Breakout #3
Scaling and modeling across time and space

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The overall motivation behind ocean acidification research is to determine how marine ecosystems will respond to future conditions.
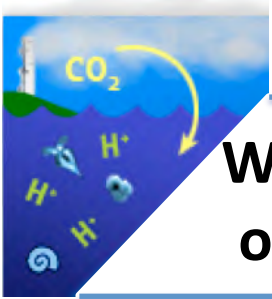
How can we conduct individual research projects so that the conclusions will feed into the development of models and general forecasts, spanning relevant time and space scales, and including multiple stressors?

What are the main scientific approaches to understanding how ocean biology, ecosystems, and BGC will change in the future.
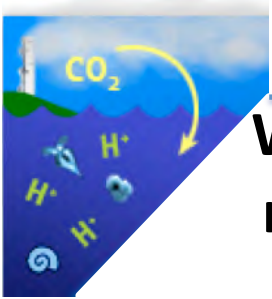
What questions are relevant to society and what predictions do we need?
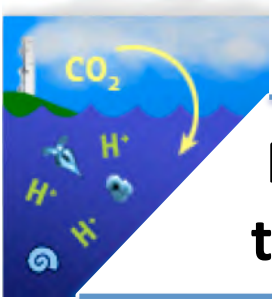
Are there any parts of the model that we know better than others?

What are the main scientific approaches to understanding how ocean biology, ecosystems, and BGC will change in the future.

- Need long term observations to validate model (chemistry, biology, physics, <u>ecosystem</u>)

- Focus on species that are ecologically relevant and/or vulnerable

- Identify the most sensitive parameters and how fast are they changing?

- Need stronger interaction between modelers, biologists, biogeochemists, and physicists

- Build smart models that include the essentials to accurately represent a system
 - Empirical models, e.g., predict pH from T, S, DO
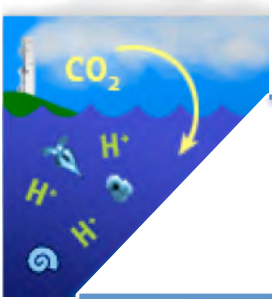
Will observational research focusing on mechanistic biological responses provide information that can be scaled over space, time, and multiple stressors?

- Yes, but approaches to date are not sufficient
  - Longer term, multiple stressors, multiple and different life stages
  - Variability in environmental parameters (min, max, mean)
  - Fundamental understanding of mechanism/process response
  - Adaptation potential?

- Process studies in natural environments with high CO_2 and FOCE
  - Set number of parameters to be measured

- Remote sensing

- Think at a bigger scale in terms of funding. Other programs receive significantly more funds.
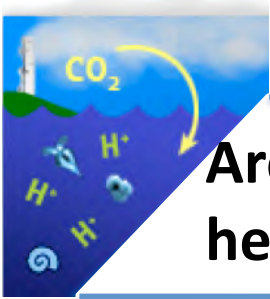
Natural OA gradients and OA fertilization – how far can we trade space for time? What are the time/space limitations?

- Need to use both natural gradients and FOCE experiments

- Natural gradients:
    - Identify existing and new opportunities/sites, e.g., LTER, CO_2 vent sites, upwelling, etc.

- FOCE:
    - Think BIG!!!
    - Alternative manipulations to reduce cost: liquid CO_2, $NaHCO_3$
    - Reverse FOCE: lower CO_2

Environments that need more study and what do they mean to scaling?

- What makes an environment important?
  - Services, vulnerability?

- Coral reefs (vulnerable),
- High latitudes (close to undersaturation),
- Coastal zones (economic value)
  - Estuaries, embayments, river plumes

- What processes do we need to estimate on a global scale and how should we do it?
  - E.g., primary productivity, calcification, dissolution

Are there statistical or analytical approaches that can be used to help estimate answers when scaling, extrapolating, or layering?
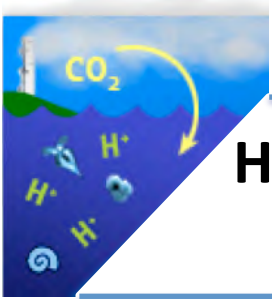
•Need mechanisms to include uncertainty; mathematical and communication challenges.

•IPCC approach?

Organism group/process	State of Knowledge	Level of Evidence	Level of Agreement	Level of Confidence
Process X	Process X will increase	limited, medium, or robust	high, medium, or low	high, medium, or low

Level of Evidence: evaluate validity of a finding (type, amount, quality and consistency of evidence.
**Level of Agreement**: proportion of studies in agreement wrt response
Level of Confidence: judgement of validity as evaluated through evidence and agreement
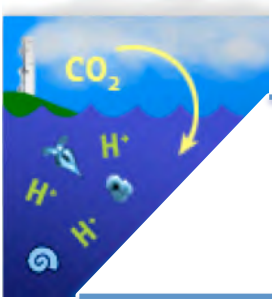
How can OCB facilitate improvements in this important aspect of understanding ocean acidification and its impacts?

- OA workshop on modeling
  - What are the main issues and where should the models be heading?
  - International meetings (SOLAS-IMBER, EPOCA, BioAcid)
  - High CO_2 world meeting 2012

- Data compilation, meta-data, data access for models (BCO-DMO?)

- Identify what stakeholders need (e.g., EPA)

Main Summary

- We are still a long way from confidently predicting ecological consequences of OA
  - Observations to validate models (experiments, time-series, process studies, natural gradients, FOCE)
  - More realistic organism experiments (multiple-stressors, life stages/history, fundamental understanding of mechanisms)
  - Better interaction between different disciplines

- Recommendations:
  - OA modeling workshop
  - Annual opportunity for interaction
  - Think BIG and broad