2003-2004 Coastal Ocean Research and Monitoring Program (CORMP)

University of North Carolina at Wilmington
NOAA Award # NA16RP2675
Progress Report, 1 August 2003 to 31 January 2004

Submitted by:

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This progress report is for NOAA grant #NA16RP2675 and is for the period 1August 2003 to 31 January 2004. Major progress has continued and it is reported in detail in the following sections. These sections, listed here in outline form, are correlated with sections of the 2003-04 CORMP proposal as follows:

- Mooring and Modeling (Sections 2 and 3)
- Sediment Transport (Section 3)
- Nutrients, Bio-Optics and Ecosystem Production in OB, LB and the CFR Plume (Section 4)
- Program Management Initiatives (Sections 5,6,7)
    - Outreach and Education (Section 6)
    - Program and Information Management (Sections 5 and 7)
    - CORMP Operations (Section 7)
    - Budgetary (Section 8)

Mooring and Modeling Component*, Proposal Sections 2 and 3, 8/1/03-1/31/04

Overview. CORMP continued support for coastal moorings, other data sources including both in-situ data and remotely sensed data, and related high performance computing numerical modeling includes:

- design of the backbone Eulerian observing system including oceanographic current, wave, temperature, salinity, pressure, coastal water level and meteorological variables
- integration of the backbone observing system for physical oceanography, meteorology and remote sensing with CORMP's biological, chemical and geological research and monitoring activities
- integration of the CORMP and Caro-COOPS observing systems, affecting an economy of scale, and ensuring full complementarities and continuity between the two programs
- application of the observational data necessary for the evaluation of the NCSU Coastal & Estuary Marine Environmental Prediction System (CEMEPS) coupled atmospheric, current, wave, estuary model system in the CORMP area of study This evaluation is in preparation for ongoing and further model development and reconfiguration of the model to incorporate the Cape Fear River Estuary and couple it to the coastal ocean and watershed model components. This model system has been developed jointly by L. Xie, L. Pietrafesa and D. Dickey of NCSU
- incorporation of the Cape Fear River Estuary into the NCSU CEMEPS Continental Margin Numerical Model for applications of coastal storm surge and flood forecasts and to initiate water quality and fisheries applications
- development of a coordinated, comprehensive expansion plan for the implementation of the full Caro-COOPS/CORMP combined mooring array based on atmospheric/ocean/estuary coupled physics of the Carolinas as related to important physio-bio-geo-chem-fish-socio-economic processes and issues

Observing Network, Data Editing, Time Series Production

With CORMP support through the NCSU subcontract, NCSU has:

1) maintained the fixed observational CORMP array and is in the process of editing all of the observational data collected to date beginning in 1999 so that maximal data verity and quality is assured
2) designed the overall monitoring network mooring array expansions within CORMP and Caro-COOPS; provided the lists of mooring equipment and supplies needed for planning for a real-time observing array

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* This section of the progress report is reported by NCSU under sub-contract from UNCW/CORMP

3) designed and constructed the moorings; defined the vessel needs for mooring deployment, recovery and servicing
4) conducted a spatial mechanistic/statistical assessment to optimize the monitoring array
5) assessed the response of a prototypical small embayment within the CORMP domain by setting and level and pattern of variation of ecologically relevant factors such as fish life histories
6) is conducting statistical evaluations related to river flow and meteorological phenomena
7) defined the forcing fields of significant atmospheric events which have struck the Cape Fear region 1996 to the present
8) acquired and combined bathymetric and elevation data for the domain surrounding and downscaling to the Cape Fear region
9) prepared observing system instruments for deployment via refurbishing, servicing and up-fits.
10) designed a new mooring system for real time recovery of data using the Iridium satellite network. NCSU is presently assessing the mooring design for detected flaws and for data transmission and recovery issues. The new real time mooring design is shown in Figure 1
11) designed a combined CORMP Caro-COOPS backbone monitoring network as shown in Figure 2
12) costed out the new real time observing network component parts

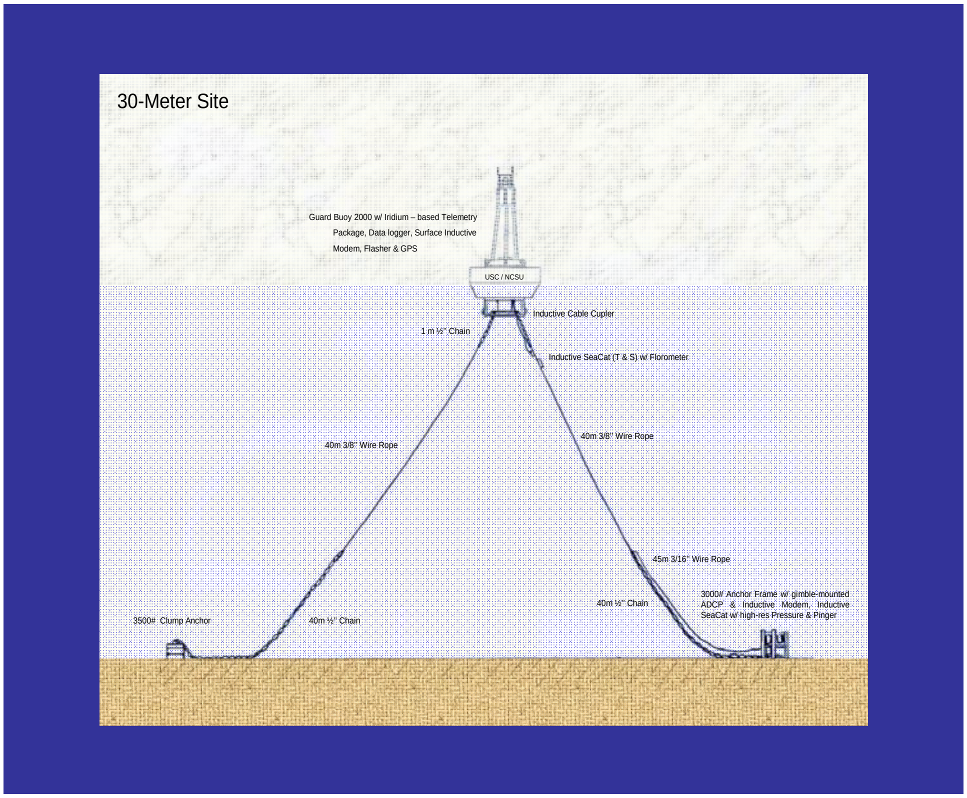


Figure 1. Proposed NCSU real time mooring design.

An Aanderaa Water Level Recorder was deployed at the Wrightsville Beach Coast Guard Station near Masonboro Inlet in 06/01 and has been maintained to date.

Data from all deployments has been distributed to UNCW staff scientists. All data has been filtered. The quality of each of the individual entire time series has required that NCSU technicians revisit each instrument sensor individually given the length of the entire time series to date; which extends back to July, 1999.

All of the current meter data and wave data have been assessed and have been found to be of excellent quality. All of the temperature data has also been determined to be of high quality. The pressure data time series are still being assessed.

The channel exhibiting the most questionable performance over time in Onslow Bay waters is conductivity. This has been attributed to bio-fouling over the course of an individual deployment and over multiple deployments. These SeaCat units do not utilize a pump to move water thru the cell. To ensure good water exchange, even with fresh anti-fouling plugs installed on the cell, biomass will still be present and degrade the measurement over time. It was determined that three months is the longest deployment possible without observing any serious signal degradation, especially during the warm weather months. After that, the effectiveness of the anti-foul plugs decreases rapidly. As a consequence, the cycle for exchanging the Seacats on the CORMP moorings has been shortened to three months, the same period currently used to change out the ADCPs.

Also recommended is that when deploying SeaCat (or other manufacturer) CT loggers on moorings, CTD casts be performed at the beginning and end of a deployment cycle. This will help, during data post processing, in comparing and analyzing the performance of the CT logger and potentially identify any fouling issues. This will allow correlation of SeaCat performance.

In keeping with the above and following the resurrection of the entire time series of all variables, all CORMP investigators will be supplied with QA/QC protocol documentation.

The NCSU technical staff has questioned the quick instrument turn-around schedule that CORMP, following NCSU QA/QC procedures, has adhered to. After discussions with NCSU personnel, more time is being allotted between recovery and redeployment to sufficiently scrutinize downloaded data to increased levels of confidence in the performance of each and every instrument. This procedure may require additional cruises and minor breaks in the time series, temporarily, but will ensure high quality of data until an instrument swap out process can be implemented.

The delay in the data QA/QC assessment and of the reconstruction of the entire, complete time series to date has been the need to assess each 6-month block of early time series to the more recent 3-month blocks which are of higher quality simply because the time for and level of biological fouling will be reduced significantly.

All wave data has been reassessed for quality and accuracy and has been determined to be of excellent quality.

In preparation for the modeling of the lower Cape Fear River system, and in anticipation of the deployment of moored instruments to provide the data necessary for model output validation, an evaluation of where the moorings need to be deployed and where data needs to be collected has been conducted.

Mr. B. Speckhart, a UNCW master's degree student is finishing his thesis documenting the response of Onslow Bay to multiple hurricanes forcing in 1999. The data time series has been reconstituted to include all T, S and P data. One of the new plots is shown in Figure 4. The data set extended through the 1999-2000 year winter as well as having documented the oceanographic response to the passage of three hurricanes. This reconstructed data set is intended be used to ground truth CEMEPS model output. The reason for the NCSU overlay was to differentiate between the new reconstructed time series and the old time series.

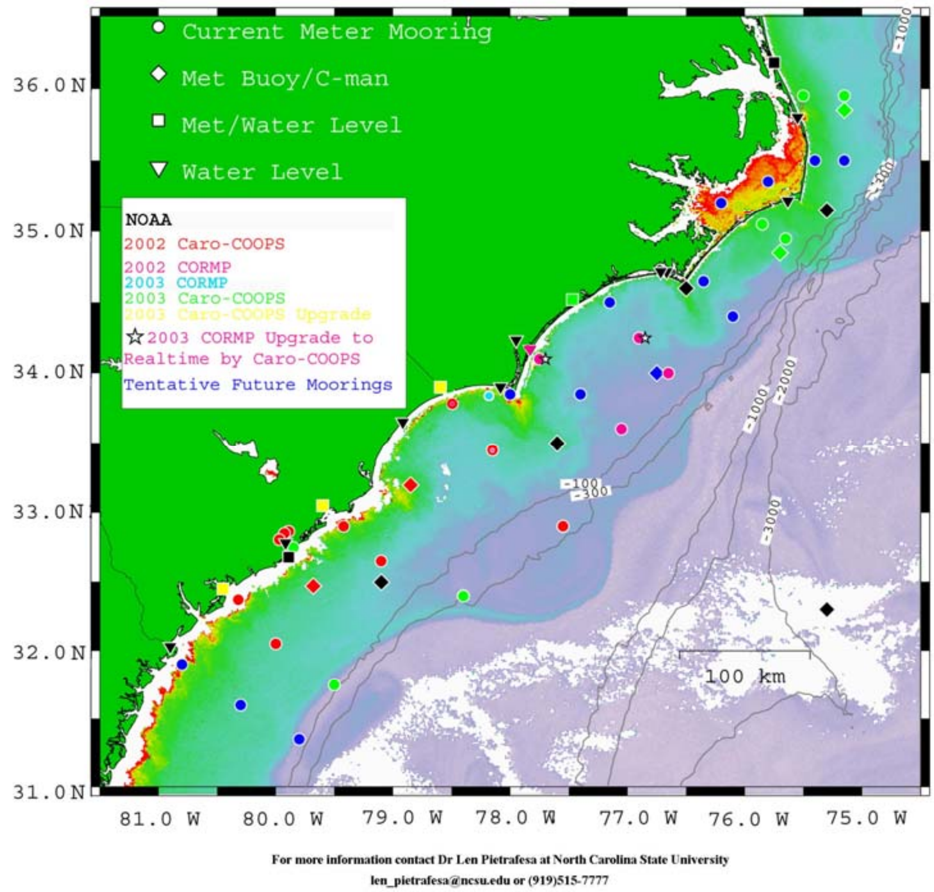


Figure 2. NCSU Proposed Carolina Observational Network

Modeling

For the 2003-2004 project year, the CORMP modeling focused on the development of a three dimensional, time dependent storm surge simulation tool for the offshore North Carolina region and the Cape Fear River Estuary (CFRE) at high resolution.

A substantial effort has been made to ensure the development of a high resolution, hydrodynamically complete and correct, state of the science quality modeling system for the offshore waters and the entire CFRE system. For example, we have adopted a triple nesting approach for model downscaling, from relatively low to relatively high spatial resolution. As a result, we have not only developed the high-resolution model for the CFRE, but we have also developed the model for two other coarser domains.

However, due to the shutdown of the North Carolina Supercomputing Center, the NCSU/CORMP modeling effort had to be repositioned to another high performance computing platform and the modeling group invested a large amount of time and effort in transferring the modeling system and data from the old supercomputing facility (which consisted of a SGI type computing platform) to the new NCSU Computing Center (an IBM Linux cluster computing platform). Thus the model and model codes had to reconfigured and tested for completeness, accuracy and efficiency. Specific accomplishments are listed below.

Accomplishment 1: Determined an optimal model domain for the CFRE and created bathymetry and land elevation data for the model domain. NCSU has:

1) determined an optimal model domain for the CFRE system through a set of test experiments
2) extracted ocean bathymetry data for the offshore coastal region of the model domain from the ETOP2 database (see Figure 3)
3) interpolated the bathymetry data into fine resolution (100m to 1km grid sizes). Applied strict data quality control in the data extraction and interpolation process;
4) extracted high-resolution bathymetry data for the near-shore coastal region and lower river estuary (Figure 3) of the model domain from NOAA Coastal topography database at high-resolution (100m grids). Applied strict data quality control during data extraction
5) extracted high-resolution land elevation data for the CFRE model domain from the NOAA Coastal topographic database. Applied strict data quality control; and
6) merged all data from (2)-(5) to create a complete land-ocean topographic database for the CFRE model (Figure 3)

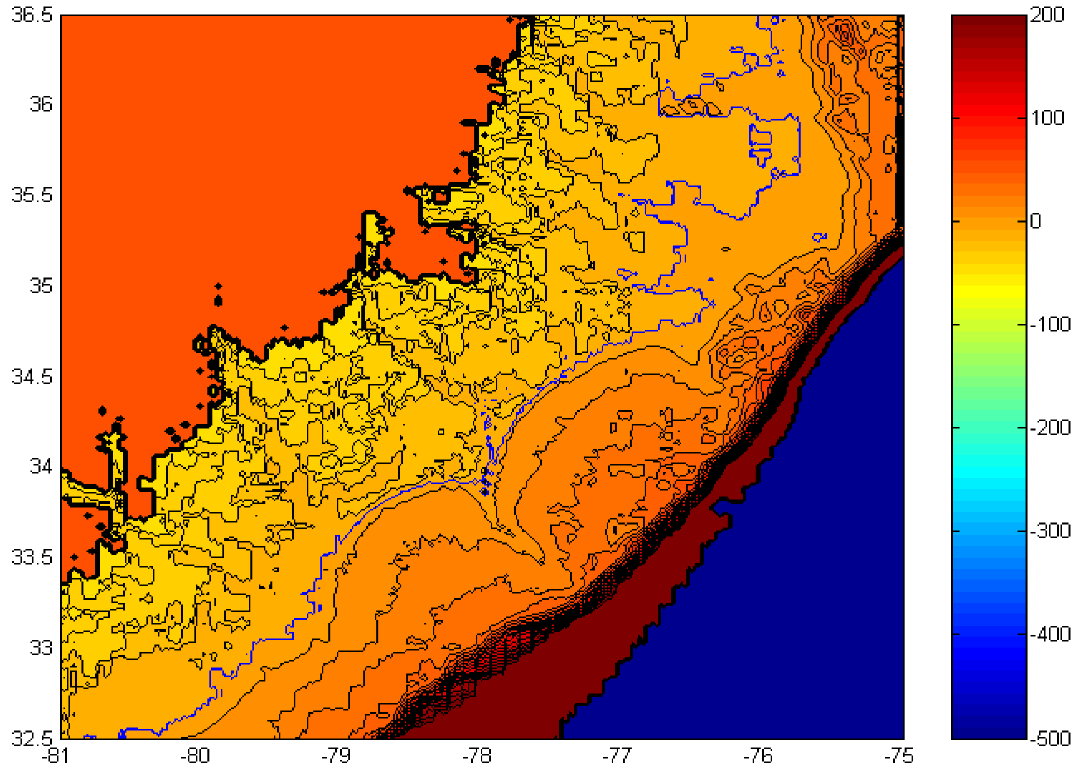


Figure 3. Depth and elevation merged data

Accomplishment 2: Configured the storm surge model for the CFRE system. NCSU has:

1) configured the model for CFRE system at 100 meter spacing. In addition to the high-resolution domain, we also configured the model at 500 m and 1 km grid spacing for the out-nesting windows, to create a triple-nesting domain (Figure 4)
2) applied for and received supercomputing time from the North Carolina Supercomputing Center (NCSC). In September 2003, NCSC was closed. Thus, we had to request supercomputing time from the newly created North Carolina State University Supercomputing Center to support the CFRE modeling project, and received support. Significant personnel and time efforts were made to transfer our modeling system from NCSC to the NCSU Computing Center
3) tested the model performance under idealized atmospheric forcing including: uniform winds and idealized hurricane winds and tracks. Tested the model stability under modest to extreme forcing conditions. Efforts were made to improve model open boundary conditions to ensure model stability

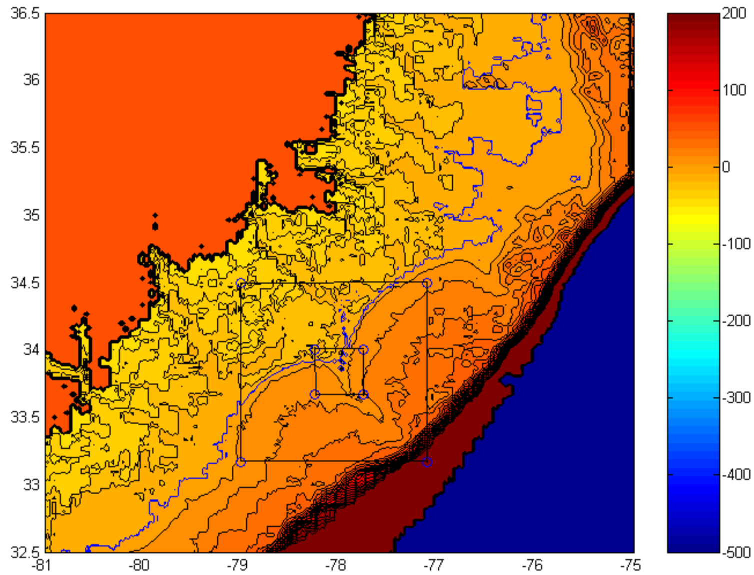


Figure 4. The model nesting configuration.

