

## NOAA AOML QUADRENNIAL REVIEW

March 18-20, 2008

Charge to Reviewers: Review of Presented Projects

Ocean Chemistry Division

1. Global Ocean Carbon Program	Rik Wanninkhof, Tsung-Hung Peng, Denis Pierrot
2. Coral Reef Ecosystem Forecasting	Jim Hendee
3. South Florida Ecosystem Restoration	Chris Kelble
4. Nutrient Dynamics in the Ocean	Jia-Zhong Zhang, Xiaolan Huang, N. Amornthammarong
5. Ecosystem Microbiology	Chris Sinigalliano
6. Ecosystem Connectivity	Elizabeth Johns

Global Ocean Carbon Program  
T.H. Peng, R. Wanninkhof, D. Pierrot

The ocean carbon program is focused on sustained observations of surface water and interior inorganic carbon observations and interpretation of trends in response to invasion of anthropogenic carbon dioxide, CO<sub>2</sub>.

Several advances from the observations are:

- Discovery large decadal variability in water column carbon, oxygen and nutrient concentrations of the Atlantic Ocean.
- Establishing a climatological global air-sea CO<sub>2</sub> flux field (Takahashi, LDEO lead) and utilization of this product along with remotely sensed observations to estimate seasonal to interannual variability in the fluxes.
- Lead technology transfer to commercialize instrumentation for surface water CO<sub>2</sub> measurements and provide international leadership in best practices of such observations.
- Provide improved parameterizations to estimate air-sea CO<sub>2</sub> fluxes.

Relevance to NOAA Strategic plan: The ocean carbon research supports the Climate Mission Goal: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond by quantification of seasonal to decadal sequestration of CO<sub>2</sub> by the ocean.

Societal Relevance: CO<sub>2</sub> is a major anthropogenic greenhouse gas contributing about 60 % to the radiative forcing imbalance. Mitigation strategies have a significant cost such that a proper carbon accounting is a must. The ocean as the largest long-term sink for CO<sub>2</sub> must be adequately constrained in carbon accounting schemes.

Technology Transfer: Tech transfer to General Oceanics Inc. to build a fully autonomous surface water CO<sub>2</sub> system with near real-time data telemetry for deployment on ships of opportunity. Over 30 units have been built in the last 18 months for world-wide customers, including the PR of China. These instruments provide a critical backbone to our global collaborative efforts to produce seasonal air-sea CO<sub>2</sub> flux maps

Evidence of collaboration: Project lead (R. Wanninkhof) is a member SOLAS working group 2 on air-sea interaction, data liaison SOLAS, working group 2, working group member NOAA ocean acidification panel, member (ad hoc) CLIVAR/CO<sub>2</sub> repeat hydrography program, member NOAA ocean color advisory panel (OCPOP), fellow of CIMAS, member and USA liaison CARBOOCEAN, guest scientist of the key lab for global change and marine-atmospheric chemistry, State oceanic administration of PR China.

Contributions of data to national and GEOSS-related data bases: Project is a key contributor to global CO<sub>2</sub> dataset of Dr. Takahashi, producer of the global air-sea flux climatology. Contributor of CO<sub>2</sub> and hydrographic data to the DOE Carbon Dioxide analysis Center (CDIAC). Contributor of CLIVAR/CO<sub>2</sub> data to the CCDHO (CLIVAR & Carbon hydrographic office). Organizer of workshops on developing and commercializing a community design pCO<sub>2</sub> system. Organizer of workshops on common operations and data reduction procedures of CO<sub>2</sub> analyzers (this workshop led to an international workshop organized by the IOCCP (the international ocean carbon coordination project of UNESCO/IOC).

Who would miss this work if not done?

The work is an integral part of the integrated carbon observing system endorsed by GOESS. Missing the ocean observing system would lead to gross miscalculation of the largest sustained sink for CO<sub>2</sub>. Dr. Wanninkhof's measurements and leadership in the Repeat Hydrography program and surface water CO<sub>2</sub>

observing from ships is a valued and recognized contribution to the understanding of global warming and climate change. That this work is of fundamental value to every citizen in the world is testified by the awarding of the 2007 Nobel Peace Prize , shared by Al Gore and the International Panel on Climate Change, to which he is a contributor.

Outstanding Papers:

Sabine, C.L., R.A. Feely, N. Gruber, R.M. Key, K. Lee, J.L. Bullister, R.H. WANNINKHOF, C.S. Wong, D.W.R. Wallace, B. Tilbrook, F.J. Millero, T.-H. PENG, A. Kozyr, T. Ono, and A.F. Rios. The oceanic sink for anthropogenic CO<sub>2</sub>. *Science*, 305(5682):367-371 (2004).

