OCB NEWS

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Southern Ocean Gas Exchange Experiment

by David T. Ho, University of Hawaii and Christopher L. Sabine, NOAA/PMEL

A major US SOLAS (Surface Ocean Lower Atmosphere Study) activity over the past two years has been the planning and execution of the Southern Ocean Gas Exchange Experiment (SO GasEx), the third in a series of US-led process studies in the open ocean aimed at improving quantification of air-sea CO_2 fluxes and the gas transfer velocity. The previous GasEx studies were conducted in the North Atlantic (GasEx-98) and in the Equatorial Pacific (GasEx-2001), and resulted in the first robust direct measurements of CO_2 fluxes from the open ocean. SO GasEx sought to build on insights gleaned and techniques honed from those experiments to fully explore the biogeochemical and physical controls on gas exchange at high winds (in excess of 10 m s^{-1}) in a globally significant CO_2 flux region (Figure 1). Although the previous GasEx studies predated the OCB program, the SO GasEx study is a process study within the Ocean Carbon and Biogeochemistry Program and the data management is being handled through the Biological and Chemical Oceanography Data Management Office (BCO-DMO).

Given the paucity of direct flux estimates at wind speeds greater than 10 m s^{-1}, there is a clear need to quantify the gas transfer velocity at higher wind speeds (Figure 2). The Southern Ocean represents an obvious candidate for

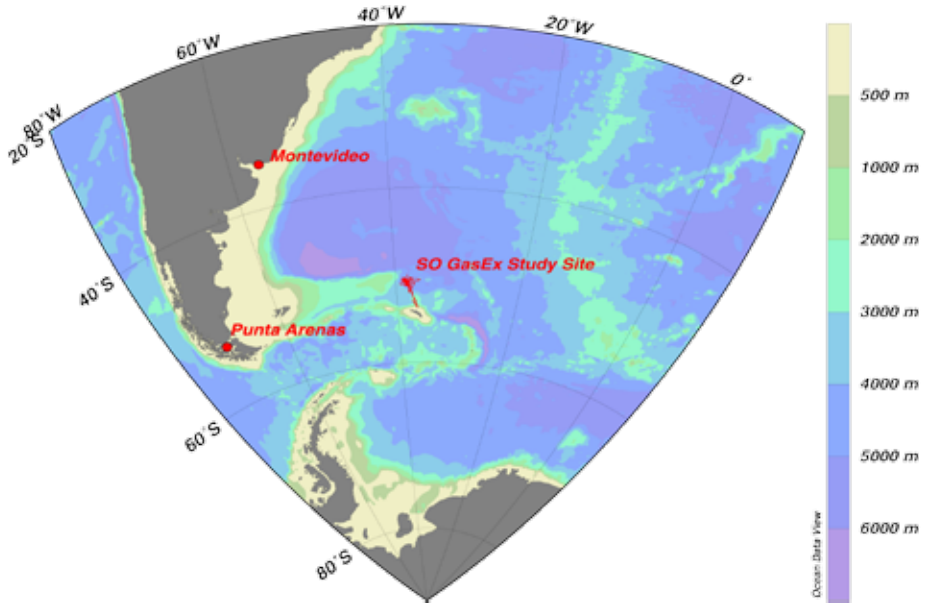

Figure 1: Map showing the cruise tracks at the SO GasEx study site near South Georgia Island, along with the locations of the two ports of call, Punta Arenas, Chile and Montevideo, Uruguay.

reliably finding these wind speeds. While it is true that high wind speeds and a large ΔpCO_2 signal can be found in other oceanic regions, such as the north Pacific in boreal winter, the Southern Ocean is of interest because it is a globally significant but poorly sampled CO_2 sink region. It is entirely possible that the Southern Ocean CO_2 flux is governed by unique factors, in addition to wind speed and ΔpCO_2. If this is the case, parameterizations developed elsewhere will not be applicable to the Southern Ocean, and will continue to lead to large errors in our estimates of the global air-sea CO_2 flux.

Questions addressed by SO GasEx

With financial support from NOAA, NASA, NSF and NERC, SO GasEx was designed to address the following questions, by making a variety of routine, as well as state-of-the-art physical, chemical, and biological measurements (Table 1):

- What are the gas transfer velocities at high winds?

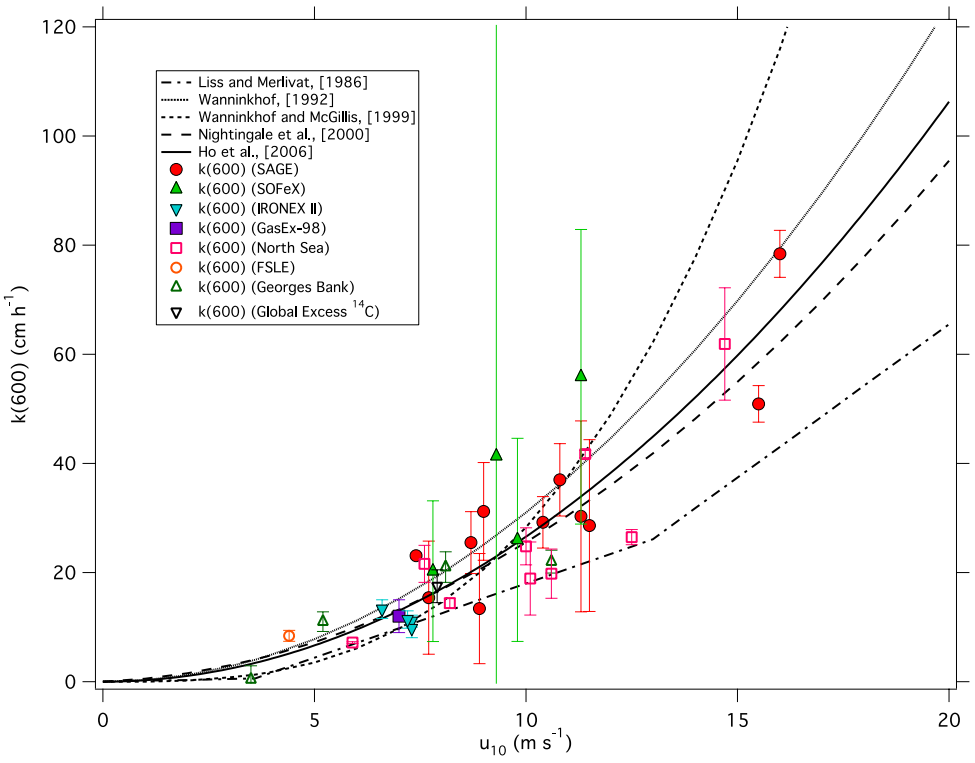

Figure 2. Results of $^3He/SF_6$ dual tracer experiments conducted in coastal and shelf areas, as well as the open ocean. Solid symbols = open ocean experiments; open symbols = coastal and shelf experiments.

The North sea data are from *Nightingale et al.* [2000b], FSLE data from *Wanninkhof et al.* [1997], GasEx-98 from [*McGillis et al.*, 2001], Georges Bank data are from *Wanninkhof et al.* [1993], and reanalyzed by Asher and Wanninkhof [1998], IRONEX data are from *Nightingale et al.* [2000a], SOFeX data are from Wanninkhof et al., [2004], and SAGE data are from *Ho et al.*, [2006]. Also shown are wind speed gas transfer parameterizations of *Wanninkhof and McGillis* [1999], *Wanninkhof* [1992], *Liss and Merlivat* [1986], *Nightingale et al.* [2000b], and Ho et al. [2006]. The SAGE and SOFeX data have been corrected for wind speed enhancement, assuming a quadratic relationship. The differences between these studies and scatter within each study suggest that relating gas transfer velocity to wind speed does not capture all the factors that affect gas exchange.

Table 1: Categories of research projects on SO GasEx.

