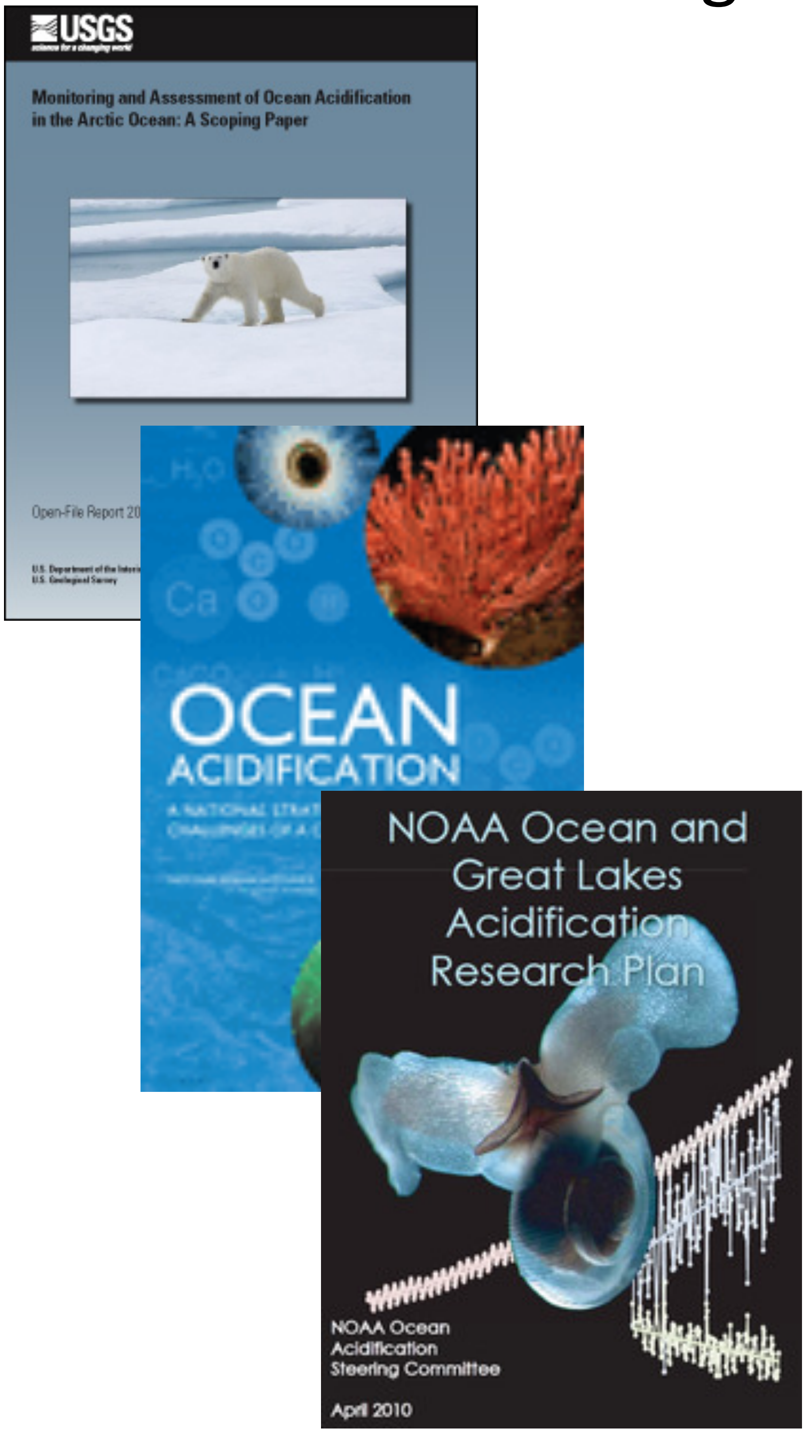
Session 1 Scientific Themes

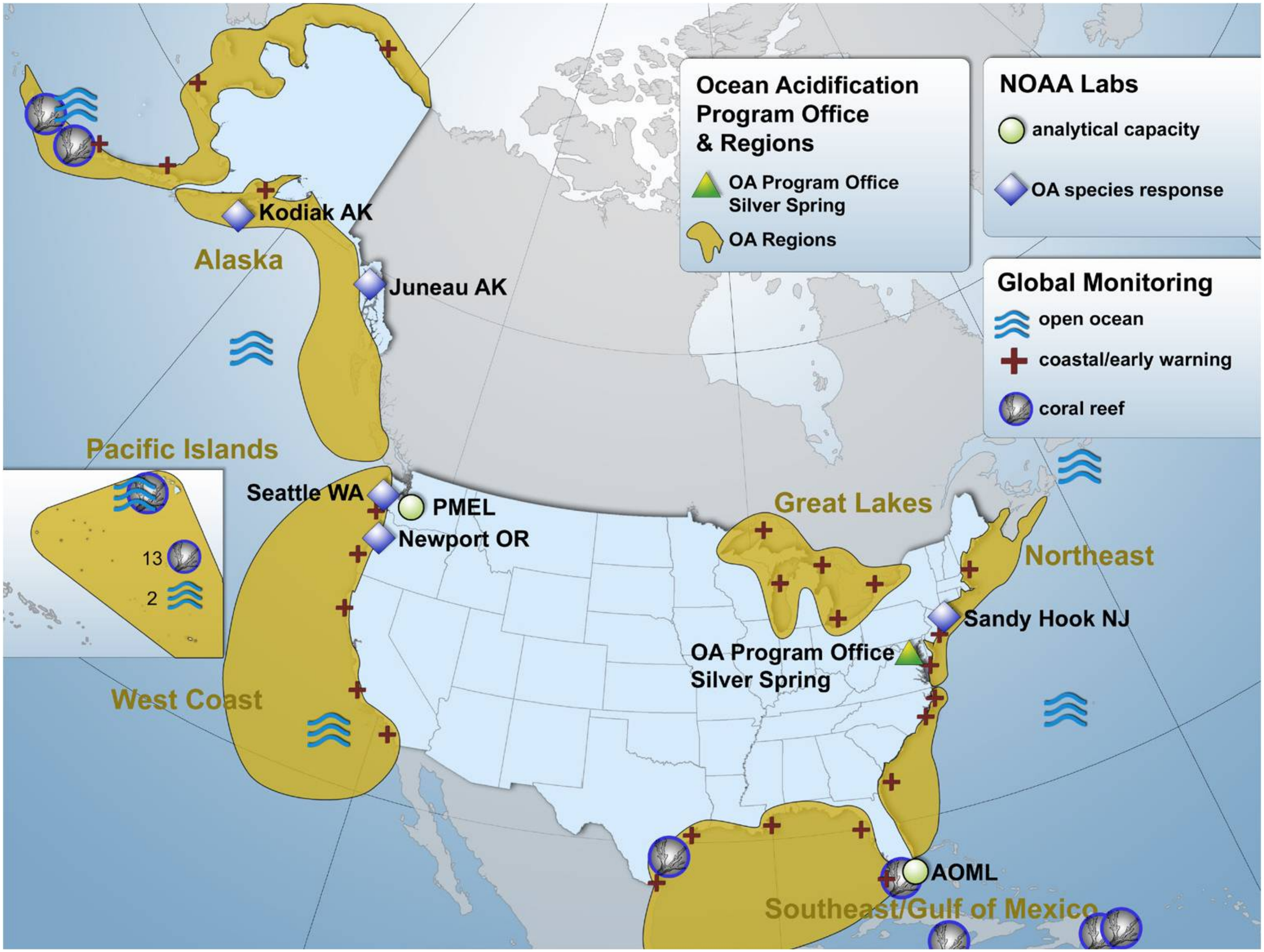
Building an Ocean Acidification Observing Network

Several Planning Documents for Observing OA



Interagency Working Group on Ocean Acidification

NOAA OAP Monitoring Program



Primary Goals for the Network

Goal 1 - Understanding of **global OA conditions**

Identify spatial/temporal patterns and assess generality of response; document and assess variation to infer driving mechanisms; quantify rate of change

Goal 2 - Understanding of **ecosystem response to OA**

Measure biological responses to physical/ chemical changes; quantify rate of change and identify areas of vulnerability

Goal 3 - Input data to **optimize OA modeling**

