NSF Annual PI Workshop, September 18-20, 2013
Presentation 3: Linking measurements to processes

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Processes:

Individuals to population: growth, survival, calcification

Community: species interactions, disturbance, stress, species composition

Ecosystem: nutrient cycling, food web dynamics, material flows, carbon fixation, nitrification

Measurements:

Carbonate chemistry (pH, pCO_2, total alkalinity), O_2, T, salinity, light (PAR)

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OMEGAS
Ocean Margin Ecosystems Group for Acidification Studies

ACIDIC
Algal Communities in Distress: Impacts and Consequences

OREGON STATE University

Outline: Linking Measurements to Processes

A. Assuming an ecosystem context, what are the needs?
   1. Field surveys (e.g., Feely et al. 2008)
   2. Time series (e.g., HOTS, BATS, MBARI)
   3. Reliable instrumentation (e.g., SeaFET)
   4. Determination of impacts of OA on ecosystems

B. What are the biological responses?
   1. Lab mesocosms – species (life history stages)
   2. Observations along natural gradients
   3. Field mesocosms

C. Current knowledge? Natural range of variability that organisms will experience and can tolerate?
   1. Field data on OA
   2. Laboratory mesocosms
   3. Field results
      a. CO2 vents

D. Current paradigm for experiments linking biogeochemistry to processes?
   1. Field mesocosms
   2. Comparative-experimental approach (C-EA): perform field experiments at multiple locations varying in (e.g.) CO_2, upwelling
   4. Hybrid approaches: Linking C-EA, field measurements to mechanism, impact
      a. Combining lab and field approaches
      b. Using field-derived OA measures in mesocosms
      c. Mechanistic links: genomics, genetics, molecular physiology, organismal physiology in ecological and evolutionary context

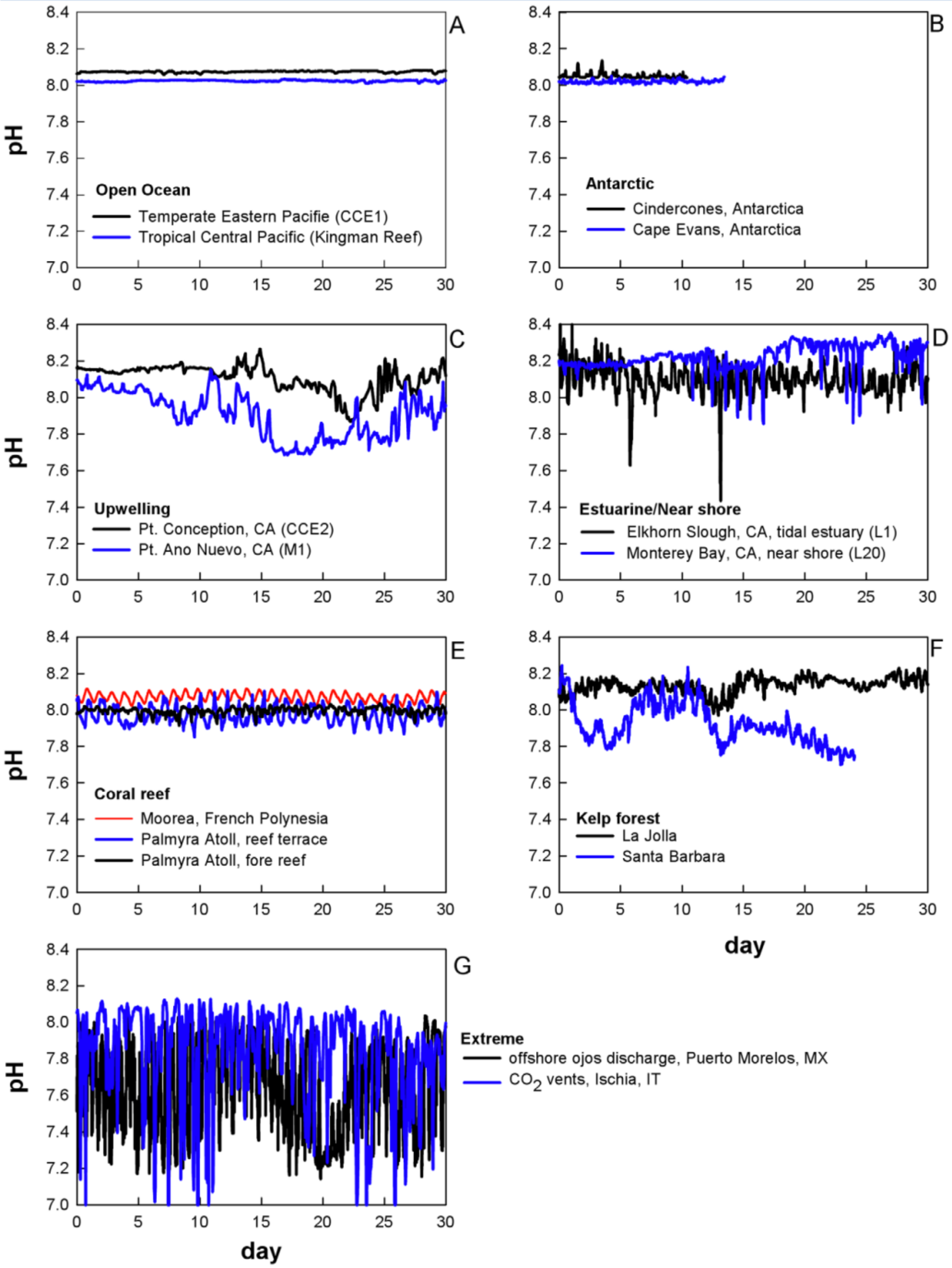
Outline: Linking Measurements to Processes