	Research Projects	Method
1	Direct Flux Measurements (CO_2, ozone and DMS)	Air-sea CO_2 (NDIR), Ozone and DMS (APIMS) flux systems
2	Bulk Meteorology and Turbulent Fluxes (winds, momentum, water vapor, temp, IR, Solar radiation, etc.)	Sonic anemometer, thermometer, pyranometer, pyrgeometer, MicroSAS
3	Integrated Gas Transfer Velocities with Deliberate Tracers (SF_6 and ^3He)	Continuous and discrete SF_6 systems (GCs) and He isotope mass spec
4	Surface and Subsurface variability (CO_2, nutrients, calcite, DMS, chlorophyll)	Shipboard underway systems, NDIR CO_2 systems, GC, EcoVSF, ICPOES, fluorometer, ACS, ISUS, SuperSoar/TOMASI
5	Autonomous Platforms	MAPCO_2, SAMI, ASIS, surface drifters, SOLO floats
6	Surface and near-surface ocean processes (wave spectra, white capping, currents)	Shipboard radar; microwave altimeter, video camera, ADCP
7	Water column hydrography, carbon and related tracers (DIC, pCO_2, Talk, temp, sal, O_2, nutrients, DOC, CDOM, PIC, O_2/Ar/N_2, DMS, particles, TSM, Chl., POC)	SOMMA, NDIR, titration, CTD, Winkler, nutrient auto-analyzer, spectrophotometer, mass spec., GC, HPLC, fluorometer
8	Primary production/new production	^{14}C and ^{15}N incubations, O_2/Ar, spectral absorption, radial photosynthetron
9	Ocean Optics	PAR sensor, FRRF, IOP cage, HTSRB, MVSM

- What is the effect of fetch on the gas transfer?
- How do other non-direct wind effects influence gas transfer?
- How do changing pCO_2 and DMS levels affect the air-sea CO_2 and DMS flux, respectively, in the same locale?
- Are there better predictors of gas exchange in the Southern Ocean than wind?
- What is the near-surface horizontal and vertical variability in turbulence, pCO_2, and other relevant biochemical and physical parameters?
- How do biological processes influence pCO_2 and gas exchange?
- Do the different estimates of fluxes agree, and if not, why?
- With the results from SO GasEx, can we reconcile the current discrepancy between model-based CO_2 flux estimates and observation-based estimates?

This study directly addresses several of the key uncertainties identified as a high priority by the Ocean Carbon and Climate Change implementation strategy for U.S. ocean carbon cycle science.

One of the ultimate goals of these GasEx studies is to be able to quantify gas transfer velocities on regional scales from remote sensing such that, when combined with regional ΔpCO_2, global air-sea CO_2 fluxes can be determined. A systematic approach to accomplish this goal involves the following steps: 1) Make direct flux measurements in the field to obtain short-term local CO_2 fluxes/gas transfer velocities; 2) Reconcile direct CO_2 flux measurements with integrated measurements of gas transfer velocities using the $^3He/SF_6$ dual tracer technique and water column mass balance estimates; 3) Understand the mechanisms controlling ocean mixed layer pCO_2 on short time and space scales; 4) Elucidate the forcing functions controlling gas transfer; 5) Relate forcing functions to parameters that can be detected by remote sensing.

SO GasEx took place in the southwest Atlantic sector of the Southern Ocean (nominally at 50°S, 40°W), near South Georgia Island (Figure 1), from February 29th to April 12th 2008 on the NOAA Ship *Ronald H. Brown* with 31 scientists representing 22 academic institutions, companies and government laboratories. The location was chosen, based on inspection of available satellite and *in situ* data, to have a ΔpCO_2 of at least 40 µatm to ensure a large enough signal to noise for direct eddy-covariance measurements of CO_2, be in an area with a relatively stable water mass (i.e., relatively weak currents and low mesoscale eddy variability) and mixed layer depth less than 50 to 70 m to allow $^3He/SF_6$ patch to be followed for up to 3 weeks, have relatively high wind speeds, long fetch and large waves, and be close to the ports

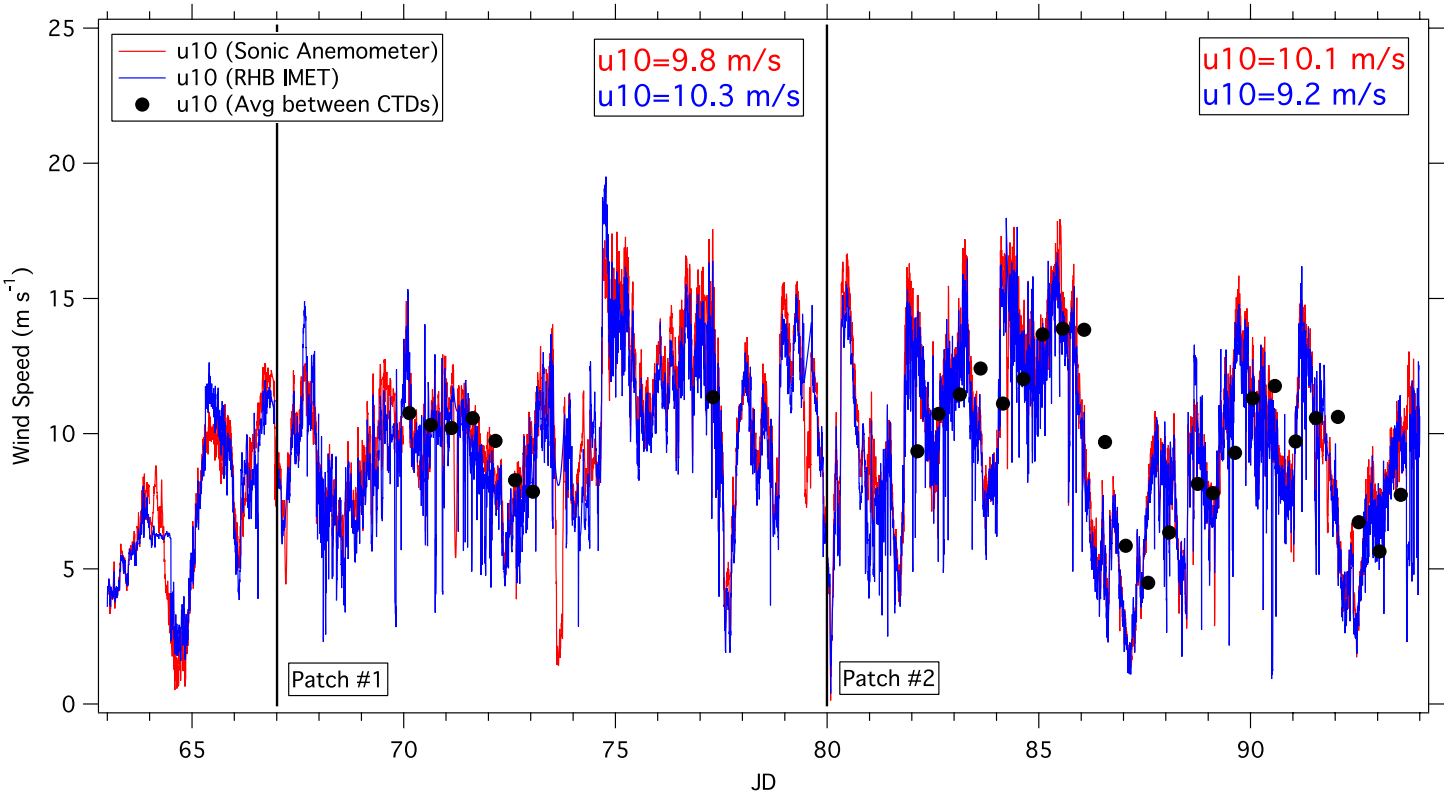

Figure 3. Wind speed during SO GasEx as measured by ship-based anemometers. In red is the sonic anemometer mounted on the jack staff, in blue is the propeller anemometer on top of the ship's superstructure. The solid symbols are the averaged wind speed between CTD stations for $^3He/SF_6$ samples. The black vertical lines denote times of tracer injections.

of call (Punta Arenas and Montevideo) to minimize transit time.

