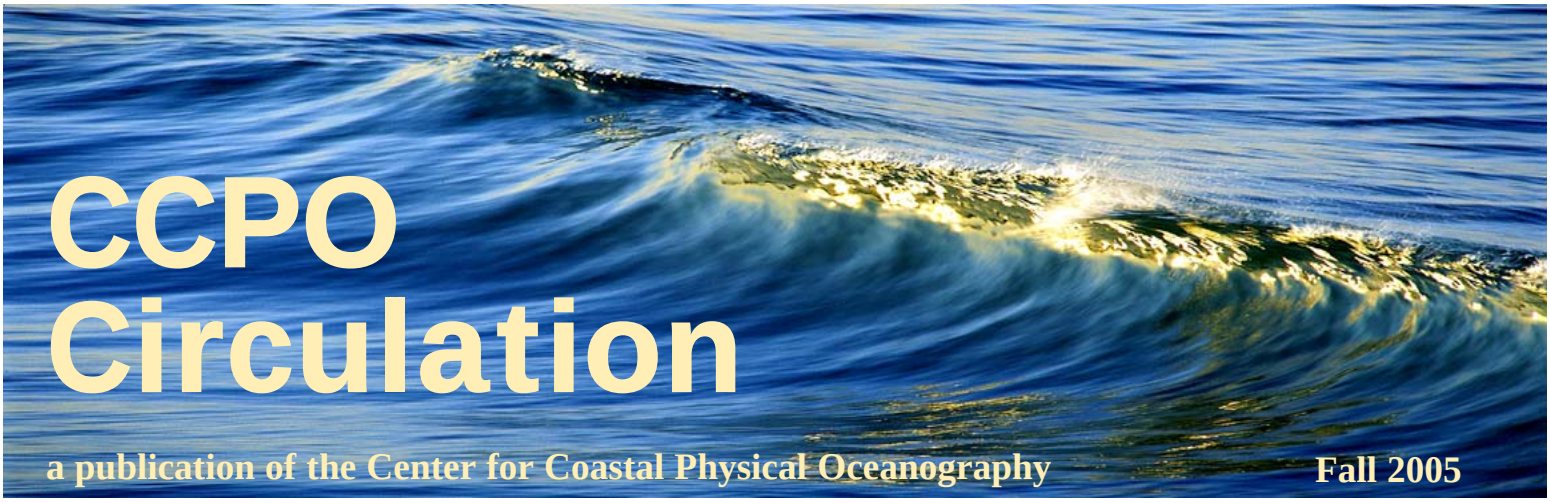


CCPO Circulation

a publication of the Center for Coastal Physical Oceanography

Fall 2005

Vol. 12 No. 2

In this issue:

The Regional Ecosystem Modeling Testbed Project

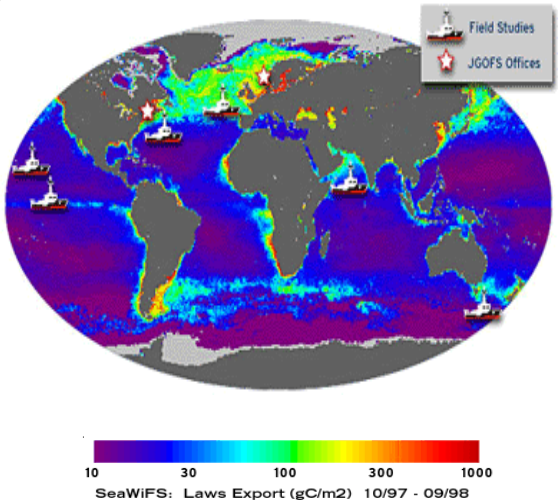
by Dr. Marjorie Friedrichs

Research Assistant Professor

The international Joint Global Ocean Flux Study (JGOFS) was organized in the mid-1980s with the goals of (1) determining and understanding processes controlling time-varying fluxes of carbon and associated biogenic elements in the ocean and (2) predicting the response of marine biogeochemical processes to climate change. The overlying practical justification for JGOFS has been the need to understand more fully the important role of the ocean as a sink for anthropogenic carbon dioxide.