Current gaps, issues, limitations

A. Assuming an ecosystem context, what are the needs?
   1. Field surveys (e.g., Feely et al. 2008) – ***Need similar surveys along all coasts***
   2. Time series (e.g., HOTS, BATS, MBARI) – ***Need more, greater geographic coverage***
   3. Reliable instrumentation (e.g., SeaFET) – ***see X-Prize discussion***
   4. Determination of impacts of OA on ecosystems – ***Still the holy grail***

B. What are the biological responses?
   1. Lab mesocosms – species (life history stages) ***– Valuable first steps***
   2. Observations along natural gradients ***– Geographically limited, but great insights***
   3. Field mesocosms ***– Better control of environment, expensive, more realistic, but limitations***
   4. Comparative-experimental approach: perform field experiments at multiple locations along environmental gradients (e.g., in CO_2, upwelling); co-location of sensors and biology ***– Powerful approach, expensive, most useful in dynamic CO_2 environments***

What do we know now? Field data on OA



Recent datasets using SeaFETs focus attention on geographic and temporal variability among major habitats, regions

Coastal variability >> open ocean

Temperate coastal > tropical

Striking spatial variation within system type

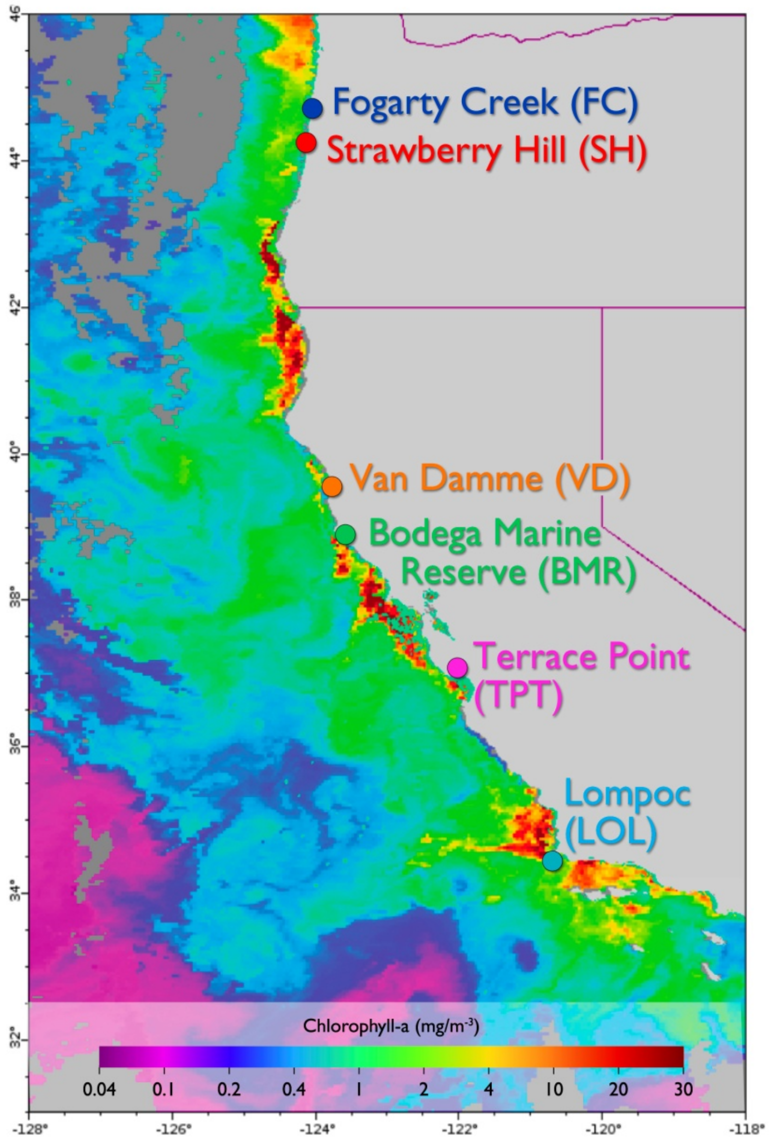
Vent systems and coastal regions offer good potential systems for field investigation of ecosystem impacts