The scientific work concentrated on quantifying gas transfer velocities using deliberately injected tracers ($^3He/SF_6$), measuring CO_2 and DMS fluxes directly in the marine air boundary layer, and elucidating the physical, chemical, and biological processes controlling air-sea fluxes with measurements in the upper-ocean and marine air. The oceanic studies used a Lagrangian approach to study the evolution of chemical and biological properties over the course of the experiment using shipboard and autonomous drifting instruments. The first tracer patch was created and studied for approximately 6 days before the ship was diverted from the study site, 350 miles to the south, to wait near South Georgia Island for calmer seas. After more than 4 days away, we returned to the study area and managed to find some remnants of the tracer patch. After collecting one final set of water column samples and recovering the two drifting buoys deployed with the patch, we relocated to the northwest, closer to the area where the first patch was started. A second tracer patch was created and studied for approximately 15 days before we had to break off the experiment and transit to Montevideo, Uruguay for the completion of the cruise.

Even though we did not encounter sustained wind speeds in the 15-25 m s^{-1} range at our study site during SO GasEx (Figure 3), we did have periods of sustained winds up to ~15 m s^{-1}, which will be a valuable addition to existing measurements of gas transfer velocities from previous experiments and other parts of the global ocean. Also,

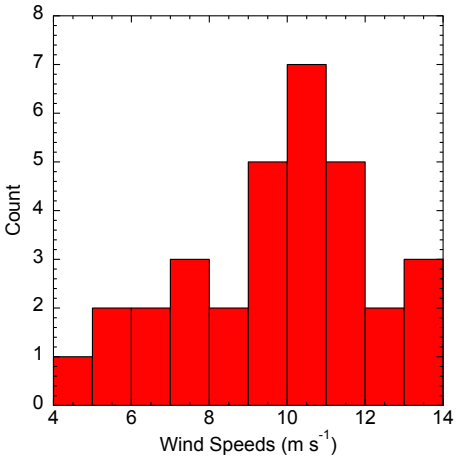

Figure 4: Histograms of average wind speeds between CTD stations. Most of the wind speeds during SO GasEx fell between 9 and 12 m s^{-1}.

we encountered a range of wind speeds (Figure 4), which should allow us to effectively evaluate existing parameterizations between wind speed and gas exchange. The experiment had more hours of eddy covariance CO_2 and DMS measurements than any other previous experiments, and the largest number of $^3He/SF_6$ samples ever taken in one gas exchange experiment.

The combination of CO_2, DMS, and O_3 flux measurements with $^3He/SF_6$ measurements of gas transfer velocities is unprecedented; along with ancillary measurements of waves, turbulence, and bubbles from a buoy that was able to remain with the tracer patch, they should allow us to elucidate mechanisms controlling air-sea gas exchange, and determine if these mechanisms are unique to the Southern Ocean. The detailed carbon system (DIC, pCO_2, TAlk), DMS, productivity, and phytoplankton measurements could also help us understand what controls CO_2 and DMS dynamics in our Lagrangian patch.

SO GasEx is an example of how multi-agency collaboration combined with collaborative efforts of academic and federal scientists could lead to a successful experiment. It also shows that for large multidisciplinary efforts, the grass roots approach needs to be supplemented by top down organization and leadership. Over the next few months, samples sent back to various laboratories will be measured, and data will be analyzed. Modeling groups are spinning up to help interpret the data. We look forward to interacting with the OCB community to consider the broader implications of the SO GasEx results as they become available. For more information on the Southern Ocean Gas Exchange Experiment please visit: http://so-gasex.org.

Chris Sabine

David Ho and Chris Sabine are the chief scientists for Southern Ocean GasEx. After a long tenure with the Lamont-Doherty Earth Observatory, David has just joined the Department of Oceanography as an Associate Professor in the School of Ocean and Earth Science and Technology at the University of Hawaii. Chris is an oceanographer with the NOAA Pacific Marine Environmental Laboratory and an affiliate professor (Department of Oceanography) and senior fellow (Joint Institute for the Study of the Atmosphere and Ocean) with the University of Washington. Chris currently serves as a member of the OCB Scientific Steering Committee and the Ocean Time-Series Advisory Committee.

David Ho

Six MS PHDS Students Participate in 2008 OCB Summer Workshop

2008 MSPHDS students at the OCB workshop. Left to right: Jorge Casillas-Maldonado, Rafael Benitez-Joubert, Warner Ithier, Elizabeth Padilla-Crespo, Leo Procise, and Wanda Vargas.

As part of our efforts on scientific outreach and broader impacts, the Ocean Carbon and Biogeochemistry (OCB) program is partnered with the MS PHDS or Minorities Striving and Pursuing Higher Degrees of Success in Earth System Science initiative. MS PHDS was developed by and for underrepresented minorities with the overall purpose of facilitating increased participation in Earth system science. This program offers networking and mentoring opportunities with federal agency program officers, professional society representatives, peers, researchers, and educators from different institutions across the country. It provides its members with professional development opportunities and exposure to various earth system science and engineering fields via participation in community activities and scientific conferences like the OCB Annual Science Workshop, held July 21-24, 2008 at the Woods Hole Oceanographic Institution (WHOI). This year, OCB hosted six students from the MS PHDS program:

Rafael Benitez-Joubert (University of Puerto Rico, Río Piedras)

Jorge Casillas-Maldonado (University of Puerto Rico, Mayagüez)

Warner Ithier (University of South Florida)

Elizabeth Padilla-Crespo (Georgia Institute of Technology)

Leo Procise (Old Dominion University)

Wanda Vargas (CUNY, Lehman College)

Each student was paired with an OCB mentor to help further engage them in the scientific program, introduce them to colleagues, and provide guidance on career paths and professional development. In addition to attending the workshop, the MS PHDS students spent one day aboard WHOI's R/V *Tioga* learning about basic oceanographic sampling and navigation techniques. After a brief introduction, students experienced hands-on exposure to a range of water, sediment, and biological sampling devices and measurements.

To expose the MS PHDS students to the wide range of potential careers in the marine sciences, the students also attended a career panel of scientific professionals in the Woods Hole community, which was a joint activity with the WHOI Summer Student Fellows Program:

2008 Career Panelists:

Larry Alade (Fishery Biologist, NOAA Northeast Fisheries Science Center)

Ben Gutierrez (Scientist, U.S. Geological Survey)

Sheri White (Assistant Scientist, WHOI Deep Submergence Laboratory)

Mike Carlowicz (Science Writer, WHOI Communications)

Paul Joyce (Dean, Sea Education Association)

Panelists discussed the experiences and challenges associated with their chosen career paths and fielded questions from the students.

Excerpts from 2008 MS PHDS students:

"Last spring, I was fortunate to have spent 6 weeks aboard the R/V *Atlantis* on the East Pacific Rise as a research assistant. The experience fueled my passion for oceanography. I jumped at the opportunity to attend the OCB Workshop. What I didn't expect was to be amidst such extensive knowledge and a broad professional range of individuals at the conference. The topic of ocean carbon was covered with insight and concern through presentations and posters, which allowed me to clearly grasp the need for research in this area.

In addition, being matched with an OCB mentor gave me a great opportunity to gain in-depth knowledge and direction with my education path and



Photos left to right: Elizabeth Padilla-Crespo (left) and Wanda Vargas deploy the sediment grab sampling device. Participants of the MSPHDS R/V *Tioga* day trip: Front (left to right): Wanda Vargas, Rafael Benitez-Joubert, Elizabeth Padilla-Crespo, Leo Procise, Jorge Casillas-Maldonado; Back (left to right): Bruce Tripp, George Hampson; Missing from photo: Warner Ithier. Jorge Casillas-Maldonado (left) and Rafael Benitez-Joubert deploy the CTD/Niskin rosette.

goals. And the highlight of it all: A day of research aboard the R/V *Tioga*. It was awesome to be in that familiar setting learning another great thing about the waters of this Earth."

