A National Oceanographic Partnership Program Award

Coastal Ocean Modeling and Observation Program

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Long-Term Goals

The long-term goal of our coordinated ONR (COMOP-II/HyCODE) and NOPP research efforts is the development and validation of a relocatable coastal ocean forecasting system. The forecasting system will consist of a coupled (atmospheric / hydrodynamic / biological / data-assimilative) numerical model and a multi-platform real-time adaptive sampling network for use in physical/bio-optical and sediment transport applications worldwide.

Objectives

Specific objectives of the COMOP-II effort include: (a) Conduct fourth and final Coastal Predictive Skill Experiment (CPSE) at LEO in collaboration with HyCODE, utilizing a comprehensive coastal prediction system incorporating atmospheric, benthic and bio-optical sub-models; (b) Extend the modeling system to provide the larger-scale modeling context for the CBLAST (Low) experiment in 2002 and 2003; (c) Synthesize datasets and model simulations from the four (1998-2001) LEO field seasons; (d) Evaluate ocean model metrics in multiple regions; and (e) Implement a two-way-coupled atmosphere-ocean prediction system utilizing the ROMS and COAMPS models.

Approach

The Coastal Ocean Modeling and Observation Program (COMOP) supports work for two separate field efforts conducted in different locations. The first is the series of Coastal Predictive Skill Experiments (CPSEs) conducted at the Long-term Ecosystem Observatory (LEO) offshore of Tuckerton, New Jersey. Model and observation network improvements tested each winter with existing data are used in an operational setting the following summer. Our phenomenological focus is on the physics of the recurrent upwelling centers that form along the southern New Jersey coast and their impact on phytoplankton distributions, in-water optical properties and dissolved oxygen. Coordinated shipboard (physical and bio-optical) and multiple AUV adaptive sampling surveys of the upwelling centers are conducted based on real-time remote sensing and *in situ* observations and model forecasts. Predictions are carried out using a hierarchy of nested and/or coupled sub-models, including: the COAMPS regional mesoscale atmospheric model, the ROMS regional ocean model http://marine.rutgers.edu/po/models/roms/index.php, and a multi-component bio-optical model *(EcoSim)*, and supporting packages for data assimilation, visualization and model assessment.

A second regional implementation of our Coastal Forecasting System is underway at the site of the CBLAST-Low experiment offshore of Martha's Vineyard, Massachusetts. There are two threads to our ocean modeling work for CBLAST. Firstly, moored observations of air-sea momentum and buoyancy fluxes, subsurface velocity, and stratification, provide validation data with which we are evaluating modeled mixed layer and vertical turbulence closure parameterizations. Secondly, hindcast simulations driven by tides, shelf-wide hydrographic observations and measured (CBLAST) or modeled (COAMPS) air-sea fluxes quantify the role of lateral advection in local depth-integrated heat budget calculations, thereby identifying the principal unobserved term in heat budget diagnostics applied to the *in situ* data.

Work Completed

LEO-15. With fieldwork for the four LEO CPSEs completed in the summer of 2001, FY2002 was a transition year for COMOP. This part of the project has entered into the analysis and synthesis phase. Objectives in the fall of 2002 and winter were to develop a preliminary evaluation of both the COAMPS atmospheric forecasts and the ROMS ocean forecasts. Results (see below) were presented in two posters at the Honolulu Ocean Sciences meeting in February (Bowers et al., 2002; Lichtenwalner et al., 2002; http://marine.rutgers.edu/mrs/coolresults/agu2002/index.html).

CBLAST-Low. ROMS has been configured for a domain bounded by 71.3W to 69.1W, 41.7N to 40.5N. This encompasses Vineyard Sound, the Nantucket Shoals, extending southward to the 90m isobath. The model grid size is 1 km. A suite of simulations have been conducted with increasing realism, culminating in the most realistic case to date which includes (1) tidal forcing at the perimeter specified from the ADCIRC northwest Atlantic model provided by R. Luettich (the 7 most significant harmonic constituents), (2) inflow/outflow open boundaries using a bi-monthly climatology provided by C. Naimie, (3) surface air-sea momentum fluxes computed using the Fairall *et al.* bulk formulae and atmospheric conditions for June-August 2001 as observed at the MVCO coastal met station. (These meteorological conditions were assumed to apply over the entire model domain).

