2004-2005 Coastal Ocean Research and Monitoring Program (CORMP)

University of North Carolina at Wilmington
NOAA Award #NA16RP2675
Annual Progress Report, August 1, 2004 to July 31, 2005

Submitted by:
Dr. Michael Durako
Dr. Lynn Leonard
Dr. Marvin Moss
Principal Investigators
UNCW Center for Marine Science
5600 Marvin K. Moss Lane
Wilmington, NC 28409
910-962-2372

1.0 Introduction

This progress report is for NOAA grant #NA16RP2675 for the period 1 August 2004 to 31 July 2005. However, since this is an annual report, we have also included key activities that occurred during the first semi-annual reporting period. The following report will detail progress over the last year for various components of CORMP and the report is organized to be consistent with the major CORMP components outlined in the 2004-2005 proposal Table of Contents.

2.0 Observing System

2.1 Mooring array

The last funding cycle has been an exciting time for CORMP with respect to the observing network. In FY04-05, in cooperation with NCSU, NDBC, U.S. Marine Corps Base at Camp LeJeune and the U.S. Coast Guard, CORMP successfully deployed 3 near-real time oceanographic/meteorologic moorings in Onslow Bay. These systems are now collecting data and reporting it via our website www.cormp.org. In addition, the data are transmitted to and reported on the NDBC web site. In addition, two replacements for future "turnarounds" of ILM2 and ILM 3 were constructed by J. Kinder, W. Sweet and J. Bichy from the NCSU technical team.

Station ILM2 was deployed on 6 Jun 05 from the *R/V Savannah* by NCSU and UNCW CORMP personnel. ILM2 is located at 34 08.4 N, 077 42.8 W and was placed in 16m of water. The buoy payload includes the controller/data-logger, GPS, Iridium modem for satellite telemetry, Inductive modem controller for communications with sub-surface instrumentation and atmospheric sensor package that includes wind speed, direction & gusts, air temperature, relative humidity, barometric pressure and solar radiation. The seafloor instrument package includes a Sea-Bird Seacat measuring temperature and salinity and outfitted with a WetStar fluorometer as well as a Digiquartz high resolution pressure sensor for the hydrostatic determination of sea level height. Additionally, the

frame is outfitted with an upward looking RD Instruments 600 Khz ADCP collecting vertical current profiles as well as directional wave spectra. Finally, a command-able recovery float system is installed to allow recovery of the frame in the event that the mooring leg to the frame is severed. To date, the buoy system has been operating properly, collecting and transmitting data on a regular schedule of every two hours.

ILM3 was also deployed on 6 Jun 05 from the *R/V Savannah*. The nominal position of the buoy system is 33 59.4 N, 077 21.5 W and was placed in water depth of 30m. The buoy payload includes the controller/data-logger, GPS, Iridium modem for satellite telemetry, Inductive modem controller for communications with sub-surface instrumentation and atmospheric sensor package that includes wind speed, direction & gusts, air temperature, relative humidity, barometric pressure and solar radiation. Additionally, a Sea-Bird Seacat is mounted to the underside of the buoy to measure sea surface temperature and salinity and is also outfitted with a WetStar fluorometer. The seafloor instrument package includes a Sea-Bird Seacat measuring temperature and salinity and outfitted with a WetStar fluorometer as well as a Digiquartz high resolution pressure sensor for the hydrostatic determination of sea level height. Additionally, the frame is outfitted with an upward looking RD Instruments 600 Khz ADCP collecting vertical current profiles as well as directional wave spectra. Finally, a command-able recovery float system is installed to allow recovery of the frame in the event that the mooring leg to the frame is severed. This buoy system was operating properly, collecting and transmitting data on its regular schedule of every two hours until 30 Jul 05, when communication to the buoy was lost. On 14 Aug 05, the Buoy Team deployed aboard the *R/V Cape Hatteras* and successfully replaced the entire buoy electronics package. An inspection of the buoy system showed no signs whatsoever of any problems or malfunctions. An analysis of the data-logger removed from the buoy indicated that the buoy system had been operating normally throughout the period. A problem with the Iridium hardware is suspected and is being investigated currently.

LEJ2 was deployed on 01 Aug 05 by NDBC and USCG personnel from the Coast Guard Cutter ELM. The nominal position of the buoy system is 34 28.8 N, 077 16.8 W and was placed in water depth of 10m. The buoy is a 3m discus buoy with an ARES payload that includes the controller/data-logger, GPS, Iridium and GOES capabilities for satellite telemetry, and sub-surface instrumentation and atmospheric sensor packages to measure and report wind speed, direction & gusts, air temperature, relative humidity, barometric pressure, solar radiation, sea-surface temperature, dissolved oxygen, pH, salinity, and turbidity. Additionally, an Anderra current meter is deployed approximately 1m below the surface to measure surface currents. The buoy includes an angular rate sensor to measure wave spectra. This buoy system has been operating normally since deployment.

Several non-real time moorings are still deployed and maintained in the CORMP region. These include LB1M, OB27, and OB5M. LB1M and OB5M include upward mounted RDI-ADCP with wave upgrades to internally record current profiles and wave data. In addition, Seabird SBE-37 CT loggers are deployed at LB1M and OB5M. A SONTEK PC-ADP is mounted in a downward configuration at OB27B from a quad pod frame and an upward looking RDI-ADCP with waves upgrade is mounted in an upward configuration. A Seabird SBE-37 CT logger is also deployed at OB27B. These instruments will continue to be deployed in non-real time mode until these sites are upgraded to real-time or discontinued to meet the needs of modeling and research efforts.

In June 2005, CORMP began installation of a real-time wave gauge from Johnnie Mercers Pier in Wrightsville Beach, NC. A 1200 Khz RD Instruments ADCP with wave upgrade was deployed in an upward configuration approximately 1000 feet from the end of the pier. The ADCP and a Falmouth Scientific Inductive CT logger are connected to the pier via a marine cable. The instruments and cable were deployed from the *R/V Martec* by CORMP staff. To date, all equipment is operational, but is internally recording. We have successfully transmitted salinity, temperature and wave files to the end of the pier and beyond the pier via an RF link. However, because there is no power to the end of the pier, we have had to develop script for a system that will conserve battery power by communicating with the underwater instruments and transmitting data only after a complete data file exists. The delay in putting this system in real-time mode has been due to problems debugging the computer code for this process. Recently, CORMP successfully compiled and tested revised script and we anticipate that the pier gauge should be completely operational and reporting by mid September. A second pier installation was proposed for the Long Beach Pier on Oak Island, NC. A permit to undertake these activities was granted in April 2005. This pier, however, has been sold and is scheduled for demolition. Consequently, CORMP had to identify a second pier and obtain permission for deployment. CORMP has gotten permission from the Ocean Crest pier owner and we are in the process of filing a permit. In the mean time, all equipment has been purchased and received for this installation. Because this pier has a power source at its seaward end, we do not anticipate encountering the same types of problems as experienced at Johnnie Mercers pier.

The Cape Fear River S4 monitoring program finally began in January 2005. D. Stanfield of NCSU was directed to oversee the effort. On 02/07/05, the S4 current meters were cleaned and readied for shipment to IOS for pre-deployment calibration. The current meters were damaged during shipping, however thus necessitating additional repair and delaying deployment. In June 2005, the repaired current meters were received by NCSU and programmed for deployment by CORMP divers. Cape Fear River S4 deployment details follow. A doublet arrangement was located at G-1 (33° 54.886'N 78° 01.380'W). This is referred to as Southport Light 1 (LL 40035). Serial number 05142287 is mounted one meter below mean lower tide. Serial number 08782071 is mounted one meter above river bottom. Water depth at this location is approximately twelve feet. A doublet arrangement located at R-12 (34° 04.577'N 77° 55.866'W). This is referred as Wilmington Short Cut Daybeacon 12 (LL 39820). Serial number 08782122 is mounted one meter below mean lower tide. Serial number 08291848 is mounted one meter above river bottom. Water depth at this location is approximately eighteen feet. A single S4 current meter was mounted on the range marker south of R-12 (34° 04.320' N 77° 55.638' W). This meter, serial number 05142286 is mounted one meter below mean lower tide. However, after one month service, this meter was removed from the site due to the USCG replacement of the range marker. Given that the original plan was to monitor the dynamics, that is the currents, salinity, temperature, and pressure to ground-truth the Cape Fear River model output for one full year, S4 data will be collected for a minimum of a year, i.e. at least until July 2006. NCSU has agreed to honor this term of the sub-award.

The top priority for all future observing subsystem operations is to maintain and sustain the existing observational network, to expand it as resources allow, and to achieve economies of scale by coordinating CORMP observational operations with Caro-COOPS. In the last 6-months, CORMP and Caro-COOPS have begun to formally work together and share resources and personnel to

conduct bi-annual rotation of the offshore moorings for both programs and to conduct inspections when needed. Leonard and Buckley are working closely to coordinate cruise schedules and other field operations. The ultimate plan is that all of the mooring turnarounds for both programs will occur during March-April and October-November timeframes.

2.2. Cruise-Based Activities

Bi-monthly cruises on the *R/V Cape Fear* continue to be conducted in the Cape Fear River Plume and in Onslow Bay. In the Cape Fear River plume, a smaller vessel is used to sample selected parameters in the months between *R/V Cape Fear* cruises. During this project year sampling was discontinued at Stations CFP3 and CFP4, and sampling was added at Stations CFP8 and CFP9. The reason for discontinuing two sites is that CORMP's first three years of funding occurred during drought years; upon cessation of the drought in early 2003 the plume was noted to extend further into oceanic waters. Stations 8 and 9 are farther offshore and allow us to capture more offshore effects of the plume, especially following major terrestrial rain events. Water quality sampling in the CFP occurred in Sept, Oct, Nov, Dec 2004, and Jan, Feb, Mar, Apr, May, Jun and Jul 2005. Samples were collected for the following parameters: depth, water temperature, pH, conductivity, salinity, turbidity, dissolved oxygen (all at three depths), ammonium, nitrate, orthophosphate, silicate, and chlorophyll *a*. Sampling for nutrients and chlorophyll at the Onslow Bay stations was successfully performed on Sept 23 and Nov 16, 2004, and on Jan 19, Mar 09, May 12, and Jul 12, 2005.