—Wanda Vargas

"Being a participant of the OCB workshop was a very enriching experience and a great opportunity. I learned where scientists stand on issues of data management, time-series, ocean observatories, etc., and most importantly where they are heading in their unified efforts. The latest public concerns of climate change and global warming are driving more research in the areas of atmospheric science, biogeochemistry and oceanography. I am no expert in this field; my background is in microbial communities from soil and groundwater, but as I expand my research interests, the area of microbial oceanography (and its role in carbon uptake and ocean acidification) is one that I'm interested in pursuing, and my participation in the OCB workshop has reaffirmed that.

I met people from Spain, Canada, Sweden, France, Italy, India, China and others. In that setting you realize how science diplomacy is becoming the driving force behind research, global relations and policy making. It also made me very proud of us, the MS PHDS students, because our attendance made the voice of underrepresented minority students heard. We mingled with the crowd asking questions, participating in discussions, and showing our commitment to achieve outstanding Earth System Science careers. In my case, I feel my attendance made the voice of Puerto Rican women dedicated to environmental research, education and outreach heard.

My favorite day of the workshop was the day we spent aboard the R/V *Tioga*. As a microbiologist, I do bench work all the time. To be out in the field learning how to take samples and measure different water column parameters is something that I had never had the opportunity to do. The *Tioga* crew and scientists onboard helped me experience how fascinating science at sea is."

—Elizabeth Padilla-Crespo

"It was a great experience for me to be at the OCB Workshop in Woods Hole. It was really encouraging and inspiring to see so many scientists from different backgrounds working together toward the same goal."

—Jorge Casillas-Maldonado

Cooley Elucidates Ocean Acidification for the Woods Hole Community

Sarah Cooley, a postdoctoral investigator working with Scott Doney at the Woods Hole Oceanographic Institution recently gave an informational lecture on ocean acidification for the "Science Made Public" series at the WHOI Exhibit Center in Woods Hole, MA.

Ocean Acidification: Will the chowder run out?

Many people already know that burning fossil fuels is increasing atmospheric carbon dioxide levels, but most don't know that it's also completely changing ocean chemistry by acidifying our oceans. In the next 50 years, survival will become increasingly hard for shellfish and corals. Learn about the connection between today's traffic jams and tomorrow's seafood supply, and hear how food shortages and economic losses worldwide may be prevented.

Thoughts About the Future of Satellite Ocean Color Observations

by David A. Siegel (UCSB), James A. Yoder (WHOI), Charles R. McClain (NASA/GSFC)

For more than a decade, the ocean biology and biogeochemistry community has been blessed by the wide availability of high quality, global satellite ocean color observations. These observations have enabled transformational science achievements throughout oceanography and Earth science. Any one of a large number of achievements can be cited from bio-optical oceanography to global carbon cycling and its relationship to climate change to harmful algal blooms to fishery sciences. Much of the credit must go to the successes of three ocean color instruments—GeoEye's SeaWiFS (launched in 1997), NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua platform and the European Space Agency's (ESA) Medium-resolution, imaging spectrometer (MERIS) on Envisat (both launched in 2002). These three satellite sensors have supplied highly precise radiometric determinations at the top of our atmosphere of the entire globe for more than a decade. It is the quality of these instruments in space, their ability to adequately sample the global ocean, as well as our ever-increasing abilities to convert these top-of-the-atmosphere signals into useful oceanographic data products that have made this promise of climate data records of our ocean biosphere a reality.

As with all things, these satellite instruments have a finite lifetime. The SeaWiFS mission is long past its expected lifetime and this year has had several spacecraft software anomalies that required it to stop imaging for several months. Similarly, MODIS/Aqua and MERIS, though in excellent health, are also beyond their expected lifetimes. Near-term plans for the U.S. have been to launch the Visible Infrared Imager Radiometer Suite (VIIRS) sensor on the NPOESS (National Polar-Orbiting Operational Environmental Satellite System) Preparatory Project (NPP) (likely launch in 2011) and NPOESS C1 (2014 launch) missions to extend the ocean color time-series started with SeaWiFS. Unfortunately, the VIIRS instrument to fly on NPP is unlikely to maintain the climate data record of the ocean's biosphere started by SeaWiFS. The issues are many, and involve aspects of sensor design and engineering, manufacturing and fabrication, and pre-launch calibration, as well as limitations on the in-flight calibration options. In particular, the integrated filter array (IFA), the component that disperses light spectrally onto the focal plane detectors, on the VIIRS flight instrument has known flaws that make it highly unlikely for VIIRS to meet the climate community's measurement requirements. There are no near-term NASA options for the U.S. science community either. The National Research Council's Earth Science and Applications Decadal Survey has placed the advanced, global ocean color mission (ACE – Aerosols, Clouds and Ecosystems) in its second tier of NASA missions with a realistic launch date no earlier than 2020 given the current budget.

It appears likely that the ocean biology and biogeochemistry communities will face a multi-year gap in our climate data records.

Simply stated, existing satellites are aging while the U.S. operational missions that are aimed to extend these climate data records (VIIRS on NPP and NPOESS) will not likely fill the need for climate or operational requirements. It appears likely that the ocean biology and biogeochemistry communities will face a multi-year gap in our climate data records. Last year, two of us (Siegel and Yoder) drafted a letter on behalf of the ocean biology and biogeochemistry communities to Dr. Michael Griffin, NASA Administrator, and Admiral Conrad Lautenbacher, NOAA Administrator, detailing these issues and our view of the near-term future of U.S. satellite ocean color observations (http://www.spaceref.com/news/viewsr.html?pid=25593). Briefly, we laid out three alternatives for continuity of the U.S. ocean color climate data record: 1) The VIIRS sensors will work as well as SeaWiFS (unlikely), or that existing satellite sensors will continue to work until ACE is launched (highly unlikely); 2) Launch a U.S. gap filler mission to provide high quality ocean color data continuity (which requires unbudgeted money); or 3) Recognize that a gap in U.S. ocean color data continuity will occur and understand the consequences of this inaction.

Responses to the letter have been mixed. More effort is clearly being placed on the characterization of VIIRS by the contracting team, and a calibration/validation plan for VIIRS ocean products is being formed under the leadership of Bob Arnone (Naval Research Laboratory). However, the IFA on the NPP flight unit will not be replaced, and it is the hope of

the contractors that these engineering anomalies can be corrected with software, though there is no precedent for this. Further, NPP is very far behind schedule and VIIRS still remains in its testing phase (see http://www.sciencemag.org/cgi/content/full/321/5896/1620a). As of today, there is little evidence demonstrating that VIIRS will be able to provide climate-quality ocean color observations.

International Missions

The response to the community letter also stressed that the upcoming gap can be covered by data from international ocean color missions. MERIS on Envisat is the same age as MODIS on Aqua, but ESA plans to keep it operational at least until its next mission, the Ocean Land and Color Imager (OCLI) on Sentinel-3, which may be launched as early as 2012. There has also been a much greater cooperation of U.S. and European scientists and engineers in the past year through the efforts of the NASA/NOAA/ESA MERIS data workshop this summer and ESA's GlobColour program. Further, the Indian Space Research Organization is launching a global mission this fall (OCM-2), and a request for proposals for international participation was recently released. These planned missions could help bridge the expected gaps in the climate data record from the U.S. perspective, but much coordination is needed to insure that this potential is realized.

There are other positive developments on the international front. This September, the International Ocean Colour Coordinating Group (IOCCG) received approval from the Committee for Earth Observation Satellites (CEOS) to develop a "virtual constellation" for ocean color observations. A virtual constellation is an international science program where multiple space agencies work together to add value (e.g. cross-calibration, improved validation, merge data) to individual missions that support international research and in particular, the operational needs of the Global Earth Observation System of Systems (GEOSS) program and the Global Climate Observing System. The major objective of the ocean color virtual constellation is to provide a time-series of climate-quality global measurements of ocean color radiance and derived products. Although the planning for the virtual constellation is a positive development, it is in its very early stages and its success will depend on the deployment of new missions and much international cooperation.