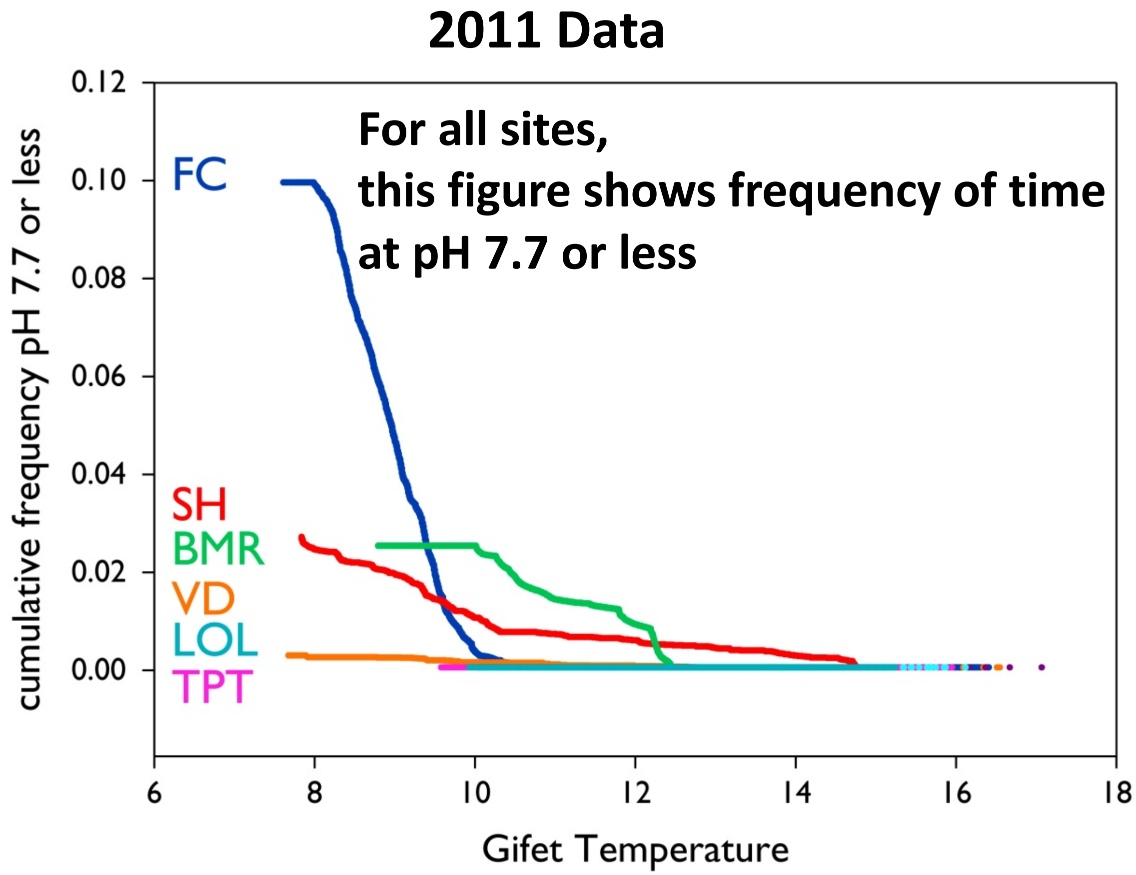
Datasets still limited in length, spatial coverage

Hofmann et al. 2011 PLoS One

What do we know now? Field data on OA

OMEGAS (Ocean Margin Ecosystem Group for Acidification Studies) Project

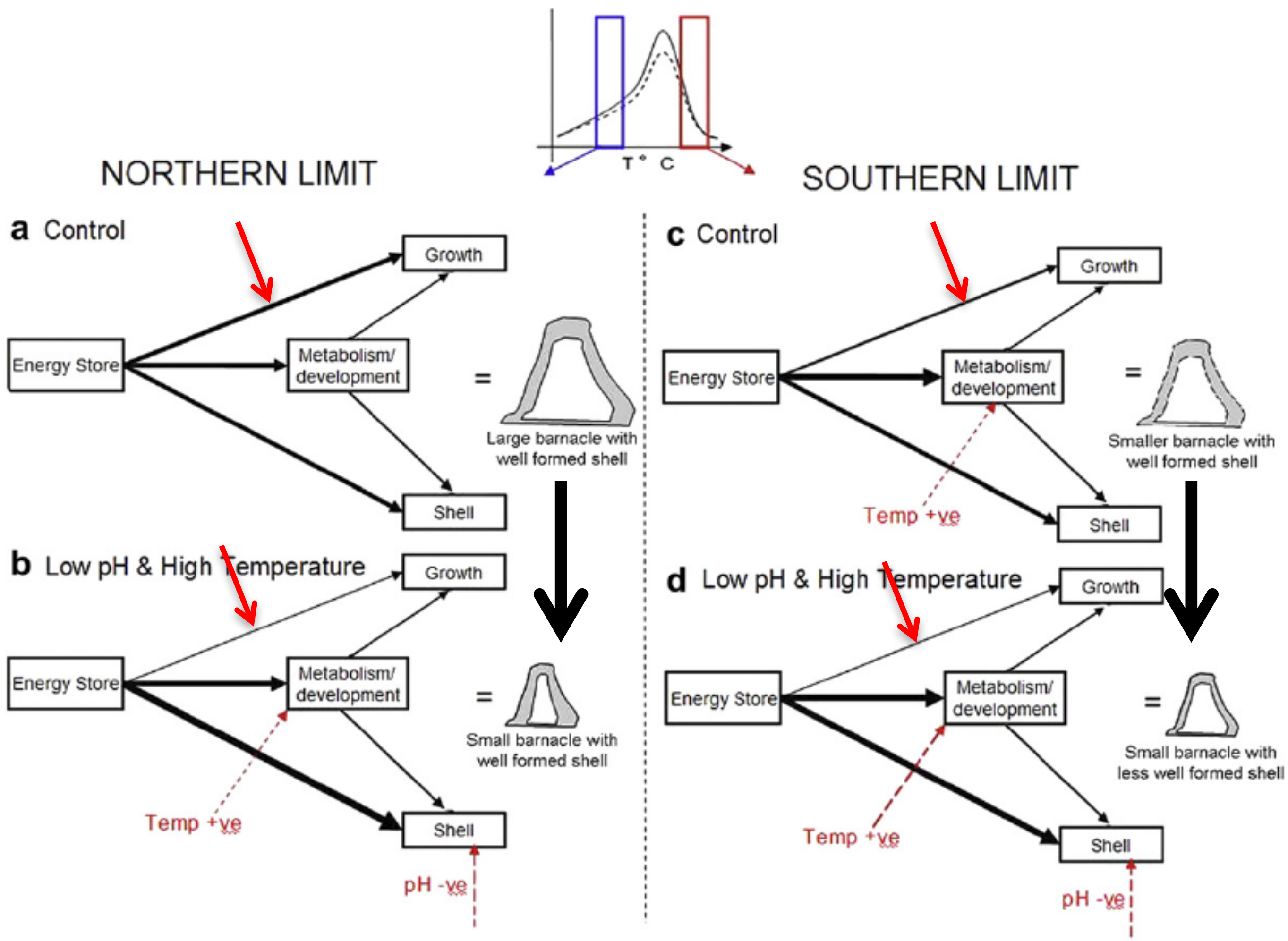




Data from Chan et al. (2013) in prep.