Results

LEO-15. Three atmospheric forecasts were available for comparison, the Global NOGAPS, the operational COAMPS, and an experiment high-resolution COAMPS run by NRL-Monterey. The atmospheric forecasts were compared to observations collected across the state of New Jersey and offshore by computing the normalized RMS error (as suggested by NRL-Monterey) for wind speed, direction, temperature, and humidity. On average, the experimental high-resolution COAMPS did as good or better than the other models by this statistical measure, with the most significant improvement in the overwater comparisons.

The three models were then examined for their forecasts of specific events. The examples chosen for study focused on the ability to forecast a mesoscale seabreeze and a rapidly moving synoptic scale storm. The experimental high-resolution COAMPS did a much better job of forecasting the development and inshore movement of the seabreeze front. In the second case, the rapidly moving low actually tracked in between the Operational COAMPS and the experimental high-resolution COAMPS, but the high-resolution COAMPS more accurately predicted the intensity of the storm.

For the LEO CPSEs, ROMS was configured for the New York Bight with a typical one km resolution grid. Tidal forcing was applied at the boundaries using ADCIRC harmonic forcing. Atmospheric forcing was provided by the Operational COAMPS (27 km) and the experimental high-resolution (5 km) COAMPS. Air-sea fluxes were calculated by the COARE algorithm. The turbulent fluxes were parameterized using the KPP and MY2.5 in the surface layer and the inverted KPP and MY2.5 in the bottom boundary layer. Bottom stress was calculated using a combined wave and current bottom boundary layer model.

An ensemble of three-day forecasts was produced twice per week during the experiment. The ensemble consisted of different combinations of atmospheric forcing and internal turbulent closure. Assimilation datasets for each forecast's initial condition included satellite SST maps, CODAR surface current maps, and subsurface CTD data. Ensembles of forecasts run in real-time were evaluated using a cross-shelf Relocatable Mooring Array (RMA) consisting of bottom-mounted ADCPs and moored thermister strings spaced every 4 km in the cross-shelf direction.

At the offshore end of the validation transect, a persistent two-layer system is observed with layers separated by a sharp thermocline. Inshore, the thermocline responds to the varying wind, with alternating upwelling and downwelling fronts developing. The alongshore flow is strongly barotropic, the cross-shore flow is clearly baroclinic. Metrics to evaluate the model's ability to reproduce the observed behavior were developed. These include depth of the maximum temperature gradient, slope of the maximum temperature gradient, average temperature above this depth, average temperature below this depth, barotropic alongshore transport, and baroclinic cross-shore transport in each layer.

A specific case chosen for the initial study was forecast cycle 3, a strong downwelling case. In response to northeast winds, a sharp downwelling front formed nearshore and moved rapidly offshore through the validation array. An ensemble of 4 forecasts with either Operational or High-Resolution COAMPS and KPP or MY2.5 closure was compared using the model metrics. The ROMS forecast that compares best is forced by the Experimental High-Resolution COAMPS with KPP closure. The biggest differences between the KPP and MY2.5 closure occur in the bottom boundary layer, where KPP predicts stronger mixing.

Throughout the spring and summer of 2002, this preliminary validation of ROMS forecasts was followed up by a more complete evaluation matrix of ROMS hindcasts.

To the ensemble, we have added different real-time assimilation schemes (OI versus nudging), different assimilation datasets (SSTs, CTDs, short range CODAR, long-range CODAR) and different vertical extension techniques for surface data (ad hoc profiles, EOFs). Results from this new ensemble of forecasts are now being evaluated with the cross-shelf RMA using the model metrics.