It seems clear that there will be a gap of U.S. ocean color data within the next decade. NASA can contribute to the international virtual constellation by flying a new U.S. mission within the next five or so years to provide climate-quality ocean color data. This mission would preferably have advanced capabilities in the UV for improved retrievals of *in situ* optically active constituents relevant to carbon cycling, such as colored dissolved organic matter (CDOM). The need for a NASA mission to follow SeaWiFS and MODIS has been articulated in the NASA Ocean Biogeochemistry Program planning document, Earth's Living Ocean: The Unseen World (http://www.icess.ucsb.edu/~davey/OBB/OBB_Report013007.pdf). The benefits of a gap filler mission are obvious, but they are balanced by the real and unbudgeted costs for this mission. If launching a U.S.-led gap filler mission is not viable, the U.S. ocean color community needs to contribute its considerable expertise to the international effort with, for example, helping to lead a Sensor Intercomparison for Marine Biological and Interdisciplinary Ocean Studies (SIMBIOS)-type program that would provide ocean color climate data records for the U.S. and international community. This program must include the calibration of multiple ocean color sensors to common standards, a vigorous field data program for vicarious calibration and product validation, new data product development and evaluation, multi-sensor data merging, multiple paths for data distribution, etc. It must be noted that a program of this scope will require substantial efforts, both financially and diplomatically, if it is to be successful in providing climate-quality data for the ocean biosphere.

Regardless of what might happen in the near-term, we are entering a new era for satellite ocean color science. The recent approval of the ocean color virtual constellation is one of any number of pieces of evidence that points to the increasing need for international cooperation. This will be especially true as we piece together climate data records from multiple satellite missions built and operated by different space agencies. But the climate-related signals that we need to measure are tiny and even the smallest differences in satellite calibration or data processing procedures can obfuscate these trends. This will require real cooperation among the many space agencies contributing to the virtual constellation, including reaching a consensus on minimum design requirements, exchanging the details of sensor pre-launch calibration and characterization data, open data policies for all satellite and field data, sharing of satellite data processing algorithms and procedures, and so on. It is only by accepting this international future and understanding its implications of how we go forward can we make actual progress towards the implementation of the planned virtual constellation of satellite ocean color observations and be able to continue our climate-scale observations of the ocean biosphere.

This letter is based upon the informed opinions of the authors and in no way represents the official positions of NASA or any other agency or organization.

U.S. GEOTRACES Atlantic Section Planning Meeting

Bill Jenkins and Bob Anderson

A three-day planning workshop was held September 22-24 at the Woods Hole Oceanographic Institution sponsored by the National Science Foundation and the U.S. GEOTRACES Scientific Steering Committee. Ed Boyle (M.I.T.) and Bill Jenkins (W.H.O.I.) organized the meeting whose goal was to design the implementation plan for the first U.S. GEOTRACES Atlantic Section, specifically centered around a sampling cruise to be carried out in the North Atlantic in 2010. The primary cruise design motivation was to improve knowledge of the sources, sinks and internal cycling of Trace Elements and their Isotopes (TEIs) by studying their distributions along a section in the North Atlantic (Figure 1). The North Atlantic has the full suite of processes that affect TEIs, including strong meridional advection, boundary scavenging and source effects, aeolian deposition, and the salty Mediterranean Outflow. The North Atlantic is particularly important as it lies at the "origin" of the global Meridional Overturning Circulation.

It is well understood that many trace metals play important roles in biogeochemical processes and the carbon cycle, yet very little is known about their large-scale distributions and the regional scale processes that affect them. Recent advances in sampling and analytical techniques, along with advances in our understanding of their roles in enzymatic and catalytic processes in the open ocean provide a natural opportunity to make substantial advances in our understanding of these important elements. Moreover, we are motivated by the prospect of global change and the need to understand the present and future workings of the ocean's biogeochemistry.

The GEOTRACES strategy is to measure a broad suite of TEIs to constrain the critical biogeochemical processes that influence their distributions. In addition to these "exotic" substances, more traditional properties, including macronutrients (at micromolar and nanomolar levels), CTD, bio-optical parameters, and carbon system characteristics will be measured. The cruise starts at Line W, a repeat hydrographic section southeast of Cape Cod, extends to Bermuda and subsequently through the North Atlantic oligotrophic subtropical gyre, then transects into the African coast in the northern limb of the coastal upwelling region. From there, the cruise goes northward into the Mediterranean outflow. The station locations shown on the map are for the "full-depth TEI" stations, and constitute approximately half of the stations to be ultimately occupied.

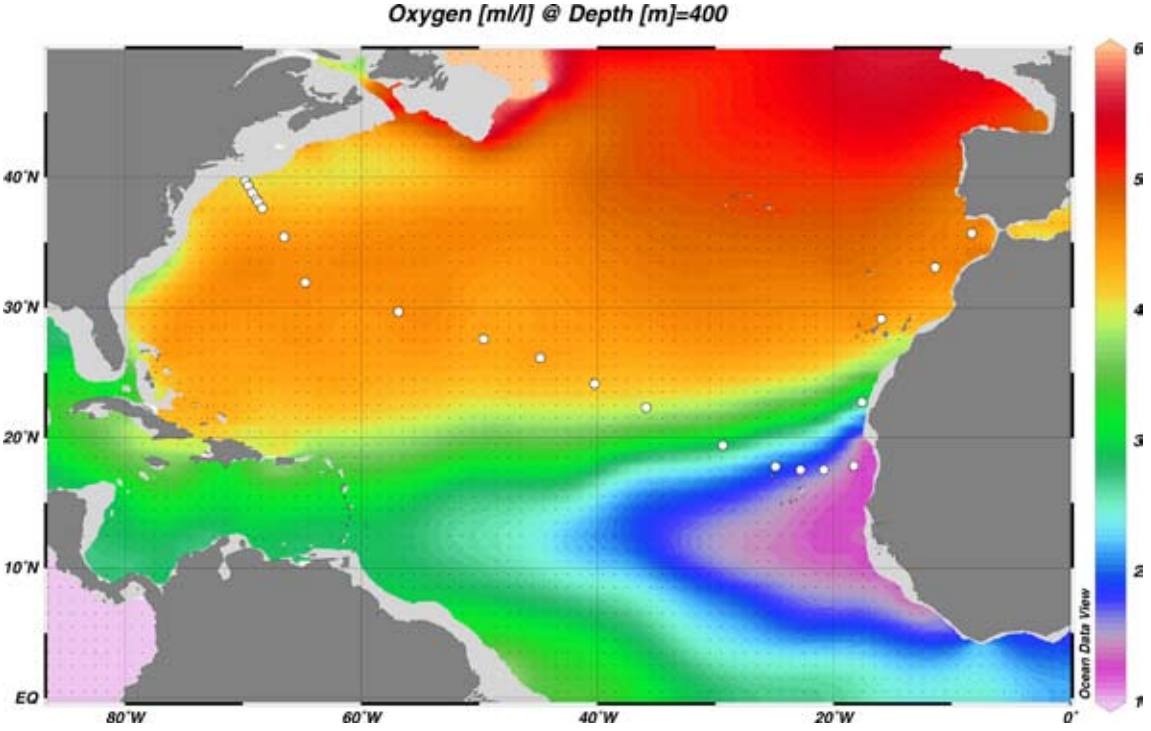

Figure 1. The proposed 2010 Atlantic GEOTRACES cruise track plotted on dissolved oxygen at 400 m depth. Data from the World Ocean Atlas (Levitus et al., 2005) were plotted using Ocean Data View (courtesy Reiner Schlitzer).

center for microbial oceanography: research and education

C·MORE linking genomes to biomes

What is C-MORE?