Water column total suspended solids were measured at the surface, mid-depth, and near-bottom at all plume sampling sites on each of the bi-monthly *R/V Cape Fear* Long Bay cruises. In addition, these samples were analyzed for percentage loss on combustion at 500 degrees Celsius. The LISST-25 was successfully deployed on the CTD in May 2005 (Fig. 1), returning depth profiles of particle size, volume concentration, and optical transmission data in the CFP. Permanent incorporation into CTD data is expected in Sept 2005. A fluorometer and transmissometer were repaired and calibrated for use in a ship flow cell under design. This system will be installed on the *R/V Cape Fear*. Deployments of SCUFA fluorescence and turbidity monitoring units at bottom depths shifted from OB27 (after 3 years) to a site in the CFR Plume to assist in eventual development of a shelf carbon flux model. Together, the wave and SCUFA data have shown that peaks in Significant Wave Height are strongly correlated with peaks in fluorescence and turbidity, and appear to indicate a resuspension signal.

At each CFR plume and Onslow Bay station, surface water samples were collected, and SeaWiFS –channel reflectances were measured at the surface using a Satlantic Micro-SAS, while depth-dependent reflectances were measured by conducting profiles with a Satlantic MicroPro free-fall radiometer. Deployment of SeaWiFS –channel Satlantic sensors was discontinued after Jan 1, 2005 and efforts refocused on data evaluation. Measurements of the attenuation of photosynthetically active radiation (PAR) using profiling with a Licor irradiance meter and scalar quantum sensors are continuing. Inherent optical properties of surface water samples from cruises were analyzed; total attenuation, and contributions to total attenuation such as CDOM absorption, particulate (detrital + pigment) absorption, and detrital absorption were determined. The Chelsea Fast Repetition Rate Fluorometer (FRRF) was deployed in vertical profiling mode at ~3 stations per cruise (depending on time availability) during Sept 2004 and Jan, Mar, May, Jul 2005 CFP cruises and Sept 2004, Jan,

May and Jul 2005 Onslow Bay cruises. A benthic sled was constructed for benthic deployment, and benthic FRRF tows were conducted during Jan and Mar 2005 cruises. The sled configuration will be used for conducting FRRF measurements in the near-bottom chlorophyll maximum layer. In addition to ship based measures of optical properties, CORMP also uses satellite remote sensing to evaluate larger scale changes in optical properties. During this funding cycle, scripts were completed to automate the receipt, geographic projection, and graphical display of MODIS SST and Chlorophyll products and to process historical SeaWiFS data through Dec 2004.

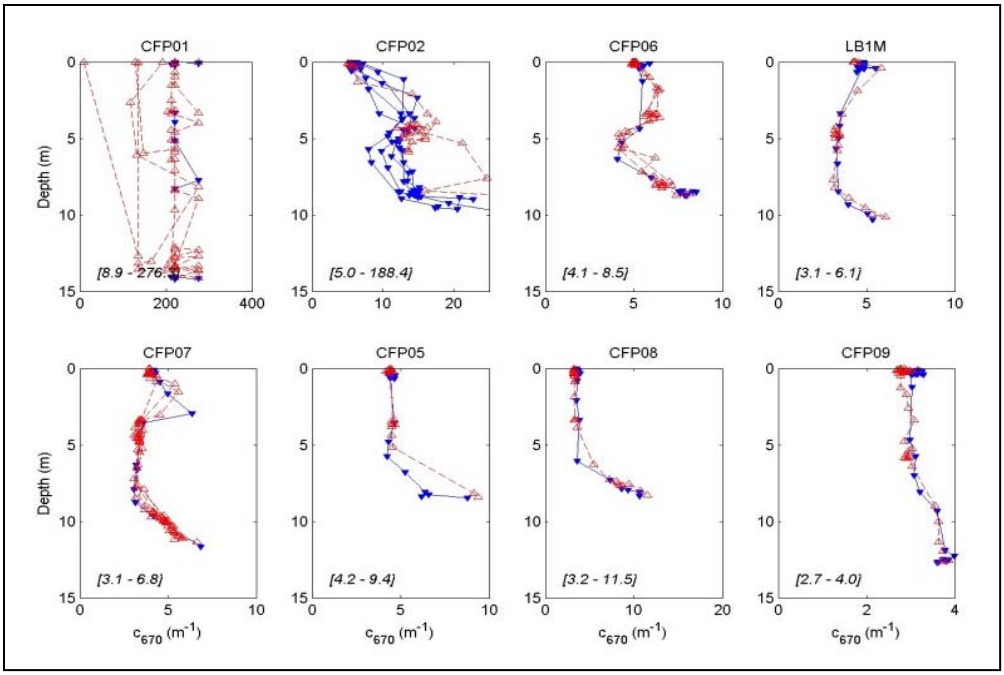

Figure 1. LISST data collected in Long Bay in May 2005. Blue down (red up) triangles are data points before (after) maximum depth was reached. They correspond to downcast (upcast) if only one cast was done. The data range is denoted by brackets.

Since the arrival of a new physical oceanography post-doctoral associate in March 2005, CORMP has undertaken additional cruise-based physical surveys to enhance our understanding of plume dynamics. A grid transect consisting of 29 CTD casts was conducted on 02 Jun 2005 to assess the horizontal and vertical domain of the CFR Plume (Fig 2). Sampling was conducted on a falling tide, with light southwest winds and minimal CFR discharge (q ~ 2500 m^3 s^{-1}). Evidence of downcoast buoyancy current was found; this buoyancy current is also predicted in hydrodynamic model runs by Xie. Appreciable vertical salinity stratification was observed within plume domain. Plume front progressed over 2 km seaward between onset and completion of sampling, presumably as a result of tidal forcing. Future plans include additional CTD sampling in CFP, and deployment of logging surface CTD sensors and upward-looking ADCPs.

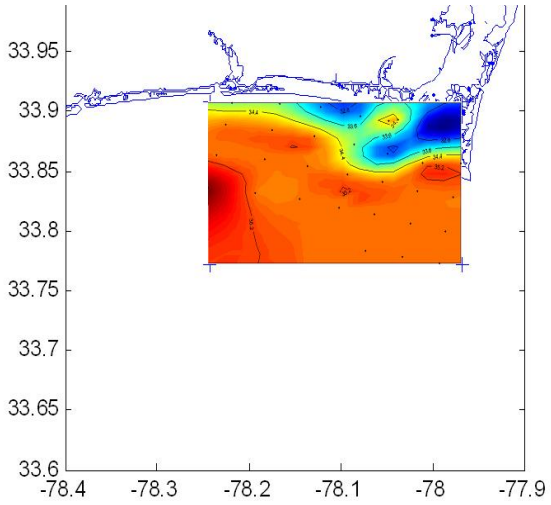

Figure 2. Surface salinity in CFRP region 2 Jun 2005. Values ranged from 29 PSU (blue) to 35.5 PSU (red).

Benthic sampling locations for the CFP for this proposal year have been modified from the 03-04 sampling year. Normal sampling for this project is conducted quarterly (winter=Jan-Feb, Spring=April-May, Summer=July-August, and fall=October-November). The current sampling locations are CFP1, CFP2, CFP6, CFP8, and CFP9. CFP8 and CFP9 are new stations off the Lockwood Folly River. CFP3 and CFP4 were dropped from the previous sampling design. Benthic grab samples were collected on Aug. 8, Aug. 11, and Nov. 30, 2004 and Feb. 17, May 18 and Aug. 26, 2005. On August 8, 2004 grab samples were collected from CFP1, CFP2, CFP6, and CFP8, five replicate grabs were collected at each station. Benthic sampling for the three Onslow Bay locations (OB5, OB15, and OB27) was conducted on Jul 26, and Oct 7, 2004 and Feb 23, May 12, and Jul 14, 2005.

Monthly blue crab samples were collected for this project from June 2004 to October 2004. For this reporting period, trawl samples were collected from the Carolina Beach sites on Aug 18, Sept 23, Oct 27 and 28, 2004. Sites were sampled around the mouth of the Cape Fear River on Aug 19, Sept 22, and Oct 26, 2004. In 2005, samples were collected on Jul 5, 6, and 7, Aug 9, 10, and 11. The period from June to October represents the critical time period for blue crab recruitment into the estuary as well as the spawning period when these crabs tend to migrate within the estuary, towards the estuary mouth. Trawl sampling was conducted at ten locations within and outside the mouth of the Cape Fear River and ten locations outside the mouth of the Carolina Beach inlet. Ten additional trawl samples were collected within the Cape Fear River from Horseshoe Bend (2 miles above Wilmington) to the mouth of the river. This sampling was conducted using a modified 20 foot Tri net, used by the Division of Marine Fisheries for monitoring crab and shrimp populations. Each sample consisted of a single ten minute tow. All organisms caught were identified and counted. All blue crabs (*Callinectis sapidus*) and the related species (*Callinectis similes*) are measured for carapace width, sex, and spawning stage.