Accomplishment 3: Created realistic forcing fields for the CFRE storm surge and lateral inundation model. NCSU:

1) configured a parametric hurricane wind model for Hurricane Fran which affected the CFRE system (Figure 5)
2) created tidal boundary forcing for the CFRE system
3) initiated the creation of the CFRE runoff (stream flow) interface for historical hurricane cases
4) searched and extracted precipitation data for the periods of recent extreme events.

Accomplishment 4 (in progress): Model calibration for selected historical hurricane cases.

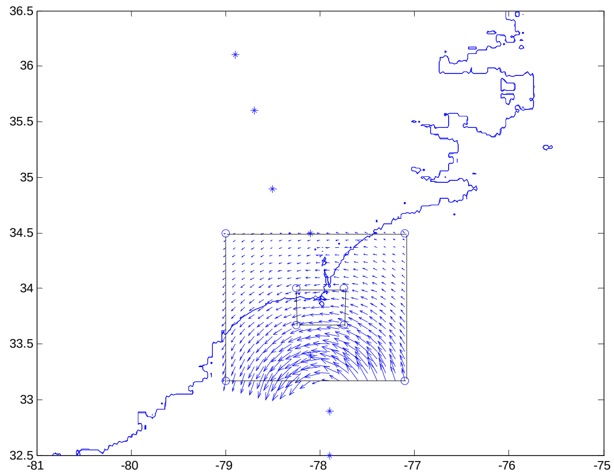
Accomplishment 5 (in progress): Model output customization and documentation. See remaining tasks below.

Despite the unexpected close-down of the North Carolina Supercomputing Center (NCSC), which created a significant amount of extra effort to protect model codes and data and to safely transfer the modeling system and data from the NCSC to the NCSU Computing Center, and reconfigure the modeling system to a new and different computing platform, the modeling effort remained focused on the CORMP model tasks and made steady progress toward complete the proposed tasks by the end of this project year.

Remaining efforts are underway to validate the model for selected historical hurricane cases. We have designed a validation strategy, selected validation variables (surge time series, timing of peak surge) and validation methods (point-wise validation, peak surge validation). The validation strategy depends on the availability of observational data and data distribution;

Also, efforts are underway to: test the model against data from Hurricane Fran. We plan to include additional historical hurricanes; analyzing model results and create visualizations of model output; and, once the modeling system is established, document the modeling system and user menu.

Figure 5. The reconstructed wind field for Hurricane Fran 1996.



Some sample animation products are available from the NCSU CFDL website:
http://dell01-112res3.meas.ncsu.edu/CFDL/

A preliminary run of the model configured for the Cape Fear River region during the passage of Hurricane Fran 1996 has been made. The preliminary model output is shown in Figure 6.

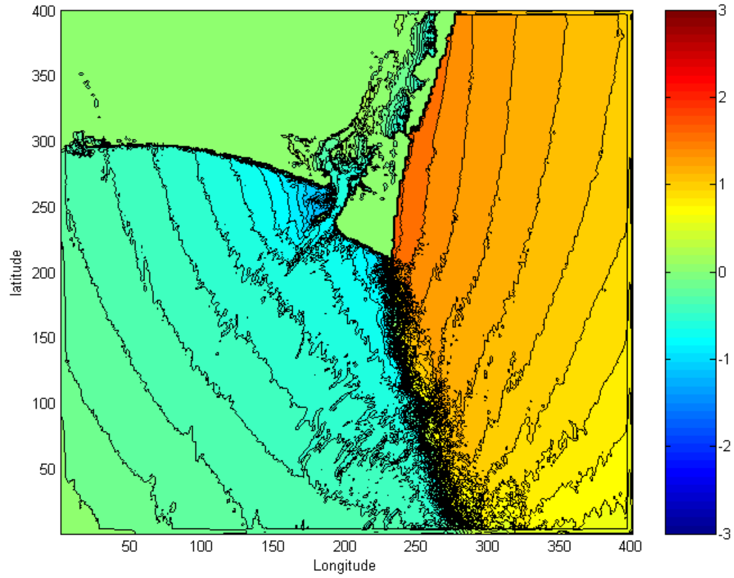


Figure 6. Preliminary example of storm surge in the inner-most domain in meters during the passage of Hurricane Fran in 1996

Sediment Transport, Proposal Sections 2 & 3, 8/03-1/04

Changes in nearshore and coastal environments in response to waves, tides, wind-driven currents, and terrestrial inputs are of fundamental interest to every coastal area of the U.S. and, as such, to the goals and objectives of NOAA itself. The primary goal of the CORMP geological monitoring program is to measure, document and interpret the changes and response of nearshore and coastal environments under these various forcing functions.

The data sets for sediment transport are generated by CORMP's two-tiered monitoring program which currently consists of both moored instrumentation and bi-monthly sampling cruises. This approach provides CORMP with an unprecedented opportunity to identify physical mechanisms driving coastal change. What follows, is a description of activities undertaken and progress made toward meeting our specific programmatic objectives between August 2003 and January 2004.

Sidescan sonar surveys

For the FY2003-FY2004 period, we proposed to collect baseline side scan sonar surveys in the vicinity of the Cape Fear River plume in Long Bay (LB) and post-storm surveys (if required) at sites OB3 and OB27 in Onslow Bay (OB). The baseline side scan survey in Long Bay was conducted in late July 2003 and the data has been mosaiked and georeferenced (Figure 7) during the months following. This survey was used to identify the variation in bottom sediment types near the river mouth and to located potential mooring locations. In August 2003, we conducted a diving (scuba) intense sampling survey within the side scan area to collect bottom sediment samples for the purpose of ground truthing the side scan data. Further, near-bottom water samples and pushcores were collected at 11 sites in the area to ascertain the composition of the near-bottom fluid muds and to identify near surface stratigraphy of bottom sediments. To date, all of the grab samples have been analyzed for grain size and organic content and these data are shown in Table 1. The fluidized mud samples have not yet been processed and we plan to complete this task during the next reporting period. Further, we hope to undertake one additional side scan cruise during this funding period in order to collect data along the cruise sampling transect.

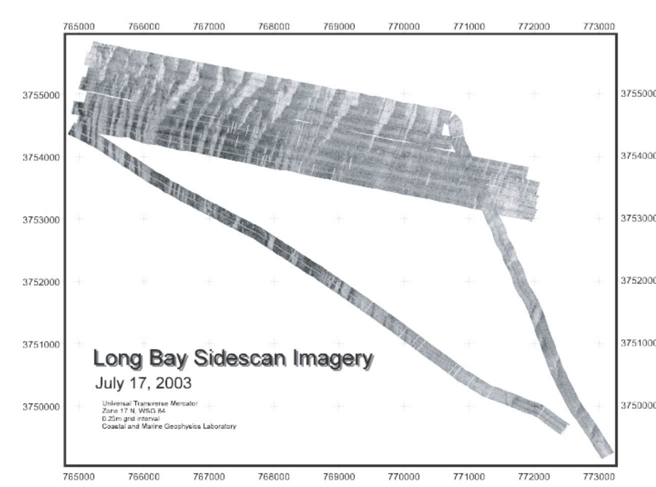


Figure 7. Long Bay sidescan imagery. Dark areas are high reflectivity sands and light areas are low reflectivity muds.

Two additional side scan surveys have been conducted in Onslow Bay during this reporting period following the passage of Hurricane Isabel in September 2003. Surveys were conducted at both the OB3 (innershelf) and OB27 (mid-shelf) monitoring sites. Imagery collected during the post-storm OB3 cruise have been mosaiked and georeferenced. The OB27 imagery is still being processed. Comparisons of the pre-storm and post-storm imagery from OB3 suggest that the hurricane had little impact on gross-scale bed morphology in the area even though considerable sediment movement occurred during the event. In total, more than 36 km^2 of high-resolution digital sidescan sonar imagery has been collected at nearshore and mid-shelf hardbottom sites in Onslow Bay. These images indicate localized displacement between contacts of coarse and fine sand bodies by as much as 25m over a one year period. These movements have important consequences for benthic infauna that are sensitive to changes in sediment texture and who reside in the sediments within 25m of a coarse/fine grain contact. Based on the physical data described below and the available side scan imagery, it appears that near-bottom flow conditions result in the frequent transport of fine sands which may cover and/or uncover underlying and adjacent coarse sand bodies.

Table 1. Grain size and organic content of surface grabs collected to ground truth side scan data.

Sample Designatio	UTM-Northin	UTM-Easting	% muds	% sands	% Organics
LB0307s2	3753761	771767	4.90%	95.10%	1.24%
LB0307s4	3753971	769775	1.89%	98.11%	1.27%
LB0307s5	3754440	769586	43.95%	56.05%	8.31%
LB0307s7	3754751	768059	93.35%	6.65%	15.68%
LB0307s11	3754042	765644	1.39%	98.61%	1.04%

Sedimentology

Sedimentology of Bottom Sediments: During the current reporting period, we proposed to continue collection and analysis of boxcores at the moorings located at OB3 and OB27, collect boxcores at any new moorings established in Long Bay, and to collect bi-monthly ponar grabs of bottom sediments at established sites along the cruise transects in Long Bay. We have collected and processed 2 to 4 boxcores approximately once every 6 weeks between July 2003 and November 2004 at both OB3 and OB27. Since new permanent mooring locations have not yet been established in Long Bay, boxcores have been collected at these sites to meet that objective. Ponar grabs, however, have been collected for all of the

Site	Date	%Mud	%Sand	%Organics
1	Sept. 2003			
	Nov. 2003	1.1%	98.9%	0.60%
	Jan. 2004	1.1%	98.9%	0.82%
2	Sept. 2003	6.6%	93.4%	1.52%
	Nov. 2003	14.0%	86.0%	2.43%
	Jan. 2004	96.6%	3.4%	14.10%
5	Sept. 2003	3.1%	96.9%	0.76%
	Nov. 2003	2.9%	97.1%	2.79%
	Jan. 2004	3.6%	96.4%	1.41%
6 *	Sept. 2003	24.4%	75.6%	5.18%
	Nov. 2003	9.8%	90.2%	2.28%
	Jan. 2004	3.7%	96.3%	1.64%
7	Sept. 2003	1.9%	98.1%	2.98%
	Nov. 2003	9.8%	90.2%	1.52%
	Jan. 2004	2.3%	97.7%	2.24%
8	Sept. 2003	1.1%	98.9%	1.23%
	Nov. 2003	1.2%	98.8%	0.79%
	Jan. 2004	1.5%	98.5%	0.61%
9	Sept. 2003	3.5%	96.5%	0.56%
	Nov. 2003	2.5%	97.5%	0.73%
	Jan. 2004	2.5%	97.5%	0.0075

Table 2. Grain size and organic content data for bottom sediment grabs collected in the vicinity of the Cape Fear River plume between September 2003 and January 2004.

cruise transect sites which are sampled bi-monthly on the RV Cape Fear. This reporting period included cruises in September and November 2003 and January 2004. In accordance with our proposed sampling processing timeline, these samples have been analyzed for grain size and organic content and the results are summarized in Table 2.

All boxcores collected, to date, at OB3 and OB27 have been subsampled and relief peels generated. All peels and subsamples have been archived. Selected subsamples from boxcores have been analyzed for grain size and organic content in order to obtain textural information needed to utilize benthic boundary layer models to evaluation sediment transport. Pre- and post-Hurricane Isabel cores have been analyzed in order to estimate the depth of reworking associated with storm passage in September 2003 (Figure 8).

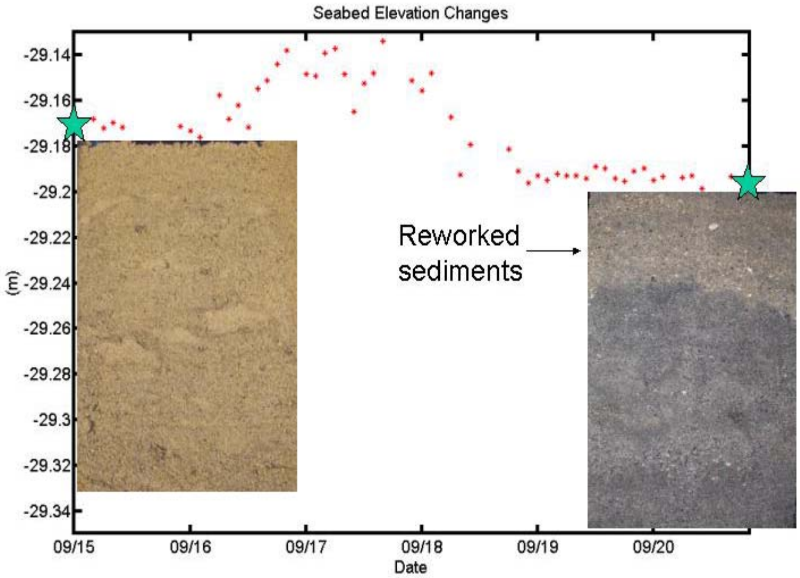


Figure 8. Pre- and post boxcores are aligned with the seabed elevation data. The storm layer is visible in the post-storm core as oxidized sediment. There was approximately 2 cm of net erosion of the seabed following storm passage although at least 7 cm of reworking is indicated given the deposition of a 5-6 cm thick storm deposit

Sedimentology of Suspended Sediment: Bi-monthly water samples from the top, middle, and bottom of the water column have been collected at each site along the Long Bay plume transects in order to determine the variation in total suspended solid (TSS) concentrations in the vicinity of the river plume. During the reporting period, data were collected on the September 2003, November 2003, and January 2004 cruises. TSS concentration (Figure 9) and percent organic content (determined by combustion) have been determined for all samples collected during the reporting period. Progress toward meeting this proposed objective is on schedule. Grain size distribution profiles of suspended particles have also been collected on each bi-monthly sampling cruise using the LISST through subcontract to Dr. George Voulgaris at the University of South Carolina. These data and the TSS data will be used to evaluate variability in the sedimentological character of plume water over seasonal time scales. These data will also be used to determine the relative contributions of terrestrial derived sediments versus the resuspension of bottom sediments.