The U.S. JGOFS participation in this program has included both regional process studies designed to estimate biogeochemical quantities and fluxes relevant to oceanic carbon cycling and time-series stations for the study of annual to decadal variability of phenomena related to air-sea exchange of carbon dioxide and the oceanic carbon cycle. Examples of the former include the North Atlantic Bloom Experiment (NABE), the Equatorial Pacific Process Study (EqPac), the Arabian Sea Process Study and the Southern Ocean Process Study. Examples

(continued on page 2)



The recently completed U.S. Joint Global Ocean Flux Study (JGOFS) was launched more than fifteen years ago amidst growing concern about the effects of anthropogenic CO_2 on global climate. Holding more than 95% of the carbon that circulates in the biosphere, the ocean carbon cycle plays the dominant role in the natural regulation of CO_2 levels in the atmosphere and their contribution to global temperature. After the completion of six field studies (locations denoted by ships on map), a synthesis and modeling phase of JGOFS was begun, which funded studies such as the Regional Ecosystem Modeling Testbed Project, described here and led by Old Dominion University's Marjorie Friedrichs. [This figure is from the U.S. JGOFS project office and adapted from a JGOFS modeling study by Laws et al., in which a temperature sensitive food web model and satellite derived ocean color data are used to estimate the annual export flux of carbon out of the surface ocean (full manuscript can be found in *Global Biogeochemical Cycles*, 2000.)]

of the latter include the Hawaii Ocean Time Series (HOT) and the Bermuda-Atlantic Time Series (BATS).

The final phase of U.S. JGOFS, which officially concluded this summer, was the Synthesis and Modeling Project which synthesized our knowledge gained from the regional process studies and time-series studies into a suite of models that could be used for prediction and monitoring of biogeochemical cycling. These vary from the simplest models including only bulk phytoplankton, zooplankton, nutrient and detrital compartments, to extremely complex multi-nutrient (nitrate, phosphate, carbon, silicate, iron) models including parameterizations for many different plankton functional groups and dissolved organic matter.

Although each of these modeling studies has advanced our understanding of biogeochemical cycling within the open ocean, few quantitative comparisons of these models have been made. Generally these models use distinct forcing fields, and their performance is evaluated using different criteria. As a result it is difficult to critically examine which ecosystem structures and formulations are most successful in a specific region, and how much complexity is required to accurately simulate major observed biogeochemical cycles. Although current dogma dictates that the simplest single size-class ecosystem models cannot adequately explain the plethora of biogeochemical observations produced by programs such as JGOFS, it has not been demonstrated that models of greater complexity will inherently produce the best estimates of bulk biogeochemical quantities and fluxes, or that they will exhibit greater predictive ability. This is because the number of parameters that must be specified from observations increases by as much as the square of the number of state variables, and quickly surpasses our ability to constrain them properly from observations.

As part of the Regional Ecosystem Modeling Testbed Project, funded by the National Science Foundation and led by Marjorie Friedrichs of CCPO, model intercomparisons are being conducted to critically and objectively examine which ecosystem structures and formulations are best able to simulate observed data across regions, and to explore the reasons for their success. Objectively assessing the performance of marine ecosystem models characterized by varying levels of complexity is not a straightforward task. First the models must be forced with identical physical fields, and second the models must be evaluated using the same biogeochemical data. Even assuming these criteria are accomplished, because model performance is largely a function of time spent tuning unconstrained parameters, it is often unclear whether two models produce different simulated distributions because of specific structural characteristics of the models or because more time has been spent tuning one of the models (Figure 1). Thus, parameter optimization techniques are a critical component of any biogeochemical model intercomparison effort.