Feely, R.A., T. Takahashi, R. WANNINKHOF, M.J. McPhaden, C.E. Cosca, S.C. Sutherland, and M.-E. Carr. Decadal variability of the air-sea CO<sub>2</sub> fluxes in the equatorial Pacific Ocean. *Journal of Geophysical Research*, 111(C8):C08S90, doi:10.1029/2005JC003129 (2006).

WANNINKHOF, R. The impact of different gas exchange formulations and wind speed products on global air-sea CO<sub>2</sub> fluxes. In *Transport at the Air-Sea Interface: Measurements, Models, and Parameterizations*, C.S. Garbe, R.A. Handler, and B. Jahne (eds.). Springer-Verlag, Berlin, 1-23 (2007).

## Coral Reef Ecosystem Forecasting

Jim Hendee

Produces ecosystem forecasts from ~120 sites around the world for Coral Reef habitats.  
Maintains growing number of coral reef monitoring stations in the Caribbean.

### Significant Accomplishments:

- Gathers many long-term data sets at major US coral reef areas
- Design, build and install custom in situ monitoring stations
- Ecosystem Forecasts, involving Integration of data from many sources for near-realtime forecasting
- New instruments modified and deployed (e.g., for coral physiology and partial pressure of CO<sub>2</sub>)

Relevance to NOAA Strategic plan: Supports NOAA's Ecosystem Goal of ecosystem-based management through ecological forecasts for environmental managers, researchers and the public. Supports NOAA's goals of understanding climate variability and change, and in serving society's needs for water and weather information.

Evidence of collaboration: Project lead (J. Hendee) is on the Little Cayman Research Center's Research Committee. He is the chair for Mini-Symposium #16 ("Ecosystem assessment and monitoring of coral reefs - new technologies and approaches") of the upcoming International Coral Reef Symposium.

Contributions of data to national and GEOSS-related data bases: The data is quality controlled and then forwarded to the Coral Program's Coral Reef Information System. The project is a member of CasaNOSA. They adhere to FGDC metadata standards.

### Who would miss this work if not done?

- \* Coral conservation scientists, policymakers, and advocates
- \* Research/developers of marine remote-sensing data products, many who rely on our station data for ground-truthing
- \* International research and resource-management collaborators in Caribbean, Australia, and Indo-Pacific island nations
- \* Marine Protected Area, preserve, and park managers
- \* Sub-tropical and tropical fisheries researchers and managers
- \* Dive-, fishing- and eco-tourism operators
- \* NWS local forecast offices in US territories of the Caribbean
- \* Regional-scale atmospheric and ocean modelers in Gulf of Mexico and Caribbean
- \* Ocean acidification and marine carbon-cycle researchers
- \* Personnel responsible for water-quality and beach monitoring inshore of Gulf of Mexico and Caribbean waters

### Outstanding Papers

Hendee, J.C., Stabenau, E., Florit, L., Manzello, D. and Jeffris, C. 2006. Infrastructure and capabilities of a near real-time meteorological and oceanographic in situ instrumented array, and its role in marine environmental decision support. In: Remote Sensing of Aquatic Coastal Ecosystem Processes, Laurie L. Richardson & Ellsworth Frank leDrew, Eds., Kluwer Academic Publishers, pp. 135-156.

Stabenau, E.R., J.C. Hendee, and L. Florit. (2006). Techniques for the automatic assessment of intense light and high sea temperature on coral response. Proceedings of the 10th International Coral Reef Symposium, p. 702-708.

Manzello DP, Brandt M, Smith TB, Lirman D, Hendee JC, Nemeth RS (2007). Hurricanes benefit bleached corals. *Proceedings of the National Academy of Sciences U.S.A.* 104 (29): 12035-12039.

South Florida Ecosystem Restoration  
Chris Kelble

Project is involved with examining, assessing, and predicting the impact of the Comprehensive Everglades Restoration Plan (CERP) on the downstream coastal ecosystem including NOAA protected resources.

Recent Advancements:

- Proposed a management action to mitigate hypersalinity.
- Examined the impact of hurricanes on the coastal ecosystem.
- Helped complete an integrated ecosystem assessment of the greater Everglades ecosystem including the nearshore area
- Evolution of field program from research to operations

Relevance to NOAA Strategic plan: Project supports NOAA goal to Protect, Restore and Manage Use of Coastal and Ocean Resources: to increase number of regional coastal and marine ecosystems delineated with approved indicators of ecological health and socioeconomic benefits that are monitored and understood.

Societal Relevance: The south Florida coastal ecosystem, including the FKNMS, is economically and culturally important yet currently is underrepresented in CERP

Who would miss this work if not done?