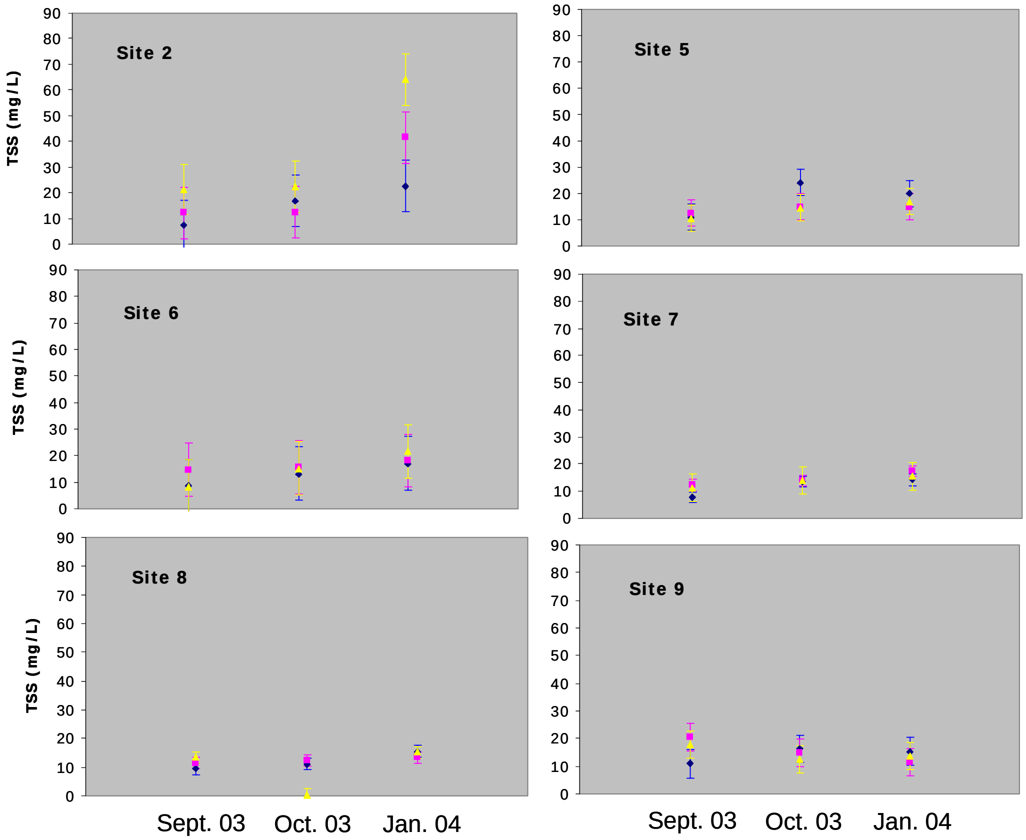


Figure 9. Mean TSS concentration in mg/L for water samples collected at top (blue), middle (pink) and near-bottom (yellow) water depths at sites 2 and 5-9. Error bars show 1 standard deviation about the mean concentration. TSS concentrations at most sites varied little with time or with depth over the period of sampling. In general, TSS concentrations were less than 30 mg/L. The highest and most variable TSS concentrations occurred at site 2 which is located closest to the river mouth. At site 2, both the ranges of concentrations and the temporal variability were very similar to those observed in the river mouth.

Boundary Layer Processes

During the period, we collected 5 months of near bottom (lowermost 1.5 meters of the water column) current data at the OB27 site. These data have been grossly examined for data quality and archived. In addition, we have collected, grossly examined and archived 5 months of seabed altimetry data at the OB27 site. By the end of the reporting period, we had analyzed more than 1,200 hours of near-bed current profiles and sea bed altimetry data collected at the OB27 site from 2000-2001, and we have identified three mechanisms leading to significant sediment transport on the mid-continental shelf: 1) wave-current interactions, 2) subtidal currents associated with sustained wind-driven flows and the intrusion of Gulf Stream water on the shelf, and 3) infragravity waves. We estimate that wave-current interactions in the bottom boundary layer at the site cause shear stresses at the sediment-water interface that exceed the critical threshold for sediment movement over 50% of the time during a typical climatological year. This result is inconsistent with the historical paradigm where it was believed that at mid-continental shelf depths on the U.S. east coast significant sediment transport only occurs during large magnitude storm events. Over the course of a *typical* year, the total net suspended sediment flux at 1 mab is in the positive along-shelf direction (southwest) and in the negative across-shelf direction (onshore). Several times more *net* transport occurs in the onshore direction (~ 142 db m s-2) than the along-shelf direction (16 db m s-2).

Four different types of events have been identified that cause significant sediment movement on the mid-continental shelf: 1) small to moderate northerly wind events, 2) Gulf Stream Intrusion events, 3) strong southerly wind events associated with the passage of frontal systems, and 4) the passage of tropical storm systems. Subtidal currents play a key role in the transport of sediment transport for all of the event types. While waves provide the resuspension mechanism, wind driven subtidal currents are important in determining the magnitude and direction of sediment transport during storm events. Subtidal currents, associated with Gulf Stream intrusion events coupled with fair-weather swell, may result in the gradual accretion of sediments (Figures 10 & 11). Moderate northeasterly wind events with sufficient duration to generate wind driven subtidal flows appear to result in an order of magnitude more sediment transport (20,237 g cm^{-2}) than wind events without developed wind–driven flows (~3,000 g cm^{-2}).

A bottom boundary layer model (bblm) (Styles and Glenn, 2000) has been used to determine shear stresses at the sediment water interface and quantify suspended sediment transport. Field measurements in the bottom boundary layer were compared with the bblm output for small to moderate wind events and for a large magnitude storm event, Hurricane Isabel. In addition, the suspended sediment concentration profiles from the model were compared with the ABS profile measurements to verify shape and magnitude as the storms increased and waned. In general, there was good agreement between the measured and model derived current profiles, and between suspended sediment measurements and the model concentration profiles for both large and small scale events (Figure 11).

One project goal for the current reporting period that remains unmet is the establishment of two additional mooring sites in Long Bay. Although the current meter instrumentation has been ordered, this process was delayed primarily due to a shift in the long-term goals of the CORMP program. During the current reporting period, senior CORMP scientific personnel agreed that all future mooring stations should have real-time capability. Therefore, it did was not judged cost effective from a time and resource perspective to pursue the establishment of non-real time systems that would be deployed for only a short-time before being replaced. Thus, before ordering the new instrumentation, it was necessary to discuss and organize our long range programmatic goals and investigate and plan an appropriate sampling strategy. We articulated our revised goals in our most recent proposal submission (FY2004-2005) and have ordered our new equipment with those goals in mind. When these instruments arrive, we are ready to place them in Long Bay in internal logging mode until new funds are available to deploy our proposed buoy systems and to convert them to a real-time capability. Once the instruments are in the water (in either mode), we will begin ancillary geological sampling at those locations. In the meantime, we have begun to collect ADCP surveys at each site along our plume sampling transects during our bi-monthly cruises. These efforts are accomplished using a downward looking ADCP that is deployed from the RV Cape Fear. Although this is not an ideal solution, it does provide some measure of the physical conditions existing when bi-monthly TSS and surface grabs are collected.

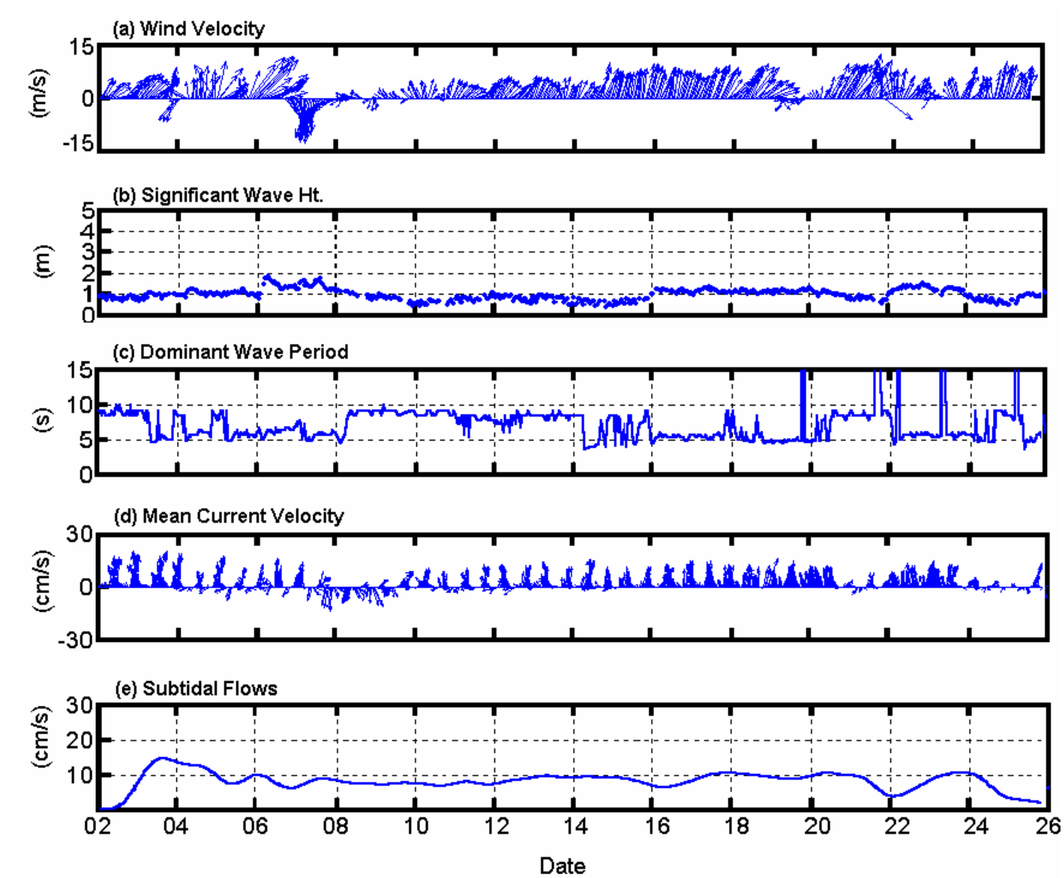


Figure 10. Wind, wave and nearbottom current data in June 2-26, 2000. Note the sustained mean currents from the south from June 10-26.

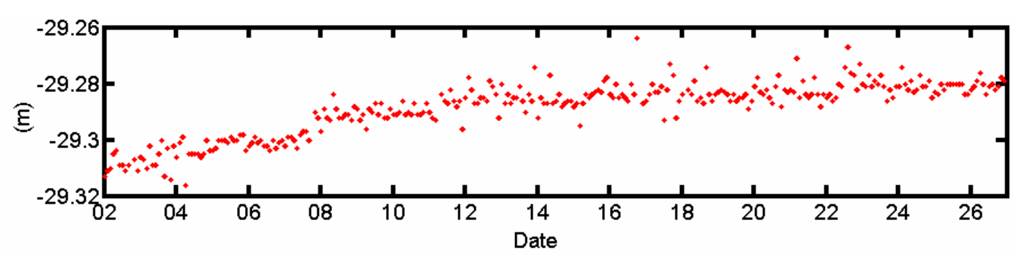


Figure 11. Seafloor elevation data from OB27 from June 2-26, 2000. The seafloor accreted by approximately 3 cm over this period.

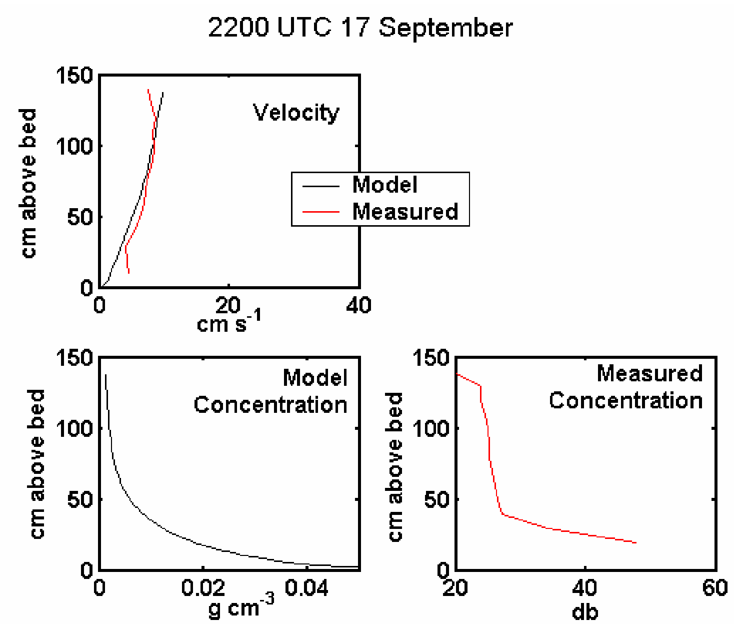


Figure 12. Comparison of the output from the benthic boundary layer model and measured parameters during near peak conditions during the passage of Hurricane Isabel. Again there was good agreement between the modeled velocity profile and the measured velocity profile in the lower 1 m. There was also good agreement in shape and magnitude of the suspended sediment profiles predicted by the model and observed using acoustic back scatter intensity provided by the ADCP.

Another major objective of our CORMP efforts has been to examine the effect of tropical storms on sediment resuspension and transport on the continental shelf. In September 2003, the passage of Hurricane Isabel provided one such opportunity to document storm effects in Onslow Bay. Using physical data collected by instruments mounted on the quad at OB27, we applied the Styles and Glenn bblm and estimate that the storm resulted in an order of magnitude more sediment transport (240,000 g cm^{-2}) than the next strongest wind event on record. Shear velocities ranged from 6 – 17 cm s^{-1} (Figure 13). Three days prior to the direct effects of the hurricane, long-period swells (14 – 17s) began to impact the area causing bedload and suspended sediment transport to occur on the mid-shelf well before the immediate impact of the storm was felt at the site.

During peak storm conditions, hurricane winds of 30 m s^{-1} directly affected the area and wind-driven currents of 12 cm s^{-1} were generated at 1 mab (Figure 13). Maximum wave-current shear velocities were coincident with wind-driven flows directed in the positive along-shelf direction (towards the southeast) resulting in large amounts of suspended sediment toward the southeast. A 5 - 6 cm thick storm deposit was present in the post-hurricane boxcores, although net erosion of 2 cm occurred at the site as a result of the storm (Figure 8). When both the thickness of the storm deposit and the pre- and post-storm bed elevations are accounted for, there was approximately 7 cm of storm reworking at the site (Figure 8). This is the first documented instance of this magnitude of reworking in this geographical vicinity.

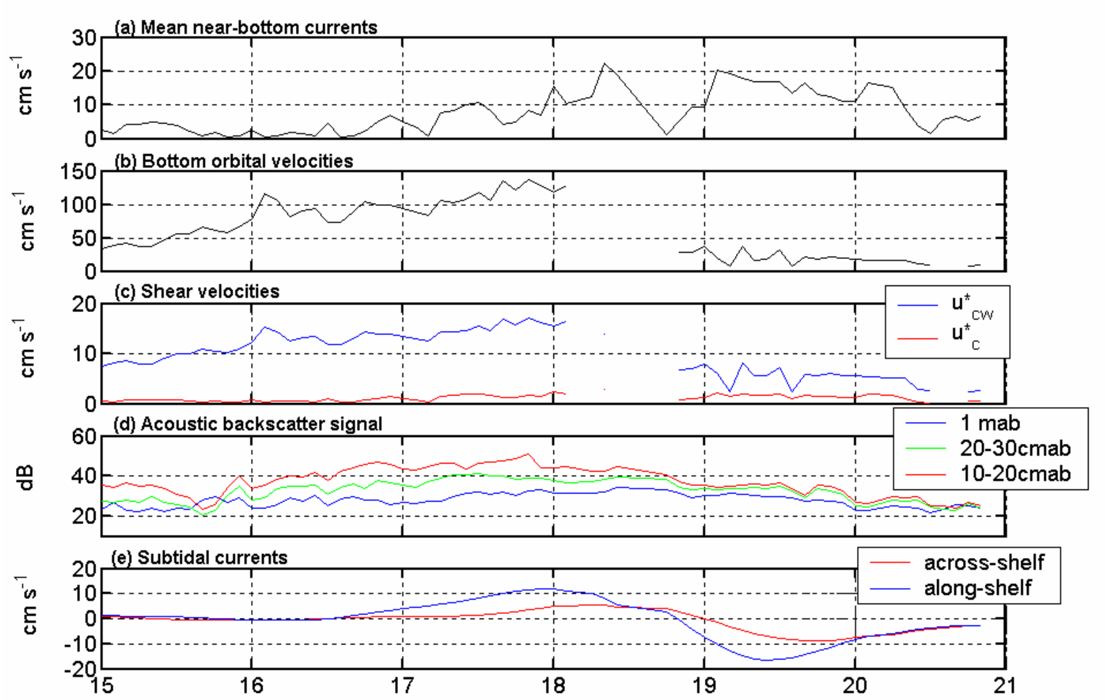


Figure 13. Near bottom conditions showing the impact from Hurricane Isabel.

