Research: BATS Q & A
For Discussion Groups

A selected list of 'unanswered questions' to our understanding of ocean biogeochemical cycling and the relevance of these unknowns to advancing our knowledge of biogeochemical processes are listed below. These questions reflect personal viewpoints and in no way does their order represent a research prioritization according to the discussion group reports.

Physical Questions

1. **What is the role of isopycnal versus diapycnal advection in the ocean?** Data could provide some closure on regional nutrient budgets as the importance of isopycnal advection is quantified.

2. **What is the extent of mixing at the base of euphotic zone?** Data will allow conversion of nutrient gradients to fluxes to better constrain the nutrient inputs into the euphotic zone.

3. **What is the quantitative impact of mesoscale variability on regional physics, and other biogeochemical processes?** Data could provide some closure on regional nutrient budgets and provide insight into ecosystem dynamics and functioning.

4. **What is the quantitative importance of event-scale phenomena (e.g. severe winter storms, hurricanes) on surface ocean biogeochemistry?** A more intensive examination of short-term blooms (3-10 days) could be important in reconciling geochemical and biological estimates of new production especially at BATS.

5. **What is the relative importance of local versus remotely forced changes in upper ocean stratification?** Water column stabilization is an important factor in many biological processes. Understanding the relevant factors controlling this stabilization is important in understanding the observed biological responses.

Biological Questions

6. **What are the controls on the oceanic biological system (in particular N₂-fixers) that allow for the oscillation between N- and P-limited conditions in the ocean gyres?** The different nutritional requirements of plankton species allow particular taxa to dominate under different conditions. Understanding this diversity is critical to determining the linkages between rate processes, biogeochemical cycling and community structure.

7. **What are the relationships among taxonomic, size and functional "structure" of plankton communities and carbon sequestration in the ocean?** Food-web structure is believed to be a major determinate of carbon
export by the biological pump, but there is little consensus on what parameters are most relevant for inter-regional comparisons or projections into the future.

8. **What is the importance of 'hybrid' metabolisms and symbioses between strict autotrophy and strict heterotrophy in marine microbes?** Widespread mixotrophy among protists as well as the recent observation of light harvesting by bacteria without subsequent fixation of carbon have large implications for the relative growth advantages of different taxa and the uncoupling of ocean energy and carbon cycles.

9. **How does plankton trophic organization impact ecosystem function (i.e. top-down control) and what feedback mechanisms are important for understanding long-term variability?** Planktonic consumers, both meso- and micro-zooplankton, are key components of the food-web, and their trophic interactions regulate the partitioning of C export between dissolved and particulate pathways.

10. **What are the rates and controls on grazing processes and plankton mortality in the surface ocean both at the total community and the population levels?** Grazing and mortality functions are important drivers in mechanistic models of marine ecosystem. Not only do precious little data exist for community-based rates at the time-series stations, as interest focuses on the dynamics of specific functional groups, more needs to be known about relative losses at the population level.

11. **What controls variability in the stoichiometry of nutrient utilization in ocean phytoplankton communities and remineralization in bacteria and zooplankton communities?** Mounting evidence suggests non-Redfieldian nutrient utilization and remineralization in the surface ocean. Mechanistic understanding of this variability is needed for ecosystem models and could be useful for reconciling nutrient budgets.

12. **What are the rates of and controls on remineralization of DOM/POM in the mesopelagic ("twilight") zone?** Data will allow a mechanistic understanding of short-term aspects of C storage in depth horizons that could potentially be ventilated.

**Geochemical Questions**

13. **What is the missing export term suggested by the $^{13}$C record?** Data could provide some closure on regional carbon budgets (see also questions above).

14. **What are the relevant mechanisms and rates of DOM production, consumption, and cycling?** DOM is the largest pool for nitrogen and phosphorus in the ocean and could play a very important role in determining carbon export or storage.
15. **What is the importance of atmospheric transient inputs?** Atmospheric transients likely lead to episodic biological events that are disproportionately important to carbon flux.

**Modeling Questions**

16. **Given that there is no biological equivalent to the Navier-Stokes equation, how should ecosystem modelers proceed to integrate biology into predictive models in a non-competitive way?** Development of an accepted theoretical construct likely would advance the accuracy and robustness of predictive ecosystem models.