3.0 Modeling

For the 2004-2005 project year, the goal of the CORMP modeling effort was to establish a demonstration scenario of the plume and water quality modeling in the Cape Fear River Estuary (CFRE). The present modeling effort is being completed through a subaward to NCSU (PI – L. Xie). From Aug 1, 2004 to Jul 31, 2005, the following modeling tasks as outlined in the proposal have been completed:

1) Meteorological support: continued development of a state of the art hurricane wind model which is necessary for storm surge and ecological modeling;
2) Physical aspect of CFRE plume: Simulations of physical (salinity) plumes under climatological runoff and wind conditions;
3) Data preparation for ecological modeling: Data preparation for boundary conditions of the 22 simulated state variables in the water quality model;
4) Ecological modeling: Ecological model grid generation;
5) Demonstration scenario development-1: hydrodynamic model calibration;
6) Demonstration scenario development-2: ecological model calibration.

Meteorological support: Accurate hurricane wind forcing was the focus of this component of the modeling effort. An improved asymmetric hurricane wind model which utilizes available real-time observations, National Hurricane Center track and intensity predictions, and a

parametric model to simulate time-dependent hurricane wind field diagnostically and prognostically was developed. Details of this model are described in Xie et al. (2005).

CFRE physical plume: Seasonal mean climatological winds were used to test the hydrodynamic model with respect to its performance on salinity plume simulation. During the fall (Sept-Nov) mean monthly winds in the CFRE region are southwestward. Mean monthly winter winds are initially southwestward during December and turn southward in Jan and by late Feb are directed southeastward. Spring is a transition season, with mean wind vectors directed towards the northeast in late May. In the summer (Jun and Jul) the Bermuda-Azores high pressure system strengths and the Icelandic low pressure cell weakens causing the winds to blow stronger and directed northeastward. The model is run using the general seasonal wind distribution for the Cape Fear River Estuary and Long Bay vicinity. The following series of graphs depict typical salinity distributions under the influence of northerly, northeasterly, southerly, southwesterly wind conditions (Fig. 3).

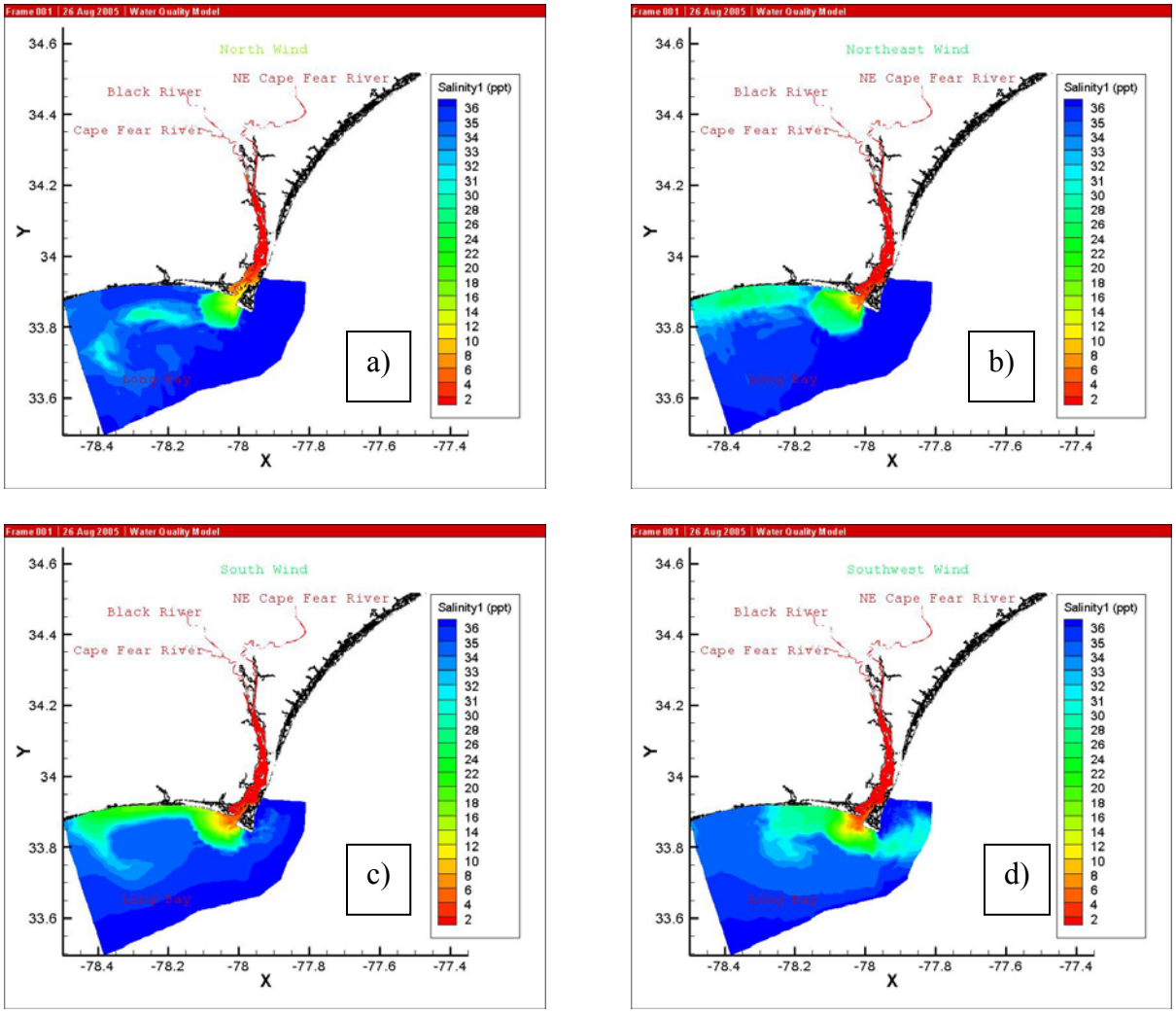

Figure 3. Simulated salinity plume driven by a) northerly, b) northeasterly, c) southerly and d) southwesterly winds.

Ecological model data preparation: During this reporting period the model team has experimented and generated a spatially varying curvilinear-orthogonal grid to best incorporate the existing monitoring stations and at the same time to boost computational efficiency. The team also has extracted high resolution bathymetry data in and near CFRE and merged them with the newly generated grid. Special effort has been made to ensure the narrow and curvy channel and several islands inside CFRE be represented. Data availability in model boundary conditions as well as cruise and monitoring periods and stations maintained by CORMP has been examined for selection of the model simulation period for the demonstration project. The modeling team has searched and extracted river discharge and water quality data (include organic carbon, ammonium, nitrite, nitrate, phosphate, organic nitrogen, organic phosphorus, total suspended solids, fraction of fine solids, and chlorophyll *a* from USGS gauge stations. Programs are being built to analyze the data and prepare for river boundary conditions.

Ecological model development: A substantial effort has been made to develop a computationally efficient, spatially varying model grid with higher resolution inside CFRE and gradually lower resolution in the continental shelf off the coast (Fig. 4). Different from the storm surge modeling effort of FY03-04, a much longer model simulation time (from months to years) is required for mainly two reasons a) water quality parameters usually have a longer spin-up time, and b) the rates of the biological and geochemical processes simulated in the water quality model are much slower than those of the hydrodynamic processes represented in the storm-surge model. Computational efficiency is hence a crucial factor to be considered in grid generation.

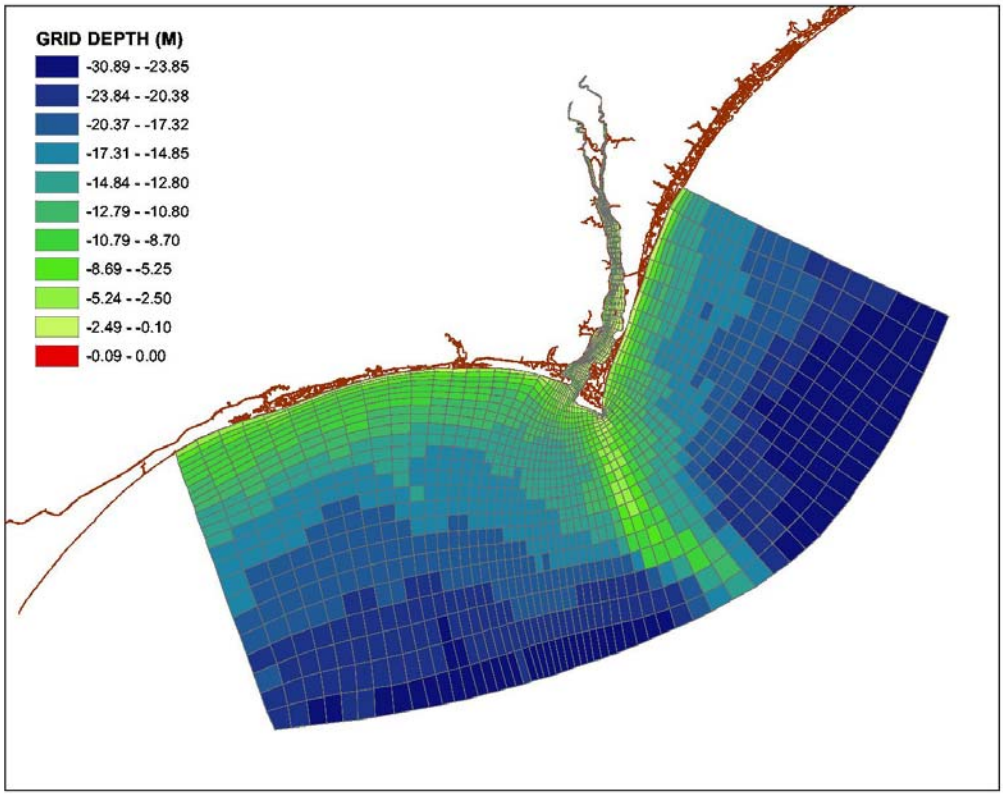

Figure 4. Ecological model grid for the Cape Fear Estuary and Upper Long Bay region. Water depths are denoted by color as indicated in the legend.