An interesting observation, made possible only through the combination of diver-collected boxcores with the moored instrumentation, is that the seabed altimeter was actually detecting a very highly concentrated layer of suspended sediment (rather than the true bottom) during peak storm conditions. During the height of the storm, the altimeter data indicate an approximate 5 cm increase in seabed elevation with large variations (up to 6 cm) in the signal during the highest energy conditions of the storm (Figure 13). These data further suggest that the seabed was accreting and that large ripples were present at the site. During peak storm conditions, however, the wave boundary layer thickness ranged from 20 – 37 cm and only weak currents were available to transport the sediments suspended in the wave boundary layer. Thus, conditions were not conducive for accretion at this time.

Further, very high returns in the acoustic back scatter (ABS) time series measurements between 10 and 30 cmab are also consistent with the presence of a highly concentrated sediment layer near the bottom (Figure 13). These observations, in conjunction with the presence of a storm layer in the boxcores and net erosion at the site, made an accurate interpretation of the altimeter data possible. We have posted summaries of our Isabel data collection efforts on our web site and notified USGS scientists in St. Petersburg, FL as to the availability of these data and additional physical data collected at the inner shelf. The USGS are currently examining the effects of the storm on the N.C. outer banks, and we anticipate that they may use some of our data in future efforts to verify existing and developing wave and sediment transport models.

Commitments and Accomplishments

To date, few problems have surfaced meeting the commitments outlined in the original proposal with the few exceptions noted above. Data collection efforts, for the most part, have progressed in a timely fashion and we have seamlessly expanded our sampling efforts into Long Bay, as described in the proposal. We remain somewhat behind schedule in the processing of boundary layer data given limited technician and scientific personnel. This is especially true for the wave and current data. We now have 2 different mooring sites in Onslow Bay; both of which collect large quantities of data. When the Long Bay sites are established, we expect that our workload will almost double. Additional student assistance during the summer months is planned, and should adequately address the backlog in the data processing.

One of our PIs (Leonard) attended the IOOS workshop at the Estuarine Research Federation Meeting in Seattle in September, and discussed some of the challenges associated with the collection and dissemination of real-time or near real-time data with several workshop participants. From these discussions, it has become apparent that additional personnel are needed to assist with equipment maintenance, downloading, and deployment and retrieval. To alleviate this workload, we requested additional technician assistance for the next grant period (see 2004-05 CORMP proposal).

Particle Size Characterization of the Cape Fear Plume Progress Report, 8-03-7-04, Proposal Section 3 (Univ S.C.)

As part of the University of North Carolina at Wilmington (UNCW) CORMP 2003-04 CORMP program under sediment transport, studies are carried out to address the spatial and temporal extent of buoyancy and sediment inputs into the ocean and how waves and tidal currents affect these inputs. This subject includes the deployment of nearshore and offshore monitoring stations by UNCW and the undertaking of ship-borne operations every two months.

The University of South Carolina (USC) (Dr. George Voulgaris) was awarded a subcontract for the period August 1st 2003 to July 31st 2004 to participate in this task and contribute in the data collection during the fieldwork and in particular during the cruises organized by UNCW.

According to the subcontract, USC is responsible in carrying out tasks that aim at:

(1) defining the particle size characteristics of the sediments carried out by the Cape Fear plume; and
(2) relating the particle dynamics to plume physical characteristics and flow dynamics

This progress report describes the activities that have been performed to date. These can be summarized into (i) participation in an organizational meeting; (ii) participation in three research cruises; (iii) pre-processing of the collected data; and (iv) some preliminary results.

Dr. George Voulgaris and Mr. Yong Hoon Kim participated in an organizational meeting with scientists from UNCW that was held at Wilmington on October 24th 2003. During that meeting the details of the experimental design were discussed and various logistical details were clarified.

Data Collection. Mr. Yong Hoon Kim participated in three 1 day-long cruises that were organized by UNCW as part of this project. These took place on the following dates: November 7th, 2003; January 6th, 2004; and March 4th, 2004.

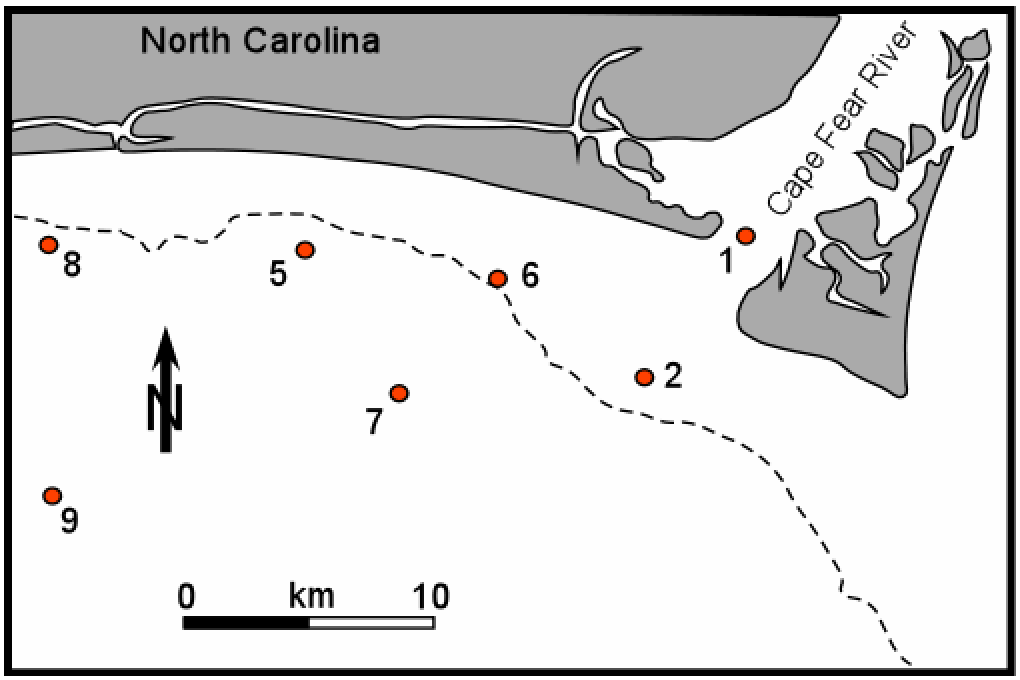


Figure14. Figure showing the Cape Fear River plume stations (1, 2, 5 to 9) established as part of the CORMP program. These stations were sampled by USC during the three cruises.

For each of the cruises USC provided the instrumentation for carrying out the measurements on particle dynamics throughout the water column. The instrumentation consisted of an Ocean Sensors 200 CTD integrated with an Optical Backscatter Sensor (OBS) and a Laser In-Situ Scattering Transmissometer (LISST-100). The OBS provided information on the bulk suspended sediment concentration in the water column while the LISST was used to provide information on the volume concentration per size fraction over the range of 1.3 to 230μm.

During each cruise, seven stations (stations 1, 2 and 5 to 9, see Figure 14) located within the region of the Cape Fear plume were occupied. At each station the instrument package was slowly lowered down through the water column to the bed. The sampling frequency for all instruments was 1Hz, which resulted in a vertical resolution of approximately 0.05m. Following data collection, and in order to increase statistical significance, the data were vertically bin-averaged into bins of 0.25 m.

Prior to pre-processing the OBS data were converted into mass concentration (g/l) using a preliminary calibration equation obtained in the laboratory using estuarine mud sediments. This calibration will be modified in the near future when the in-situ data, collected by the UNCW researchers, become available. Grain size distribution and volume sediment concentration (for the range 1.3 to 230 µm) was obtained from the scattering characteristics of the laser light obtained using the LISST system.

The LISST instrument uses a 670 nm Laser to measure *in-situ* grain size distribution based on light transmittance through a sample volume of water. Light that is scattered by particles in the water column is received by an array of photodetectors consisting of 32 different log-spaced bins representing 32 different diffraction angles which in turn correspond to different particle size ranges. The area distribution for each size class is related to the scattered light energy by:

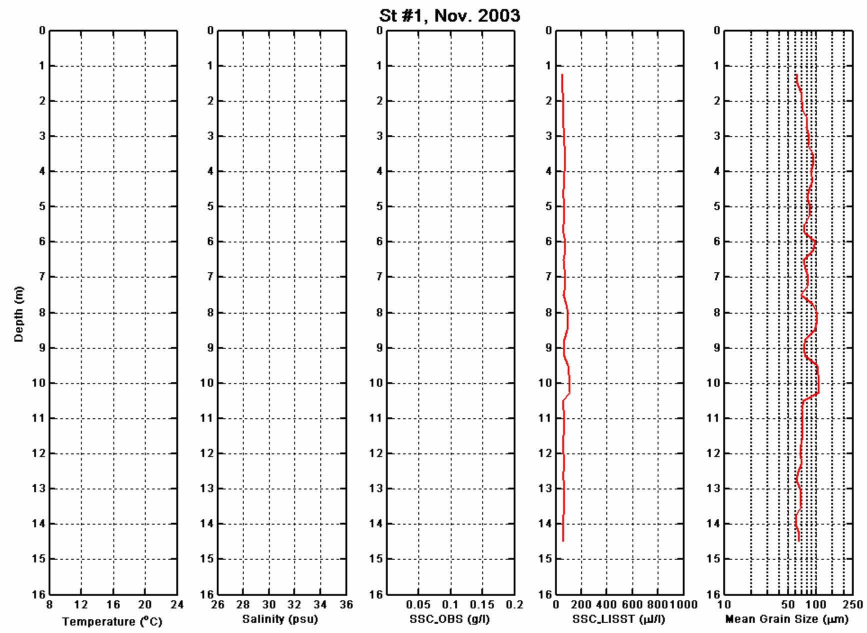
$$E = K \cdot N$$

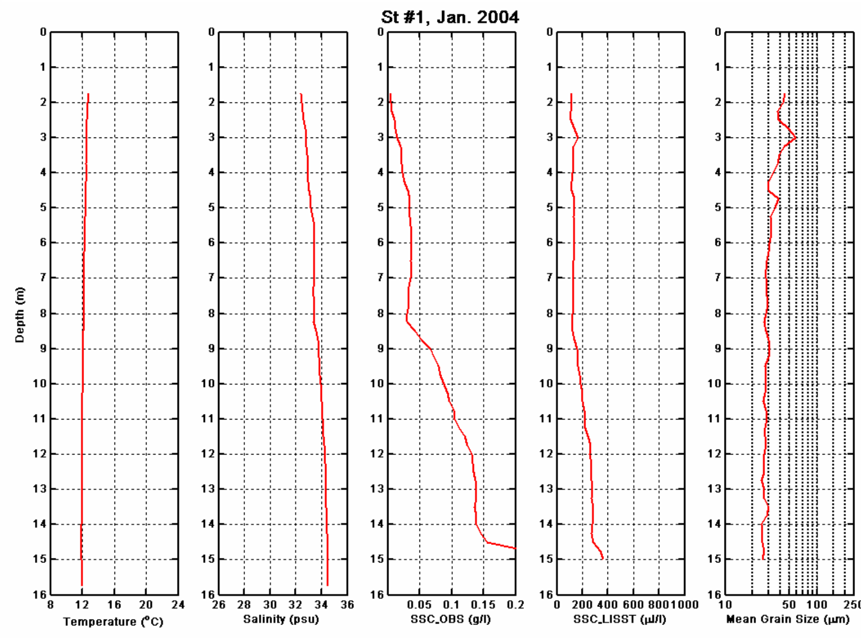
(1) where E = the light energy detected by all of the photodetector rings of the LISST and K = an inversion matrix developed based on light scattering theory (Agrawal and Pottsmith, 2000). The LISST measures E and the area concentration is estimated by using equation (1). The volume distribution is found by multiplying the area distribution for each size class by the mean diameter for that size class and dividing by a calibration constant C. Any particles larger than 230 µm (the maximum measuring limit of LISST-100B) are accounted for in the bins of the largest particles that the LISST can differentiate. Although this leakage of light from coarser particles can lead to an overestimation of concentration of particles around 230 µm in size, the relative change of grain size distribution can be resolved by the LISST measurements. This dominant grain size distribution was expressed by the geometric mean grain size (GM) calculated from the percentiles of the volumetric concentration LISST data using Folk and Ward's (1957) statistical method:

$$GM = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

(2) where ϕ_{16}, ϕ_{50}, ϕ_{84} are the 16%, 50% and 84% percentiles of the distribution.

Preliminary Results. Vertical variations as a function of time have been measured for temperature, salinity, suspended sediment concentration and mean particle size for each station sampled during the three cruises. An example of such data representations is illustrated on the following page. **(**Copies of all pre-processed data have been given to CORMP.)





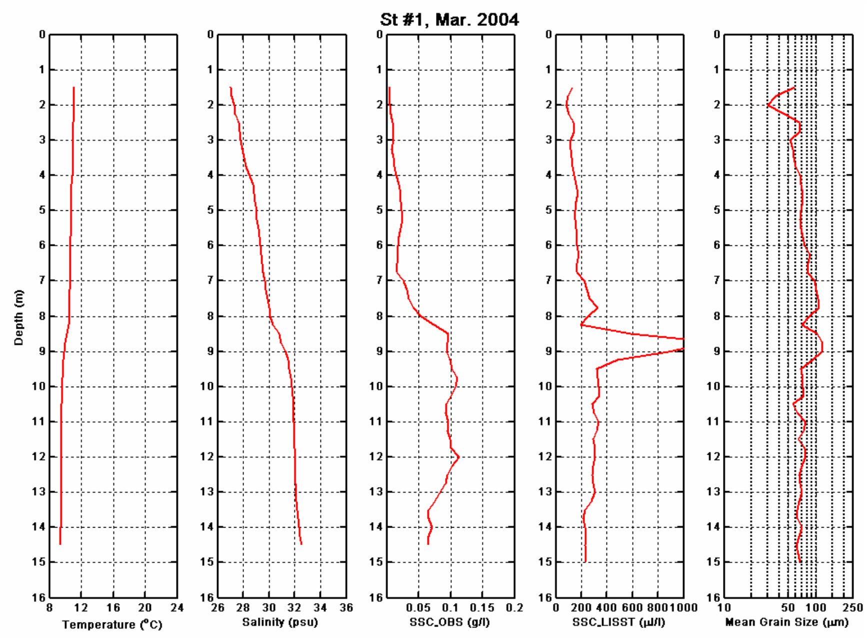


Figure A.1. CFP-St.1: Vertical variability of (i) temperature; (ii) salinity; (iii) bulk suspended sediment concentration (from OBS); (iv) volumetric suspended sediment concentration; and (v) mean particle size estimated from the LISST data for the November 2003 (top left), January 2004 (top right) and March 2004 (bottom left) cruises. (Note: during the November 2003 cruise no CTD data were collected due to instrument malfunction.

Nutrients, Bio-Optics and Ecosystem Production in Onslow Bay, Long Bay, and the Cape Fear River Plume, Proposal Section 3, 8 /1/03-01/31/04

Water Quality and Nutrients

Great progress has been made in addressing objectives for the 2003-2004 CORMP proposal. 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. We are amassing a solid data-base of both planktonic and benthic algal biomass and the physical and chemical factors influencing them (Tables 3, 4 & 5). Clearly, planktonic chlorophyll and nutrients in the nearshore Long Bay well exceed those of nearshore and offshore Onslow Bay (Table 3). 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 (Table 3).

Table 3. Average nutrient, chlorophyll *a*, and irradiance characteristics of selected CORMP surface water sampling stations in a river-influenced area of Long Bay compared with non-river influenced Onslow Bay (2000-2003).

Station	CFR2	CFR6	OB5	OB27	OB63
Chlor *a* ($\mu g\ l^{-1}$)	3.73	3.07	0.42	0.10	0.12
NO_3 (μM)	3.17	1.36	0.11	0.24	0.41
NH_4 (μM)	1.57	1.08	0.30	0.70	0.84
Depth z (m)	10	10	15	27	118
K_{PAR} / m	1.37	0.68	0.23	0.14	0.16
I_Z as % I_0	0.01	0.11	3.17	2.28	<0.01
Distance from shore (km)	5	7	8	45	100

Another objective was to determine if variability in productivity in Onslow Bay is seasonal and closely correlated with nutrient levels and physical processes. We do not yet have productivity rate measurements, but we have copious phytoplankton biomass data in the form of chlorophyll *a*. In Onslow Bay there does not seem to be any major seasonality associated with nutrients and phytoplankton biomass. Nutrient concentrations are clearly related to physical advection processes. Nitrate concentrations are highest offshore at OB63 in near bottom waters and mid-depth waters (Table 4). This nitrate is evidently advected into the system from near-bottom Gulf Stream intrusions onto the shelf. However, in those deep areas (> 50 m) solar irradiance has been attenuated to the extent that not enough light is available for the deep phytoplankton to utilize the nitrate (and ammonium) to produce significantly higher biomass than in surface waters (Table 4). Spatially, phytoplankton biomass on average is 3-4X higher at OB5 than either OB27 or OB63 (Table 3). However, inorganic nitrogen concentrations are lower at all depths at OB5 than the offshore locations (Table 3 and 4). Possibly, available nitrate at OB5 is rapidly assimilated by phytoplankton in these well-lit waters, yielding the greater chlorophyll *a* biomass found in nearshore Onslow Bay (Table 4).