To facilitate these intercomparisons, the Regional Testbed Team has developed a set of regional 'testbeds' that contain one-dimensional physical forcing fields and model code, as well as biogeochemical data that can be used for assimilation or model validation. These testbeds can be used as a forum through which individual investigators can objectively compare different biogeochemical models and specific parameterizations. By running different ecosystem models using identical physical forcing fields, and by implementing the variational adjoint method to assimilate the same biogeochemical data and optimize the parameters in each model, different ecosystem models and modeling approaches can be objectively compared. There is an urgent need to identify ecosystem model structures and formulations that are geographically portable and are able to perform well in diverse regions and physical settings. If such structures can be identified, and the reasons for their success understood, we will have taken a significant step toward ocean biogeochemical prediction.

Work to date has focused on two regions: the equatorial Pacific (140°W) and the Arabian Sea (15.5°N, 61.5°E); plans for other regions including NABE, the Southern Ocean, BATS, and HOT are currently underway. Twelve models ranging between the simplest four component (phytoplankton, zooplankton, nutrients, detritus) models to very complex models with more than 20 different compartments have been run in the assimilative testbed framework at both the EqPac and Arabian Sea locations. Initial results indicate that the simple models can fit the data well at individual sites, but are less likely to be able to simultaneously fit data at multiple sites. Multiple size class models with iron explicitly included as a state variable are best able to simultaneously fit data from the equatorial Pacific and the Arabian Sea (Figure 2).

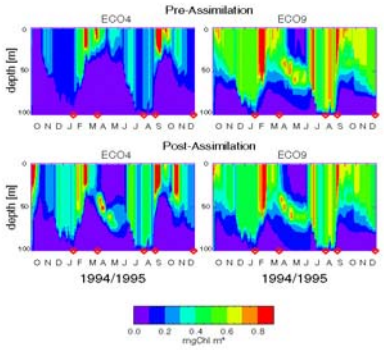


Figure 1. *Mean profile of simulated distributions of phytoplankton chlorophyll obtained through the use of a simple four compartment ecosystem model (ECO4, left two panels) and a more complex multi-size class ecosystem model (ECO9, right two panels) both prior to any parameter optimization, (upper two panels) and after objective optimization (bottom two panels). Prior to the parameter optimization the models produce very different simulations; however, after both models undergo the same objective optimization, the results are much more similar, e.g., both models produce deep chlorophyll maxima.*

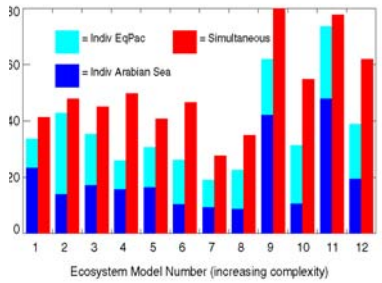


Figure 2. *Model-data misfit for twelve ecosystem models (ordered in terms of increasing complexity) for the individual assimilation of the Arabian Sea data (dark blue bars) and the EqPac data (light blue bars), as well as for the simultaneous assimilation of both data sets (red bars). The simplest four models (#1-4) can reproduce the data at each individual site as well as the most complex model (#12), but cannot reproduce the data sim-ultaneously at both sites as well as Model #12. The four models explicitly including iron produce the lowest model-data misfits when data from both sites are assimilated.*

Arnoldo Valle-Levinson takes Faculty Position at University of Florida

by Larry Atkinson

This August, Arnoldo Valle-Levinson left CCPO and took a position in the department of Civil and Coastal Engineering at the University of Florida in Gainesville.

Twelve years ago, he came to CCPO as a post-doc after finishing his Ph.D. at SUNY, Stony Brook. When Old Dominion University had an opening for a tenure track position a few years later, he applied for and was soon appointed as an Assistant Professor. Since then, his research career blossomed with an amazing speed.

Young faculty are encouraged to develop their personal research programs, and he certainly did. With internal funding, Sea Grant funding and ship time, and Minerals Management Service funding, Arnoldo got going, but he soon perfected his NSF proposal skills winning a series of grants including one recently with colleagues, Jay Austin and Jamie Pringle. Arnoldo has done research and published with a diverse group of people. When I attempted to list the scope of his collaborators using Goggle/Scholar and the Citation Index, the list was too long and complicated for this article.