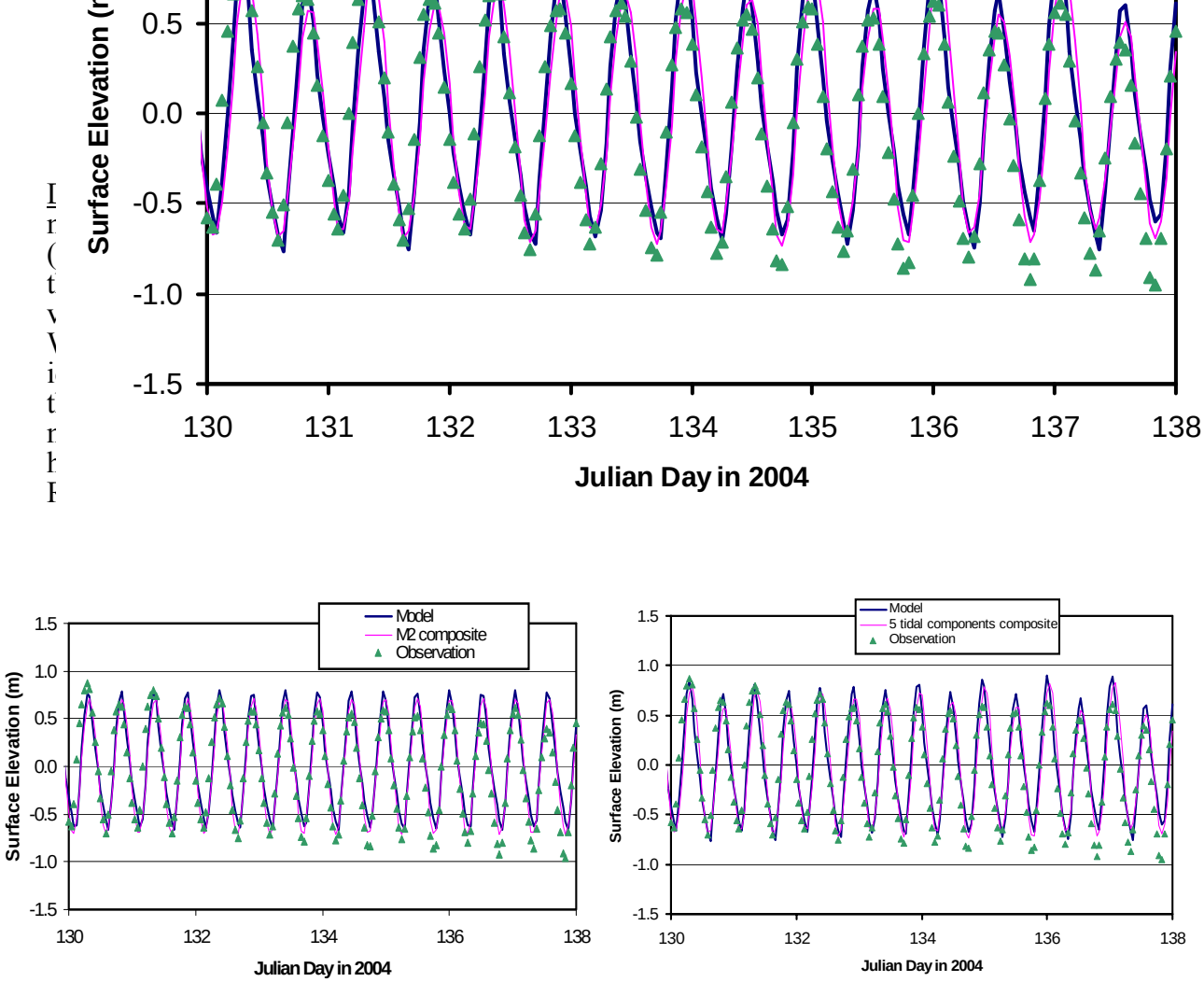

Figure 5. Comparison of surface elevations among observations, harmonic composite, and model results for M_2 tide (left figure) and M_2, S_2, N_2, O_1 and K_1 tides (right figure).

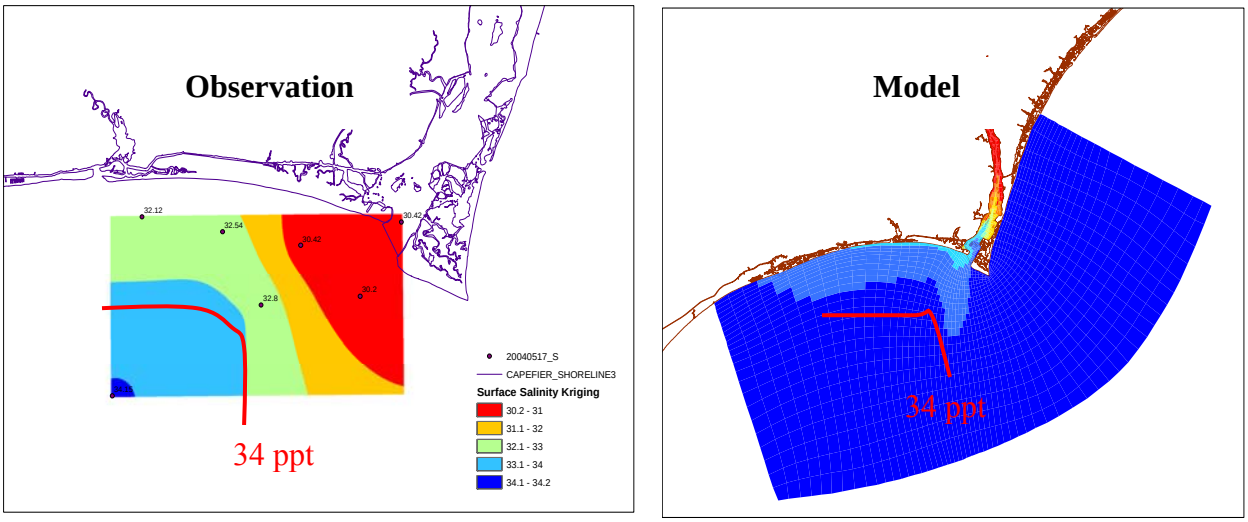

Figure 6. Observations and model results of salinity distributions on 5/17/2004.

Demonstration scenario ecological model calibration: During the reporting period the model team has obtained additional water quality data from LCFRP, which have been combined with USGS monitoring data to provide initial and river boundary conditions for the model scenario. The model code has been modified to allow additional light limitation on phytoplankton growth due to CDOM. The team has calibrated the ecological model according to temporal variations of chlorophyll a, nitrate, ammonium, phosphate within the Cape Fear River Estuary (Fig. 7) and has calibrated the ecological model according to spatial variations of chlorophyll a at the plume region on 5/17/2005 (Fig. 8)

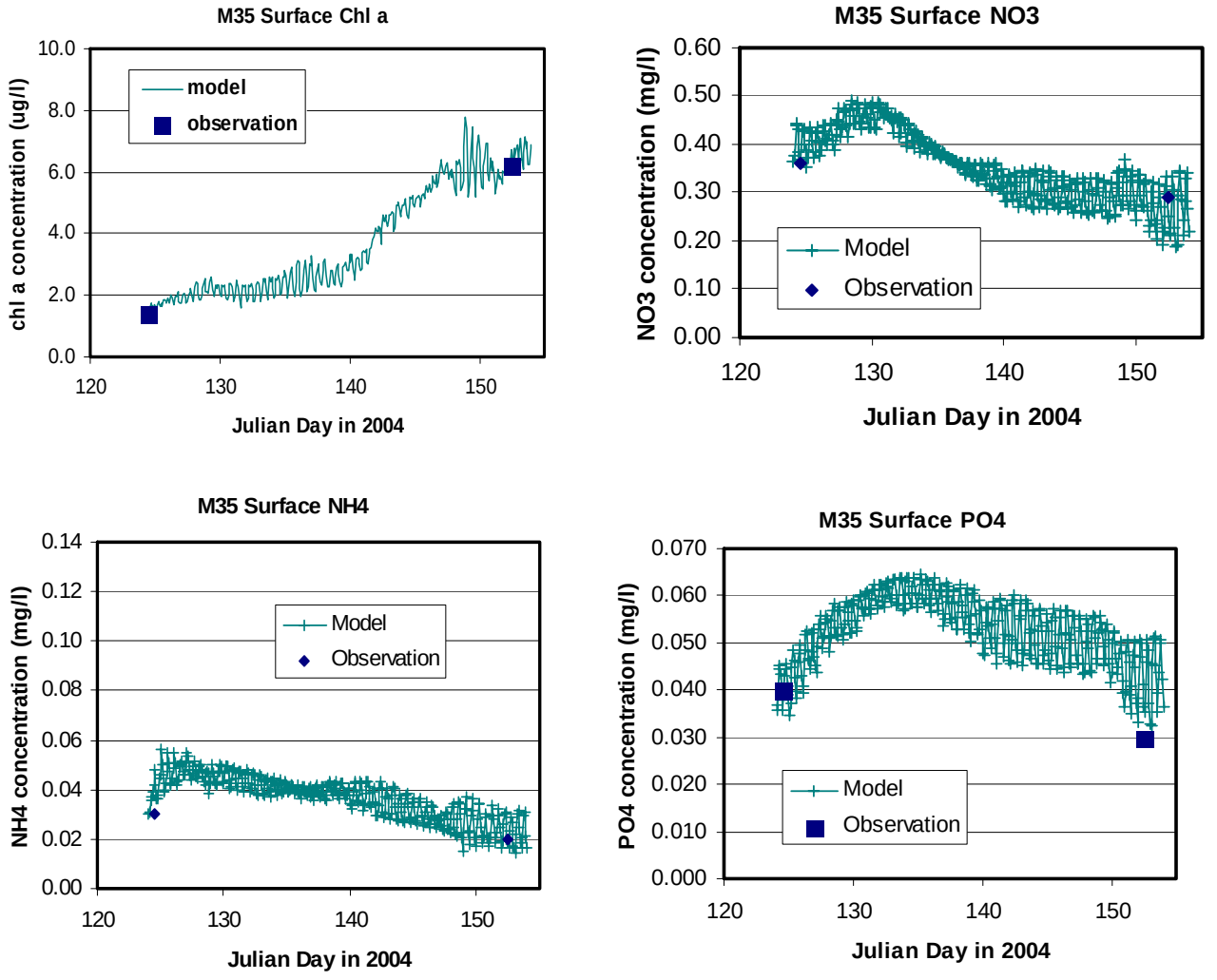

Figure 7. Model results and observations of surface chlorophyll a, nitrate, ammonium, and phosphate concentrations at station M35 (middle of Cape Fear River Estuary).