Provide spatially and temporally resolved data for model conditions and evaluation (assist with #1 &2)

National and International Coordination Meetings

Seattle Workshop

June 2012

62 scientists from 23 countries

- Carbon chemists, oceanographers, biologists, data managers and modelers

- National representation from USA, UK, Norway, Chile, Australia, China, France, Mexico, Sweden, Bermuda, Canada, Germany, Iceland, India, Israel, Italy, Japan, New Zealand, Poland, South Africa, S. Korea, Taiwan and Venezuela

St. Andrews Workshop

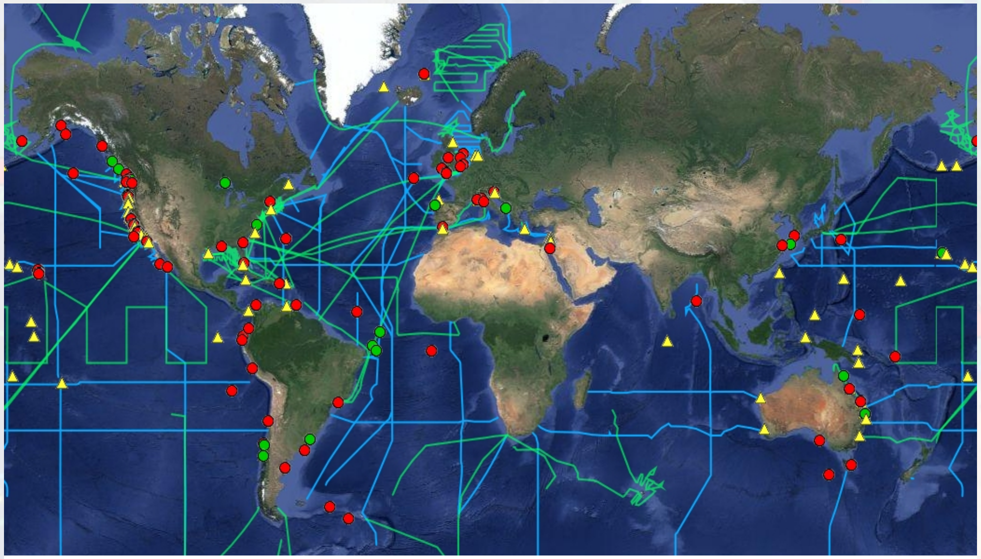
July 2013

85 scientists from 28 countries

- Carbon chemists, oceanographers, biologists, data managers, modelers, and social scientists