CBLAST-Low. A 90-day simulation for the summer of 2001 was compared to thermistor string data from the 2001 ASIT mooring. The comparison reveals several shortcomings of this initial model configuration, and improvements are being implemented in summer 2002 to address these. The principal shortcoming is that the simulated temperature at the ASIT mooring site undergoes a significant warming trend. Simulated Lagrangian particles in the model indicate that the passage of warm Vineyard Sound water through Muskegat Channel, and subsequent

advection past the model ASIT site, contribute to this erroneous heating. Further analysis of the ROMS results is proceeding to identify whether this advection pathway is correct or possibly adversely influenced by incomplete resolution of bathymetry and coastline details that affect the tidal exchange though Muskegat Channel. Alternatively, the model Vineyard Sound waters may be overheating due to the air-sea flux parameterization or the use of MVCO conditions over the sound. The introduction of spatially variable high-resolution COAMPS surface conditions will show whether the latter hypothesis is correct.

These early results have indicated clear directions for model improvement and validation. The simulated heat budget at the location of the CBLAST LOW 2002 moorings and the tower will be examined in detail looking for potential influences of advection in the heat budget (including the flow through Muskegat Channel, but also from the Nantucket Shoals, and cooling from upwelling to the southwest). Also to be examined are resolution issues for the momentum budget that might help site the locations of the extended array instruments in subsequent field studies.

Impact and Applications

Assembly Resolution No. 209 (http://www.njleg.state.nj.us/2002/Bills/AR/209_I1.HTM) was introduced to the 210th Legislature of the State of New Jersey on November 25, 2002 commending the Rutgers University Coastal Ocean Observation Lab (R.U. COOL) for their collaborative research begun during the NOPP/ONR Coastal Predictive Skill Experiments, and further encouraging us to continue. It specifically commends R.U. COOL for (a) using new technologies (developed through NOPP partnerships) to enhance oceanographic research and maritime safety, (b) for collaborating with other research groups to better understand and predict how the ocean interacts with the shoreline, the atmosphere, and with life, including man, (c) has operated a real-time coastal observatory as a model for a national observation network, (d) has made significant contributions to New Jersey's human and ecological health and safety in conjunction with the regional National Weather Service Forecast Office by forecasting weather conditions for the public as well as more specialized users in the aviation and maritime communities, (e) for building a special public website where teachers can join scientists in the COOL classroom, and (f) providing innovative materials to teachers to develop scientific literacy.

In addition to the recognition by the NJ State Assembly, the greatest impacts were achieved through partnerships between industrial developers, government labs and academic users. Here we focus on (a) three key enabling technologies for coastal observing systems (high resolution satellites, compact HF Radars, and long-duration autonomous underwater gliders), and (b) high resolution coastal atmospheric forecasts with realistic oceanic boundary conditions.

National Security and Homeland Defense

Collaborations with Rutgers and NRL remote sensing groups continue for the validation of new remote sensing products from ocean color sensors, and their application to data from U.S. as well as foreign environmental satellites tracked during the Coastal Predictive Skill Experiments. New high resolution (spatial and spectral) satellites will be calibrated to provide better information on complex coastal waters.

Access to the full international constellation reduces revisit intervals. Images from multiple satellites enable diurnal variations to be tracked.

Compact CODAR HF Radars are now being evaluated for over-the-horizon shiptracking applications. Government (ONR, DOD Counterdrug Technology Development Program, Coast Guard), academic (Rutgers) and industry (CODAR Ocean Sensors and Applied Mathematics, Inc) partners are currently testing the tracking capabilities for large container ships and mid-size (87') Coast Guard vessels. DOD Counterdrug enhancements to the program will include tests with small Go Fast boats. This opens up the possibility for the deployment of a dual-use national CODAR HF radar network that can be used for homeland defense (ship tracking) and health and human safety (current mapping).

Flights of individual long-duration autonomous Webb Gliders were conducted during the NOPP/ONR Coastal Predictive Skill Experiments. The data was transferred in near real-time to the Naval Research Lab – Stennis, where it was assimilated into each evenings MODAS model run. The Glider data was shown to improve the depiction of the sharp summer thermocline in the MODAS products. MODAS products are used by NLMOC on a daily basis to support the U.S. fleet.