We had many good times in Chesapeake Bay, Chile and Mexico. I will miss that. I am sure he will do well, and we look forward to his visits and hearing about his new projects in Florida. I can just see him now working the many tropical estuaries of Florida with new colleagues there.

Jay Austin takes Faculty Position at University of Minnesota, Duluth

by John Klinck

Jay A. Austin arrived at CCPO in November 2001 having completed a postdoctoral appointment at Oregon State University with Jack Barth. He brought with him considerable experience observing coastal circulation off the Oregon shelf and analyzing processes through simple models. Jay's Ph.D. work with Steve Lentz looked at inner shelf processes on the North Carolina coast. These two very different coastal systems gave Jay wide experience in near-shore oceanic processes.

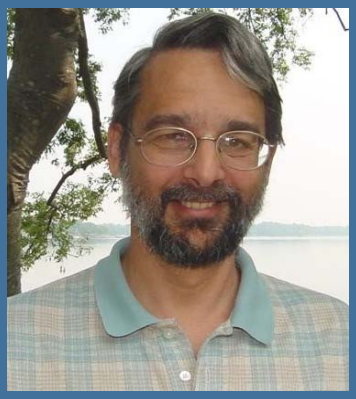
Jay came to CCPO as a research scientist and expanded his areas of interest to estuaries, specifically Chesapeake Bay. He took over the monthly measurements across the Bay mouth. He also analyzed the historical EPA observations in the Bay.

During his time at CCPO, Jay was instrumental in expanding our observing capacity and is currently working on real-time observations in the Bay. He is involved both in installing sensors and analyzing the results. During the last academic year, Jay converted to being a self-supporting research professor and was successful in obtaining a variety of research funding. A number of articles in previous editions of *CCPO Circulation* document some of his activities.

Jay has accepted an Assistant Professor position in the Large Lakes Observatory at the University of Minnesota Duluth. He will teach classes in physical limnology as well as traditional physics his position is in the Physics Department. He is in the process of reviving his undergraduate training in physics, as well as learning to ignore salinity.

We wish Jay and his wife, Elizabeth Austin-Minor, and their son, Benjamin, much happiness in their new home. They will have an opportunity to enjoy winter sports, which was not very practical anywhere near Tidewater Virginia. They are also studying the dialect of their new home ("You Betcha!") to better understand their neighbors.

Notes from the Director



In the last newsletter, I mentioned that people who work here are the important part of CCPO. We now have the news that two members of CCPO are moving to other institutions: Arnoldo Valle-Levinson to the University of Florida and Jay Austin to the University of Minnesota, Duluth. Each has contributed to the Center in many ways. Each has represented the high quality of work at CCPO at meetings and through collaborations around the world. We are sorry to see them leave.

The flip-side of their leaving is that new faculty are being hired in their positions (one search is nearing its end and a second search is just starting.) Research centers depend on a certain amount of turn-over to maintain a competitive and active program. These new researchers will bring new capabilities, ideas and energy to CCPO.

CCPO is not a directed research and development activity addressing specific problems, but is rather a collection of researchers who study variousaspects of the coastal ocean. We work independently much of the time but casual conversations and quick consultations are important. We all gain from these interactions.

I wish Arnoldo and Jay much success in their new positions. I look forward to interactions with the new faculty when they arrive.

John M. Klinck

Oceanography Day at Christ The King School

During academic year 2004/05, the faculty at Christ The King (CTK) School in Norfolk, Virginia continued to develop a curriculum that incorporates marine science into science instruction for students in kindergarten, elementary grades, and middle school grades. The curriculum follows from a pilot program that was started in academic year 2003/04 with the encouragement of Ms. Miriam Cotton, school principal; Ms. Jan Mislan, science curriculum director; and Ms. Karen Warden, fifth grade teacher, who initiated an effort to include marine science as an integral part of the overall science curriculum for CTK kindergarten to eighth grade students. Marine science-based themes are regarded by science educators as being one of the more effective and appropriate mechanisms to engage students in science because of the integrated nature of the discipline. The experiences at CTK School show that this is certainly true.