What do we know now? Linking lab mesocosms to field

Using lab mesocosm studies to predict population performance at limits of geographic range – *Semibalanus balanoides* in UK



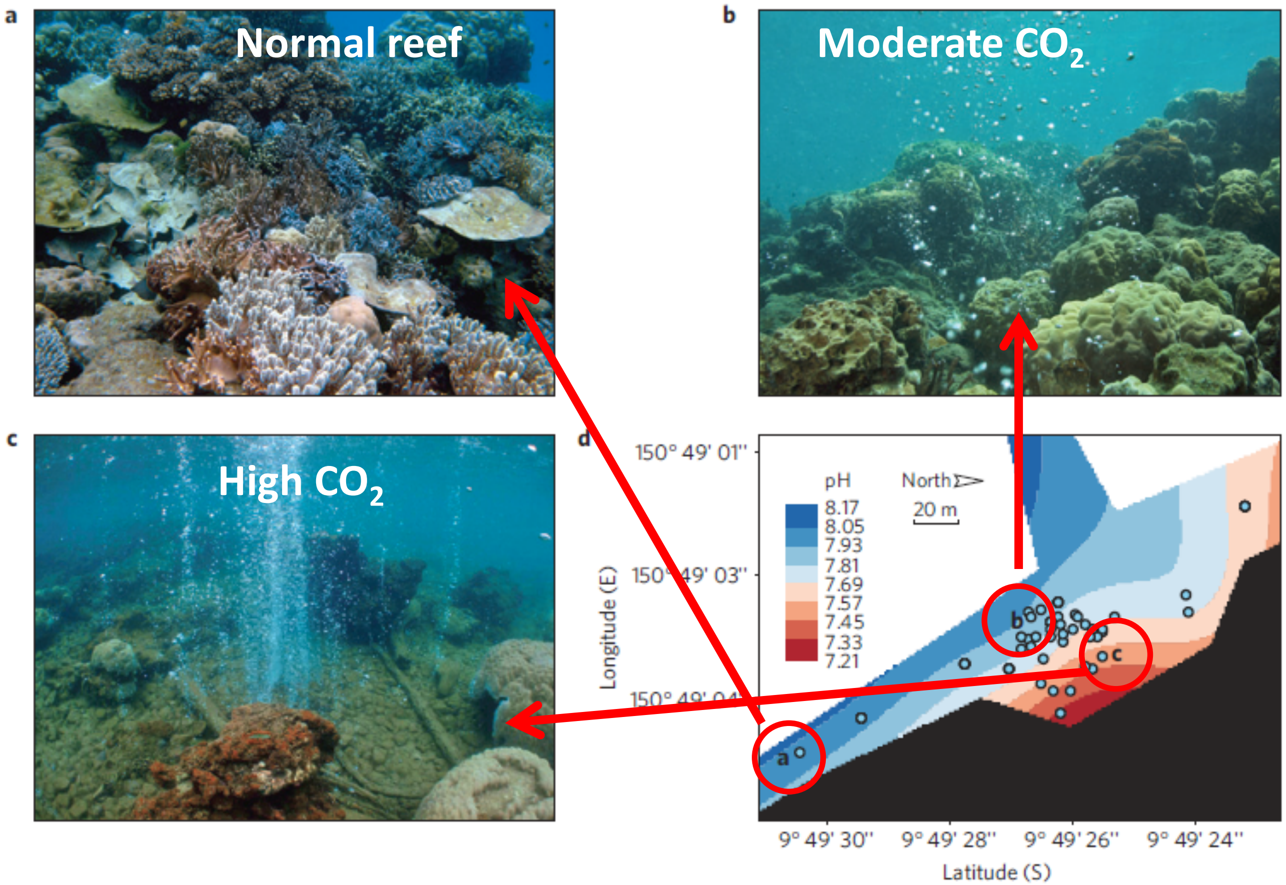
Energy allocation in post-larvae likely to shift to metabolism & shell formation w. inc T and reduced pH

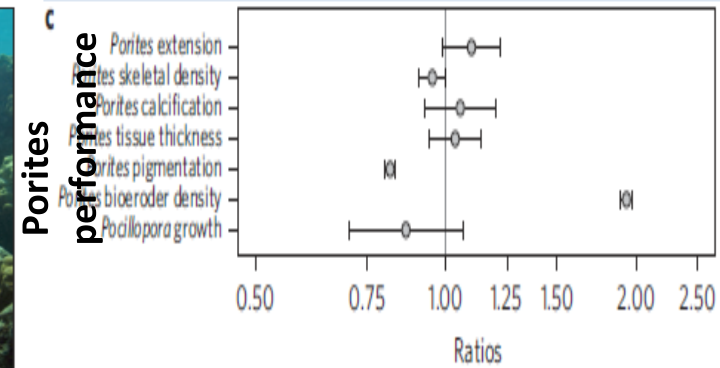
Result?
Trouble at both ends but esp. southern (reproduction reduced at T >~10^{o}C; shell has more high Mg, dissolution likely greater)