- National representation from USA, UK, Norway, Chile, Australia, China, France, Mexico, Sweden, Bermuda, Canada, Germany, Iceland, India, Israel, Italy, Japan, New Zealand, Poland, Ireland, Spain, Denmark Netherlands, South Africa, S. Korea, Malaysia, Philippines, Taiwan, Thailand, Brazil

What Already Exists – Or Is Planned



http://www.pmel.noaa.gov/co2/story/Global+OA+Observing+Network

Example – Need your input

Current Observing Assets

1. Moorings
2. Repeat Hydrographic Cruises
3. VOS cruises
4. Wave and Profiling Gliders

Current Process Studies

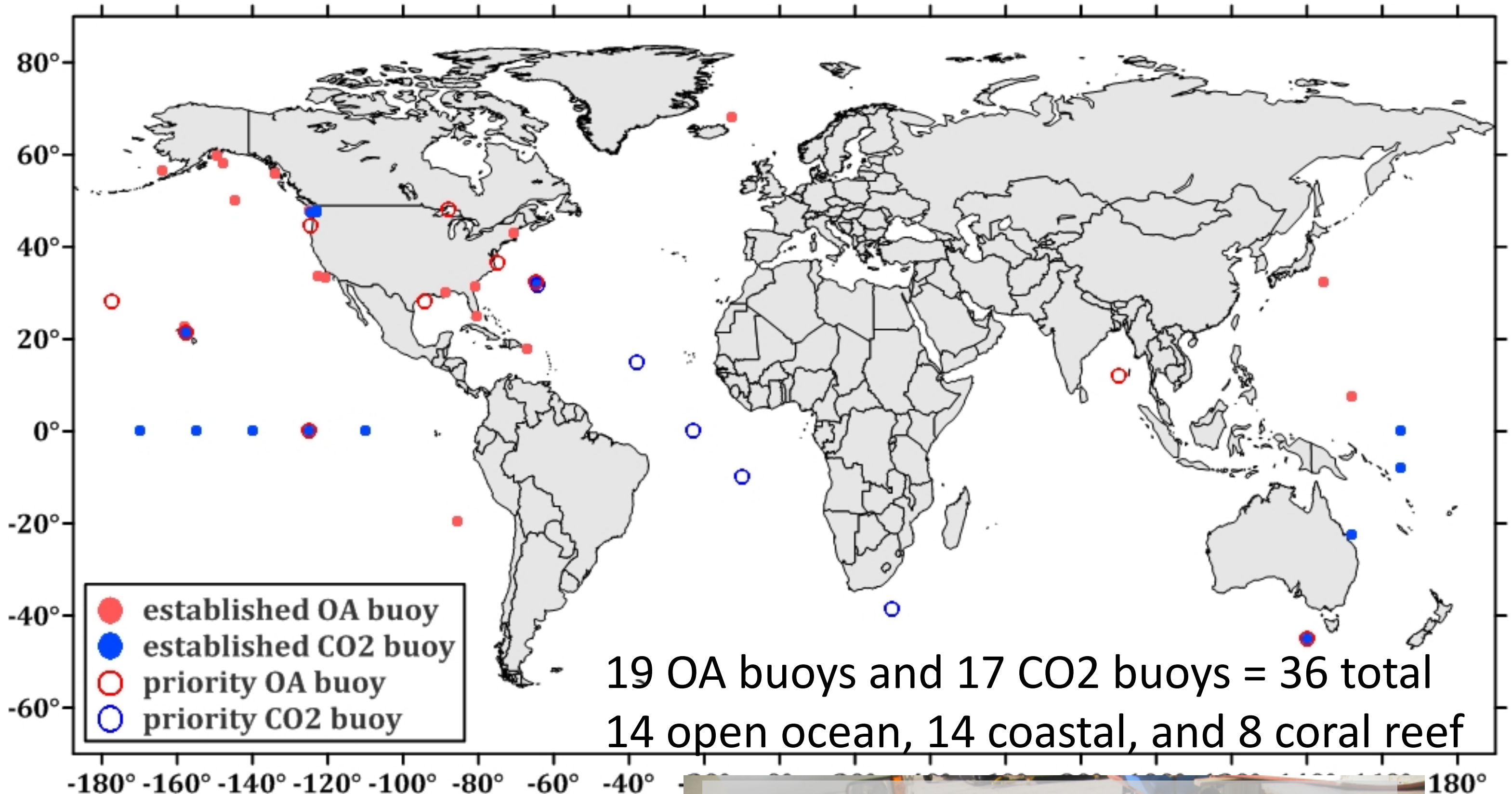
We need to create and maintain an updated list off all process study sites and where biological manipulations are being done.

"We need to effectively integrate the resources that are available through a cohesive network, where measurements and process studies are complimentary to one other. This can be done by focusing on and integrating four critical aspects of OA: 1) spatial extent, 2) temporal duration, 3) level of intensity, and 4) biological responses."