Table 4. Nutrient and chlorophyll *a* distribution at surface (S), middle (M), and bottom (B) stations at the Onslow Bay sampling sites, presented as mean and standard deviation. Mid-depths were approximately 7, 13, and 58 m, for OB5, OB27, and OB63, respectively (2000-2003).

Station		OB5	OB27	OB63
NO_3 (μM)	S	0.11±0.18	0.24±0.17	0.41±0.43
	M	0.08±0.15	0.23±0.17	1.38±1.11
	B	0.13±0.07	0.24±0.18	4.66±3.06
NH_4 (μM)	S	0.33±0.30	0.70±0.50	0.84±0.82
	M	0.31±0.27	0.81±0.88	0.73±0.36
	B	0.33±0.24	0.83±1.08	1.07±0.98
PO_4 (μM)	S	0.11±0.03	0.26±0.55	0.20±0.30
	M	0.13±0.05	0.27±0.56	0.31±0.21
	B	0.15±0.09	0.17±0.12	0.59±0.38
$Si(OH)_4$ (mM)	S	NA	1.18±1.54	0.82±0.60
	M	NA	1.13±1.12	1.00±0.52
	B	NA	0.40±0.46	1.19±0.72
Chlor *a* (μg l^{-1})	S	0.42±0.20	0.10±0.08	0.12±0.17
	M	0.41±0.19	0.12±0.09	0.14±0.10
	B	0.47±0.18	0.24±0.19	0.11±0.17

NA = no data available

An additional objective was to determine if variability in productivity in CFP and LB is seasonal and related to CFR discharge, but exhibits temporal and spatial displacement from nutrient levels because of light attenuation. Water column phytoplankton clearly dominate in terms of chlorophyll *a* biomass in the Cape Fear River plume nearshore Long Bay compared with both nearshore and offshore Onslow bay (Table 5). The nutrient load from the river, augmented by estuarine phytoplankton, undoubtedly drives this situation (Table 3). Our earlier CORMP data showed a statistical correlation between river flow and nitrate concentrations as far out as Stations CFP5-7 (reported at SEERS and ERF meetings). However, the turbidity and CDOM load from the river attenuate light below the plume, so that sediment chlorophyll *a* is much lower in the plume area as opposed to OB5 and OB27 (Table 5). Sediment chlorophyll *a* at OB63 is constrained by solar irradiance deficiency due to the great depth (Tables 3 and 5).

Table 5. Measured and estimated average areal chlorophyll *a* concentrations of selected CORMP water column (WC) and sediment (SED) sampling stations in a river-influenced Long Bay area and non-river influenced Onslow Bay (2000-2003).

Station	CFP2	CFP6	OB5	OB27	OB63
WC Chlor *a* (mg m^{-2})	37.3	30.7	6.5	3.4	14.6
SED Chlor *a* (mg m^{-2})	12.3	10.7	58.3	70.0	<10.0

SED Chlor *a* for CFP 2 and CFP6 was computed from samples collected during 2003 (n = 7 and 8, respectively); SED Chlor *a* for OB5 and OB27 also collected in 2003 (n = 12 and 11, respectively), and OB63 from Cahoon et al. (1990) and Cahoon et al. (1992).

To summarize, two adjoining regions of the South Atlantic Bight (SAB), Onslow Bay and nearshore Long Bay, are being investigated in terms of nutrient and chlorophyll *a* concentrations and distributions over a three-year period. Onslow Bay represents the northernmost region of the SAB, and receives very limited riverine influx. In contrast, Long Bay, just to the south, receives discharge from the Cape Fear River, draining the largest watershed within the State of North Carolina. Northern Long Bay is a continental shelf ecosystem that has a nearshore area dominated by nutrient, turbidity and water-color loading from inputs from the river's plume. Average planktonic chlorophyll *a* concentrations ranged from 4.2 $\mu g\ l^{-1}$ near the estuary mouth (CFP2), to 3.1 $\mu g\ l^{-1}$ 7 km offshore in the plume's influence (CFP6), to 1.9 $\mu g\ l^{-1}$ at a non-plume station 7 km offshore to the northeast (CFP3). Average areal planktonic chlorophyll *a* was approximately 3X that of benthic chlorophyll *a* at plume-influenced stations in Long Bay. In contrast, planktonic chlorophyll *a* concentrations in Onslow Bay were normally < 0.50 $\mu g\ l^{-1}$ at a nearshore (8 km) site OB5, and < 0.15 $\mu g\ l^{-1}$ at sites located 45 and 100 km offshore (OB27 and OB63). However, high optical water quality (K_{PAR} 0.10-0.25 m^{-1}) provides a favorable environment for benthic microalgae, which are abundant both nearshore at OB5 (average 58.3 mg m^{-2}) and to at least 45 km offshore at OB27 in Onslow Bay (average 70.0 mg m^{-2}) versus average concentrations of 10-12 mg m^{-2} for river-influenced areas of Long Bay. This provides evidence that much of the inner shelf food web in Onslow Bay is based on benthic microalgal production, in contrast to a plankton-based food web in northern Long Bay and more southerly areas of the SAB. A manuscript based on these results has been produced (Mallin, M.A., L.B. Cahoon and M.J. Durako, "Contrasting food-web support bases for adjoining river-influenced and non-river influenced continental shelf ecosystems") that has been submitted *to Estuarine, Coastal and Shelf Science.* The reviews were quite favorable and the manuscript us presently being revised.

Finally, a long-standing objective of the CORMP program has been to analyze the effect of major events on coastal and shelf waters. We had that opportunity in Fall 2003. On September 18, 2003, Hurricane Isabella passed over Onslow Bay, offshore of the North Carolina coast. Large amounts of suspended sediment transport occurred after hurricane winds began to directly affect the area and wind-driven currents were generated. Acoustic backscatter signals indicated extremely high levels of suspended sediments in the bottom boundary layer during peak conditions of the storm, especially in the lower 30 cm. Sampling was performed three days before and five days after the event at the surface, mid-depth, and bottom of the water column at stations located 8 (OB5), 20 (OB15), and 45 (OB27) km offshore. Total phosphorus, orthophosphate, and nitrate concentrations showed little difference between pre-and post-hurricane samples. However, ammonium concentrations increased 2-7X over pre-hurricane conditions at all sites and depths. Total nitrogen increased 20-30% at the middle and near bottom depths but was unchanged at the surface. Contrary to our expectations, chlorophyll *a* did not increase following the event, and decreased from 2.5 to 0.5 μg/L in OB5 surface waters. The event caused secchi depth to decrease from 12.0 to 4.5 m at OB5, from 13.0 to 6.0 m at OB15, and from 11.0 to 7.0 m at OB27. We hypothesize that decreases in light availability constrained phytoplankton productivity despite the increased inorganic nitrogen (ammonium) concentrations following the storm. Further, any resuspension of benthic microalgae into the water column did not lead to increased water column chlorophyll *a* concentrations. The effect of deep mixing by Hurricane Isabella was to suppress rather than enhance phytoplankton productivity in Onslow Bay. These results will be presented at the Spring 2004 meeting of the Southeastern Estuarine Research Federation at Harbor Branch, Florida, by P.I. Mallin along with coauthors O'Reilly, Leonard, Wrenn, Souza and Wells.

User Group Interactions. Dr. Michael Mallin met again with North Carolina Shellfish Sanitation in Morehead City and discussed their stations and program for regular monitoring of microbial pathogen indicators. They are aware of the work reported here and CORMP efforts and abilities to obtain supplemental microbial data following events that could propel land-derived pathogens seaward. Also, Dr. Mallin and other CORMP principals have discussed CORMP's objectives and capabilities with the Lower Cape Fear River Program Technical Committee and Advisory Board. Some of the CORMP data discussed here will be used in Dr. Rich Huber, Professor, UNCW Watson School of Education and a CORMP contributor, who is using CORMP data to produce a user-friendly computer-based teaching tool as a CORMP public outreach and public education mechanism.

Fisheries

<u>Plankton sampling.</u> Objectives: 1) To characterize the distribution, abundance and seasonality of commercially-important finfish and shellfish larvae in the vicinity of the Cape Fear River discharge plume, and 2) to examine the implications of environmental variability in plume conditions for fishery recruitment.

Progress: Activities for the period July-January 04 included continued monitoring and research of the influence of the Cape Fear River discharge plume on recruitment processes in fishes and decapod crustaceans. Plankton sampling for finfish and decapod larvae was completed as proposed for this period at plume, estuarine and ocean stations in the vicinity of the Cape Fear River discharge plume (Figure 15).

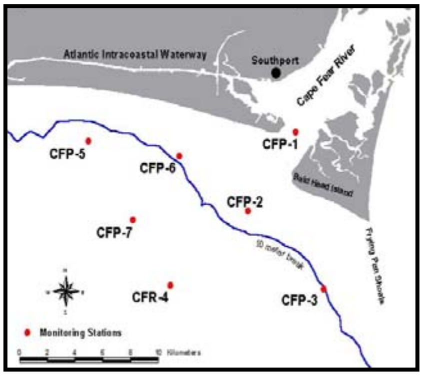


Figure 15.
Location of estuarine (CFP-1), plume (CFP-2, CFP-6) and ocean (CFP-4, CFP-7) stations sampled for larval finfishes and decapods, Jul-Dec 2003.

Relatively favorable wave conditions during the period permitted samples to be collected during all months except November. Sorting and taxonomic identification of all samples (n-180) collected during the period have been completed . A summary of ichthyoplankton collected in 2003 is provided in Table 6.

Table 6. Taxonomic summary of the abundance of larval fishes collected at plume, ocean and estuary stations during 2003 sampling.

		Habitat		
Family	Species	Plume	Ocean	Estuary
Blenniidae	Hypsoblennius hentzi	0	2	0
Carangidae	Caranx crysos	6	4	0
	Decapturus punctatus	0	1	0
Clupeidae	Brevoortia tyrannus	0	0	2
Engraulidae	Anchoa spp.	81	38	13
Gobiidae	Gobiosoma bosci	89	0	1
Paralichthyidae	Paralichthys spp.	6	0	0
Triglidae	Prionotus spp.	2	0	0
Sciaenidae	Micropogonias undulatus	128	2	2
	Leiostomus xanthurus	21	1	8
	Cynoscion nebulosus	3	1	0
	Cynoscion regalis	12	1	1
	Menticirrhus americanus	41	2	0
	Stellifer lanceolatus	2	0	0
Soleidae	Trinectes maculatus	36	0	0
Sparidae	Lagodon rhomboides	3	3	85
Syngnathidae	Hippocampus erectus	0	1	0
	Total	430	56	112

Preliminary inspection of larval concentration (# per m^3) data for the July-December 2003 period reveals generally higher values at plume stations (Figure 16). This pattern is consistent with previous data from 2003 and 2002 which indicate that plume stations often support higher concentrations of larval fishes than adjacent ocean stations. The pattern suggests that plume environments may provide chemical and/or physical cues which serve to attract and aggregate larval fishes.

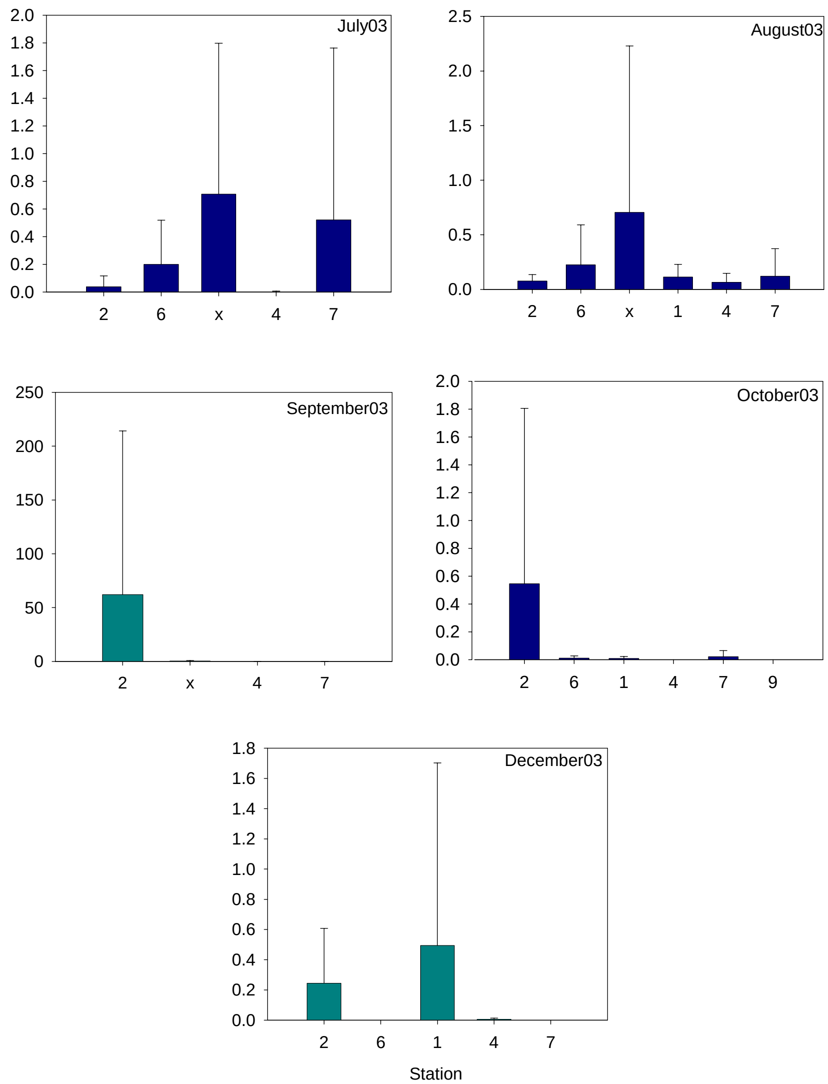
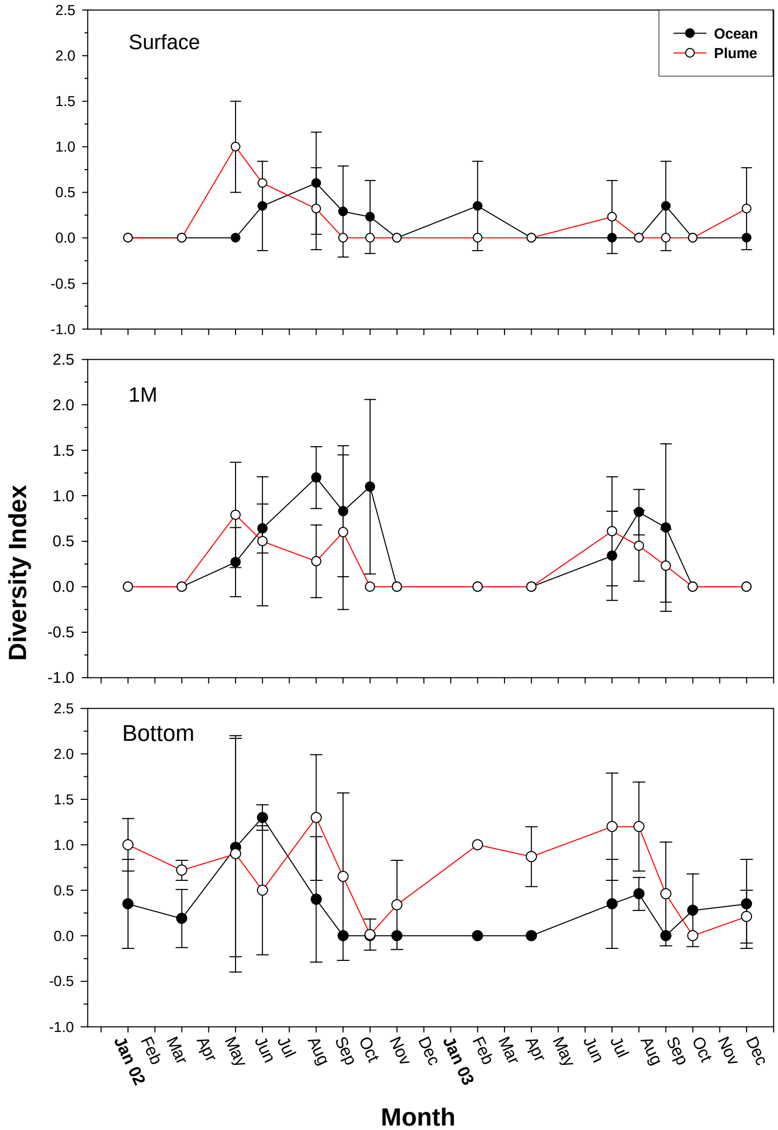


Figure 16. Monthly estimates of larval fish concentration (# per m^3) at estuarine (station 1), plume (stations 2, 6 and x) and ocean (stations 4, 7 and 9) for the period July-December 2003.