Findlay et al. 2010 Est Coast Shelf Sci
Findlay et al. 2010 Ecology

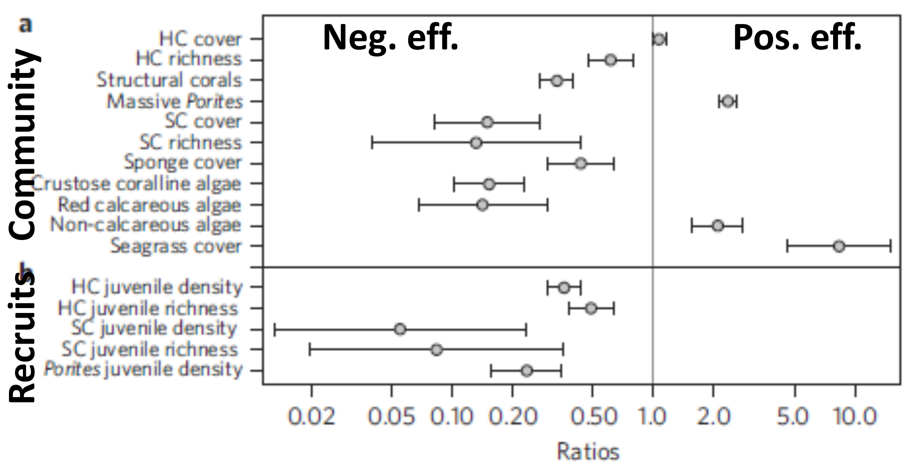
What do we know now? Obs along natural gradients

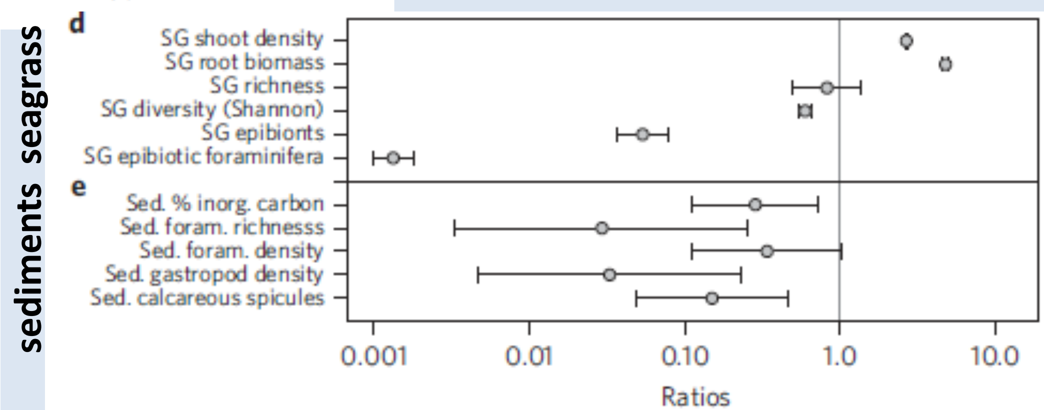
Field studies of CO_2 effects on coral communities: New Guinea





Conclude: Communities in moderate CO_2 profoundly different from those in ambient CO_2