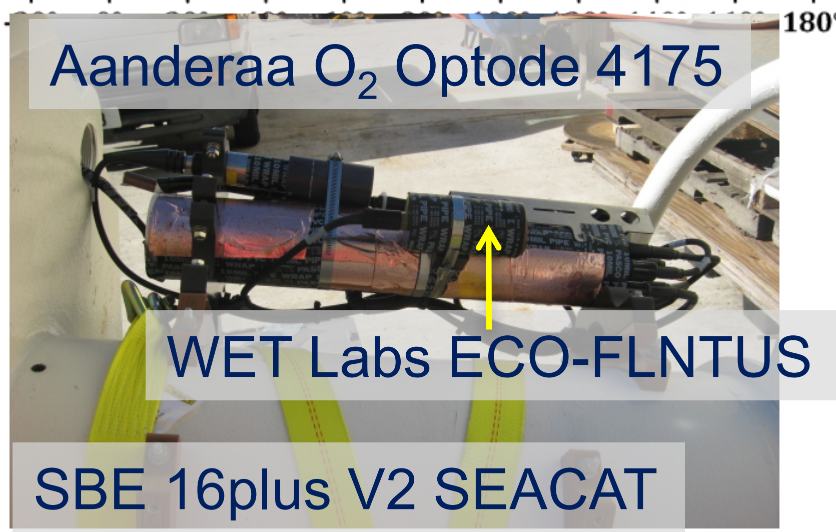
Mathis and Feely - Building an Integrated Coastal Ocean Acidification Monitoring Network in the U.S. Elementa: Science of the Anthropocene – In Press