Economic Development

Energy security is a vital concern to growing coastal population centers. In New Jersey, peak energy demand coincides with peak summertime coastal populations. Forecasting energy loads in these areas is critically dependent on the proper forecasting of seabreeze, which, at times, can effect the entire coastal state of New Jersey. Seabreezes, in turn, were shown to be highly influenced by coastal upwelling and downwelling, demonstrating the need for coupled atmosphere/ocean forecasting. Economic impacts on the energy industry are measured in the millions of dollars per day. Initial funding for growing partnerships between U.S. government (NWS), state government (NJ Board of Utilities), academic (Rutgers) and industry (Public Service Electric and Gas) has been made available to improve our ability to forecast seabreezes. The seabreeze study will further contribute to ongoing studies of local renewable energy sources, since new transmission lines cannot be added to the existing power grid, new energy sources are required where the demand is greatest.

Quality of Life

Based on the NOPP successes with autonomous Glider, a series of ONR SBIR contracts between Webb Research and Rutgers for new payloads and fleet control systems was initiated. With NSF and NOAA support, and in partnership with Mote Marine Lab, and non-profit non-governmental organization, were recently demonstrated to be capable of fleet operations in search of Red Tides on the West Florida shelf. It is envisioned that the Gliders will be able to maintain a continuous presence on the west Florida shelf, and provide an early warning system for red tides so that appropriate actions can be taken.

A joint project between the Rutgers University Coastal Ocean Observation Lab and the University of Medicine and Dentistry of New Jersey (UMDNJ) Division of Allergy and Immunology have begun a program to examine the effect of seabreeze on pollen distributions and allergy related doctors visits across the state of New Jersey.

Science Education and Communication

The NOPP/ONR Coastal Predictive Skill Experiments highlighted the need for skilled people trained in the operation of observing systems and forecast models, but not necessarily Ph.D. scientists. Based on this experience, Rutgers has initiated a new Masters in Operational Oceanography degree. Both Navy and NOAA labs have indicated their support for this. Current academic partners include the University of Alaska – Fairbanks, and the Nansen Institute in Bergen, Norway. Exchanges between the partners has already begun. It is expected that the need for masters level graduates trained in observatory operations will be required to run the envisioned national observing system.

Transitions

National Security and Homeland Defense

The Chinese satellite FY1-D is being tracked by NRL to provide a additional source of imagery for Navy operational needs.

Three different hyperspectral sensors (NRL, NOAA, NASA) were flown for the first time in the same location, and over the same fleet of calibration vessels while simultaneous atmospheric measurements were obtained. This has resulted in the best hyperspectral calibration and validation dataset for the NRL COIS sensor envisioned for future satellite launches.

Real-time CODAR ocean current maps updated every hour on the World Wide Web are used by the Coast Guard for Search and Rescue. Methods to input the data directly into the Coast Guard Search and Rescue algorithms are being separately pursued by the Coast Guard. The CODAR data is also regularly used by the NOAA Oil Spill Response team for tankers entering and leaving Delaware Bay.

Autonomous Gliders, built by Webb Research operated by the Rutgers, will participate in DOD mine hunting exercises planned for the fall of 2003.

Economic Development

Published calibration and validation studies for compact CODAR HF Radars conducted by this NOPP project and others have contributed to their now widespread acceptance by the scientific community. Webb Gliders, which underwent their first sea trials during the NOPP/ONR CPSEs, have now been sold to several academic and Canadian government groups.

Quality of Life

The Rutgers Coastal Ocean Observation Lab Web site, expanded for scientists to use during the Coastal Predictive Skill Experiments continues to be maintained. Access peaks in the summer, with the average number of hits exceeding 60,000 per day. Approximately 70% are from the general public.

Science Education and Communication

The components of the coastal ocean observatory developed and demonstrated during the NOPP/ONR-sponsored Coastal Predictive Skill Experiments that are sustainable are now being used by the NSF-sponsored Mid-Atlantic Center for Ocean Science Education Excellence (MA COSEE) for K-12 education.

