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## Scientific Outcomes and Future Challenges of the Ocean Carbon and Biogeochemistry Program

BY HEATHER M. BENWAY AND SCOTT C. DONEY

The ocean plays a major role in shaping Earth's climate, regulating levels of key atmospheric trace gases such as carbon dioxide on time scales of decades to millennia. Much progress has been made in understanding the global carbon cycle; quantifying major carbon sources, sinks, and transport pathways; and tracking the fate of anthropogenic carbon released from fossil fuel combustion and deforestation. However, many key questions remain regarding the magnitude and evolution of ocean uptake of anthropogenic carbon and the likely biogeochemical and ecosystem responses and feedbacks to future changes in ocean chemistry and climate.

Through its support and coordination of US and international activities, the Ocean Carbon and Biogeochemistry (OCB) Program (<http://www.us-ocb.org>) promotes study of the ocean's evolving role in the global carbon cycle in the face of environmental variability

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and change. Formed in 2006 as one of the major activities of the US Carbon Cycle Science Program (<http://www.carboncyclescience.gov/about>), OCB facilitates collaborative, interdisciplinary research opportunities and develops scientific products and activities within the United States and in collaboration with international partners. The OCB Project Office receives support from the US National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). Specific OCB objectives include quantifying and predicting oceanic uptake and release of greenhouse gases and improving our understanding of the environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two. Recent OCB research foci include:

- » Climate- and human-driven changes in ocean chemistry and associated impacts on biogeochemical cycles and marine ecosystems
- » Ocean carbon uptake and storage
- » Estuarine and coastal carbon fluxes and processes, including exchanges with open ocean, terrestrial, and atmospheric reservoirs
- » Water column and seafloor ecological and biogeochemical processes and

associated effects on carbon export and the biological pump

- » Molecular-level responses of marine organisms (primarily lower trophic levels) to their changing environment
- » Impacts of evolutionary changes on plankton community structure, function and biogeochemical cycling in the face of global change

OCB plays many community support roles:

- » Communication of scientific outcomes, products, and opportunities via Web pages as well as email lists and newsletters
- » Planning and organization of community activities, such as science workshops, short courses, synthesis activities, and working groups
- » Providing input on behalf of the OCB research community to national planning initiatives such as the US Carbon Cycle Science Plan and a national ocean acidification research program
- » Development and coordination of outreach products and activities, including classroom resources (e.g., lab kits) and informational materials for policy-makers, media, and the general public (e.g., ocean acidification FAQs)

Under the leadership of its Scientific Steering Committee and subcommittees, OCB coordinates and oversees activities to advance high-priority research areas. In addition to an annual summer workshop that focuses on broad interdisciplinary themes related to OCB research priorities, OCB supports smaller group activities that address targeted research questions. Such efforts have yielded a range of outcomes, including new collaborations and funded projects, high-level publications, synthesis products, and implementation plans for new research and observational initiatives. Recent OCB and partner activities include:

- » Joint working groups between the OCB and US Climate Variability and Predictability (CLIVAR) communities that bring together experts in biogeochemistry, ocean physics, and climate dynamics to identify effective model validation strategies and address key questions surrounding climate change and ocean carbon cycling
- » A coastal carbon workshop and joint coastal synthesis activities with the North American Carbon Program, convening researchers across the land-ocean continuum to quantify carbon fluxes in the coastal zone
- » An ocean acidification workshop, ocean acidification PI meetings, and a short course (Benway et al., 2010) for early career scientists focused on effective design of ocean acidification experiments
- » A workshop and resulting science plan that describes a comprehensive strategy for Southern Ocean biogeochemistry and ecosystem research
- » A workshop to explore more routine shipboard collection and integration of molecular biological and biogeochemical data sets that precipitated


the GeoMICS (Global scale Microbial Interactions across Chemical Surveys) community initiative

The core of OCB research constitutes ocean observations from multiple platforms spanning a wide range of spatial and temporal scales. Observational synthesis efforts have resulted in important milestones such as inventorying and tracking the movement of anthropogenic CO<sub>2</sub> through the world ocean and assessing regional sensitivity to ocean acidification. Given the critical role of ocean observations in supporting these types of research, OCB seeks to inform and facilitate ongoing and emerging community-based ocean observing systems and initiatives. Recent activities include:

- » A workshop and town hall meeting to discuss prospects for a global-scale ocean observing system based on state-of-the-art biogeochemical sensors deployed on profiling floats and gliders
- » A workshop that brought together biogeochemists, biologists, and engineers to discuss a global biogeochemical flux observatory to quantify carbon fluxes associated with the biological pump
- » Ocean time-series community efforts:
  - A community workshop to synthesize major scientific outcomes and prioritize future research and operational objectives of US time series (Church et al., 2013)
  - An international workshop (cosponsored by the International Ocean Carbon Coordination Project and IOC-UNESCO) to examine the sampling and analytical protocols being used at shipboard biogeochemical time-series sites with the goal of improving data intercomparability among sites (Lorenzoni and Benway, 2013)
  - An international network of

shipboard biogeochemical time-series sites to maintain up-to-date information about measurements, methods, and scientific results and products, and to improve coordination and communication among time-series scientists

- » Gathering OCB community feedback on observational programs (e.g., CLIVAR CO<sub>2</sub>/Repeat Hydrography)
- » Providing input to NASA's next satellite ocean color mission PACE (Pre-Aerosol, Clouds, and ocean Ecosystem)

Through its leadership and coordination efforts, OCB helps create opportunities for the research community. However, the energy and success of OCB ultimately depend on the involvement of individual scientists through participation in OCB activities and development and submission of competitive proposals to funding agencies. We welcome and encourage participation from all who are interested. Please explore the OCB website (<http://www.us-ocb.org>) and contact the OCB Project Office ([hbenway@whoi.edu](mailto:hbenway@whoi.edu)) with any questions you may have. 

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