Moorings

PMEL + many partners

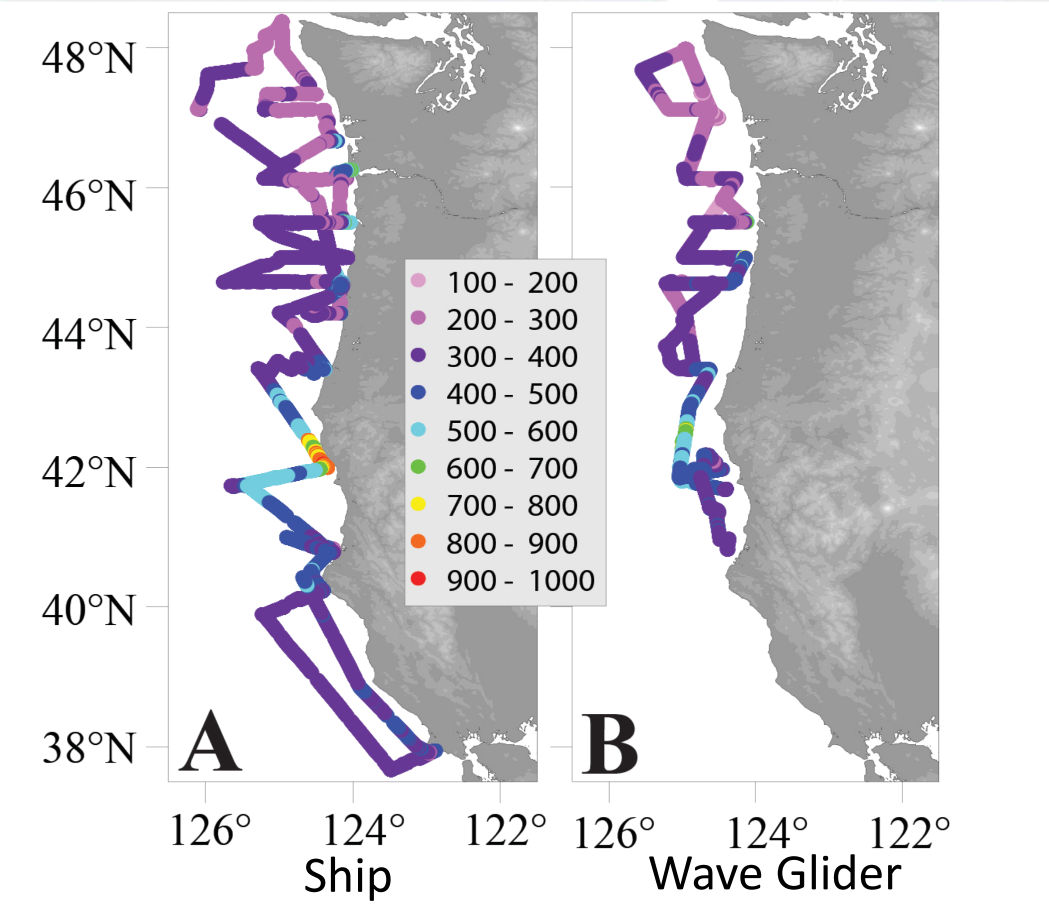


- OA instrument package:
  - MAPCO$_2$
  - SAMI^2 pH



VOS and Wave Glider Data

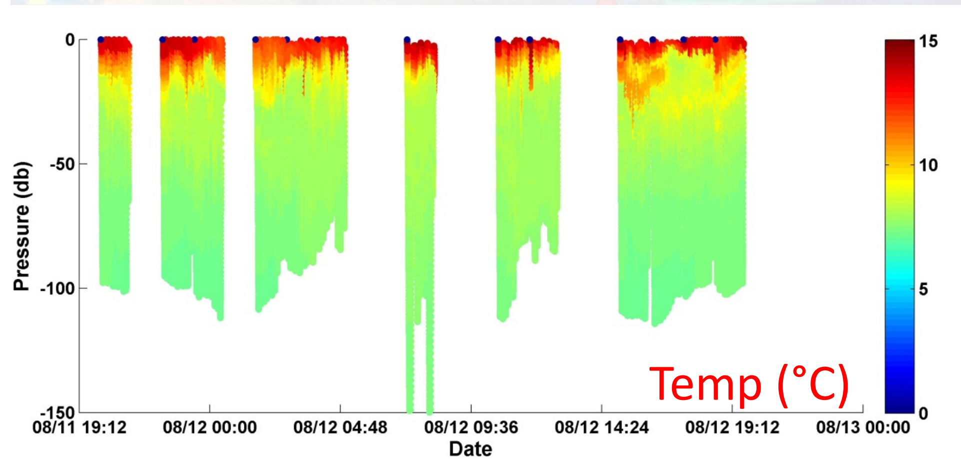
"Spatial Extent"

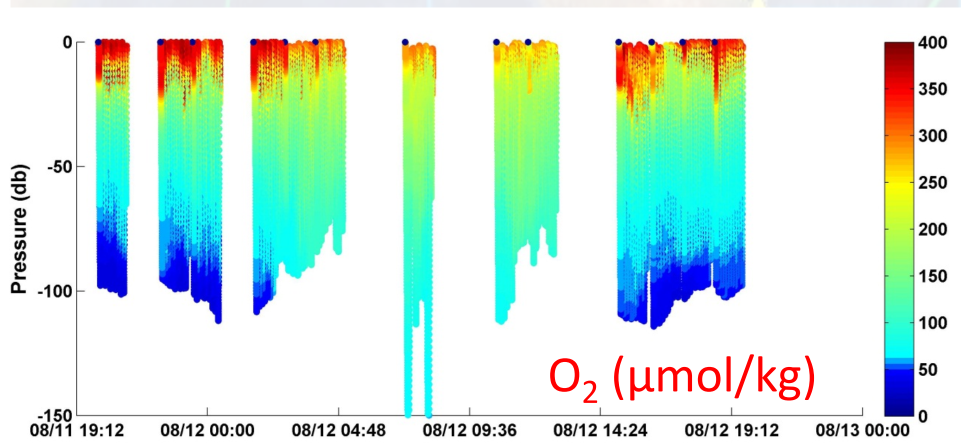


Measurements from underway pCO_2 during West Coast survey cruise, August 2011 and wave glider during July – September 2011.

Preliminary data from Slocum glider deployment along 44.2°N (August 11 – Sept. 1, 2011)