Everyone who relies on Keys coral reef systems being healthy: fishermen, tourists, those depending on the tourism economy. The South Florida Water Management District relies on this project to make informed decisions that potentially affect millions of people and may involve millions of tax dollars. The U. S. Army Corps of Engineers relies on the data from this program and is currently funding this project.

Outstanding Papers:

Kelble, C. R., E. M. Johns, W. K. Nuttle, T. N. Lee, R. H. Smith, and P. B. Ortner. 2007. Salinity patterns of Florida Bay. *Estuarine Coastal and Shelf Science* 71: 318-334.

Hu, C. M. F. E. Muller-Karger, C. Taylor, K. L. Carder, C. Kelble, E. Johns, and C. A. Heil. 2005. Red tide detection and tracing using MODIS fluorescence data: A regional example in SW Florida coastal waters. *Remote Sensing of Environment* 97: 311-321.

Serafy, J. E., T. R. Capo, and C. R. Kelble. 2006. Live capture of larval billfishes: Design and field testing of the continuous access neuston observation net (CANON). *Bulletin of Marine Science* 79: 853-857.

Nutrient Dynamics in the Ocean  
Jia-Zhong Zhang, Xiaolan Huang, N. Amornthammarong

Program includes methods development, sample analysis, data interpretation for coastal and deep ocean water nutrients (nitrate, nitrite, ammonium, phosphate, and silicate).

Recent Advancements:

- Development of liquid waveguide nutrient measurement systems
- Observation of the nano-molar nitrate diel variation in the open ocean.
- Mapping nano-molar phosphate spatial gradient in Florida Bay water.
- Establish the equations describing water-sediment phosphate equilibria

Relevance to NOAA Strategic plan: Program supports the Ecosystem Mission Goal: Protect, Restore and Manage Use of Coastal and Ocean Resources. Program also supports the Climate Mission Goal (through support of the Global Carbon Program). Program also supports Research Tools for Improving Products, Services and Information (Technology and the Mission Support Goal).

Societal Relevance: The program addresses societal needs on local, regional, national and international scales. Nutrient measurements are needed in the carbon program (global warming) and in wastewater and inlet discharges (for local regulation).

Who would miss this work if not done?

This work is needed by the Global Carbon Program and the Coastal Ecosystem Program. Reliable nutrient values are needed by coastal environment regulators and by the regulated community, e.g., water and sewer authorities. This program is regarded as a unique source of unbiased, high-quality basic nutrient measurements, and would be missed by all who need such measurements. The national and international ocean nutrient science community relies on the AOML nutrient dynamics program for high quality, low detection limit measurements and measurement technology. In addition, everyone who will benefit from advances in the science of Florida Bay and other low-phosphorous estuaries and ecosystems will benefit from the advancements being made.

Outstanding Papers:

Zhang, Jia-Zhong (2006) Enhanced sensitivity in flow injection analysis using a long pathlength liquid waveguide capillary flow cell for spectrophotometric detection, *Analytical Sciences*. 22: 57-60.

Jia-Zhong Zhang and Xiao-Lan Huang (2007) Relative importance of solid –phase phosphorus and iron in sorption behavior of sediments. *Environmental Science and Technology*, 41(8): 2789-2795, DOI: 10.1021/es061836q.

Natchanon Amornthammarong and Jia-Zhong Zhang (2008) Shipboard Fluorometric Flow Analyzer for High-Resolution Underway Measurement of Ammonium in Seawater. *Analytical Chemistry*, 80(4): 1019-1026; (Article) DOI: 10.1021/ac701942f

## Ecosystem Microbiology in the Coastal Ocean

Chris Sinigalliano

The traditional methods for microbial water quality assessment need improvement, as they are inappropriate or inaccurate for many coastal environments, especially in sub-tropical or tropical coastal ecosystems. AOML is involved in developing and deploying new rapid, sensitive, and high-throughput molecular approaches for microbial water quality assessment that can provide simultaneous information on presence and sources of multiple targets of microbial contamination in the coastal environment.

### Three most important contributions:

- Development and deployment of molecular microbial detection and source-tracking methodologies for improved microbial water quality assessment in coastal waters.
- Application of molecular methodologies to investigate impacts of major storm events such as Hurricane Katrina on microbial water quality of coastal regions.
- Development of portable molecular-based marine biosensors for rapid, sensitive, and accurate assessment of microbial water quality of coastal ecosystems.

Relevance to NOAA Strategic Plan: Program supports the 5-year Ecosystem Mission Goal: Protect, Restore, and Manage Use of Coastal and Ocean Resources. Program also supports Research Tools for Improving Products, Services and Information (Technology and the Mission Support Goals).