Throughout the 2004/05 academic year, marine science examples were used in all grade levels to illustrate basic science concepts and students in each grade did marine science-related projects. The finale for the year was an Oceanography Day that was held at CTK School on May 20, 2005, which was attended by students, faculty, and interested parents.

The Oceanography Day program included exhibits by each grade that showed the projects created by students during the school year. The Virginia Aquarium provided a touch tank so that students could see and handle some marine invertebrates. The CCPO exhibit provided hands-on experience with oceanographic sampling equipment, a Chesapeake Bay simulation model, and plankton samples. CCPO research scientist **MIKE DINNIMAN** showed the students how to run the Chesapeake Bay simulation model. CCPO director and professor, **JOHN KLINCK,** helped students determine salinity with a refractometer and CCPO research scientist, **OLGA POLYAKOV,** oversaw viewing plankton under a microscope. **EILEEN HOFMANN** (CCPO Professor), **JULIE MORGAN** (CCPO program specialist) and **AMANDA RENWICK** (outreach coordinator from the Department of Ocean, Earth and Atmospheric Science, Old Dominion University) maintained an exhibit with information on how to become an oceanographer and on some of the environmental issues facing marine systems. This exhibit also included shells and preserved marine specimens that the students could handle and touch. Their exhibit was quite popular because of the key chains and pens that they handed out to students.

***JOHN KLINCK**, CCPO director and professor, describes how a Niskin bottle is used to do water sampling. **ERIK CHAPMAN**, a CCPO doctoral student, shares his experiences about working with penguins.*

(continued on page 5)

The most popular exhibit was an Adélie penguin study specimen, which was provided by Dr. Steve Emslie from the University of North Carolina, Wilmington. **ERIK CHAPMAN** (CCPO graduate student) and Dr. Bill Fraser from the Polar Oceans Research Group in Sheridan, Montana answered questions about the Adélie penguin. The penguin was outfitted with a satellite transmitter similar to the ones deployed by Dr. Fraser's research group on Adélie penguins in the Antarctic.

The highlight of the CTK Oceanography Day was the presentation to the assembled students and faculty by Dr. Bill Fraser entitled, "A Year in the Life of Emma the Penguin". The presentation provided a chronicle of Emma the Penguin's activities from the time she was first tagged with a satellite transmitter, through arrival at her colony on a small island off the west Antarctic Peninsula to lay her eggs and raise her chick, and until she returned

While students touch an Adélie penguin study specimen, Dr. Bill Fraser of the Polar Oceans Research Group explains how a satellite transmitter is attached to the penguin's back.

to her colony the following year. Dr. Fraser recounted an entertaining and informative story of Emma's activities and antics over the year. He also showed how Emma is part of a larger marine ecosystem and talked about how changes in this system could affect her. Dr. Fraser drew upon his many years of experience in Adélie penguin research to provide a story that was compelling and scientifically interesting to the audience. The extended question and answer period following Dr. Fraser's presentation showed that students of all ages had listened well to his talk.

The incorporation of marine science concepts into the science curriculum at CTK School has added a dimension that makes learning science fun and exciting. The focus on marine science will continue in academic year 2005/06.

Boy Scout Merit Badge Program

Interest and participation in the Boy Scout Oceanography Merit Badge program that has been developed by CCPO faculty and staff has continued to grow. The spring 2005 Merit Badge program took place on May 21, 2005 and included about 30 Boy Scouts and chaperones from Troop 13 of Hampton, VA and Troop 81 of Yorktown, VA. Scoutmaster Bill Pinter of Troop 81 and Cheryl Brackin, a parent representative from Troop 13, arranged for the Scouts from their troops to participate in the Merit Badge program.