~5 day transit of Heceta Bank, observations of T, S, and optode-O_2

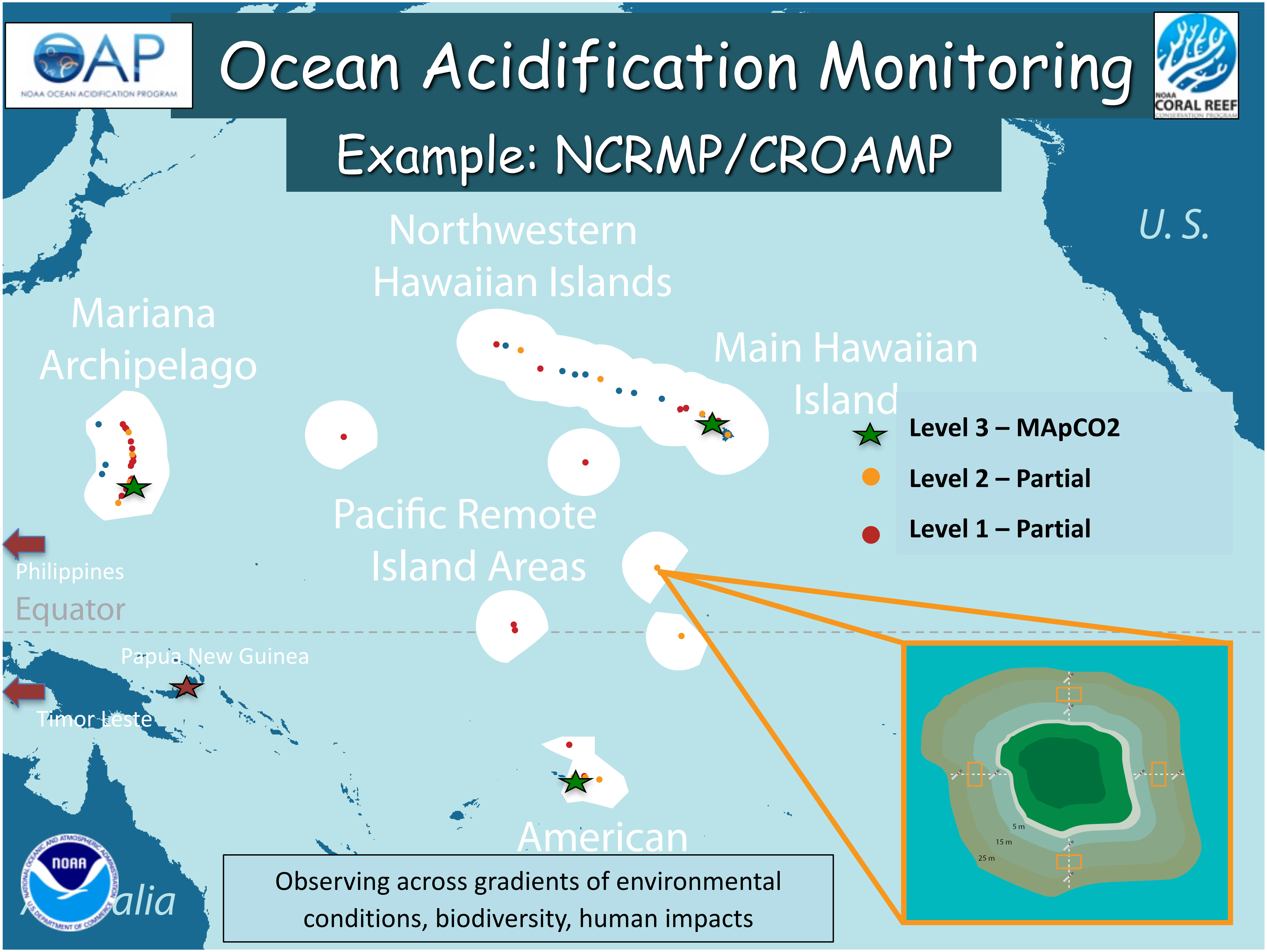




Juranek, Personal Communication

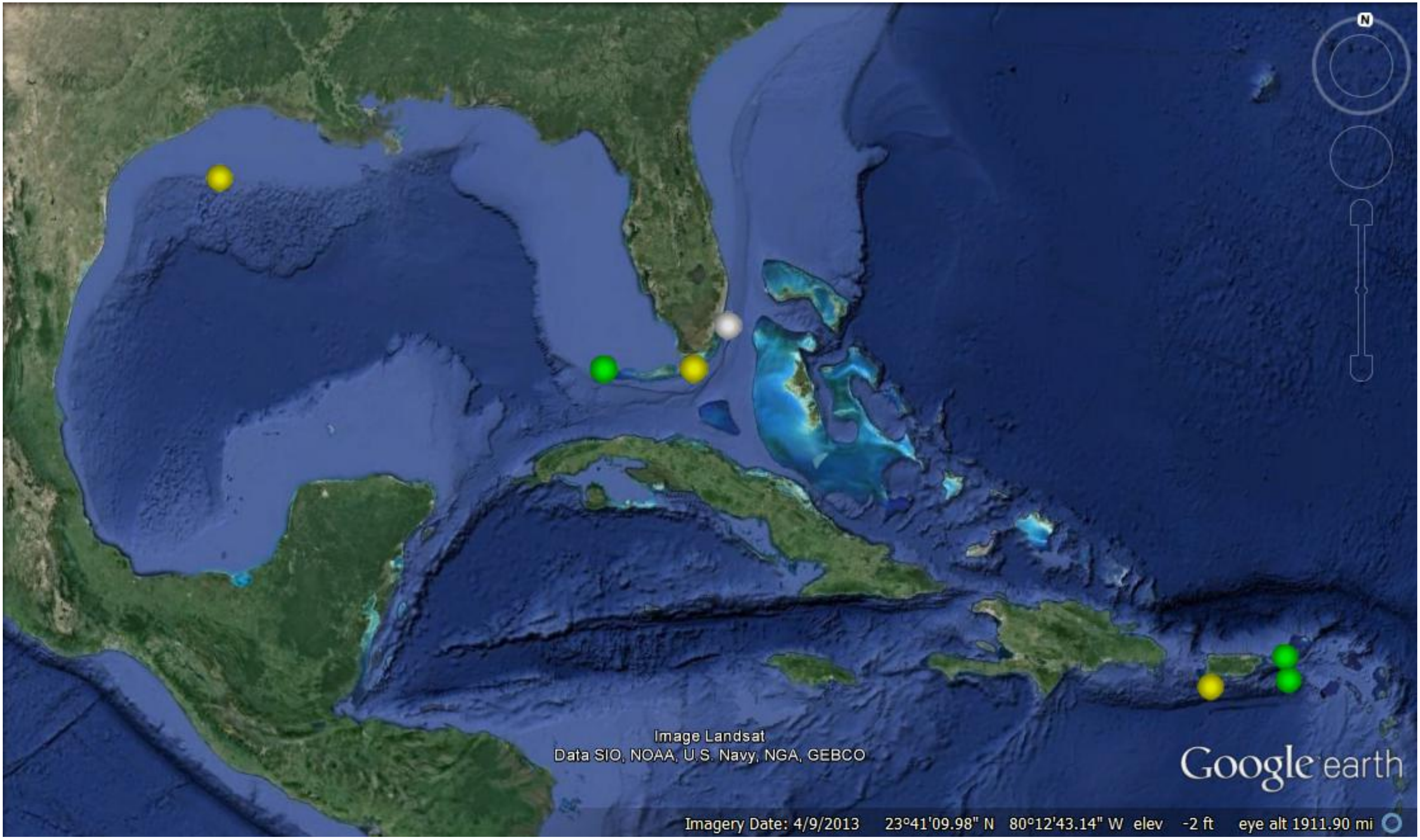
Ocean Acidification Monitoring

Example: NCRMP/CROAMP



Ocean Acidification Monitoring

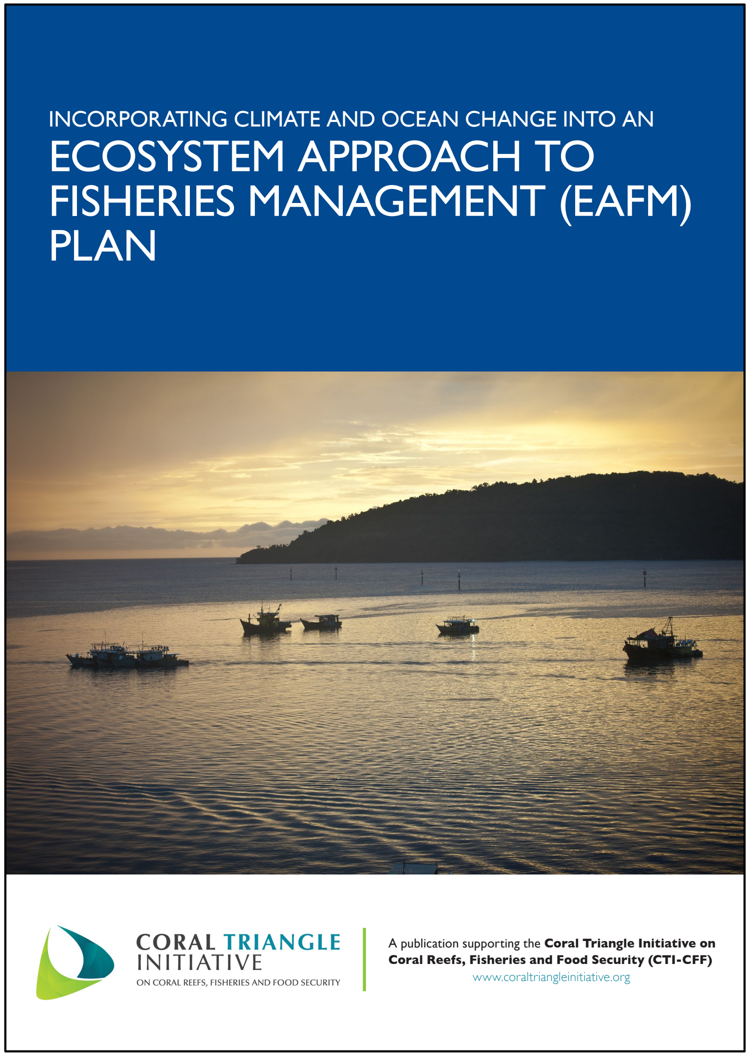
Example: NCRMP/CROAMP



Coral Observations

- Reef Assessment & Monitoring (Macro)
  - Benthic cover (hard & soft corals), fish, macroinvertebrates...
- Seawater carbonate chemistry
  - Spatial patterns across environmental & human gradients
  - Temporal- long-term changes, shorter-term processes.
- Ecological impacts of acidification
  - Calcification rates
    - Coral coring – provide history of past
    - Crustose Coraalline Algae – reef building cement