Statistical analyses are underway to examine the influence of discharge variability on the composition, abundance and diversity of larval assemblages collected in the CFR plume during 2002 (drought conditions with unusually low river discharge levels) to those for 2003 (high precipitation and river discharge). Preliminary observations indicate that higher discharge during 2003 may have positively influenced bottom diversities at plume stations (Figure 17).



Mean (+ 1 standard deviation) Shannon-Wiener diversity indices by depth for plume versus ocean stations.

Figure 17

As proposed for 2003-04, trawl surveys targeting the juvenile stage of blue crabs are scheduled for summer 2004. Trawling will be conducted in the vicinity of the Cape Fear River plume and will compliment the larval data in terms of identifying the role of this coastal area in the fishery recruitment and production process.

Biochemical & Otolith Analyses. The objectives of the biochemical and otolith analyses it to develop indicators of individual growth and nutritional condition which can be applied to resource species in an efforts to examine the influence and importance of the Cape Fear River discharge plume as essential fish habitat. This objective is an important component of the hypothesis that plume environments may increase fishery production through trophic enhancement.

Progress: Indicators of growth (otolith increment width analysis) and condition (cytochrome oxidase and hexokinase enzyme activity) that were developed for this project have now been applied to three commercially-important species [spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*) and brown shrimp (*Farfantepenaeus aztecus*)] to examine the relative value of estuarine versus plume habitats as finfish and shellfish nurseries. For example, preliminary data for Atlantic croaker suggest that individuals collected from plume habitats were displaying similar rates of growth (Figure 18) and levels of nutritional condition (Figure 19) as individuals from estuarine habitats.

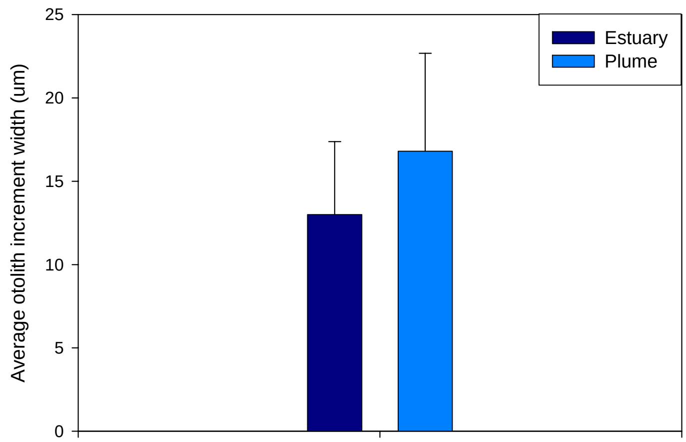


Figure 18. Mean otolith increment widths for Atlantic croakers collected from estuarine versus plume habitats during summer 2003.

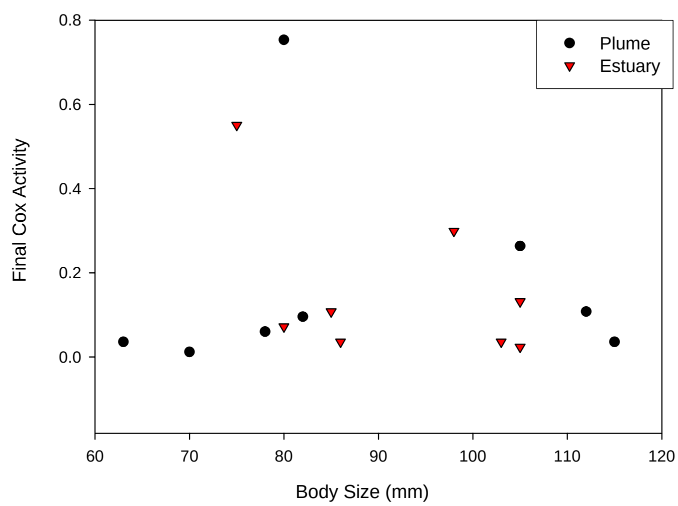


Figure 19. Cytochrome oxidase activity levels measured for individual Atlantic croakers from estuarine versus plume habitats.

Genetic Assays. Objectives of the genetic assays is to apply previously developed genetic assay techniques (developed under CORMP and NC SeaGrant support) to determine the species composition of portunid larvae collected as part of the monthly sampling of the Cape Fear River Plume.

Progress in the genetic assay portion is summarized as follows: Portunid larvae (N=46) were detected in plume samples collected in July, August, September and October (Table 7). DNA was extracted from individual larvae, and subjected to a multiplex PCR amplification designed to distinguish *C. sapidus* from *C. similis* (see previous reports for details of assay). Overall, 52% (24/46) of the megalopae collected were identified as *C. sapidus* based on the results of the assay, 20% (9/46) were identified as *C. similis*, and the remainder generated no signal. Monthly results are shown in Figure 20. We performed sequence analysis (562 base pairs of the mtDNA COI coding region) of a subset (35) of the samples to verify the results of the assay. In all cases the assay identification of *C. sapidus* was supported by the sequence analysis. A fraction of the samples (2/9) designated to be *C. similis* by the assay were identified as *Portunus gebbesii* by the sequence analysis. The assay category of “no signal” consisted of *Portunus* spp.(4/13), *C. ornatus* (2/13) and unknown species (7/13).

Table 7: Sample information for portunid larval samples subjected to genetic identification.

Date	Station-depth- sample number	Number of portunid larvae
7-16-03	X – B – 1	4
	2 – B – 2	1
8-14-03	1 – B – 2	2
	2 – B – 2	1
	6 – B – 1	1
9-26-03	X – B – 2	4
	2 – B – 1	12
	2 – B – 2	5
	2 – 1m – 1	1
	2 – 1m – 2	1
	2 – S – 2	1
	4 – B – 2	1
	7 – B – 1	1
10-13-03	1 – B – 1	1
	1 – B – 2	1
	2 – B – 1	4
	2 – B – 2	3
	2 – 1m – 2	1
	9 – B – 1	1

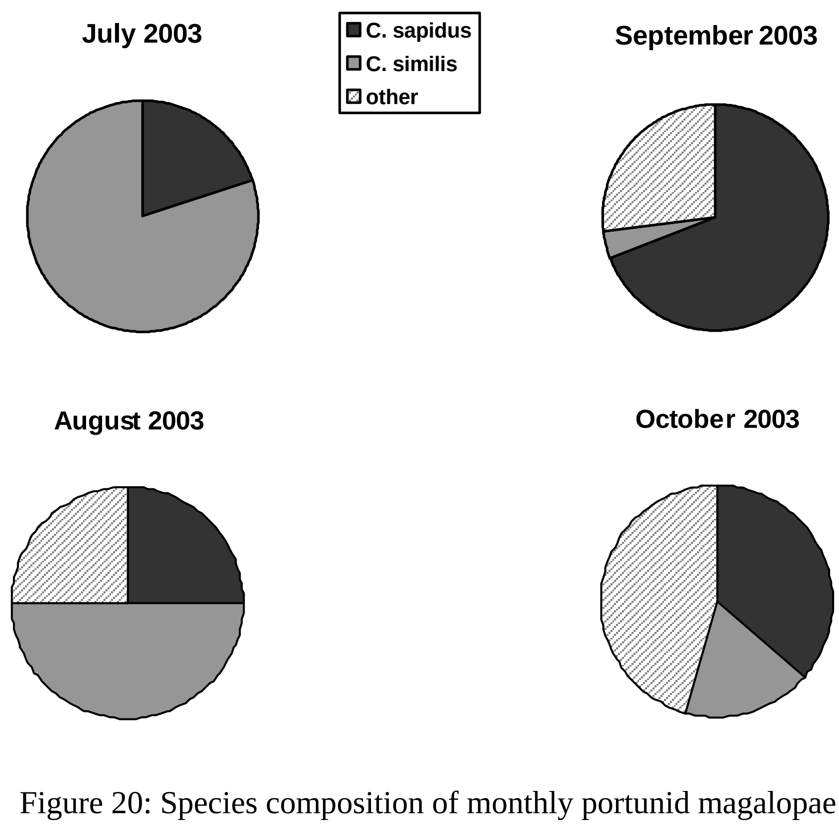


Figure 20: Species composition of monthly portunid magalopae samples based on multiplex PCR assay.

Partnership activities. Coordinated efforts have been developed and initiated with Dr. Dennis Allen (Baruch Institute, University of South Carolina) who began sampling in the Winyah Bay discharge plume following the CORMP design and protocols used to monitor recruitment in the Cape Fear River discharge plume. This collaborative sampling will enable us to examine larger-scale/coastwide recruitment patterns. Colleagues at Baruch Laboratory collected monthly samples from Winyah Bay plume during the expected period of peak blue crab recruitment (Aug-October). These samples are currently being sorted and processed for taxonomic identification by personnel at Baruch Lab.

Optical Properties, Primary Production and ENSO Effects

ENSO Effects on the CORMP Coastal Region. The primary objective for ENCO effects was "to test the hypothesis that climatic (ENSO) variability exerts a greater influence on water quality and system productivity in river-influenced areas (LB) compared with areas with little river influence (OB), using regression-based statistical examination of the relationships among meteorological variation, river discharge, nutrient levels, optical characteristics, pigments, and system productivity."

CORMP has obtained monthly average river discharge data from 115 river gauging stations in the southeast US (SEUS = Florida, Georgia, South Carolina, North Carolina) spanning mountain, piedmont, and coastal plain geographical provinces for the period 1950-2003. We have also obtained monthly index data for the El Niño/Southern Oscillation (ENSO) for the same period, including values of the Southern Oscillation Index (SOI) and values for sea surface temperature (SST) in Niño region 1+2 (eastern equatorial Pacific, Galapagos and coastal South America areas) and Niño region 3 (central-eastern equatorial Pacific). Analyses to date indicate that correlations are weaker for river discharge vs. SOI than vs. either SST index, and that correlations between river discharge and SST are strongest for SST in Niño region 1+2. In addition, correlations are stronger after 1980 than before. Table 8 for 1980-2003 presents these correlations in descending order, showing that the effect of ENSO variability is very strong in portions of the SEUS centered around coastal Georgia. These data indicate that ENSO variability exerts a strong effect on the delivery of water and river-borne materials (sediments, nutrients, pollutants) into the South Atlantic Bight.

Statistical analyses of these relationships are continuing, and will include analysis of the strength of correlations during successive 20-year periods from 1950 onward, analysis of the strength of correlations geographically (with mapping), and multiple regressions to determine the effects of basin size, location, period, and other variates on the relationship. Ultimately regressions (predictive relationships) will be generated for river discharge vs. ENSO status for each river basin in the SEUS.

Newer and more robust models to forecast ENSO conditions promise to make the spatial correlations we are developing valuable in predicting river discharges and, hence, concomitant effects on water supplies, estuarine salinity distributions, and coastal ocean salinity and temperature patterns. For example, a new model from Ohio State University (www.stat.ohio-state.edu/~sses/collab_enso.php) predicts ENSO effects on sea surface temperatures in the eastern Pacific, which we have found to correlate unusually well with river discharge patterns in the SEUS.

Primary Production. Specific objectives were:

1) Determine if the relative vertical distribution of primary producer biomass varies predictably with light flux and nutrient availability, and
2) Determine if benthic primary producers dominate in clear, nutrient-poor waters and phytoplankton dominate in waters with higher light attenuation coefficients and nutrient levels.

These two objectives have been addressed by ongoing measurements of phytoplankton and benthic microalgal biomass (as mg chlorophyll *a* m^{-2}), nutrients (*u*M inorganic N and P), and light flux (k_{PAR} and *u*E m^{-2} s^{-1}) at Cape Fear River plume stations and at Onslow Bay stations. A manuscript has been submitted which describes these results more fully. The data show quite clearly that the low nutrient, high-light flux waters in Onslow Bay support very low phytoplankton biomass but very high benthic microalgal biomass (Figure 21), while the reverse is true in the turbid, high-nutrient Cape Fear River plume. Thus, we have shown that the effect of river discharge is to favor phytoplankton production over benthic microalgal production in portions of the shelf receiving significant inputs of river water, and that unaffected shelf waters are dominated by benthic and near-bottom production.

Other objectives were:

3) Assess whether spatially- and temporally-integrated primary and secondary production is highest in waters influenced by the Cape Fear River plume (CFP), and higher overall in Long Bay than in Onslow Bay,
4) Assess effects of variability in primary production and detrital inputs on consumer species composition and secondary production (biomass).
5) Determine if variability in productivity in OB is seasonal and closely correlated with nutrient levels and physical processes.
6) Determine if variability in productivity in CFP and LB is seasonal and related to VFR discharge, but exhibits temporal and spatial displacement from nutrient levels because of light attenuation.

Efforts reported on these objectives in this subsection are primarily with regard to the focus on primary production and primary producer biomass.

Primary production is to be assessed using Fast Repetition Rate Fluorometry, using a ship-deployed Chelsea Instruments Fast Tracka FRRF. The instrument was ordered as soon as resources were available in August 2003. The instrument was delivered in January 2004. We are currently working on configuration and logistics issues, and will begin calibration work shortly. This work will specifically address objectives 3-6 above. Primary producer biomass has been measured as water column chlorophyll *a*, benthic chlorophyll *a*, and as near-bottom fluorescence measured by SCUFA instruments deployed at OB 27 and OB 3. Comparisons of integrated water column chlorophyll *a* and benthic chlorophyll *a* show that a large majority of the primary producer biomass at both stations is benthic (Figures 22 & 23). Note that there is evidence of both seasonal variation and an effect of Hurricane Isabel (Sept. 16, 2003) on benthic microalgal biomass. Isabel did not remove all benthic chlorophyll *a*, perhaps owing to the storm's more easterly track, offshore winds, and relatively short duration. This work partially addresses objective 5.

Near-bottom fluorescence data from OB 27 show a distinct spring bloom, a summer bloom, and a resuspension effect by Hurricane Isabel (Figure 24). They illustrate the strong variability in primary producer biomass that characterize this ecosystem and the importance of continuous monitoring in capturing these events. Quarterly or even monthly sampling, as in many previous efforts, would have seriously underestimated the magnitude and variability of these responses. This work also partially addresses objective 5 and efforts described in Section 3 of the CORMP proposal for 2003-04.

Our data also show that there are three somewhat overlapping groups of primary producers in these waters: a distinct phytoplankton group that is relatively well studied (although insufficiently so for many predictive purposes), a distinct benthic microalgal group that is more well studied in this coastal ecosystem than anywhere else, but, again, poorly studied in most respects, and "tychopelagic" group of easily resuspended microalgae that live on or near the bottom and comprise the frequent near-bottom chlorophyll *a* maxima found in these coastal ecosystems. Virtually nothing is known about this assemblage except as occasional portions of the other two groups. Our data from SCUFA deployments and directed diver sampling efforts provide the first systematic exploration of the biomass of this group. We will direct FRRF studies toward measuring productivity of this assemblage.

Accomplishments within this area of the nutrients, optical properties and primary production fall into three main areas:

- Continued bi-monthly measurement of biogeochemical and optical properties of Onslow Bay (OB) and the Cape Fear River plume/ Long Bay (CFP).
- Upgrades to remote sensing processing capabilities.
- Preparations for use of Fast Repetition Rate Fluorometry (FRRF).

In accord with plans stated in Section 4.2.2, cruises in the plume region were conducted monthly (CFR) and bimonthly (OB), with parameters measured including: temperature, salinity, turbidity, pH, dissolved oxygen, nitrate, ammonium, total nitrogen, orthophosphate, total phosphorus and chlorophyll a, zooplankton and meroplankton. Optical measurements made include the diffuse attenuation of photosynthetically available radiation, spectral CDOM, pigment and detrital absorption, and surface and profiling reflectances at SeaWiFS wavebands. SeaWiFS Level 1A HRPT data were obtained for the period Aug 2002-Dec2003. Various network issues have been resolved. A necessary Linux Red Hat 9 computer has been set up and a SeaDAS 4.5 version installed. The setup and configuration for a Sun workstation (on loan from URI)is nearly completed which provides access to a current IDL license and allows batch processing of both SeaWiFS and MODIS ocean color data. Primary production measurements have not yet been undertaken as the FRRF instrument referenced in the proposal was delivered in January 2004 (see above, this Section). Work continued on a test tank and deployment frame, while post-processing software was obtained and contacts with experienced users established in preparation for test deployments of the FRRF.