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Consideration for Excellence in Partnering Award

A series of four Coastal Predictive Skill Experiments (CPSE) conducted at Rutgers Longterm Ecosystem Observatory (LEO) offshore Tuckerton, NJ, were supported by a three successive NOPP grants:

> J.F. Grassle, S. M. Glenn, D.B. Haidvogel, C.J. von Alt, E.R. Levine, D.E. Barrick, B. Lipa, J.W. Young, 1997-1999. Multi-scale Model-Driven Sampling with Autonomous Systems at a National Littoral Laboratory, $1,000,000 NOPP, $338,338 match.
>
> S. M. Glenn, D.B. Haidvogel, R. Avissar, J.F. Grassle, O.M.E. Schofield, C.J. von Alt, E.R. Levine, D.C. Webb, D.E. Barrick, B. Lipa, J.W. Young and R.P. Signell, 1998-2000. Demonstration of a Relocatable Regional Ocean Atmosphere Modeling System with Coastal Autonomous Sampling Networks, $990,000 NOPP, $725,600 match.
>
> S.M. Glenn and O.M.E. Schofield, 2000-2002. Multi-scale model-driven sampling with autonomous systems at a national littoral laboratory (continuation grant), $600,000 NOPP, $352,944 match.

NOPP provided the main support for the 1998 & 1999 CPSEs, with additional support provided by ONR, NOAA/NURP and NSF. Based on their success, ONR supported significant enhancements to the CPSEs through their Hyperspectal Coupled Ocean Dynamics Experiment (HyCODE) in 2000 and 2001 and their CBLAST program in 2001.

Ocean Sector Diversity

Partners directly supported by NOPP to participate in the CPSEs:

> *Academic Partners*: Rutgers University, Woods Hole Oceanographic Institution
>
> *Industry Partners*: CODAR Ocean Sensors, RD Instruments, Webb Research Corporation
>
> *Government Partners*: Naval Undersea Warfare Center, United States Geological Survey

Additional leveraged partners that joined the CPSEs:

> *Academic Partners*: Woods Hole Oceanographic Institution, California Polytechnic University, Cornell University, Dalhousie University, Lamount Doherty Earth Observatory, Oregon State, Scripps Institute of Oceanography, University of California Santa Barbara, University of Southern Mississippi, Louisiana State University, University of Portugal.
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> *Industry Partners*: Bosch Aerospace, ExxonMobil, HOBI Labs, MetOcean, Planning Systems Inc., Prarie Starfish, Satlantic, Sequoia Scientific, SeaSpace Corp., Spectral Technology Innovation & Research

Government Partners: National Weather Service, Naval Air Warfare Center, Naval Oceanographic Office, Naval Research Lab (Washington, Stennis and Monterey), U.S. Naval Reserve

Non-profit Research Partners: Florida Environmental Research Institute, Monterey Bay Research Institute, Harbor Branch

Partner Involvement:

Rutgers University coordinated all four CPSEs, deployed and operated the real-time observation network, and tested a coupled forecast system consisting of the Regional Atmospheric Modeling System (RAMS) and the Regional Ocean Modeling System (ROMS). CODAR Ocean Sensors supported the field use of their HF Radars with numerous software upgrades and calibration experience, providing real-time data for adaptive sampling and forecast model assimilation. Woods Hole conducted their initial tests and first operational use of REMUS AUVs. RD Instruments designed and provided the ADCPs for the WHOI REMUS vehicles and the Rutgers moorings, enabling the REMUS data to be validated. Webb Research conducted their first open ocean tests and operational use of the Slocum Gliders, providing subsurface data that was assimilated into models by Rutgers and NRL-Stennis. The Naval Undersea Warfare Center used their REMUS vehicle for turbulence sampling to provide validation data for the different turbulence closure algorithms used by ROMS. USGS upgraded the ROMS forecasting model for tides, and further applied it to forecasting needs in Massachusetts Bay.

Matching Contributions:

The original three NOPP grants list over $1,416,932 in matching funds contributed by the partners. This is far exceeded by the additional time contributed and funding raised by the partners as they entrained other scientists and engineers into the summer CPSEs. The leveraging the NOPP activities was a key ONR consideration in the selection of Tuckerton, NJ as one of the Hyperspectral Coupled Ocean Dynamics Experiment (HyCODE) sites. Combining the NOPP and ONR efforts resulted in approximately 200 researchers participating in the 2000 & 2001 CPSEs at Tuckerton. Daytime work focused on hyperspectral sensors on the NRL, NOAA and NASA aircraft that flew coordinated flights over the same piece of ocean for the first time while a fleet of calibration vessels with intercalibrated sensors was lined up along the flight paths in different water masses identified by ocean forecasts and the real-time data. Simultaneous atmospheric measurements were made from shore in the vicinity of calibration panels with known spectral signatures. Night-time work focused bioluminescence observations from ships, REMUS AUVs and Navy SEAL divers deployed in regions with high expected bioluminescence based on ocean forecasts and real time data. Through CBLAST, the new Navy high resolution atmospheric forecast model was tested for its ability to produce better forecasts of mesoscale weather patterns as well as local seabreezes, and to determine what effect the high resolution atmospheric forecasts had on the ocean forecasts.