    - Net Ecosystem Calcification
  - Standardized indices of biodiversity – resilience?
  - Bioerosion
  - Microbial composition/diversity – adaptation?
  - Habitat structure - Link to fisheries

Recent Progress



Heenan, Brainard et al. (2013)*Incorporating climate and ocean change into an Ecosystem Approach to Fisheries Management.*

Young, Cohen, et al. manuscript on spatial distribution of carbonate chemistry across the Pacific Islands

Richards, Price, et al. manuscript on spatial distribution of accretion rates across the Pacific Islands

Cohen et al. manuscript on spatial distribution of calcification rates, nutrients, and saturation states across the Pacific Islands

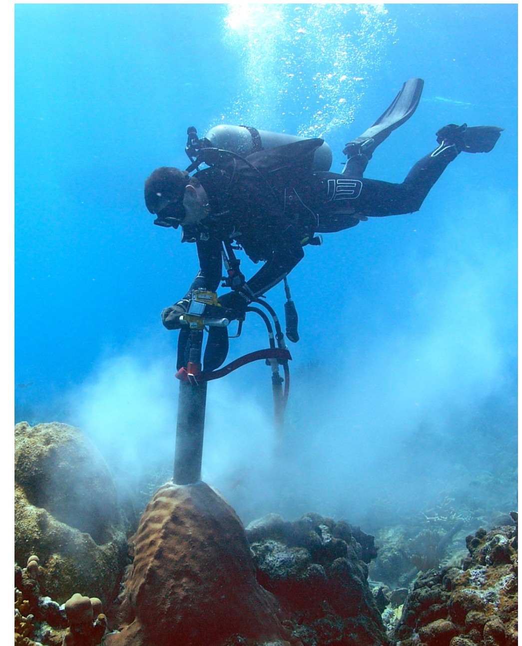
Timmers et al. analyses of cryptobiota diversity monitoring.