A postdoctoral researcher (Wendy Woods) was hired. Dr. Woods will be playing a significant role, taking the lead in conducting CORMP remote sensing, optical and primary production measurements.

Additional outreach and user group contacts. Data from the SCUFA deployments in Onslow Bay have been included in a web-based interactive oceanography teaching module being developed for CORMP by Dr. Richard Huber at UNCW (and CORMP), that is, the "Riverview" web site. This web site will be linked with the new American Society of Limnology and Oceanography's (ASLO) Education website once it is beta-tested, thus gaining a national audience for these CORMP data sets.

Data on benthic microalgal biomass have been provided to the ECOPATH modeling effort sponsored by the South Atlantic Fisheries Management Council (Cahoon, L.B. Benthic microalgal biomass and production in the South Atlantic Bight). This modeling effort is intended to predict fisheries yields and sustainable fishing levels in the South Atlantic Bight. Data from CORMP are a critical component of this effort.

Data and critical review have also been provided to assist in development of the NC Division of Marine Fisheries' Coastal Habitat Protection Plans for soft-bottom communities. CORMP data have been the principal source of benthic primary producer data for this effort. An additional contribution to this effort will come in the form of data analysis that will address the quantity and source directions of particulate loading to hard-bottom habitats represented by concentrations of near-bottom particulates and near-bottom flow vectors. This CORMP effort will ultimately permit estimation of the area around a hard-bottom community that must be protected from disturbance. This will have value to the Coastal Habitat Protection Plans, the NC Division of Coastal Management, the EPA, the Army Corps of Engineers, the National Marine Fisheries Service, and the Minerals Management Service in evaluating proposals for dredge material disposal, mineral extraction activities, and seabed construction activities and their effects on hard-bottom resources.

One CORMP investigator (Cahoon) has been contacted by representatives of the N.C. state veterinarian's office who are investigating the possibility of ocean dumping of animal carcasses in the event of mass mortalities from natural disaster or agro-terrorism. This effort is being pushed by the U.S. Departments of Agriculture and Homeland Security. Among the many issues that must be addressed in the planning efforts are issues of nutrient and pathogen loading to coastal ocean ecosystems, flow patterns and dispersal of materials, and decomposition rates and effects in different oceanic disposal scenarios. Workshops are planned for the near future, and marine science investigators from CORMP and UNCW will be involved.

Table 8. Correlations (r) between SST index values for Niño regions 1+2 and 3 vs. river discharges at SEUS river gauging stations, 1980-2003.

Gauging Station name	site_no	latitude	longitude	Region	r
OCMULGEE RIVER AT LUMBER CITY, GA	2215500	31.9202	-82.6740	NINO1_2	0.624
VALLEY RIVER AT TOMOTLA, NC	3550000	35.1390	-83.9805	NINO1_2	0.612
OCONEE RIVER AT DUBLIN, GA	2223500	32.5446	-82.8946	NINO1_2	0.609
FLINT RIVER AT NEWTON, GA	2353000	31.3068	-84.3385	NINO1_2	0.606
OOSTANAULA RIVER AT RESACA, GA	2387500	34.5783	-84.9414	NINO1_2	0.583
FLINT RIVER AT MONTEZUMA, GA	2349500	32.2982	-84.0438	NINO1_2	0.582
OCONEE RIVER AT MILLEDGEVILLE, GA	2223000	33.0896	-83.2154	NINO1_2	0.582
ETOWAH RIVER AT CANTON, GA	2392000	34.2398	-84.4963	NINO1_2	0.577
CATALOOCHEE CREEK NEAR CATALOOCHEE, NC	3460000	35.6673	-83.0726	NINO1_2	0.576
FLINT RIVER NEAR CULLODEN, GA	2347500	32.7214	-84.2325	NINO1_2	0.575
COOSAWATTEE RIVER NEAR ELLIJAY, GA	2380500	34.6718	-84.5085	NINO1_2	0.571
OCMULGEE RIVER AT MACON, GA	2213000	32.8386	-83.6206	NINO1_2	0.565
BRIER CREEK AT MILLHAVEN, GA	2198000	32.9335	-81.6512	NINO1_2	0.562
FLAT RIVER AT DAM NEAR BAHAMA, NC	2086500	36.1488	-78.8283	NINO1_2	0.560
CHATTAHOOCHEE RIVER NEAR COLUMBIA, AL	2343801	31.2593	-85.1102	NINO1_2	0.559
COOSA RIVER NEAR ROME, GA	2397000	34.2004	-85.2566	NINO1_2	0.556
CHESTATEE RIVER NEAR DAHLONEGA, GA	2333500	34.5281	-83.9397	NINO1_2	0.552
PEE DEE RIVER AT PEEDEE, SC	2131000	34.2043	-79.5484	NINO1_2	0.547
MIDDLE OCONEE RIVER NEAR ATHENS, GA	2217500	33.9467	-83.4228	NINO1_2	0.543
ALAPAHA RIVER AT STATENVILLE, GA	2317500	30.7041	-83.0332	NINO1_2	0.543
BROAD RIVER AT ALSTON, SC	2161000	33.1765	-81.4804	NINO1_2	0.538
REEDY RIVER NEAR WARE SHOALS, S. C.	2165000	34.4173	-82.1515	NINO1_2	0.535
LITTLE RIVER NEAR MT. CARMEL, SC	2192500	34.0715	-82.5007	NINO1_2	0.535
SWANNANOA RIVER AT BILTMORE, NC	3451000	35.5684	-82.5448	NINO1_2	0.532
PEE DEE R NR ROCKINGHAM, NC	2129000	34.9458	-79.8697	NINO1_2	0.528
CHATTOOGA RIVER NEAR CLAYTON, GA	2177000	34.8140	-83.3060	NINO1_2	0.527
SALUDA RIVER NEAR GREENVILLE,S.C.	2162500	34.8423	-82.4807	NINO1_2	0.526
LYNCHES RIVER AT EFFINGHAM, S. C.	2132000	34.0515	-79.7540	NINO1_2	0.526
SALUDA RIVER NEAR WARE SHOALS, SC	2163500	34.3918	-82.2235	NINO1_2	0.524
WATAUGA RIVER NEAR SUGAR GROVE, NC	3479000	36.2385	-81.8226	NINO1_2	0.520
CHIPOLA RIVER NR ALTHA, FLA.	2359000	30.5341	-85.1652	NINO1_2	0.517
LYNCHES RIVER NEAR BISHOPVILLE, S. C.	2131500	34.2502	-80.2137	NINO1_2	0.514
WATEREE RIVER NR. CAMDEN, SC	2148000	34.2446	-80.6540	NINO1_2	0.514
SOUTH FORK CATAWBA RIVER AT LOWELL, NC	2145000	35.2853	-81.1011	NINO1_2	0.511
STEVENS CREEK NEAR MODOC, SC	2196000	33.7293	-82.1818	NINO1_2	0.509
LINE CREEK NEAR SENOIA, GA	2344700	33.3192	-84.5222	NINO1_2	0.509
CAPE FEAR RIVER AT LILLINGTON, NC	2102500	35.4063	-78.8131	NINO1_2	0.508
CAPE FEAR R AT WILM O HUSKE LOCK NR TARHEEL, NC	2105500	34.8349	-78.8239	NINO1_2	0.504
ESCAMBIA RIVER NEAR CENTURY, FL	2375500	30.9652	-87.2341	NINO1_2	0.504
SALUDA RIVER AT CHAPPELLS, SC	2167000	34.1779	-81.8609	NINO1_2	0.498
BROAD RIVER NEAR CARLISLE, S. C.	2156500	34.5963	-81.4220	NINO1_2	0.497
BLACK CREEK NEAR MCBEE, S. C.	2130900	34.5140	-80.1831	NINO1_2	0.496
FRENCH BROAD RIVER AT ASHEVILLE, NC	3451500	35.6093	-82.5785	NINO1_2	0.490

CHOCTAWHATCHEE RIVER AT CARYVILLE, FLA.	2365500	30.7757	-85.8277	NINO1_2	0.485
CAPE FEAR R AT LOCK #1 NR KELLY, NC	2105769	34.4043	-78.2936	NINO1_2	0.484
AR RIVER NEAR TAR RIVER, NC	2081500	36.1949	-78.5831	NINO1_2	0.478
REEDY RIVER NEAR GREENVILLE, SC	2164000	34.8001	-82.3651	NINO1_2	0.476
SOUTH FORK EDISTO RIVER NEAR DENMARK, S.C.	2173000	33.3932	-81.1332	NINO1_2	0.475
EDISTO RIVER NR GIVHANS, SC	2175000	33.0279	-80.3915	NINO1_2	0.475
BROAD RIVER NEAR BOILING SPRINGS, NC	2151500	35.2110	-81.6976	NINO1_2	0.474
ROCKY RIVER NEAR NORWOOD, NC	2126000	35.1486	-80.1758	NINO1_2	0.474
MAYO RIVER NEAR PRICE, NC	2070500	36.5349	-79.9914	NINO1_2	0.474
FLAT RIVER AT BAHAMA, NC	2085500	36.1826	-78.8786	NINO1_2	0.474
NEUSE RIVER NEAR CLAYTON, NC	2087500	35.6474	-78.4058	NINO1_2	0.473
YADKIN RIVER AT YADKIN COLLEGE, NC	2116500	35.8567	-80.3869	NINO1_2	0.472
FRENCH BROAD RIVER AT ROSMAN	3439000	35.1423	-82.8243	NINO1_2	0.465
CONGAREE RIVER AT COLUMBIA, SC	2169500	34.2502	-80.2137	NINO1_2	0.464
BLACK RIVER AT KINGSTREE, SC	2136000	33.6613	-79.8359	NINO1_2	0.462
LUMBER RIVER AT BOARDMAN, NC	2134500	34.4424	-78.9603	NINO1_2	0.461
NORTH PACOLET RIVER AT FINGERVILLE, S. C.	2154500	35.1210	-81.9859	NINO1_2	0.461
UWANNEE RIVER AT ELLAVILLE, FLA	2319500	30.3847	-83.1718	NINO1_2	0.460
ROANOKE RIVER AT ROANOKE RAPIDS, NC	2080500	36.4605	-77.6345	NINO1_2	0.459
CHOCTAWHATCHEE RIVER NR BRUCE, FLA.	2366500	30.4510	-85.8983	NINO1_2	0.457
COOSAWHATCHIE RIVER NEAR HAMPTON, SC	2176500	32.8363	-81.1318	NINO1_2	0.456
SOUTH FORK NEW RIVER NEAR JEFFERSON, NC	3161000	36.3932	-81.4070	NINO1_2	0.455
LITTLE PEE DEE R. AT GALIVANTS FERRY, S.C.	2135000	34.0571	-79.2470	NINO1_2	0.455
CATAWBA RIVER NEAR ROCKHILL, SC	2146000	34.9849	-80.9740	NINO1_2	0.454
SATILLA RIVER NEAR WAYCROSS, GA	2226500	31.2383	-82.3246	NINO1_2	0.454
SALKEHATCHIE RIVER NEAR MILEY, SC	2175500	32.9890	-81.0526	NINO1_2	0.452
CHATTAHOOCHEE RIVER NEAR WHITESBURG, GA	2338000	33.4771	-84.9008	NINO1_2	0.449
FISHING CREEK NEAR ENFIELD, NC	2083000	36.1510	-77.6928	NINO1_2	0.446
YADKIN RIVER AT WILKESBORO, NC	2112000	36.1526	-81.1456	NINO1_2	0.440
YADKIN RIVER AT PATTERSON, NC	2111000	35.9915	-81.5582	NINO1_2	0.438
OCHLOCKONEE RIVER NR BLOXHAM, FLA.	2330000	30.3833	-84.6549	NINO1_2	0.438
SAVANNAH RIVER AT AUGUSTA, GA	2197000	33.3738	-81.9429	NINO1_2	0.436
ROCKY CREEK AT GREAT FALLS, SC	2147500	34.5654	-80.9198	NINO1_2	0.433
HAW RIVER AT HAW RIVER, NC	2096500	36.0871	-79.3670	NINO1_2	0.429
TAR RIVER AT TARBORO, NC	2083500	35.8944	-77.5331	NINO1_2	0.429
NORTH FORK EDISTO RIVER AT ORANGEBURG, SC	2173500	33.4835	-80.8734	NINO1_2	0.421
LINVILLE RIVER NEAR NEBO, NC	2138500	35.7948	-81.8901	NINO1_2	0.412
POTECASI CREEK NEAR UNION, NC	2053200	36.3707	-77.0264	NINO1_2	0.382
NORTH BUFFALO CREEK NEAR GREENSBORO, NC	2095500	36.1204	-79.7081	NINO1_2	0.346
CONTENTNEA CREEK AT HOOKERTON, NC	2091500	35.4291	-77.5827	NINO1_2	0.346
SUWANNEE RIVER AT FARGO, GA	2314500	30.6806	-82.5606	NINO1_2	0.337
SUWANNEE RIVER AT WHITE SPRINGS, FLA.	2315500	30.3258	-82.7382	NINO1_2	0.332
KISSIMMEE RIVER AT S-65,NEAR LAKE WALES, FLA.	2268903	27.8042	-81.1978	NINO1_2	0.319
PENHOLOWAY CREEK NEAR JESUP, GA	2226100	31.5669	-81.8382	NINO1_2	0.298
ECONFINA RIVER NEAR PERRY, FLA.	2326000	30.1708	-83.8238	NINO1_2	0.289
NORTHEAST CAPE FEAR RIVER NEAR CHINQUAPIN, NC	2108000	34.8279	-77.8330	NINO1_2	0.289
WACCAMAW RIVER NEAR LONGS, SC	2110500	33.9127	-78.7150	NINO1_2	0.289
TELOGIA CREEK NR BRISTOL, FLA.	2330100	30.4266	-84.9277	NINO1_2	0.258

OCKLAWAHA RIVER AT EUREKA,FLA.	2240500	29.3725	-81.9026	NINO1_2	0.253
CAMPS CANAL NR ROCHELLE, FLA.	2241000	29.5761	-82.2498	NINO1_2	0.228
UPPER 3 RUNS NEAR ELLENTON	2197300	33.5637	-81.8740	NINO1_2	0.210
SHOAL RIVER NR CRESTVIEW, FLA.	2369000	30.6974	-86.5708	NINO1_2	0.210
SALUDA RIVER NEAR COLUMBIA, SC	2169000	34.0140	-81.0879	NINO1_2	0.193
NORTH PRONG ST. MARYS RIVER AT MONIAC, GA.	2228500	30.5177	-82.2304	NINO1_2	0.191
ST. MARKS RIVER NEAR NEWPORT, FLA.	2326900	30.2669	-84.1499	NINO1_2	0.182
NEW RIVER NEAR GUM BRANCH, NC	2093000	34.8491	-77.5194	NINO1_2	0.163
ECONFINA CREEK NEAR BENNETT, FLA.	2359500	30.3846	-85.5566	NINO1_2	0.135
CHATTAHOOCHEE RIVER NEAR NORCROSS, GA	2335000	33.9972	-84.2019	NINO1_2	0.134
WITHLACOOCHEE RIVER NR DADE CITY, FLA.	2312640	28.6961	-82.1093	NINO1_2	0.130
SOPCHOPPY RIVER NR SOPCHOPPY, FLA.	2327100	30.1294	-84.4943	NINO1_2	0.104
SANTA FE RIVER NEAR FORT WHITE, FLA.	2322500	29.8488	-82.7151	NINO1_2	0.075
BLACKWATER CREEK NEAR CASSIA, FL	2235200	28.8772	-81.4890	NINO1_2	0.069
WITHLACOOCHEE RIVER NR DADE CITY, FLA.	2311500	28.3525	-82.1259	NINO1_2	0.063
KISSIMMEE R AT S-65E NR OKEECHOBEE, FLA.	2273000	27.2259	-80.9626	NINO1_2	-0.005
WACCASASSA RIVER NR GULF HAMMOCK, FLA.	2313700	29.2041	-82.7690	NINO1_2	-0.023
WITHLACOOCHEE-HILLSBOROUGH OV NR RICHLAND,FLA	2311000	28.2714	-82.0979	NINO1_2	-0.070
ST. JOHNS RIVER NR DELAND, FLA.	2236000	29.0083	-81.3826	NINO1_2	-0.127
ALAFIA RIVER AT LITHIA FL	2301500	27.8722	-82.2112	NINO1_2	-0.141
SHINGLE CREEK AT AIRPORT NR KISSIMMEE, FLA.	2263800	28.3042	-81.4509	NINO1_2	-0.150
JANE GREEN CREEK NEAR DEER PARK, FLA.	2231600	28.0745	-80.8881	NINO1_2	-0.193
ECONLOCKHATCHEE RIVER NR. CHULUOTA, FLA.	2233500	28.6781	-81.1140	NINO1_2	-0.200
FISHEATING CREEK AT PALMDALE, FLA.	2256500	26.9326	-81.3148	NINO1_2	-0.242
OCMULGEE RIVER AT LUMBER CITY, GA	2215500	31.9202	-82.6740	NINO3	0.477
FLINT RIVER AT NEWTON, GA	2353000	31.3068	-84.3385	NINO3	0.440
ETOWAH RIVER AT CANTON, GA	2392000	34.2398	-84.4963	NINO3	0.430
OCONEE RIVER AT DUBLIN, GA	2223500	32.5446	-82.8946	NINO3	0.428
ALAPAHA RIVER AT STATENVILLE, GA	2317500	30.7041	-83.0332	NINO3	0.425
SWANNANOA RIVER AT BILTMORE, NC	3451000	35.5684	-82.5448	NINO3	0.419
CHIPOLA RIVER NR ALTHA, FLA.	2359000	30.5341	-85.1652	NINO3	0.415
CHATTOOGA RIVER NEAR CLAYTON, GA	2177000	34.8140	-83.3060	NINO3	0.413
SALUDA RIVER NEAR GREENVILLE,S.C.	2162500	34.8423	-82.4807	NINO3	0.412
CHESTATEE RIVER NEAR DAHLONEGA, GA	2333500	34.5281	-83.9397	NINO3	0.406
CHATTAHOOCHEE RIVER NEAR COLUMBIA, AL	2343801	31.2593	-85.1102	NINO3	0.403
FLINT RIVER AT MONTEZUMA, GA	2349500	32.2982	-84.0438	NINO3	0.402
UWANNEE RIVER AT ELLAVILLE, FLA	2319500	30.3847	-83.1718	NINO3	0.400
SALUDA RIVER NEAR WARE SHOALS, SC	2163500	34.3918	-82.2235	NINO3	0.397
OCONEE RIVER AT MILLEDGEVILLE, GA	2223000	33.0896	-83.2154	NINO3	0.396
OCMULGEE RIVER AT MACON, GA	2213000	32.8386	-83.6206	NINO3	0.393
YADKIN RIVER AT YADKIN COLLEGE, NC	2116500	35.8567	-80.3869	NINO3	0.391
MIDDLE OCONEE RIVER NEAR ATHENS, GA	2217500	33.9467	-83.4228	NINO3	0.391
PEE DEE RIVER AT PEEDEE, SC	2131000	34.2043	-79.5484	NINO3	0.388
BRIER CREEK AT MILLHAVEN, GA	2198000	32.9335	-81.6512	NINO3	0.388
COOSAWATTEE RIVER NEAR ELLIJAY, GA	2380500	34.6718	-84.5085	NINO3	0.386
SOUTH FORK NEW RIVER NEAR JEFFERSON, NC	3161000	36.3932	-81.4070	NINO3	0.386
YADKIN RIVER AT PATTERSON, NC	2111000	35.9915	-81.5582	NINO3	0.385