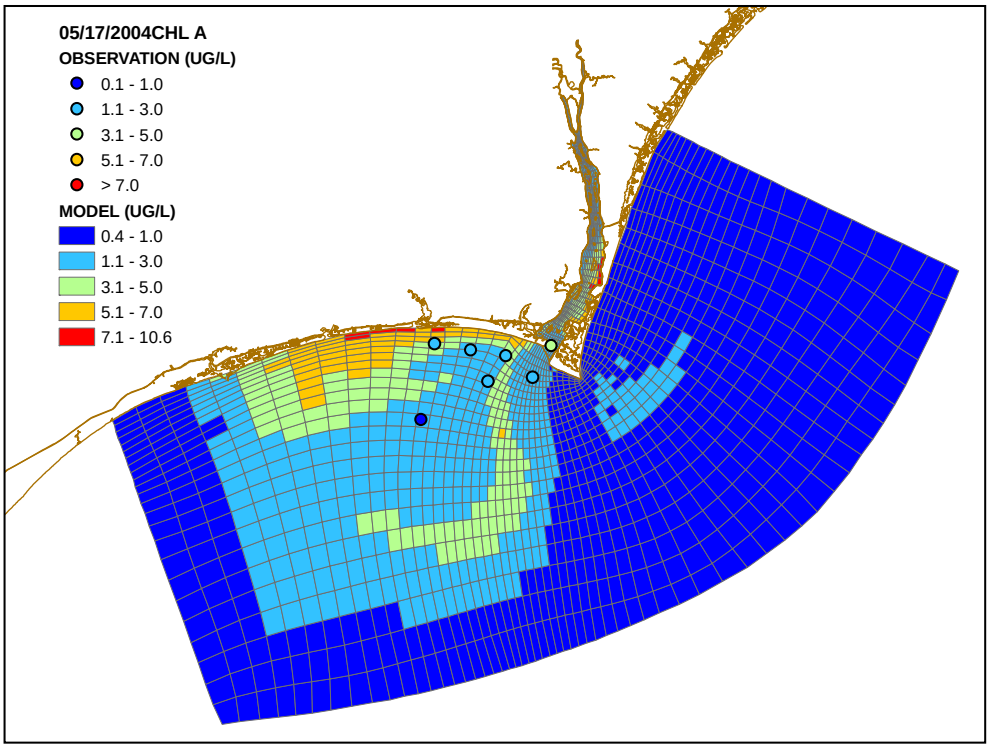

Figure 8. Model results and observations of surface chlorophyll a distributions on 5/17/2004.

4.0 Research and Data Products

4.1 New Data Sets

We now have an extensive CORMP data set on the CFR plume that spans the period February 2000 through the present. These data complement the existing data set for Onslow Bay. Key data products are highlighted below:

During this funding cycle, new data sets based on the trawl samples have been generated. These data sets include crab species and abundance around the inlets as well as data on shrimp and fish species collected in these same regions. These data sets are of particular interest to the Division of Marine Fisheries (DMF) that uses them to open and close the shrimp fishery in the Cape Fear region. CORMP has also compiled data on the Northern Kingfish (*Menticirrhus saxatilis*). These data are of interest to DMF as they develop the fisheries management plan for that species.

CORMP benthic infauna (Fig. 9) and fish species (Fig. 10) data collected since 2000 have been analyzed. These results show that the plume has enhanced diversity and abundance of fisheries species) compared to sites characterized as open ocean or sites characterized as estuarine.

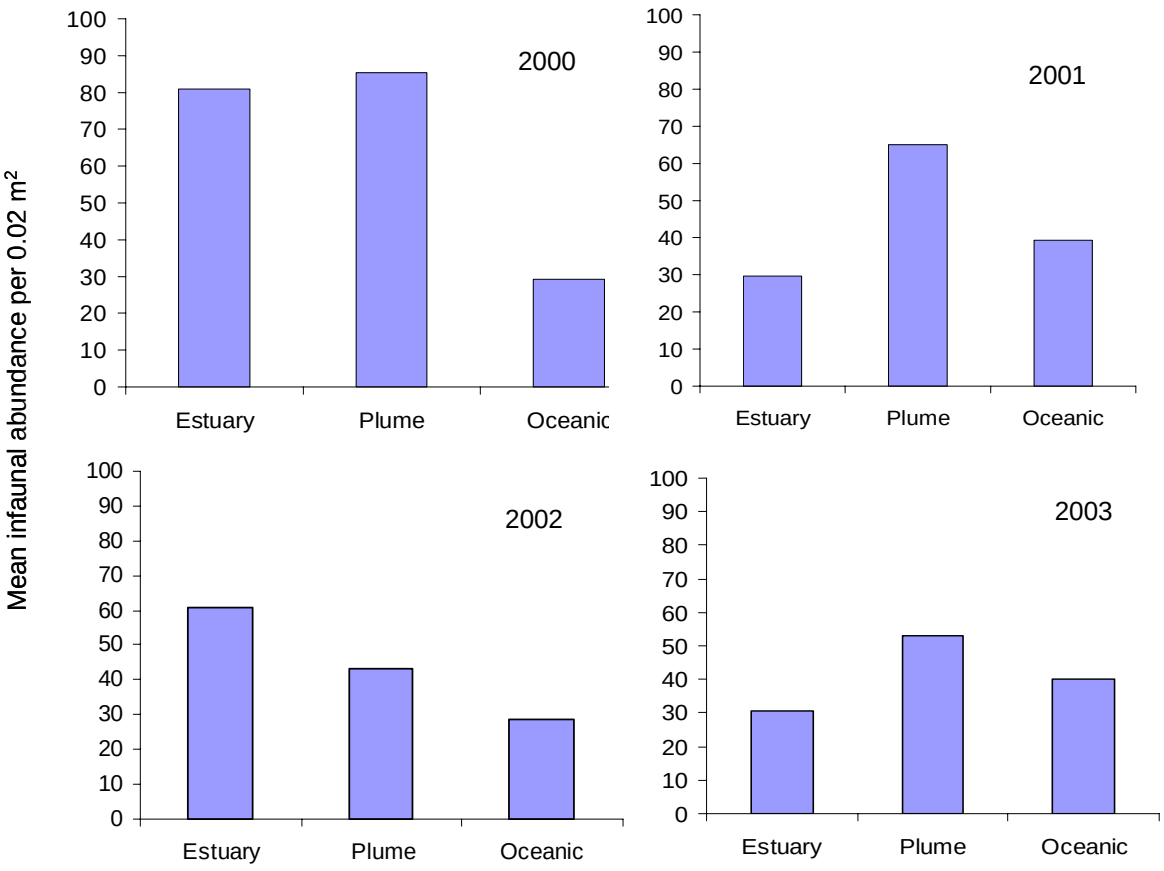

Figure 9. Benthic infaunal abundance data collected at Long Bay sites described in section 2.2—Observing Network-Cruise-based Activities

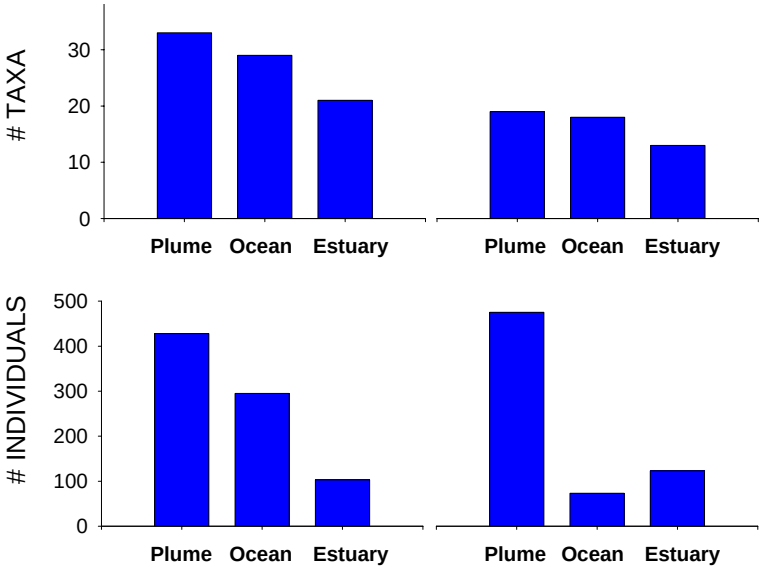

Figure 10. Fisheries abundance and diversity data collected at Long Bay sites in 2002 and 2003.