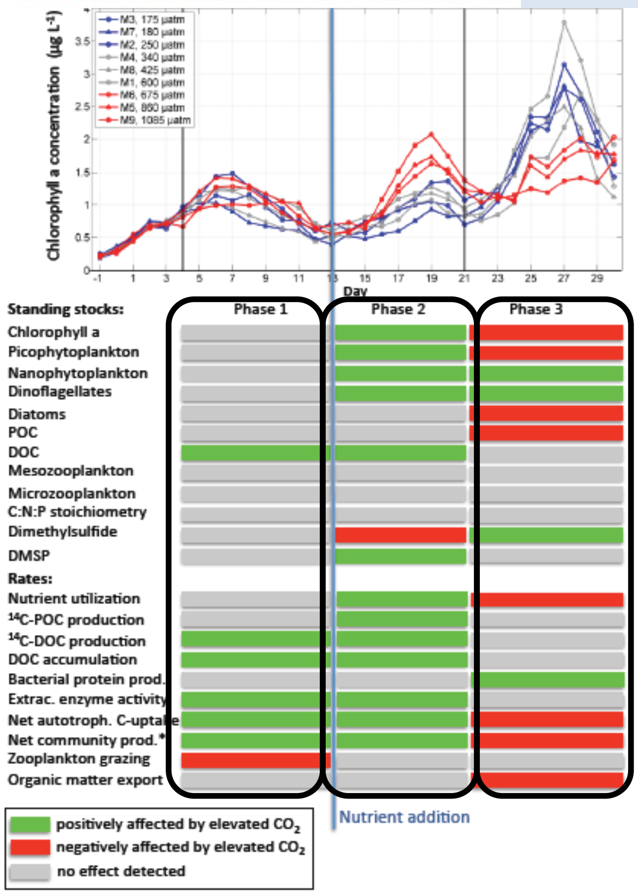


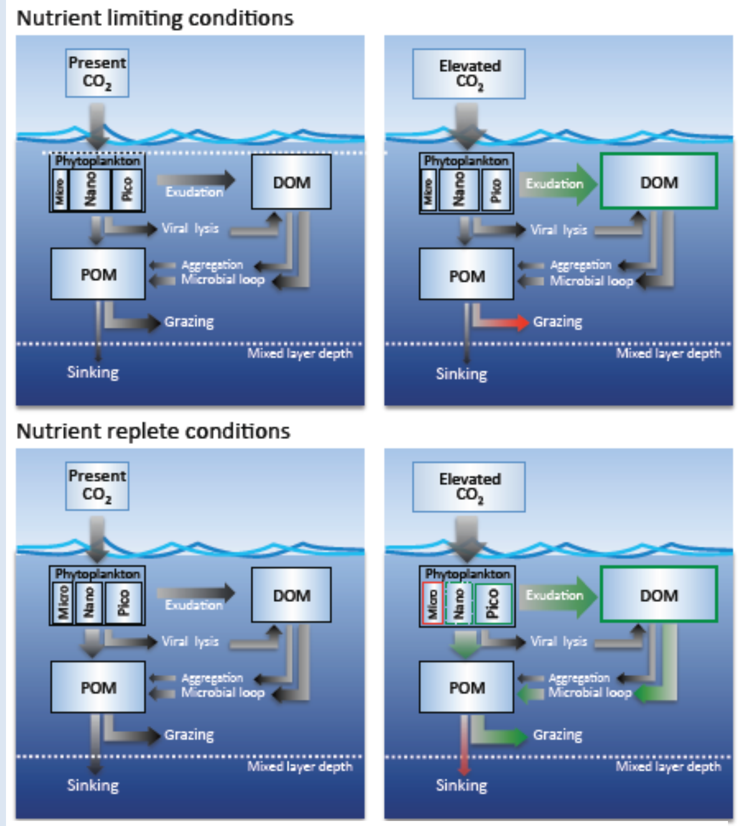


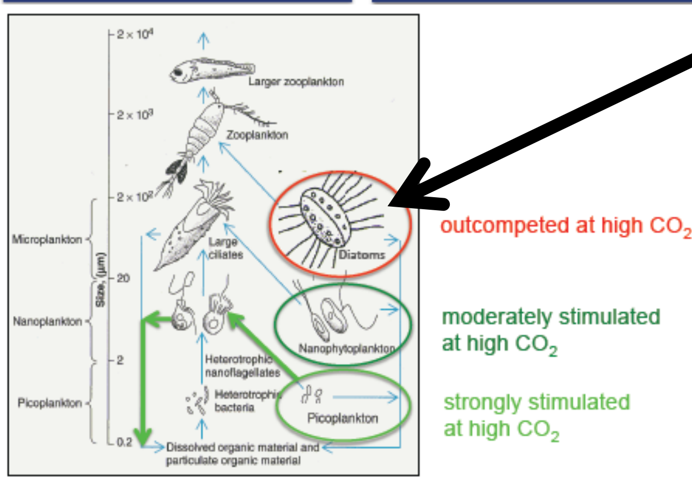
Fabricius et al. 2011 Nat Cl Chnge

Current paradigms? Field mesocosms

Arctic pelagic ecosystem dynamics: mesocosm study







Field mesocosms near Svalbard: Early results

Minimal effect of CO_2 before nutrient addition

After nutrient addition, most measures stimulated then inhibited by high CO_2

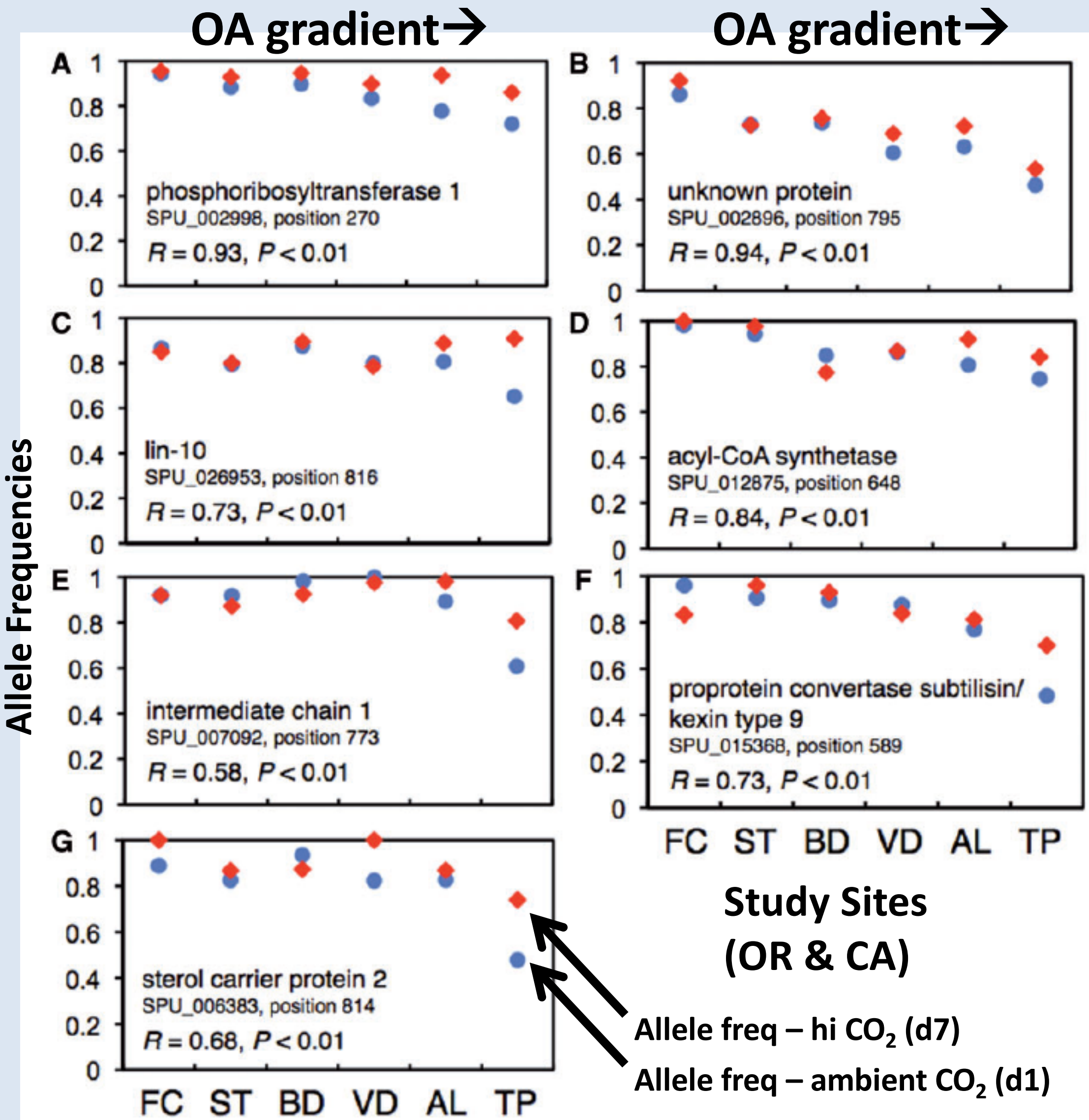
At the community level, diatoms were outcompeted by smaller phytoplankton