The Center for Microbial Oceanography: Research and Education (C-MORE) is a multi-institution Science and Technology Center, established by the National Science Foundation in 2006. Headquartered at the University of Hawaii at Manoa (UHM), C-MORE partner institutions include the Massachusetts Institute of Technology (MIT), Woods Hole Oceanographic Institution (WHOI), Oregon State University (OSU), University of California at Santa Cruz (UCSC), and the Monterey Bay Aquarium Research Institute (MBARI). C-MORE's mission is to facilitate a more comprehensive understanding of the diverse assemblages of microorganisms in the sea, ranging from the genetic basis of marine microbial biogeochemistry, including the metabolic regulation and environmental controls of gene expression, to the processes that underpin the fluxes of carbon, related bio-elements, and energy in the marine environment. The Center's research is organized around four interconnected themes: Microbial biodiversity; metabolism and C-N-P-energy flow; remote and continuous sensing and links to climate variability; and ecosystem modeling, simulation and prediction. The strength of C-MORE resides in the synergy created by bringing together experts who traditionally have not worked together and this, in turn, facilitates the creation and dissemination of new knowledge on the role of marine microbes in global habitability.

Opportunities for K-12 Teachers

C-MORE's education program is "K through Grey". In this issue, we will describe some opportunities for K-12 teachers; other aspects of the education program will be covered in future issues.

Grants for Education in Microbial Science (GEMS)

C-MORE awards mini-grants (up to $1000) to K-12 public school teachers to foster awareness in microbial science. Funds may be requested for equipment, consumable supplies, substitute teacher compensation to enable the teacher to participate in shipboard or laboratory experiences, bus transportation for field trips, and other projects related to microbial science. Every grant requires a C-MORE sponsor, so we expect this program to significantly promote interaction between C-MORE scientists, other stakeholders in science and education, K-12 teachers and students. To find a sponsor, please visit the C-MORE team webpage http://cmore.soest.hawaii.edu/team.htm. Any member of the C-MORE team, including graduate students, can serve as a sponsor.

Science Teachers Aboard Research Ships (STARS)

Approximately once a month, C-MORE and the Hawaii Ocean Time Series HOT program operate a four-day research cruise. K-12 teachers are invited to apply to join a C-MORE scientist-educator on selected cruises (approximately 3-4 times per year). Teachers have the opportunity to participate in every aspect of sampling aboard the ship, and work alongside other teachers and scientists. Activities include hands-on oceanographic sampling, processing and analysis of samples in the lab, and classroom exercises and lectures.

Although teachers learn about all aspects of oceanography during these cruises, particular emphasis is placed on the exciting and emerging field of microbial oceanography! To learn more and download an application form, please visit http://cmore.soest.hawaii.edu/education/opportunities.htm#teacher-at-sea.

Upcoming C-MORE Events

We invite you to participate in an upcoming special session at the Fall

C-MORE—page 16

OCB Implementation: A Bottom-Up Approach

Unlike several previous and existing programs, OCB employs a bottom-up rather than top-down approach to organizing community science efforts. This means that more than ever, we need your energy and participation to translate the scientific ideas and strategies developed at OCB workshops into field and research programs. OCB serves as a coordinating body to help publicize upcoming field opportunities, facilitate collaboration from different research teams, disseminate research findings, data sets and model products, and develop and share educational and public outreach materials.

Although there is not an exclusive funding mechanism in place for OCB research, funding is already available through existing programs, and agency managers are encouraging large coordinated proposals from the OCB community!

Please view the list of OCB-relevant funding opportunities on the OCB website. When preparing proposals, we encourage you to explicitly state the relevance and importance of your work to OCB's mission and goals. While OCB cannot endorse or fund research projects---that is the purpose of the peer review process put in place by the federal science agencies—we encourage you to contact the OCB Project Office as you are developing your proposal. Specifically, the Project Office may be able to help with coordinating and leveraging complementary projects and enhancing education, outreach and diversity activities. Affiliation with and contributions to a large program like OCB guarantee far-reaching impacts in research and education.

Specific Examples of OCB Implementation

Working Committees

OCB has established an Ocean Time-Series Advisory Committee, chaired by Debbie Bronk, to review existing ocean biogeochemical time-series (e.g., HOT, BATS, CARIACO), develop recommendations to improve the effectiveness and inter-comparability of these time-series, and interface with the OCB research community to identify and communicate needs for existing and future time-series sites. Please visit the OCB website for a list of committee members.

OCB has also established an Ocean Acidification Subcommittee, co-chaired by Joan Kleypas and Richard Feely, to provide input on ocean acidification research priorities, develop and disseminate education and outreach materials via an OCB ocean acidification website, and strengthen ties to international ocean acidification activities (e.g., European Project on Ocean Acidification, or EPOCA). Please visit the OCB website for a list of committee members.

Communication and Outreach

A key objective of the OCB Project Office is to communicate OCB-relevant information to the national and international scientific communities and broader audiences. The two principal modes of communication and outreach are the OCB website and the OCB newsletter (OCB News). The OCB website serves as a clearinghouse for information on research, education, and legislation relevant to ocean biogeochemistry and ecology, such as the Federal Ocean Acidification Research And Monitoring Act. Specific website functions include publicizing meetings and workshops; posting scientific planning documents, white papers, newsletters, and workshop reports; providing up-to-date meeting and workshop logistics; highlighting relevant current events; listing OCB PI project information; and archiving data. The OCB newsletter is published three times a year and targets a broad scientific readership. Each issue contains scientific articles by OCB scientists highlighting new and interesting OCB-relevant research, programmatic updates, OCB education and outreach activities, and a calendar of upcoming OCB-relevant events. Please contact the Project Office if you would like to contribute to OCB News.

Links to U.S. and International Activities

A key objective of the OCB Project Office is to strengthen ties to related national and international activities, such as Ocean Carbon and Climate Change (OCCC), the Global Carbon Project (GCP), Surface Ocean Lower Atmosphere Study (SOLAS), Integrated Marine Biogeochemistry and Ecosystem Research (IMBER), U.S. Carbon Cycle Science Program (USCCSP), North American Carbon Program (NACP), CARBOOCEAN, GEOTRACES, and International Ocean Carbon Coordination Project (IOCCP). Current OCB Project Office activities include partial support of an IMBER workshop focused on the mesopelagic November 9-13, 2008 in Miami, FL, an IOCCP time-series workshop November 5-7, 2008 in La Jolla, CA, and an international workshop to develop a best practices guide

for ocean acidification research November 19-21, 2008 in Kiel, Germany. The Project Office is also assisting in the coordination of a coastal synthesis for the NACP Interim Synthesis Activities. Specific information about these activities is included later in this newsletter.

Workshops

In addition to the OCB annual summer science workshop, which focuses on broad interdisciplinary themes, the OCB Project Office supports two targeted scientific scoping workshops per year to give the research community a public venue for discussing research challenges and implementation approaches to address specific OCB research priorities. We expect that discussions at these workshops and by the broader research community will motivate self-identified groups and individuals to develop and submit proposals post-workshop to OCB-relevant funding targets.

Previous OCB Scoping Workshops

October 9-11, 2007: Ocean Acidification scoping workshop (Final edits of workshop report in progress; OCB Project Office will notify OCB community when final report is released)

May 6-8, 2008: Terrestrial and Coastal Carbon Fluxes and Exchanges in the Gulf of Mexico (Workshop report under review by workshop planning committee; community release scheduled for October 2008)

Upcoming OCB Scoping Workshops

April 28-30, 2009: "Long-term remote *in situ* observations of ocean biogeochemical cycles at ocean basin to global scales using profiling floats and gliders" – Moss Landing, CA. This workshop will focus on the implementation of a long-term observing system for marine biogeochemistry using chemical and biological sensors deployed on autonomous platforms, such as profiling floats, gliders or other long-endurance autonomous vehicles. The workshop planning committee includes Kenneth Johnson, Steve Emerson, Steve Riser, Mary Jane Perry, Emmanuel Boss, Arne Kortzinger, Niki Gruber, Hervé Claustre, and Dennis Hansell. The organizers will send out an announcement when the workshop website (registration, logistical details, etc.) becomes available.

