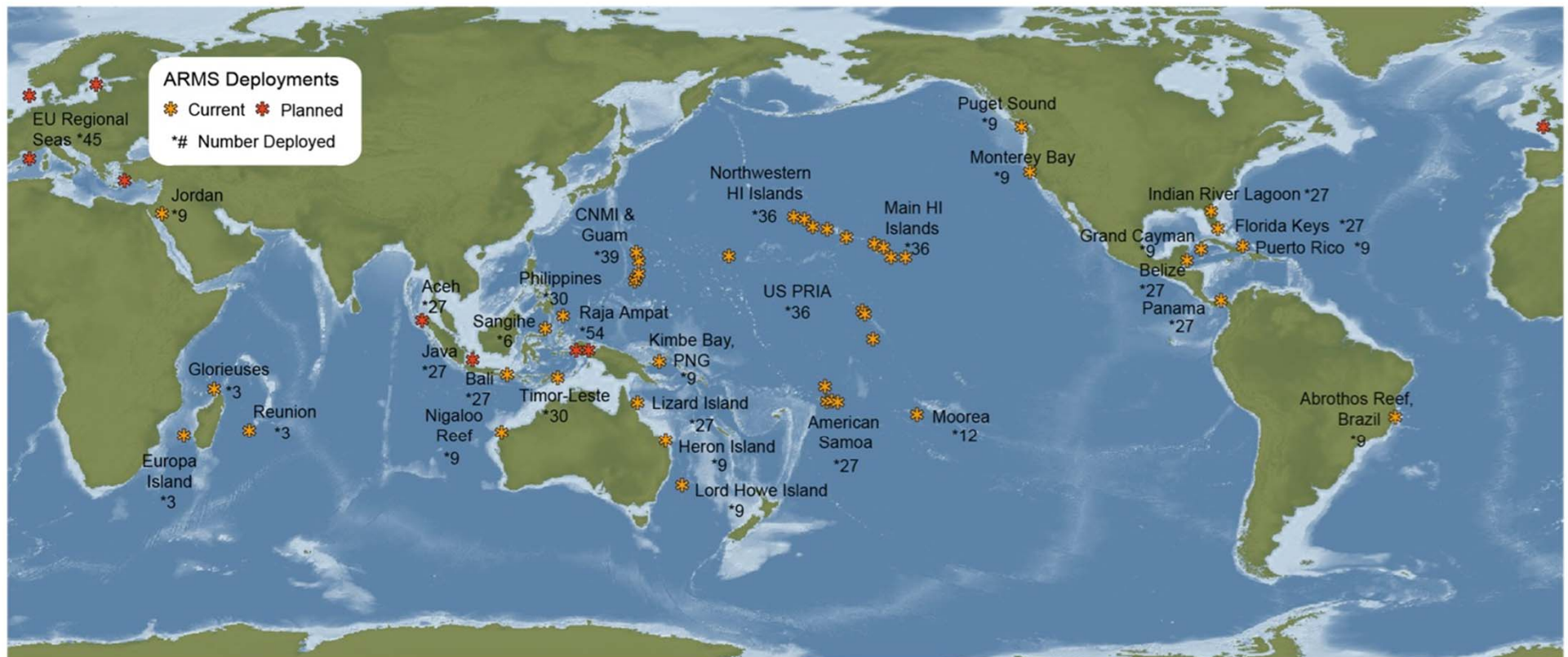
Spatial variability and contextual relationship with benthic cover



Baseline Assessment of Net Calcium Carbonate Deposition Rates for U.S. Pacific Reefs