Short-term but valuable approach

Riebesell et al. 2013 Biogeosciences

Current paradigms? Linking in situ pH to adaptive potential using mesocosm experiments

Variation in gene expression along an upwelling/CO_2 coastal mosaic



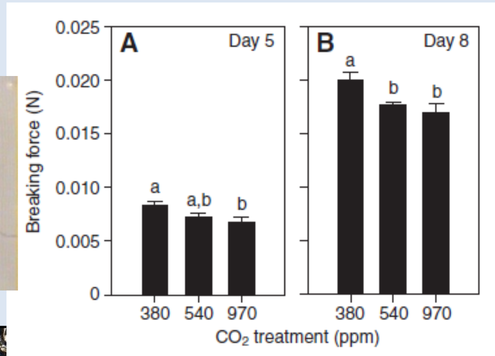
Across six sites from central OR to southern CA,
Expression of genes likely responding to acidification in *S. purpuratus* changes upon exposure to high CO_2.

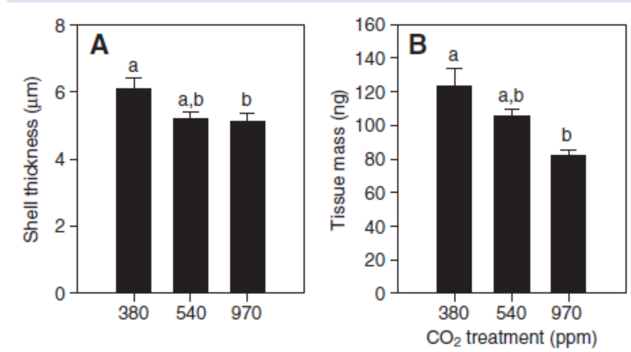
Suggests genetic variation is associated with local pH regime, and thus, that adaptation potential exists in this species

Pespeni et al. 2013 Int Comp Biology

Current paradigms? Hybrid/consortium approach

Response of the "ecosystem engineer," *Mytilus californianus*, to OA

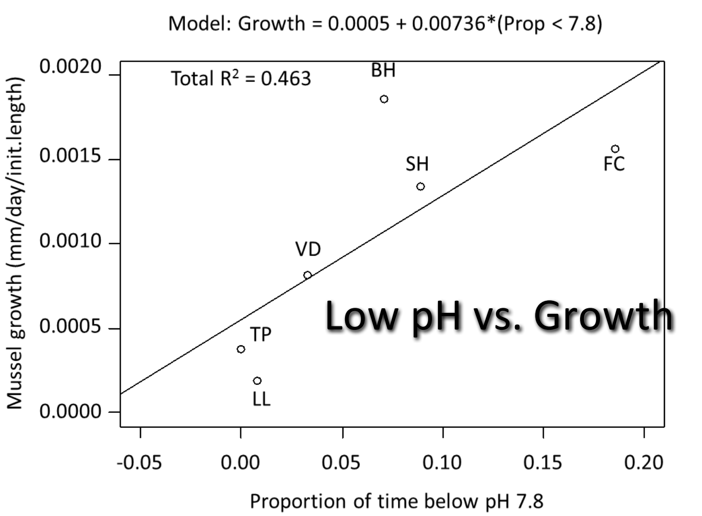


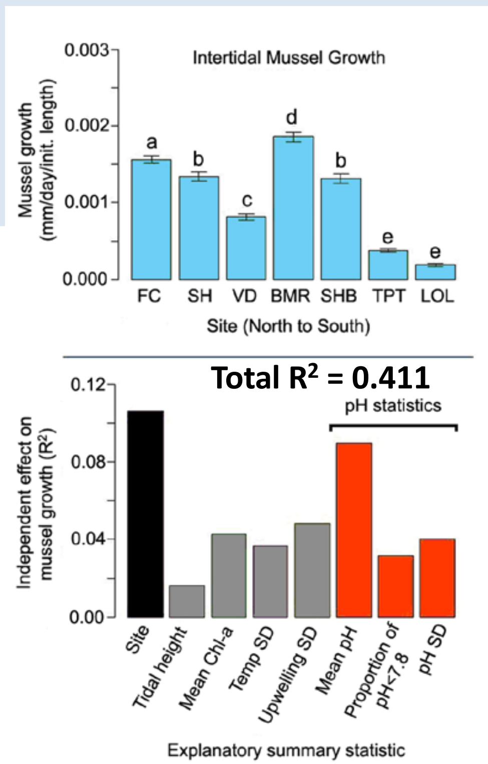


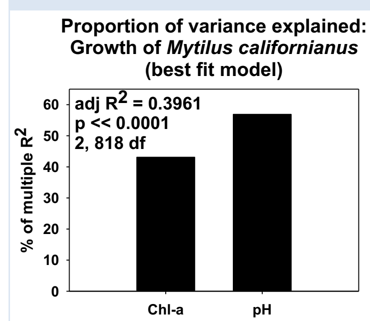
Larvae severely impacted by OA

(Gaylord et al. 2011 JEB)

Adult growth is affected by OA, but evidently POSITIVELY!



