
# OCB Ocean Acidification Short Course

***November 2-13, 2009***
***Woods Hole, MA USA***

## Participant Learning Outcomes

Upon completion of the short course, participants will have gained increased knowledge in four areas relevant to OA research: 1) monitoring carbonate chemistry; 2) chemical measurements for $CO_2$ –perturbation experiments, 3) experimental design of ocean acidification experiments, and 4) data reporting guidelines. Specifically, course participants will gain experience with:

### *Monitoring the inorganic carbon system in seawater*

- Know what systems are currently available to measure different parameters of the inorganic carbon system in seawater
- Know what parameters need to be measured in order to calculate aragonite and calcite saturation state and all other parameters of the carbonate system, using CO2SYS and seacarb
- Know what ancillary seawater measurements are needed to calculate all the parameters of the $CO_2$/carbonate system
- Know what algorithms can be used as proxies for aragonite and calcite saturation state
- Know the advantages and disadvantages of the different platforms: moored surface sensors, gliders, satellite tracked Lagrangian drifters, underway measurements, autonomous discrete water samplers
- Be familiar with the requirements for maintenance/calibrations/groundtruthing of specific platforms and instruments
- Know what temporal and spatial sampling is required for open-ocean and coastal ecosystems

### *Measurements of the parameters of the inorganic carbon system in seawater for manipulative $CO_2$-perturbation experiments*

- Know methods to measure dissolved inorganic carbon, total alkalinity, pH and $pCO_2$ including the accuracy and precision of each method, the use of certified reference materials, the typical sample volume required, and the advantages and disadvantages of each method;

- Know what other variables must be known and at what accuracy to calculate all the parameters of the inorganic carbon system in seawater (temperature, salinity, nutrients, barometric pressure);
- Be able to use CO2SYS, seacarb, or similar programs to calculate all parameters of the inorganic carbon system;
- Appreciate the importance of high quality measurements of the parameters of the $CO_2$/carbonate system through the propagation of errors in calculations;
- Understand why $pH_{NIST}$ is generally not used in measurements of the seawater $CO_2$/carbonate system;
- Understand why one cannot assume that bubbling seawater with air of known $CO_2$ concentration will result in the seawater with the same $pCO_2$ value (i.e. understand gas exchange rates of unperturbed and perturbed water)
- Understand why the seawater $CO_2$ chemistry should be monitored throughout the experiment or at least at the beginning and the end of the experiment. Be able to compute or model how the carbonate parameters will change in your experimental system for a given set of assumptions about water volume, surface area, and organism biomass.

## *Design of ocean acidification experiments*

- Advantages and disadvantages of various methods for seawater $CO_2$ system manipulations- acid additions versus bubbling, acid plus bicarbonate additions, steady state equilibration versus dynamic seawater $CO_2$ chemistry experimental designs, etc. The need for consideration of how these choices will affect interpretation of experimental results
- Strengths and weaknesses of culture approaches and natural community manipulations- what each can and cannot do.
- Experimental design methodology, including volume scaling issues from beakers to mesocosms to potential in situ approaches; batch versus semi-continuous versus continuous cultures, etc.
- Appreciate the need to consider appropriate acclimation times for short term experiments, and how to address issues of short term acclimation versus long term adaptation and evolution. Molecular approaches for studying population responses to OA.
- The use of different strains/cell lines, and consideration of how responses may be modulated by natural genotypic and phenotypic variability within diverse natural populations.
- Experimental approaches to looking at potential interactions with other variables such as temperature, salinity, light, nutrients, trace metals
- Know the various methods to measure calcification in benthic and planktonic organisms and the advantages and disadvantages of each method (interest? How about other rate measurements?)

- Need for appropriate replication and statistical approaches, standardization and intercomparison among methods of biological rate and standing stock measurements.
- Trade-offs between experiments with many replicate tanks versus single tank or mesocosm experiments that are repeatedly sampled over time.
- Understand appropriate sampling that is needed for frequency and spatial resolution for the carbon species

## *Data reporting guidelines*

- Know units to report for various measurements, accuracy and precision
- Where to submit data

## *Modeling for scientific use- modeling for policy makers*

- Understand the major models that are currently being used scientifically for local, regional and global OA models and the type of data used from experiments and monitoring
- Understand how the models are being used – and what questions are being asked- by policy makers