2009: Southern Ocean scoping workshop (Solicitation just ended, decision to be announced Fall 2008)

OCB to Help Coordinate Coastal Synthesis Activities

In late June, the OCB Project Office sent out a call for participation in a Coastal Synthesis as part of the North American Carbon Program (NACP) Interim Synthesis Activities. The objective of this activity is to stimulate the synthesis and publication of recent observational and modeling results on carbon cycle fluxes and processes along the North American continental margin. At the OCB summer workshop, we organized a breakout session to begin planning the coastal synthesis.

We have broken down the proposed synthesis effort into five U.S. geographical sub-regions (Atlantic Coast, Pacific Coast, Gulf Coast, Arctic Coast, and Laurentian Great Lakes). At this time, we encourage you to take stock of your ongoing projects and think about how you might contribute to one or more of the regional syntheses. To join a synthesis activity, visit the NACP interim synthesis activities website and click on the email list link for your region of interest, and you will be prompted to enter your email address and set up a password. Regional leads are starting to initiate contact with their regional groups via these email lists. To facilitate communication between and within the regional coastal synthesis groups, the NACP office has also set up a wiki.

NACP researchers will present some of the findings of the NACP Interim Synthesis Activity at the 2009 2nd NACP All-Investigators Meeting, which will be held February 17-20, 2009 in San Diego, CA. Although the coastal synthesis activity is in its introductory phase, we are planning to participate in this meeting. In addition to poster and breakout sessions, there will be a dedicated plenary session for the Coastal Synthesis Activity. Once discussions are underway within and among regional groups, we will coordinate our input to this meeting.

Open Nominations for Scientific Steering Committee Members

OCB just completed its first open nomination period for new Scientific Steering Committee (SSC) members. The OCB SSC, established in February 2006 jointly by NSF, NASA and NOAA, promotes, plans, and coordinates collaborative, multidisciplinary research opportunities related to carbon cycling and associated marine biogeochemical cycles and ecosystem processes. SSC members serve a term of 3 years with approximately 1/3 membership turnover per year. For more information on OCB and its current SSC, please visit www.us-ocb.org/about. New SSC members from the recent open nomination period (ended 10/3/08) will be announced in Fall 2008.

Seeking OCB Projects and Field Opportunities

OCB Projects include any project that falls within the broad scientific themes of OCB,

Overarching Scientific Themes

Improve understanding and prediction of:

- oceanic uptake and release of atmospheric CO_2 and other greenhouse gases;
- climate-sensitivities of biogeochemical cycles and interactions with ecosystem structure

Currently Identified Priorities

- Ocean acidification
- Terrestrial/coastal carbon fluxes and exchanges
- Climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles
- Mesopelagic ecological and biogeochemical interactions
- Benthic-pelagic feedbacks on biogeochemical cycles
- Ocean carbon uptake and storage

and is self-identified by the PI(s) as an OCB activity. Current OCB projects include a combination of individual PI grants and mid-sized projects (multiple PIs), with a view toward larger coordinated studies. We are continu-

OCB Projects—page 16

OCB to Co-Sponsor International Meetings

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Program is organizing a gathering, or "IMBIZO" November 9-13, 2008 in Miami, FL that will include three focused concurrent workshops: Mesopelagic, bathypelagic, and end-to-end food webs. The three workshops will be co-located, and joint plenary and poster sessions will provide a forum for stimulating discussion among experts in different disciplines and strengthen the scientific link between biogeochemistry and ecosystem research. Participants will include zooplankton and fishery biologists, biogeochemists, physical oceanographers, microbial ecologists, and ecosystem/biogeochemistry modelers. Since mesopelagic ecosystems and biogeochemistry currently represent a high-priority research topic for OCB, the Project Office is providing travel support for a selected group of U.S. participants to attend the workshop.

To support and strengthen the international ocean carbon and biogeochemical time-series effort, the International Ocean Carbon Coordination Project (IOCCP) is coordinating a time-series workshop *"Changing Times: An International Ocean Biogeochemical Time-Series Workshop"* November 5-7, 2008 at Scripps Institution of Oceanography in La Jolla, California. Time-series data play a critical role in OCB science, and the upcoming workshop represents an opportunity for OCB to participate in planning and implementation of global time-series networks. Therefore, the OCB Project Office is providing travel support for members of the Ocean Time-Series Advisory Committee to attend this workshop.

Ocean acidification remains a very high priority for OCB, as evidenced by its recent development of an ocean acidification subcommittee. OCB is working with the IOCCP and the European Project on Ocean Acidification (EPOCA) to partially sponsor U.S. participation in an international workshop to develop a best practices guide for ocean acidification research. This workshop will take place November 19-21, 2008 in Kiel, Germany.

OCB Workshop Summaries

2008 Ocean Carbon and Biogeochemistry Summer Science Workshop

The third annual Ocean Carbon and Biogeochemistry (OCB) summer science workshop sponsored by the National Science Foundation took place July 21-24, 2008 at the Woods Hole Oceanographic Institution in Woods Hole, MA, convening 147 participants. Daily plenary and poster sessions focused on three interdisciplinary themes:

1) Climate sensitivity of ecosystem structure and associated impacts on biogeochemical cycles

Speakers addressed impacts of

climate variability, climate change and ocean acidification on marine calcifiers, pelagic food-web dynamics, benthic fauna, fluxes to the deep-ocean, and oxygen minimum zone extent and evolution.

2) Carbon uptake and storage

Speakers summarized recent ocean carbon flux trends and key controlling processes in critical regions such as the Southern Ocean, the northern oceans, and the Gulf of Mexico. One speaker described a new tracer-based back-calculation method for reconstructing anthropogenic carbon uptake in the world's oceans.

3) Temporal trends in ecosystem variability

Presentations in this theme focused on how satellite- and ocean-based time-series, paleoclimate records, and regional programs such as GLOBEC advance our understanding of marine biogeochemical cycling and feedbacks between climate and marine ecosystems and provide critical data to improve complex ecosystem models.

During daily breakout sessions focusing on important subtopics under each theme, participants discussed field-based, remote sensing, and modeling strategies to address critical knowledge gaps. Two common threads emerged repeatedly throughout the workshop: 1) the importance of the Southern Ocean in the global carbon cycle; and 2) the need to expand observational capabilities for the OCB community by leveraging underway ship systems, autonomous platforms and the Ocean Observatories Initiative (OOI). Specific observational challenges include improved quantification of planktonic functional group distributions, lateral transport, benthic-pelagic coupling, and air-sea CO_2 fluxes and food web changes.

Additional highlights of the OCB summer workshop included a planning session for OCB coordination

of a coastal synthesis as part of the North American Carbon Program's interim synthesis activities, a presentation of exciting new results on the Spring 2008 plankton bloom (North Atlantic Bloom Experiment), a plenary discussion of OCB's leadership role in defining future carbon cycle research directions, and plenary discussions following up on two recent OCB scoping workshops, one on ocean acidification and one on terrestrial and coastal carbon fluxes and exchanges in the Gulf of Mexico.

For further information (meeting agenda, list of participants, talks, live web-casts, etc.), please visit http://www.whoi.edu/sites/ocbworkshop2008.

Scoping Workshop on Terrestrial and Coastal Carbon Fluxes and Exchanges in the Gulf of Mexico

The OCB Project Office sponsored its second scoping workshop on "Terrestrial and Coastal Carbon Fluxes in the Gulf of Mexico" May 6-8, 2008 in St. Petersburg, FL. The goal of the workshop was to bring together researchers to discuss potential integrated research projects related to carbon fluxes and exchanges in the Gulf. Approximately ninety scientists attended, representing U.S. and Mexican research organizations, academic institutions, and government agencies.