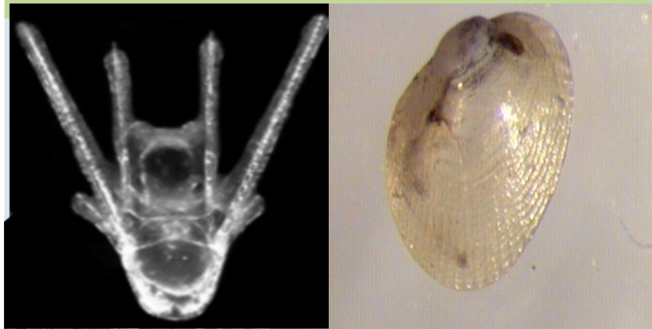




Time series from field deployed sensors

Rose et al. in preparation

Where should we go? Research Consortium Approach



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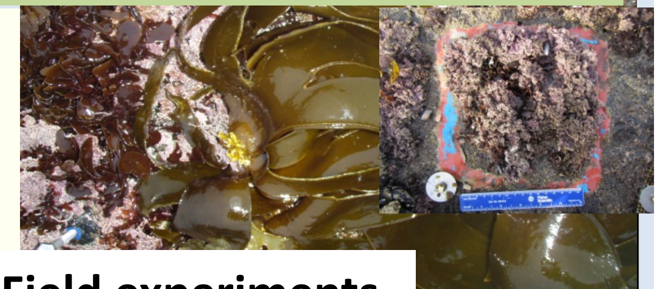
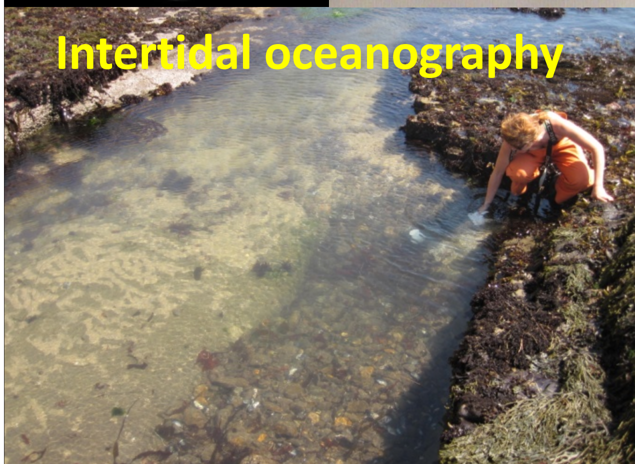


Field experiments

Intertidal oceanography



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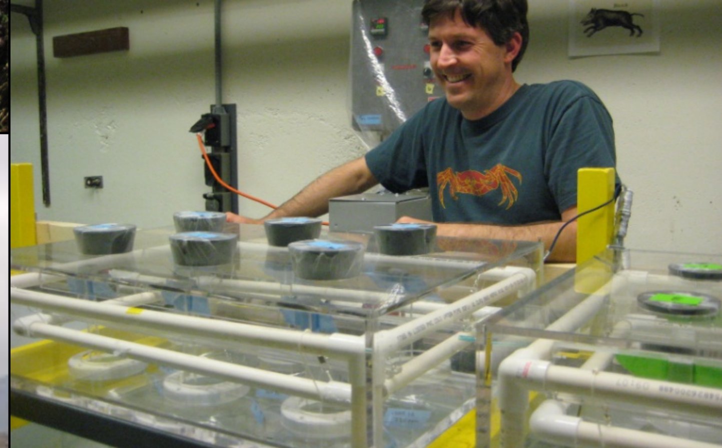
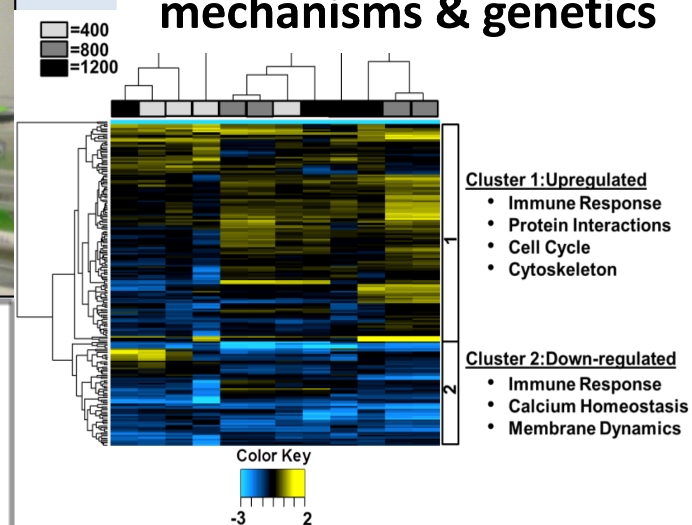
Algal Communities in Distress: Impacts and Consequences

OA mesocosm experiments



Molecular physiological mechanisms & genetics



Nearshore oceanography

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Modified, from Ann Russell & Gretchen Hofmann