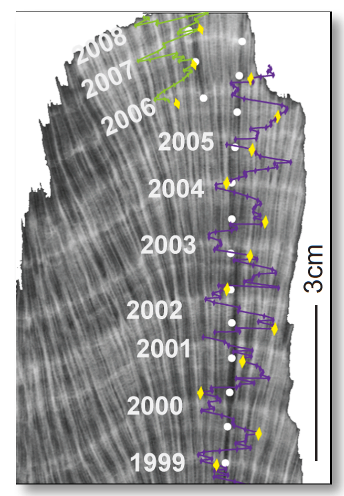
Geological OA Research
State of Knowledge

PETM provides best analog for future OA:
•Evidence for rapid carbon injection
•0.25-0.45 decrease in pH
•Ω_A reduction of 3 to 1.5
•Largest extinction among deep-sea benthic forams in deep sea
•Gradual shift from calcareous red algae and corals to larger benthic forams. and collapse of coralgal reefs in shallow water
•Marginal marine settings = species changes in coccolithophorids and dinoflagellates
•In open ocean = occurrence of deformities in some calcareous nannoplankton

Mesocosm experiments, in situ measurements, and modeling activities are better characterizing carbonate dissolution thresholds, carbonate mineralogy, and accumulation rates in various habitat types.
(e.g. Langdon et al. 2003, Yates and Halley 2006, Silverman et al. 2009, Yamamoto et al. 2012).

Broad scale analysis of coral cores is helping tease-out regional effects and variability (e.g. De'ath et al. 2009).





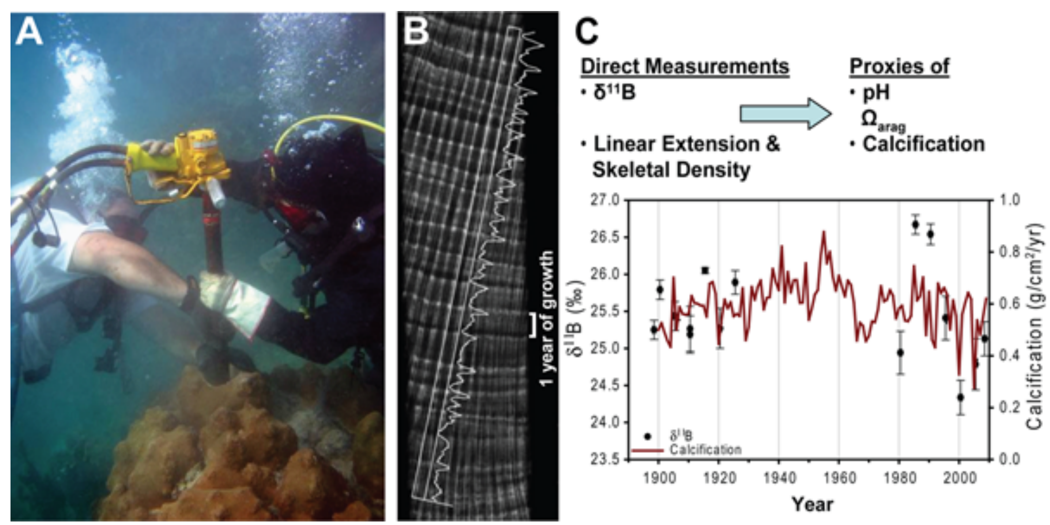
Geological OA Research
Tools and Limitations

Tools include:

•Trace element and isotope proxies to infer past seawater carbonate chemistry (B isotopes; B, U, Zn to Ca ratios of marine carbonates; $\delta^{13}C$ of alkenones)
•Measurement of accumulation and preservation of $CaCO_3$ in marine sediments
•Changes in carbonate shell structure and composition
•In situ measurement and experimentation on carbonate dissolution thresholds
•Measurement of carbonates, mineralogy, and dissolution features in marine sediments
•Recent changes in carbonate shell structure and composition
•Monitoring of elevation changes compared to changes in habitat structure

Limitations:

•Many past events occurred slowly over time and are not good analogs of future
•All events impacted by multiple stressors
•Regional variation in effects
•Lack of open-ocean sediments = increasingly poor temporal and spatial resolution further back in time.
•Future-relevant analogs must be based on rapid or pulsed $C0_2$ release events = difficult to quantify.



Questions to think about going into the breakout:

Breakout 1. Characterizing the system: observing, measuring, perturbing

- Are there important components of the existing observing programs that are missing?
- Are there other observing programs that need to be developed?
- What temporal/spatial measurement frequencies are required to characterize systems?
- How do we coordinate these observing programs with laboratory and process studies?

OA Moorings – Coastal, Coral and Open Ocean

“Temporal Resolution”

Existing Moorings

1. Papa – North Pacific
2. La Push – Coastal Washington
3. CCE1 - California Current
4. CCE2 – California Current
5. GOM – Gulf of Maine
6. Coastal MS – Gulf of Mexico
7. Gray’s Reef – Coastal Georgia
8. WHOTS – Hawaii
9. KEO - Kuroshio Current
10. Stratus – Eastern Tropical Pacific
11. La Parguera - Puerto Rico
12. Kaneohe - Oahu, HI
13. GAKOA – Northern GOA
14. SEAK – Eastern GOA
15. M2 – Bering Sea
16. Kodiak - Northern Gulf of Alaska
17. Iceland – North Atlantic
18. Chuuk - Micronesia
19. NH10 – Coastal Oregon
20. RAMA – Indian Ocean
21. Cheeca Rocks – Florida Keys