4.2 Presentations at Scientific Meetings

Alphin, T, Posey, M. Lankford, T. 2005. Assessment of faunal pattern (distribution and composition) in the Cape Fear River plume. The 34th Benthic Ecology Meetings, Williamsburg, VA.

Bingham, F. 2004. Shallow Water Temperature Response to Passing Hurricanes in Onslow Bay, NC, 1999. 18th DUNCOC Symposium, Beaufort, NC, November 19-20, 2004.

McGee, D.K., R.A. Laws, and L.B. Cahoon. A deep water benthic diatom assemblage from outer shelf-upper slope sediments, Onslow Bay , N.C. ASLO meeting, Feb., 2005. This work demonstrated the presence of a viable benthic diatom assemblages at depths and light flux levels much lower than all previous reports have indicated.

McGee, D.K., R.A. Laws, and L.B. Cahoon. A deep water benthic diatom assemblage from outer shelf-upper slope sediments, Onslow Bay , N.C. ASLO meeting, Feb., 2005. This work demonstrated the presence of a viable benthic diatom assemblages at depths and light flux levels much lower than all previous reports have indicated.

Slattery, M. and Leonard, L. 2004. Effects of the Cape Fear River plume on inner shelf sedimentation, Long Bay, NC. 2004. Southeastern NC. Southeastern Estuarine Research Society, Wilmington, NC. p. 29.

Wren, P.A. and Leonard, L.A. 2004. The effects of tropical cyclones on sediment transport patterns adjacent to a hardbottom reef in Onslow Bay, NC., EOS Trans. AGU 85(47), Fall Meet. Suppl., Abstract OS21B-1237.

Woods, W.L., P. Kowalczuk, T. Wynne, R.P. Stumpf, V. Ransibrahmanakul , M. J. Durako, W. J. Cooper, D. H. Wells, J. J. Souza. 2004. Ocean color remote sensing in southeastern U.S. coastal waters and evaluation of atmospheric correction improvements to radiometric match-ups. Ocean Optics XVII, 25-29 Oct 2005, Fremantle, Australia.

Wren, P.A., and L.B. Cahoon. Bottom boundary layer delivery of chlorophyll *a* and POC to a hard bottom reef community in Onslow Bay, North Carolina. ASLO meeting, Feb., 2005. This work developed near-bottom flow and biomass data into material transport estimates for the OB27 site based on CORMP SCUFA and PC-ADP data.

4.3 Peer-Reviewed Publications and Theses

Blanton, Brian O.; Werner, Francisco E.; Seim, Harvey E.; Luettich, Richard A., Jr.; Lynch, Daniel R.; Smith, Keston W.; Voulgaris, George; Bingham, Frederick M.; Way, Francis. Barotropic tides in the South Atlantic Bight. J. Geophys. Res., Vol. 109, No. C12, C12024.

Dafner, E.V., M.A. Mallin, J.J. Souza, H.A. Wells and D.C. Parsons. (In press). Nitrogen and phosphorus species in the coastal and shelf waters of southeastern North Carolina, Mid-Atlantic U.S. coast. *Marine Chemistry*.

Kowalczuk, P., J. Stoň, W. J. Cooper, R. F. Whitehead, and M. J. Durako. 2005. Characterization of chromophoric dissolved organic matter (CDOM) in the Baltic Sea by excitation emission fluorescence spectroscopy. *Marine Chemistry* 96:273-292.

Mallin, M.A., L.B. Cahoon and M.J. Durako. 2005. Contrasting food-web support bases for adjoining river-influenced and non-river influenced continental shelf ecosystems. *Estuarine, Coastal and Shelf Science* 62:55-62.

Markovsky, W.C. 2004. Influence of the Cape Fear River discharge plume on ichthyoplankton distribution and abundance. M.S. Thesis, University of North Carolina at Wilmington

Quattrini, A. M., D. G. Lindquist, F. M. Bingham, T. E. Lankford and J. J. Govoni, 2005. Distributions of larval Fishes among Water Masses in Onslow Bay, North Carolina: Implications for Cross-shelf Exchange. Fisheries Oceanography,14:3, 1-19.

Speckhart, B. 2004. Observational Analysis of Shallow Water Response to Hurricanes in Onslow Bay, NC in 1999. Masters Thesis, University of North Carolina Wilmington.

Wren, P.A. and L. A. Leonard. 2005. Sediment transport on the mid-continental shelf in Onslow Bay, North Carolina during Hurricane Isabel. *Estuarine, Coastal, and Shelf Science.*

Xie L., S. Bao, L.J. Pietrafesa, K. Foley and M. Fuentes, 2005: A Real-Time Hurricane Surface Wind Forecasting Model: Formulation and Verification. Monthly Weather Review (in press).

Xie L., L.J. Pietrafesa, M. Peng, S. Bao, H. Liu, 2005: The NCSU Coastal Estuarine and Marine Environment Prediction System (CEMEPS). Invited presentation at the Ocean University of China, Qingdao, China, July 29, 2005.

Manuscripts in review or in preparation:

Cahoon, L.B., M.A. Mallin, F.M. Bingham, S.A. Kissling, and J.E. Nearhoof. Effects of Hurricane Floyd on the lower Cape Fear River Estuary and coastal ocean, submitted to *Estuarine, Coastal and Shelf Science.*

Kowalczuk, P., M. J. Durako, W. J. Cooper, D. Wells, and J. J. Souza. (submitted). Comparison of radiometric quantities measured in water and above water and derived from SeaWiFS imagery in South Atlantic Bight. *Continental Shelf Research.*

Lankford, T. In preparation. Influences of the Cape Fear River discharge plume on fisheries recruitment. *Estuaries*.

4.4 Accomplishments and Constraints

Productivity: One of our principal objectives was to determine if benthic primary producers dominate in clear, nutrient-poor waters and phytoplankton dominate in waters with higher attenuation coefficients and nutrient levels. The Mallin, Cahoon and Durako paper is now

published and demonstrates that planktonic chlorophyll and nutrients in the nearshore Long Bay well-exceed those of nearshore and offshore Onslow Bay. Likewise, suspended sediments and CDOM from river discharge contribute to much higher light attenuation in the plume-influenced area of Long Bay than in any portion of Onslow Bay that this program samples.

Water Quality: Two new CORMP-related water quality papers have been accepted for publication, both in *Marine Chemistry* (see Dafner et al. *in press* and Kowalczuk et al. 2005, above). One of the key issues in Defner et al. is how organic nutrient species dominate the pools of total nitrogen and total phosphorus in local coastal marine waters. As most nutrient distribution and nutrient limitation papers are primarily concerned with inorganic nutrients, this provokes thought that the organic nutrient pool may play a larger role in driving coastal primary production than generally considered. This provides a theoretical basis for future research activities along these lines.

Bio-Optics: Collaborative research continued with Drs. Rick Stumpf, Varis Ransibrahmanakul and Timothy Wynne (NOAA National Ocean Service, Center for Coastal Monitoring and Assessment). The focus of this work is the improvement of coastal water products with improved atmospheric correction. NOAA/NOS has provided satellite data processed with an atmospheric correction including absorbing aerosol correction. These data will be compared with satellite data processed using the standard SeaDAS software (no absorbing aerosol correction) and also compared to *in situ* measurements from the same day, to determine whether better agreement is observed. The goal of this research is the quantitative use of ocean color data for the retrieval of biogeochemical surface water constituents such as chlorophyll and CDOM concentrations, facilitating long-term monitoring efforts.

Bio-Optics: Consultation with Robert Arnone (Naval Research Laboratory, Stennis Space Center, MS) has indicated the need for continuing coastal water radiance data in support of ocean color validation and atmospheric correction algorithm improvement. The technical feasibility of outfitting a CORMP NODC buoy with a SeaPRISM radiometer is being investigated, with the intent to pursue a collaboration in which CORMP would provide NRL with radiometer data in support of NRL coastal validation work for MODIS and follow-on ocean color missions, and NRL would provide CORMP with improved coastal ocean color products for the region.
Sediment dynamics: Recruited M.S. student (L. Davis) to complete thesis work on sediment transport in Long Bay.

Benthic Ecology: CORMP program data collected as part of the blue crab habitat utilization project was used to leverage funds from the North Carolina Blue Crab Program to extend the scope of future sampling efforts to include the entire mesohaline and oligohaline regions of the Cape Fear estuary. These data will model the distribution of blue crabs from the coastal ocean to the tidal freshwater regions of the Cape Fear estuary.

Benthic Ecology: In addition to the information collected on the size, abundance, spawning condition of blue crabs we also collected data on the size and density of the two main commercially important species of shrimp, the brown shrimp (*Farfantepenaeus aztecus*) and the white shrimp (*Litopenaeus setiferus*). This information was provided to the North Carolina Division of Marine Fisheries as part of data sharing partnership and was used to open and close the commercial shrimp

harvesting grounds in the Cape Fear region. In future seasons this data will be provided in a web based format to allow instantaneous access to the data.

Fisheries: A partnership between UNCW, CORMP and the NOAA/Rutgers University/CMER Bluefish Research Program has been organized to expand spatial coverage of larval fish sampling in Onslow Bay. Sampling is scheduled to begin in summer 2005 and will enhance our ability to document influences of the CFR plume on fish recruitment. CORMP researchers will team with investigators from other coastal states (NY, NJ, MD and FL) to develop a synoptic, coastwide index of juvenile fish recruitment to assist state and federal fisheries managers with stock assessments and development of fisheries management plans.