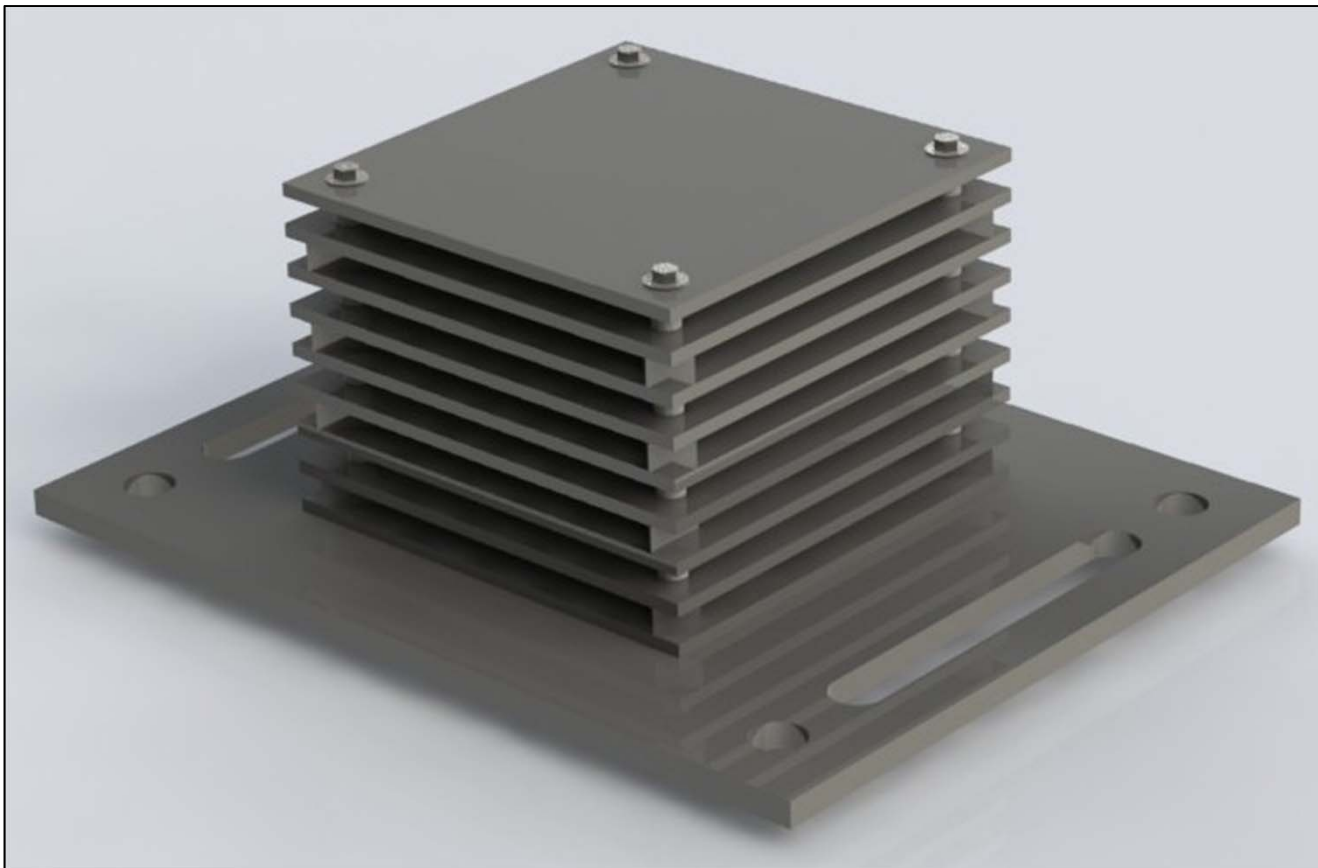
Bernardo Vargas-Angel, et al. (in review 2015)

Cryptic Biodiversity within the Reef - Autonomous Reef Monitoring Structures (ARMS)





Autonomous Reef Monitoring Structures (ARMS)





Why ARMS?



- **Coral reef ecosystems have an estimated 1-9 million species, most of which are unknown**
- **Assessment and long-term monitoring of cryptic species did not exist before ARMS**
- **Provides a global baseline of biodiversity with which to monitor changes over time, particularly in response to climate change and ocean acidification**
- **Establishes a systematic and consistent metric to**
- **assess spatial patterns and monitor changes in**
- **diversity over time**
- **A standardized tool to enhance ecosystem based management**



Autonomous Reef Monitoring Structures (ARMS)





Conclusions



- **Ocean Acidification will increasingly impact coral reefs, biodiversity, fisheries, coastal protection, and communities worldwide and in the Pacific Islands region**
- **CRED has established a suite of consistent/systematic, cost-effective time series observations of carbonate chemistry and key ecological/biological indicators to inform policy & resource management decisions in the Pacific Islands**
- **Need to continue long-term monitoring the ecological impacts of Ocean Acidification in the Pacific Islands**



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Questions?