Partner Long-Term Commitment

Partnerships spawned by the NOPP CPSEs at LEO in 1998 and 1999 remain active and are expanding. Partnerships between Rutgers and three different industry groups (CODAR, Webb

Research & SeaSpace) are building the New Jersey Shelf Observing System (NJSOS), covering 100 times the area of the original NOPP CPSEs. Over $12 million in new NJSOS-related partnering grants were awarded in the last year.

The partnership between Rutgers and CODAR Ocean Sensors continues to be funded by ONR, first to test long-range HF Radars, then to develop multistatic HF Radar networks, and now to develop shiptracking procedures for homeland defense applications. The Rutgers/CODAR partnership has expanded to include Applied Mathematics Inc (experts in submarine tracking algorithms), the Coast Guard, and the DOD Counterdrug Technology Development Program Office.

The Rutgers/Webb Research Corp partnership has been expanded to include Mote Marine Lab (nonprofit) and Wetlabs Inc. It is now funded by ONR, NSF and NOAA to add hyperspectral sensors to the Slocum Gliders, to use agent oriented programming (similar to that used on NASA deep-space probes) for autonomous operation of a glider fleet, and then to use the fleet to search for red tides on the West Florida shelf.

The Rutgers partnership with SeaSpace, Inc is now supported by an NSF grant to install a X-band satellite data acquisition system at Rutgers to access the international constellation of new high-resolution ocean color sensors.

Data from the RDI ADCPs deployed on the Rutgers moorings was used to detect a REMUS ADCP manufacturing problem, and correct the data in software. The resulting success of both the vehicle and its sensor payload led to increased Navy funding to accelerate REMUS development. The Woods Hole REMUS vehicle is now a commercial product constructed by a spin-off company Hydroid. Over 20 vehicles have been sold to the Navy SEALS for operational use, and several others to academic institutions for scientific use.

The NUWC REMUS vehicle equipped with turbulence sensors and operated in the CPSE was used by NUWC in other NOPP projects in Massachusetts. A new partnership between NUWC and UMass-Dartmouth for AUV turbulence studies has evolved.

The new ROMS model was tested in a shallow coastal environment featuring wind and river forcing, strong stratification, overlapping turbulent boundary layers, and topographic interactions, focusing the direction of future model development efforts. The CPSEs provided the largest amounts and most diverse types of data for any ROMS test to-date, further focusing efforts on the development of real-time data assimilation capabilities. The ROMS model now has over 300 users in over 25 countries with a website (www.ocean-modeling.org) supported by ONR. An NSF Information Technology Research grant was awarded to 10 partners from 5 institutions to develop advanced real-time data assimilation algorithms for ROMS that will make use of the CPSE datasets. ROMS is actively being coupled to the next generation Weather Research & Forecast (WRF) atmospheric model (www.wrf-model.org) with planned activities through 2008.

The USGS partner (Rich Signell) is now using ROMS in the Adriatic to support SACLANT activities. USGS is adding sediment transport algorithms to ROMS, and activity partially supported by the Sediment Transport NOPP project.

The Regional Atmospheric Modeling System (RAMS) run locally by Rutgers scientists in 1999 and 2000 is now run operationally by AtMET, a consulting company started in August, 2001 (www.atmet.com).