AUV surveys: The Webb Research Corporation Slocum Glider was received by NURC and test deployed in Onslow Bay on 24 June 2005 with NURC and CORMP personnel in attendance. This fieldwork was conducted in collaboration with Dr. Harvey Seim and Catherine Edwards of UNC Chapel Hill, who tested a similar glider simultaneously. Various technical tasks were completed in preparation for the first glider mission, including: installation of a SIM card; setup of communication software and an ftp site for real-time data retrieval; removal, repair and reinstallation of a malfunctioning sensor; development of glider control software programs for a planned first mission in Onslow Bay; incorporation of sensor calibration coefficients into the glider software; and development of Matlab programs for automated data processing, web display and update of glider data every 4 hours during deployment. In addition, preparations have been made for a glider sensor calibration experiment in a tank, and a transmissometer was refurbished for future inclusion on the CTD during cruises, for glider validation.

5.0 Data Management

5.1 Data management structure

CORMP has made significant advances in its data management structure over the last funding cycle. These advances have been due to the efforts of the CORMP data manager, Xiaoyan Qi, who has worked closely with other data management teams in the region including Caro-COOPS and NCCOOS. As early as July 2004 Xiaoyan Qi met with data managers at Caro-COOPS to discuss the prototype for the new version of Meta-DOOR and to determine how CORMP can possibly use the current version of Meta-DOOR to create FGDC-compliant metadata. In September 2004 Dr. Lee Dantzler and Xiaoyan Qi met with Sara Haines and Dr. Harvey Seim at UNC Chapel Hill to discuss cooperation between CORMP and NCCOOS to share data management standards, approaches and lessons learned. In November 2004, Xiaoyan Qi participated in the SEACOOS data management workshop. This was followed in December 2004 by a meeting between Dr. Fred Bingham and Xiaoyan Qi and data managers from Caro-COOPS, CMO and OHH to share data management experiences. As a result of these meetings and workshops, CORMP now has a defined data management structure that describes how data (real time and non-realtime) are received, reviewed, formatted, archived and disseminated (Fig. 11).

Data are now hosted by an Apache webserver and PostgreSQL database server set up on Dell Precision 670 workstation. A DODS netCDF server and DODS Relational Database Server are also

installed on the workstation. In Oct 2004 CORMP purchased a Dell PowerEdge 2650 Server. This server was set up the same as CORMP workstation. The CORMP webpage was moved to the Dell Poweredge server after initial testing, configuration and installation. The CORMP workstation is kept as a development server while CORMP PowerEdge 2650 serves the webpage to public. These two machines are mirrored with each other. Most cruise data and mooring data from the CORMP operation team and CORMP research team are put into the centralized PostgreSQL database system.

Following the deployment of the CORMP real-time buoys, Drs. Durako, Bingham and Xiaoyan Qi visited CaroCOOPS and discussed how CORMP can take advantage of CaroCOOPS' existing infrastructure to assure CORMP real time data streams from ILM2 and ILM3 and to transmit the data to all interested stakeholders (i.e.CORMP, NDBC and USC) smoothly. This activity marks yet another successful integration of two sub-regional partners who are working collaboratively, in non-duplicative ways, to ensure the timely dissemination of quality oceanographic data.

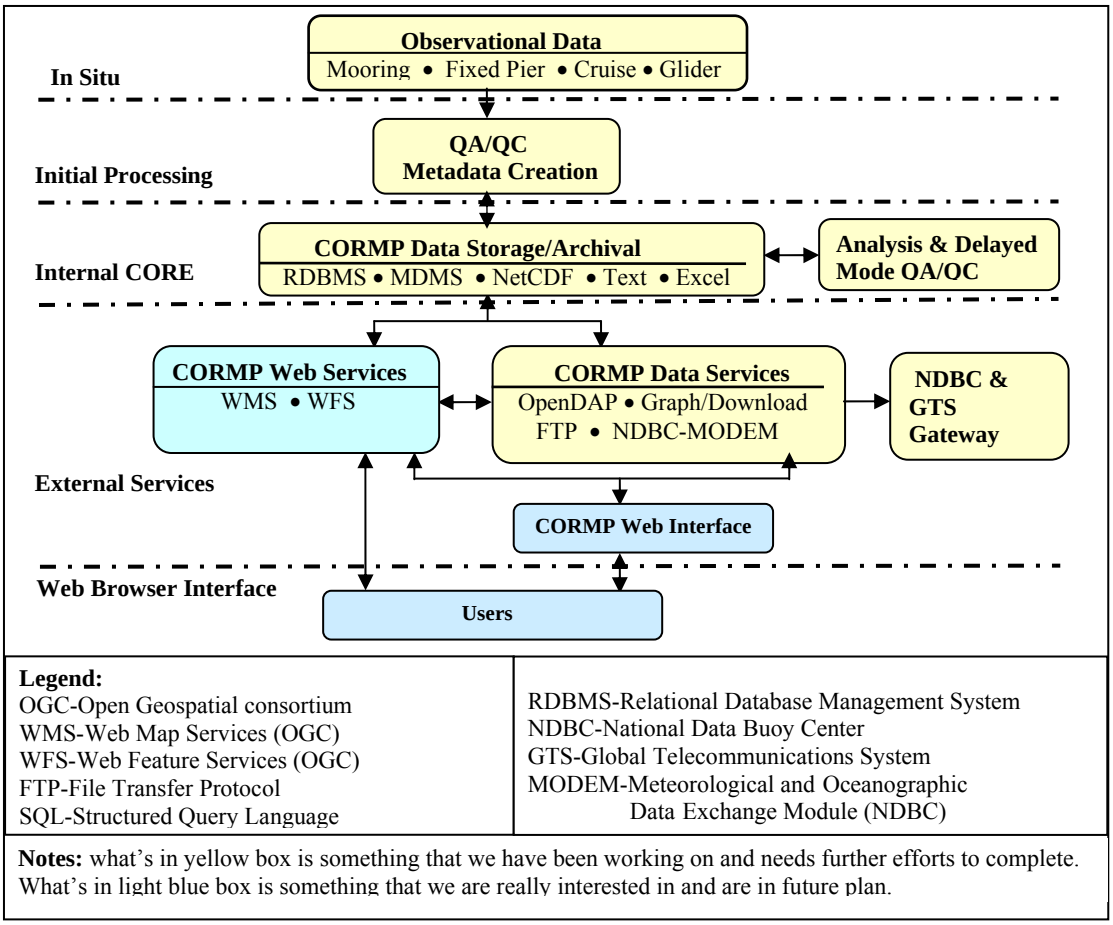

Figure 11. CORMP data management structure.

5.2 Data QA/QC

CORMP data management efforts have also included efforts to conduct QA/QC of previously collected non-realtime data and to adopt QA/QC standards, where they exist, for the real-time data

streams. Many of these activities were supervised by Dr. Fred Bingham who attended the QARTOD Meeting in Norfolk, VA on February 28 - March 2, 2005 and the "Real-time Data QA/QC Workshop" in Columbia, SC on December 7, 2004. Under Dr. Bingham's supervision, graduate student, Chris Canaday, reviewed ADCP and pressure data collected at non-real time moorings up to April 2004 and issued a data quality report to CORMP administration. This report indicated that the data collected at the non-realtime moorings were mostly of good quality; however, some issues were noted with regards to sampling frequencies that may affect the usefulness of the data for some types of analyses. Temperature, pressure and conductivity data quality from the non-realtime OB1-4 moorings up to April 2004 also were evaluated and another report was issued to CORMP administration. Conductivity data quality problems, in particular, have continued at these sites over the entire time period. Two immediate solutions were proposed and implemented: redesign the mounting brackets for the CT sensors to increase flushing, and increase maintenance frequency. These actions are being evaluated at all non-realtime sites and at the plume mooring. A program for performing real-time QA/QC on the ILM2 and ILM3 data streams was developed. The procedures are based primarily on climatologies derived from Frying Pan Tower, OB27 and OB3. The installation of the real-time moorings created new challenges with respect to QA/QC. Using information from workshops and in consultation with the Caro-COOPS data management team, CORMP has developed a basic automated check for problem data. These data are submitted to NDBC and presented on NDBC website as well as on the CORMP homepage.

5.3 Web-Site Development

Another key data management activity involved the expansion and redesign of the CORMP webpage. Several key activities were undertaken to improve the CORMP data portal and also to facilitate coordination and communication among CORMP staff, scientists, and partners. The CORMP website now displays real time data from a number of observational sources in the Cape Fear region through a simple and well-designed interface to access real-time and archived data. Activities related to website development are listed below:

1) "Graph and Download" webpage was developed to visualize the CORMP cruise CTD data and the CORMP mooring data.
2) A system which can automatically retrieve streamflow data from USGS webpages and calculate the Cape Fear River discharge was set up. The Cape Fear River Discharge data is updated on the daily basis and is available on http://www.cormp.org/stream.php
3) A database driven, web-based instrument and operation tracking system was developed to better manage the instruments and planning the operations.
http://www.cormp.org/internal/trackmooring.php (login required).
4) Developed a web calendar to track planned and future activities within CORMP.
http://www.cormp.org/webcalendar/login.php (login required).
5) Web statistics were incorporated to record the website usage.
6) Expanded the website to present real time data around the region from NWS, NDBC, Caro-COOPS and USGS.

We are pleased to report that following the successful deployment of ILM2, ILM3 and LEJ2, the CORMP website successfully absorbed these data streams and provided quality-controlled data to users in a timely manner.

In the coming year, CORMP plans to a) continue to build the CORMP data management system; b) create FGDC-compliant metadata to ensure data disseminated from website are complete and of high quality; c) communicate with IOOS/DMAC to adopt QA/QC standards as they evolve. Other major data management endeavors include: a) expand/modify existing metadata to meet national and IOOS standards once they are established; b) implement web services (WFM, WMS, and Mapserver) to enhance the interoperability; and c) finalize emergency data management plans. For the latter, we have begun a discussion of provisions for emergency situations, such keeping our website up during storm events. One of the recommendations was to move the CORMP server up to the main UNCW campus. This is an important step and discussions were initiated with main campus IT personnel to implement this move in the upcoming year. Another possible activity is to participate in the mirroring of the CORMP website by Caro-COOPS.