Societal Relevance: Program addresses societal needs for a wide variety of stakeholders at the local, regional, and national level. Improvements in microbial water quality sensing methods are universally needed, and results of this research benefit water management, fisheries, beach management, environmental research, regulatory agencies, community organizations, coastal residents, public health officials, etc.

### Challenges:

- The Microbiology Program at AOML is short-handed in personnel and would benefit from additional post-doctoral level personnel in the lab.
- The Microbiology Program is challenged by non-standardization of molecular source-tracking methodologies and controls in the literature and among peers. The Program benefits from additional cross-laboratory validation of molecular methodologies. (This cross-laboratory validation of molecular methodology is currently being conducted between AOML and several other laboratories, and this cross-laboratory QA/QC program is expected to be expanded in the near future).

### Who would miss this work if not done?

Beach managers, water quality managers, fisheries managers (particularly shellfisheries), public health officials, regulatory agencies, and ecosystem management entities (such as Florida Keys National Marine Sanctuary) will miss this work if it is not done. Mandates are already in place for microbial water quality testing in most coastal states, using culture-based methods that are widely recognized as inadequate or inappropriate for many of the ecosystems with such mandated testing. This leads to significant economic cost in testing, and economic loss in potentially inappropriate warnings and closures that still may not adequately address the potential health risks to the ecosystems and coastal human populations. However, currently no better standard methods are available to such managers or agencies with the responsibility for monitoring microbial water quality. More accurate, reliable, and rapid methods to replace culture-based approaches for this are urgently desired by a widespread water-resource management community, but such molecular-based approaches cannot gain widespread acceptance without further development, validation testing, standardization of assays and controls, and technology transfer. AOML is involved in all aspects of this development.



Outstanding Papers:

Sinigalliano, C.D., M.L. Gidley, T. Shibata, D. Whitman, T.H. Dixon, E. Laws, A. Hou, D. Bachoon, L. Brand, L. Amaral-Zettler, R.J. Gast, G.F. Steward, O.D. Nigro, R. Fujioka, W.Q. Betancourt, G. Vithanage, J. Mathews, L.E. Fleming, and H.M. Solo-Gabriele. Impacts of Hurricanes Katrina and Rita on the microbial landscape of the New Orleans area. *Proceedings of the National Academy of Sciences*, 104(21):9029-9034 (2007).

LaGier, M.J., J.W. Fell, and K.D. Goodwin. Electrochemical detection of harmful algae and other microbial contaminants in coastal waters using hand-held biosensors. *Marine Pollution Bulletin*, 54(6):757- 770 (2007).

Baums, I.B., K.D. Goodwin, T.L. Kiesling, D. Wanless, M.R. Diaz, and J.W. Fell. Luminex detection of fecal indicators in river samples, marine recreational water, and beach sand. *Marine Pollution Bulletin*, 54(5):521-536 (2007).

Ecosystem Connectivity  
Elizabeth Johns

This project involves scientists from AOML working collaboratively with scientists from SEFSC to determine the degree of physical and biological connectivity of the coral reefs of NOAA's Florida Keys National Marine Sanctuary (FKNMS) with upstream coral reef ecosystems.

Significant Results:

- The FKNMS is strongly linked by ocean currents to waters of the Yucatan Peninsula.
- Eddies and gyres are important in establishing the time and length scales of the physical connectivity
- This physical connectivity between geographically separated spawning grounds may have an important influence on the degree of biological connectivity between larval reef species populations

Relevance to NOAA Strategic plan: The project supports NOAA's 5-year Ecosystem Mission Goal to Protect, Restore and Manage Use of Coastal and Ocean Resources.

Who would miss this work if not done?

The importance of our work on the physical and biological connectivity between coral reef ecosystems of Florida, the Gulf of Mexico, and the Caribbean Sea is that it helps to demonstrate the importance of considering the larger-scale system as a whole rather than focusing on individual regional-scale issues. The results will be of use to coral reef resource managers as they design optimal Marine Protected Areas (MPAs), and to NMFS interests such as Fisheries conservation strategies and stock assessments. The adverse effect if the work is not done is that resource managers will not have the scientific information that they need most in order to make sound decisions.

Specifically, if this work is not done I believe that the resource managers of the Florida Keys National Marine Sanctuary, the National Marine Fisheries Service, and the resource managers of the U.S. Virgin Islands will be lacking the critical information necessary to do their jobs successfully. Ultimately the general public will also lose out as these valuable and irreplaceable coral reef ecosystems are deleteriously affected by a lack of timely and strategic science-based management.