One result demonstrated during the CPSEs by the partnership between Rutgers, the Naval Research Lab- Monterey, and the National Weather Service was the ability of high resolution atmospheric forecast models to predict seabreezes. Further NOAA-funded study by Rutgers and the National Weather Service indicates that seabreezes can be affected by coastal upwelling, and the seabreezes can effect nearly the entire state of New Jersey. This has lead to new partnerships with the NJ Bueroe of Public Utilities and energy companies (PSE&G, Connectiv) that are designing a seabreeze monitoring and forecasting program for the summer of 2003. The University of Medicine and Dentistry of New Jersey is partnering to look at the effect of seabreeze on pollen distributions and the associated doctors office visits across the state during the same period.

The website developed for NOPP CPSEs continues to be maintained on a year round basis. Usage peaks in the summer at a daily average above 60,000 hits per day. Coast Guard search and rescue, and NOAA oil spill response teams are regular users of the website. Coastal observatories are the focus of the new, 5-year duration, NSF-funded Mid-Atlantic Center for Ocean Science Education Excellence (MA-COSEE). The MA-COSEE center will use datasets available from the website for the K-12 education programs they develop.

Success in Project Objectives

The NOPP effort was a proof of concept program in which an integrated coastal ocean observatory and a data assimilative coupled atmosphere/ocean model were operated in real-time for a one month period every

summer from 1998-2001. The scientific motivation was the multi-disciplinary adaptive sampling of coastal upwelling, its relation to topography, and its effect on phytoplankton distributions, and ultimately, dissolved oxygen concentrations. A major objective was to provide a well sampled ocean for assimilation into numerical models, resulting in ensemble forecasts that included sensitivities to atmospheric forcing, boundary conditions, and internal turbulence parameterizations, not simply initial conditions. A second major objective was to provide the datasets and ensemble forecasts in real-time to scientific users for adaptive sampling and process studies. One measure of success in these objectives is the number of conference presentations and publications on these subjects. Over 100 presentations have been made by participants in the NOPP CPSEs at scientific and engineering conferences in the last four years (88 of these powerpoint presentations are available on the Rutgers website http://marine.rutgers.edu/cool/). Many of the initial results have been published as conference papers, and continue to make it into the reviewed literature (see references below). A special issue of JGR on Coastal Observatories has been approved, with 4 participants in the NOPP CPSEs acting as guest editors. Papers are being submitted from several observatories, including over 10 from the NOPP CPSEs that are already submitted or are nearing submission.

The approaches developed through the NOPP CPSEs at Tuckerton are now being transitioned to other regions by many of the participating scientists. Portions of the NOPP observatory have been expanded,

Leading to the development of the larger shelf-wide observatory, NJSOS. Similarly patterned after the NOPP CPSEs, a 5 year, $4.7 million NSF COOP grant has been award to conduct studies of the Hudson river plume within the NJSOS operational observatory. The experiments are planned for May of 2004, 2005 and 2006. As with the NOPP CPSEs, numerous other groups are expected to augment the core program. The approach has been further transitioned through growing partnerships to the West Florida Shelf for the study of red tides, and to the region off the port of Bergen, Norway for dual use (shipping and the effect of coastal currents on phytoplankton distributions).

Education was an integral part of the NOPP CPSEs. Through NOPP, ONR, NOAA/NURP and NSF support, approximately 30 students received both hands-on training in the operation of the latest platforms and sensors, and also collected extensive datasets for their theses. One outgrowth of this was the realization that a new type of practical oceanographer was needed to operate the rapidly growing national network of coastal observatories. Demonstrating their commitment to this, Rutgers has started a new Masters in Operational Oceanography program, and has received state seed funds to grow the program.

Publications

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Related Projects

The ONR-sponsored HyCODE project, led by Oscar Schofield, sponsored most of the bio-optical component of the July, 2001 HyCODE/COMOP Coastal Predictive Skill Experiment.

A National Oceanographic Partnership Program Award

The ONR-sponsored CODAR Rapid Environmental Assessment project is expanding the CODAR observation network offshore to the shelf break with new Long-range CODARs and onshore to the beach with Bistatic CODARs.

The ONR-Sponsored Terrain-following Ocean Modeling System (TOMS) project, led by Hernan Arango, is merging portions of the widely-used Princeton Ocean Model (POM) with ROMS to produce TOMS.

ONR and the Great State of New Jersey have sponsored the acquisition of 4 Webb Glider AUVs and the development of new communications and control software for applications in the New York Bight.

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