The in-class portion of the Oceanography Merit Badge requirements was covered in a presentation by CCPO professor, **EILEEN HOFMANN**. Also, oceanographic sampling equipment, such as the conductivity-temperature-depth (CTD) system, was described prior to encountering the real thing on the field trip portion of the program. The fun part of the presentation consisted of pictures and video of oceanographic research conducted by CCPO scientists in the Antarctic. **JULIE MORGAN**, CCPO Program Specialist, provided information about CCPO and the undergraduate marine sciences program at Old Dominion University, and handled overall merit badge program logistics.

The "hands-on" portion of the merit badge program started with arrival at the R/V *Fay Slover*, which is the Old Dominion University research vessel docked at the local National Oceanic and Atmospheric Administration facility. At the ship, the Scouts met **CAPTAIN PATRICK CURRY**, marine technician **LAURA GIBSON**, and CCPO research scientist **OLGA POLYAKOV**. After a safety briefing by Laura Gibson, the R/V *Slover* departed for a short trip along the Elizabeth River so that everyone could have the opportunity to experience cruising on an oceanographic research vessel. The Scouts on the foredeck learned about the loudness of the horn on the R/V *Fay Slover*.

*With the assistance of CCPO research scientist, **OLGA POLYAKOV**, a boy scout prepares to deploy a plankton net from the stern of the R/V Fay Slover*

During the outward bound portion of the cruise, Laura and Olga explained about oceanographic equipment and how sampling is done on a research vessel. On the return portion, the Scouts took water samples by hanging Niskin bottles on a wire. Throwing the messenger down the wire was a big hit. The Scouts also did a plankton net tow and a bottom mud grab. Checking out at the net sample showed that a bloom of ctenophores was going on in the Elizabeth River. There were also lots of copepods and filamentous algae that could be seen under a microscope. Sorting through the bottom mud sample yielded lots of empty worm tubes. Everyone had a good time doing the requirements for the Oceanography Merit Badge. One Scout even took the remains of the plankton tow home for future study!

Meeting & Workshop Reports

The Second Regional Ecosystem Modeling Testbed Workshop

The second Regional Ecosystem Modeling Testbed Project Workshop was held March 21 - 23, 2005 at the Center for Coastal Physical Oceanography, Old Dominion University. Fourteen scientists from nine different institutions attended this very successful meeting, including:

Larry Anderson (Woods Hole Oceanographic Institution)
Robert Armstrong (MSRC, Stony Brook)
James Christian (CCCMA, Victoria)
John Dunne (NOAA/GFDL)
Jeff Dusenberry (Woods Hole Oceanographic Institution)
Marjorie Friedrichs (Old Dominion University)
Masahiko Fujii (University of Maine)
Eileen Hofmann (Old Dominion University)
Raleigh Hood (HPL, University of Maryland)
John Kindle (NRL, Stennis Space Center)
John Klinck (Old Dominion University)
Markus Schartau (MSRC, Stony Brook)
Yvette Spitz (Oregon State University)
Jerry Wiggert (Old Dominion University)

The goals of the workshop were: (1) to investigate why certain models fit certain data better than others, in the Equatorial Pacific, in the Arabian Sea, and in both sites simultaneously; (2) to discuss methodological issues concerning the implementation of the testbed framework; (3) to determine how best to assess the performance of the models; (4) to outline the upcoming presentations at international meetings this spring/summer and (5) to discuss the future of the Testbed Project.

Three of the Regional Ecosystem Modeling Testbed Workshop participants (from left to right: Masahiko Fujii, Raleigh Hood and Yvette Spitz) working on their data assimilative ecosystem models.

Results stemming from this workshop were presented at the European Geosciences Union (EGU) meeting in Vienna (April 25-29, 2005), and at the Advances in Marine Ecosystem Modelling research symposium in Plymouth (June 27-29, 2005).

Prior to the workshop, participants were provided with the testbed framework, which included Fortran routines for processes including advection, diffusion, mixing, sinking, and attenuation. In addition, standard forcing time series (mixed layer depth, vertical and horizontal advection, solar radiation), initial