Twelve plenary speakers summarized the current state of knowledge on carbon dynamics in various parts of the Gulf of Mexico system and highlighted processes of primary importance in controlling variability in fluxes and fates. During breakout sessions, workshop participants engaged in more detailed discussions of topics highlighted during the plenary sessions, and formulated questions that will drive future research projects and field programs. The primary objective of future Gulf of Mexico research is to achieve an understanding of material and energy fluxes, exchanges, and fates so that we can anticipate river–ocean system changes related to global-scale climate changes.

On the final day of the workshop, there was a plenary discussion of future research directions in the Gulf of Mexico, in which participants formulated a single overarching research

Scoping Workshop—page 16

OCB Activities Calendar

OCB ACTIVITIES

April 28-30, 2009: OCB Scoping Workshop: "Long-term, remote *in situ* observations of ocean biogeochemical cycles at ocean basin to global scales using profiling floats and gliders," Moss Landing, CA

July 20-23, 2009: OCB summer science workshop, Woods Hole, MA

OCB-RELATED ACTIVITIES *CO-SPONSORED BY OCB

2008

September 22-26: ICES 2008 Annual Science Conference, Halifax, Nova Scotia

September 22-24: Implementation of US GEOTRACES Atlantic Section Workshop, Woods Hole, MA

October 1-3: Implementation of US GEOTRACES Pacific Section Workshop, Los Angeles, CA

October 5-10: DISCO XXI (chemical oceanography) and PODS V (physical oceanography) Symposia for new PhDs, Honolulu, HI

October 6-8: SCOR/IAPSO Workshop on Deep Ocean Exchange with the Shelf (DOES), Cape Town, South Africa

October 6-8: 2nd Symposium on the Ocean in a High-CO_2 World, Musée Océanographique, Monaco

October 6-10: Ocean Optics XIX, Il Ciocco, Tuscany, Italy

October 9-23: Training Session on Remote Sensing Data Analysis. Corvallis, OR, contact: oig@scert.ru

October 11-15: Eco-DAS Symposium (Ecological Dissertations in the Aquatic Sciences, formerly DIALOG) for new PhD's in ecological oceanography and limnology, University of Hawaii at Manoa

October 20-24: SCOR 50th Anniversary Symposium and General Meeting, Woods Hole, MA

October 20-23: AGU Chapman Conference on Organic Matter Fluorescence, University of Birmingham, Edgbaston, Birmingham, UK

October 21-23: Hyperspectral Infrared Imager (HyspIRI) Science Workshop, Monrovia, CA

October 27-29: International Congress "Anthropogenic impacts on the Marine Environment," ISMAL, Algeria

November 2-9: DISCCRS IV Interdisciplinary Climate Research Symposium, Saguaro Lake Ranch, AZ

November 3-5: Constrain, understand and model biocomplexity in plankton communities, Napoly, Italy

November 5-7*: Changing Times: An International Ocean Biogeochemical Time-Series Workshop (IOCCP/OCB), Scripps Institution of Oceanography, La Jolla, CA

November 9-13*: IMBER IMBIZO: Biogeochemical and ecosystem interactions in a changing ocean, Miami, FL

November 11-15: World Conference on Marine Biodiversity, Valencia, Spain

November 19-21*: International workshop on best practices for ocean acidification research, Kiel, Germany

November 19-22: IMPETUS 2008: Techniques in Polar Ocean Observation and Monitoring, St. Petersburg, Russia

December 2-6: PORSEC 2008: Oceanic manifestation of global changes: The 9th Pan Ocean Remote Sensing Conference, Guangzhou, China

December 3-5: 4th Aquarius/SAC-D Science Workshop, Puerto Madryn, Chubut, Argentina

December 13-14: GEOTRACES Intercalibration Workshop, Larkspur Hotel Union Square, San Francisco, CA (Saturday and Sunday, 08:00 AM - 6:00 PM), please email geotraces@ldeo.columbia.edu for online instructions to reserve hotel room

December 15–19: 2008 Fall AGU Conference, San Francisco, California (visit www.us-ocb.org/meetings/index.html to download a list of OCB-relevant sessions)

2009

Jan 25–30: ASLO Aquatic Sciences Meeting, Nice, France (visit www.us-ocb.org/meetings/index.html to download a list of OCB-relevant sessions)

February 17–20: 2nd NACP All-Investigators Meeting, San Diego, CA

March 2-6: 11th Pacific Science Inter-Congress, Tahiti, French Polynesia, Session 2: "Climate Change and Ocean Acidification" Co-Chairs: Julie Cole and Jean-Pierre Gattuso

March 10-12: Climate change: Global risks, challenges, and decisions, Copenhagen, Denmark

March 23-26: GREENHOUSE 2009: Climate change and resources, Perth, Australia

March 25-27: The 3rd Argo Science Workshop: The Future of Argo, Hangzhou, China

Calendar

April 26-30: Social Challenges of Global Change - International Human Dimensions Programme on Global Environmental Change (IHDP) Open Meeting, Bonn, Germany

June 22-26: 3rd GLOBEC Open Science meeting, Victoria, BC

September 13-19: International Carbon Dioxide Conference, Jena, Germany

September 21-25: Ocean Obs 2009: Ocean Information for Society: Sustaining the Benefits, Realizing the Potential, Venice, Italy

November 30-December 11: UN Climate Change Conference, Copenhagen, Denmark

FUNDING OPPORTUNITIES

October 9, 2008: NOAA Global Carbon Cycle Program (letters of intent due August 11, 2008)

October 30, 2008: NASA Earth Science Division Applied Sciences Program, "Earth Science for Decision Making: Gulf of Mexico Region"

November 18, 2008: NSF Dynamics of Coupled Natural and Human Systems

February 15, 2009: NSF Chemical Oceanography and Biological Oceanography proposal submission targets

NSF Emerging Topics in Biogeochemical Cycles: Proposals must cross disciplinary boundaries of two or more divisions in NSF Geosciences (e.g. ATM, EAR, OCE) or of at least one division in Geosciences and a division in another NSF directorate. Relevant proposals are to be submitted to an existing NSF Geosciences (GEO) program according to the program's regular target or deadline dates. A GEO program must be identified as the lead program.

Update

OCB Projects —from page 13

ally building on the project list for the OCB webpage and invite you to send us information about any of your projects that you feel address the broad scientific themes of OCB. We have also included a heading for *"Upcoming Field Opportunities"* on the OCB projects page to help scientists in the OCB community gain access to potential data collection opportunities and build new collaborations. Please be as specific as you can when advertising or seeking to participate in upcoming field opportunities (e.g., cruise dates, locations, measurement capabilities, etc.). Please send all information about OCB projects and upcoming or ongoing field campaigns to Heather Benway (hbenway@whoi.edu).

Scoping Workshop—from page 14

question, divided the Gulf into five regions and identified specific processes and research challenges for each region. Participants discussed and provided recommendations to agencies and the community to encourage the continuation of monitoring data and the mining of historical data to help tune existing and new models that link watersheds and oceans. Such data and their use in models will help identify unknowns and better define important process-level questions. The ocean community also recommended better integration with the North American Carbon Program to help identify existing measurement gaps.

The workshop agenda, list of participants, background papers, and many of the presentations and posters are available online: http://www.whoi.edu/sites/GMxCarbon. The first draft of the workshop report has been released to the workshop planning committee for review, and will be available on the workshop website for public viewing this Fall.

CMORE—from page 10

American Geophysical Union (AGU) meeting (December 15-19, 2008):

B47: Recent Advances in Microbial Oceanography

Microbes dominate our planet, especially our oceans. Microbial oceanography seeks to develop a comprehensive understanding of the role of microorganisms in the structure and function of marine ecosystems. This session focuses on recent advances in this relatively new discipline. We particularly welcome presentations on the following themes:

- Microbial biodiversity
- Metabolism and C-N-P-energy flow
- Remote and continuous sensing and links to climate variability
- Ecosystem modeling, simulation and prediction
- Educating the next generation of microbial oceanographers.

OCB News

is an electronic newsletter that is published by the OCB Project Office. Current and previous issues of OCB News can be downloaded (.pdf format) from:

www.us-ocb.org/publications

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