6.0 Education and Outreach

6.1 Education

The CORMP marine science professional development pilot program for middle and high school teachers was highly successful. Five science teachers from New Hanover, Onslow, Bladen, and Brunswick County Schools participated. The initial summer workshop was held July 26 - 29 2004 at the UNCW Center for Marine Science and six 1-day Saturday seminars were held monthly. Activities and lesson plans using CORMP resources and archived data were developed during the Saturday sessions. Based on the success of the first summer workshop, two sessions were offered during summer 2005 (July 11-14 and August 1-4). A total of 18 teachers took advantage of the workshops to learn more about CORMP and how to integrate research into the classroom. At the end of each session, teachers were given CD's that contained video footage of CORMP research activities and the real-time buoy deployments; photo files of common marine life in southeastern NC; and classroom activities and lesson plans. CORMP is continuing to work with the UNCW Science and Math Education Center (SMEC). SMEC Director Karen Shafer will remain involved in the CORMP education program and will help facilitate teacher recruitment for the 2006 CORMP Summer Teacher Workshops.

CORMP sponsored two Summer Ventures Students during July 2005. They spent four weeks immersed in CORMP fieldwork and lab research while also completing individual research projects based on their own personal research interests.

CORMP has been trying to implement the Data Visualization Tools (DVTs) developed at the UNCW Watson School of Education and has had some success; however, due to the large volume of data in the DVTs teachers are finding them difficult to implement in the classroom. The teachers are providing feedback on ways to enhance the DVTs and make them more effective, especially the *Riverview* product. Lesson plans for the *Riverview* website are being developed and will be ready for teacher workshops by summer 2006.

The Teacher and Student Resources link on the CORMP website has been updated to include lesson plans, video footage and photographs for use in the classroom. CORMP is in the process of

developing short DVD movies for use in middle and high school classrooms. The DVD's will provide footage of CORMP field operations, highlighting the equipment used to collect data, diving operations, and underwater video of flora and fauna in the region. Education and Outreach staff, as well as CORMP PI's, have visited middle and high schools in Eastern North Carolina to take CORMP into the classroom.

6.2 Outreach

In efforts to increase public awareness of CORMP, outreach personnel cultivate partnerships with super-users in the region. Partnerships have been established with the following organizations:

1) Johnnie Mercer's Pier, Wrightsville Beach, NC and Ocean Crest Pier, Oak Island, NC. Both of these piers will serve as shore based, real-time mooring locations for CORMP monitoring equipment.
2) US Marine Corp Base Camp Lejeune to jointly purchase the NDBC buoy which was deployed in Onslow Bay, NC on August 1, 2005.
3) US Army Corp of Engineers will be provided wave data collected from the pier based moorings. USACE will process the data for use in their shoreline erosion models. All processed data will be provided back to CORMP researchers.
4) The National Weather Service, Caro-COOPS and CORMP are jointly working together to create a new NWS Marine Weather webpage specifically for the NC/SC coastlines. This Carolina's Coast webpage will take the place of the current NWS marine page and it will incorporate CORMP, Caro-COOPS, NDBC, USGS and NWS real-time data onto one site to create a "one-stop shop" for anyone looking for the current and forecasted marine conditions.
5) The Wilmington NWS Weather Forecast Office sponsors the Rip Current Awareness Strategies Team (RCAST). CORMP real-time data collected at the two pier sites will be used by NWS to forecast rip currents for New Hanover and Brunswick Counties. CORMP is also working with RCAST to develop informational materials to increase public awareness concerning rip currents.
6) CORMP has hosted meetings with local super users to provide information on the program and the mooring systems. These groups are working with CORMP to provide feedback on buoy placement and possible applications for the data being collected.
    a. North Carolina State Ports
    b. US Coast Guard Marine Safety Office, Wilmington Office
    c. Cape Fear River Pilots Association
    d. US Army Military Ocean Terminal Sunny Point
7) The NCDMF continues to rely on CORMP's data for brown and white shrimp size counts. These data are collected along with the crab trawls and are made available to NCDMF immediately for use in determination of fishery status in the Cape Fear region (both in the river proper and in the coastal ocean around the mouth of the Cape Fear). CORMP researchers are also collaborating with NCDMF for the East Coast Blue Crab tagging program.
8) CORMP PIs have continued collaboration with NC Department of Agriculture and Consumer Services Emergency Planning Division regarding possible ocean disposal of mass animal mortalities in the event of disaster. CORMP oceanography input will be critical in

development of this project. Developed detailed field experimental protocol to be incorporated into preliminary science proposal.

CORMP also has been successful in securing additional funding to support related outreach and data dissemination activities. First, CORMP PI Lynn Leonard and Dr. Doug Gamble (UNCW Earth Sciences) were awarded a grant for $74,890 by the NOAA-Coastal Services Center to create "Coastal Climatology Products for Recreation and Tourism End-Users in Southeastern NC." This grant also supported outreach and web development initiatives based on seasonal climatology for the region. Second, CORMP was awarded a $5000 grant from the UNCW Information Technology department to purchase equipment beneficial for use in educational seminars and website development. Based on the grant proposal, the IT department invited CORMP to participate in the UNCW technology showcase which highlighted innovative programs at UNCW for the public.

CORMP public outreach efforts increased dramatically during the last six month. Talks regarding new real-time moorings have been given on a grass roots level to regional sport fishing associations, Coast Guard Auxiliary flotillas, Sail and Power Squadrons, SCUBA clubs and at community events. The goal of these outreach efforts is to increase public knowledge of CORMP, our on- and off-shore real-time platforms, and how each community group can work with us to ensure the operability of the moorings. CORMP also hosted two media cruises to observe the deployments of the ILM2 and LEJ2 buoys. Both cruises garnered state-wide print, radio and television press. The newspaper articles were picked up by the Association Press, increasing their circulation across the state and in Virginia and South Carolina.

CORMP is working with private industry partners, WeatherFlow, Hurricanelivenet.com, Fryingpantower.com, and NCWaterman.com to provide real-time data for website value added products. Each of these organizations have endorsed CORMP's real-time data and highlight our program on their websites.

7.0 Program Management

7.1 Cooperative and Interoperability Efforts

- L. Leonard and M. Moss attended the SECOORA workshop in Jacksonville, FL in December 2004.
- L. Leonard, M. Durako and M.Moss attended the COTS/ONR WORKSHOP in November 2004 in Charleston, SC. At this meeting, she agreed to co-chair the "Common Interface" workgroup for the IOOS-open IOOS Interoperability II demonstration.
- CORMP hosted an initial meeting of representatives of regional observing programs, NDBC, and NOAA to discuss future plans to expand the Carolinas mooring array.
- L. Leonard and M. Moss attended the Southeast Regional Ocean Observing Priorities Meeting in Charleston, SC in Feb. 2005.
- L. Leonard is on the Steering Committee for the Open IOOS II Interoperability Demonstration project
- L. Leonard, M. Moss and J. Dorton are members of various SECOORA business planning teams
- L. Leonard attended the NFRA meeting at OceansUS in March 2005

- L. Leonard and M. Moss attended the IOOS Demonstration Project/IOOS Implementation Conference in D.C. in June 2005
- L. Leonard, M. Moss and J. Dorton attended the SECOORA business planning meeting in July 2005.
- L. Leonard and M. Moss briefed NC Congressional staff in D.C. July 2005.
- L. Leonard, M. Moss and M. Fletcher briefed NOAA on CORMP-CaroCOOPS interoperability and integration in July 2005.
- Bingham attended web seminars on "ADCP Waves Measurement Techniques - I" and on "ADCP Waves Measurement Techniques - II". November 2004. Given by Paul Devine from RD Instruments.
- Marshall attended the Outreach & Education informational meeting in Raleigh, NC; SEACOOS 2004 fall meeting, Charleston, SC;, and Waves Workshop, Columbia, SC

Of particular note is the CORMP, Caro-COOPS and NWS-Wilmington partnership to create the Carolinas Coast website. This activity is an excellent example of cooperation among and between COTS programs and other federal partners. This initiative, which has been underway since Feb. 2005, has resulted in the development of a one-stop shop for marine observations in the Carolinas. Although not yet available to the public, after evaluation and review, this site will replace the marine weather sites for the Wilmington NC, Newport NC, and Charleston SC weather forecast offices. The feedback on this project thus far is overwhelmingly positive and NWS forecast offices throughout the region have contacted CORMP and Caro-COOPs to discuss duplicating our efforts.

7.2 Personnel Changes

- Hired D. Kennedy as a marine/mooring engineer to construct pier moorings and assist with offshore moorings. Oct. 2004.
- Hired J. Dorton as outreach coordinator in Nov. 2004.
- Hired Boyce Steiner as Administrative Assistant in Jan. 2005.
- New full-time technician, Steve Hall, began working with operations team in Jan. 2005.
- Hired B. Speckhart as a electronics technician (time-limited) in Apr. 2005.
- D. Ihnat resigned from his part-time position with CORMP in Feb. 2005.
- J. Marshall resigned as education coordinator effective Aug. 1 2005 to return to teaching.
- We have still not been able to fill the second data manager position even though we have extended two offers. The search is ongoing and we have resumed interviews. We hope to have this position filled by the end of Sept. 2005.
- M. Moss will step down as CORMP PI effective Sept. 1 2005. L. Leonard has been appointed PI by the UNCW Provost and will assume the position on Sept. 1.