FLINT RIVER NEAR CULLODEN, GA	2347500	32.7214	-84.2325	NINO3	0.385
FRENCH BROAD RIVER AT ASHEVILLE, NC	3451500	35.6093	-82.5785	NINO3	0.383
REEDY RIVER NEAR WARE SHOALS, S. C.	2165000	34.4173	-82.1515	NINO3	0.381
YADKIN RIVER AT WILKESBORO, NC	2112000	36.1526	-81.1456	NINO3	0.380
ROANOKE RIVER AT ROANOKE RAPIDS, NC	2080500	36.4605	-77.6345	NINO3	0.378
VALLEY RIVER AT TOMOTLA, NC	3550000	35.1390	-83.9805	NINO3	0.378
SOUTH FORK CATAWBA RIVER AT LOWELL, NC	2145000	35.2853	-81.1011	NINO3	0.376
WATAUGA RIVER NEAR SUGAR GROVE, NC	3479000	36.2385	-81.8226	NINO3	0.375
COOSA RIVER NEAR ROME, GA	2397000	34.2004	-85.2566	NINO3	0.374
OOSTANAULA RIVER AT RESACA, GA	2387500	34.5783	-84.9414	NINO3	0.370
MAYO RIVER NEAR PRICE, NC	2070500	36.5349	-79.9914	NINO3	0.370
BROAD RIVER NEAR BOILING SPRINGS, NC	2151500	35.2110	-81.6976	NINO3	0.368
LITTLE RIVER NEAR MT. CARMEL, SC	2192500	34.0715	-82.5007	NINO3	0.365
REEDY RIVER NEAR GREENVILLE, SC	2164000	34.8001	-82.3651	NINO3	0.363
LYNCHES RIVER AT EFFINGHAM, S. C.	2132000	34.0515	-79.7540	NINO3	0.363
BROAD RIVER AT ALSTON, SC	2161000	33.1765	-81.4804	NINO3	0.361
FRENCH BROAD RIVER AT ROSMAN, SC	3439000	35.1423	-82.8243	NINO3	0.359
PEE DEE R NR ROCKINGHAM, NC	2129000	34.9458	-79.8697	NINO3	0.359
NORTH PACOLET RIVER AT FINGERVILLE, S. C.	2154500	35.1210	-81.9859	NINO3	0.358
FLAT RIVER AT DAM NEAR BAHAMA, NC	2086500	36.1488	-78.8283	NINO3	0.353
WATEREE RIVER NR. CAMDEN, SC	2148000	34.2446	-80.6540	NINO3	0.352
BROAD RIVER NEAR CARLISLE, S. C.	2156500	34.5963	-81.4220	NINO3	0.352
SATILLA RIVER NEAR WAYCROSS, GA	2226500	31.2383	-82.3246	NINO3	0.350
LYNCHES RIVER NEAR BISHOPVILLE, S. C.	2131500	34.2502	-80.2137	NINO3	0.344
ESCAMBIA RIVER NEAR CENTURY, FL	2375500	30.9652	-87.2341	NINO3	0.343
SAVANNAH RIVER AT AUGUSTA, GA	2197000	33.3738	-81.9429	NINO3	0.343
EDISTO RIVER NR GIVHANS, SC	2175000	33.0279	-80.3915	NINO3	0.342
OCHLOCKONEE RIVER NR BLOXHAM, FLA.	2330000	30.3833	-84.6549	NINO3	0.336
SALUDA RIVER AT CHAPPELLS, SC	2167000	34.1779	-81.8609	NINO3	0.336
CATALOOCHEE CREEK NEAR CATALOOCHEE, NC	3460000	35.6673	-83.0726	NINO3	0.335
CAPE FEAR RIVER AT LILLINGTON, NC	2102500	35.4063	-78.8131	NINO3	0.327
BLACK RIVER AT KINGSTREE, SC	2136000	33.6613	-79.8359	NINO3	0.326
KISSIMMEE RIVER AT S-65,NEAR LAKE WALES, FLA.	2268903	27.8042	-81.1978	NINO3	0.326
CATAWBA RIVER NEAR ROCKHILL, SC	2146000	34.9849	-80.9740	NINO3	0.325
LINVILLE RIVER NEAR NEBO, NC	2138500	35.7948	-81.8901	NINO3	0.324
CHOCTAWHATCHEE RIVER AT CARYVILLE, FLA.	2365500	30.7757	-85.8277	NINO3	0.323
COOSAWHATCHIE RIVER NEAR HAMPTON, SC	2176500	32.8363	-81.1318	NINO3	0.322
CAPE FEAR R AT WILM O HUSKE LOCK NR TARHEEL, NC	2105500	34.8349	-78.8239	NINO3	0.322
CHATTAHOOCHEE RIVER NEAR WHITESBURG, GA	2338000	33.4771	-84.9008	NINO3	0.322
CONGAREE RIVER AT COLUMBIA, SC	2169500	34.2502	-80.2137	NINO3	0.317
STEVENS CREEK NEAR MODOC, SC	2196000	33.7293	-82.1818	NINO3	0.315
CHOCTAWHATCHEE RIVER NR BRUCE, FLA.	2366500	30.4510	-85.8983	NINO3	0.313
NEUSE RIVER NEAR CLAYTON, NC	2087500	35.6474	-78.4058	NINO3	0.311
SOUTH FORK EDISTO RIVER NEAR DENMARK, S.C.	2173000	33.3932	-81.1332	NINO3	0.308
FLAT RIVER AT BAHAMA, NC	2085500	36.1826	-78.8786	NINO3	0.303
CAPE FEAR R AT LOCK #1 NR KELLY, NC	2105769	34.4043	-78.2936	NINO3	0.301
AR RIVER NEAR TAR RIVER, NC	2081500	36.1949	-78.5831	NINO3	0.299
LINE CREEK NEAR SENOIA, GA	2344700	33.3192	-84.5222	NINO3	0.297

BLACK CREEK NEAR MCBEE, S. C.	2130900	34.5140	-80.1831	NINO3	0.297
LITTLE PEE DEE R. AT GALIVANTS FERRY, S.C.	2135000	34.0571	-79.2470	NINO3	0.293
SUWANNEE RIVER AT WHITE SPRINGS, FLA.	2315500	30.3258	-82.7382	NINO3	0.285
HAW RIVER AT HAW RIVER, NC	2096500	36.0871	-79.3670	NINO3	0.284
SUWANNEE RIVER AT FARGO, GA	2314500	30.6806	-82.5606	NINO3	0.281
FISHING CREEK NEAR ENFIELD, NC	2083000	36.1510	-77.6928	NINO3	0.280
ROCKY RIVER NEAR NORWOOD, NC	2126000	35.1486	-80.1758	NINO3	0.279
ECONFINA RIVER NEAR PERRY, FLA.	2326000	30.1708	-83.8238	NINO3	0.278
LUMBER RIVER AT BOARDMAN, NC	2134500	34.4424	-78.9603	NINO3	0.274
NORTH FORK EDISTO RIVER AT ORANGEBURG, SC	2173500	33.4835	-80.8734	NINO3	0.273
SALKEHATCHIE RIVER NEAR MILEY, SC	2175500	32.9890	-81.0526	NINO3	0.272
ROCKY CREEK AT GREAT FALLS, SC	2147500	34.5654	-80.9198	NINO3	0.262
TAR RIVER AT TARBORO, NC	2083500	35.8944	-77.5331	NINO3	0.261
NORTH BUFFALO CREEK NEAR GREENSBORO, NC	2095500	36.1204	-79.7081	NINO3	0.256
OCKLAWAHA RIVER AT EUREKA,FLA.	2240500	29.3725	-81.9026	NINO3	0.249
PENHOLOWAY CREEK NEAR JESUP, GA	2226100	31.5669	-81.8382	NINO3	0.248
CAMPS CANAL NR ROCHELLE, FLA.	2241000	29.5761	-82.2498	NINO3	0.237
TELOGIA CREEK NR BRISTOL, FLA.	2330100	30.4266	-84.9277	NINO3	0.217
ST. MARKS RIVER NEAR NEWPORT, FLA.	2326900	30.2669	-84.1499	NINO3	0.195
CONTENTNEA CREEK AT HOOKERTON, NC	2091500	35.4291	-77.5827	NINO3	0.191
POTECASI CREEK NEAR UNION, NC	2053200	36.3707	-77.0264	NINO3	0.184
WITHLACOOCHEE RIVER NR DADE CITY, FLA.	2312640	28.6961	-82.1093	NINO3	0.179
WACCAMAW RIVER NEAR LONGS, SC	2110500	33.9127	-78.7150	NINO3	0.175
NORTH PRONG ST. MARYS RIVER AT MONIAC, GA.	2228500	30.5177	-82.2304	NINO3	0.169
NORTHEAST CAPE FEAR RIVER NEAR CHINQUAPIN, NC	2108000	34.8279	-77.8330	NINO3	0.169
CHATTAHOOCHEE RIVER NEAR NORCROSS, GA	2335000	33.9972	-84.2019	NINO3	0.136
ECONFINA CREEK NEAR BENNETT, FLA.	2359500	30.3846	-85.5566	NINO3	0.134
SALUDA RIVER NEAR COLUMBIA, SC	2169000	34.0140	-81.0879	NINO3	0.130
SHOAL RIVER NR CRESTVIEW, FLA.	2369000	30.6974	-86.5708	NINO3	0.125
WITHLACOOCHEE RIVER NR DADE CITY, FLA.	2311500	28.3525	-82.1259	NINO3	0.120
SANTA FE RIVER NEAR FORT WHITE, FLA.	2322500	29.8488	-82.7151	NINO3	0.106
KISSIMMEE R AT S-65E NR OKEECHOBEE, FLA.	2273000	27.2259	-80.9626	NINO3	0.090
NEW RIVER NEAR GUM BRANCH, NC	2093000	34.8491	-77.5194	NINO3	0.081
SOPCHOPPY RIVER NR SOPCHOPPY, FLA.	2327100	30.1294	-84.4943	NINO3	0.070
BLACKWATER CREEK NEAR CASSIA, FL	2235200	28.8772	-81.4890	NINO3	0.067
Upper 3 Runs near Ellenton	2197300	33.5637	-81.8740	NINO3	0.064
WITHLACOOCHEE-HILLSBOROUGH OV NR RICHLAND,FLA	2311000	28.2714	-82.0979	NINO3	0.022
WACCASASSA RIVER NR GULF HAMMOCK, FLA.	2313700	29.2041	-82.7690	NINO3	-0.022
SHINGLE CREEK AT AIRPORT NR KISSIMMEE, FLA.	2263800	28.3042	-81.4509	NINO3	-0.024
ALAFIA RIVER AT LITHIA FL	2301500	27.8722	-82.2112	NINO3	-0.035
FISHEATING CREEK AT PALMDALE, FLA.	2256500	26.9326	-81.3148	NINO3	-0.072
ECONLOCKHATCHEE RIVER NR. CHULUOTA, FLA.	2233500	28.6781	-81.1140	NINO3	-0.072
JANE GREEN CREEK NEAR DEER PARK, FLA.	2231600	28.0745	-80.8881	NINO3	-0.076
ST. JOHNS RIVER NR DELAND, FLA.	2236000	29.0083	-81.3826	NINO3	-0.080

Figure 21. Benthic chlorophyll a (B Chla) vs. integrated water column chlorophyll a (Int WC Chla) at OB 3. Values are means ± 1 std. dev.

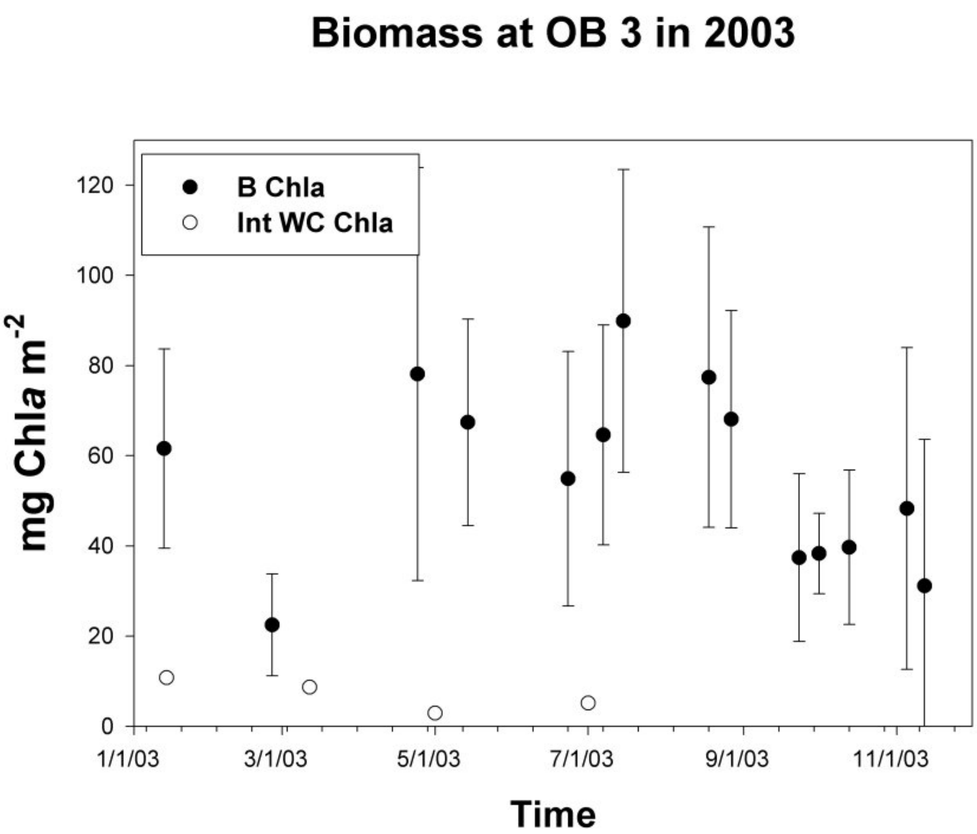
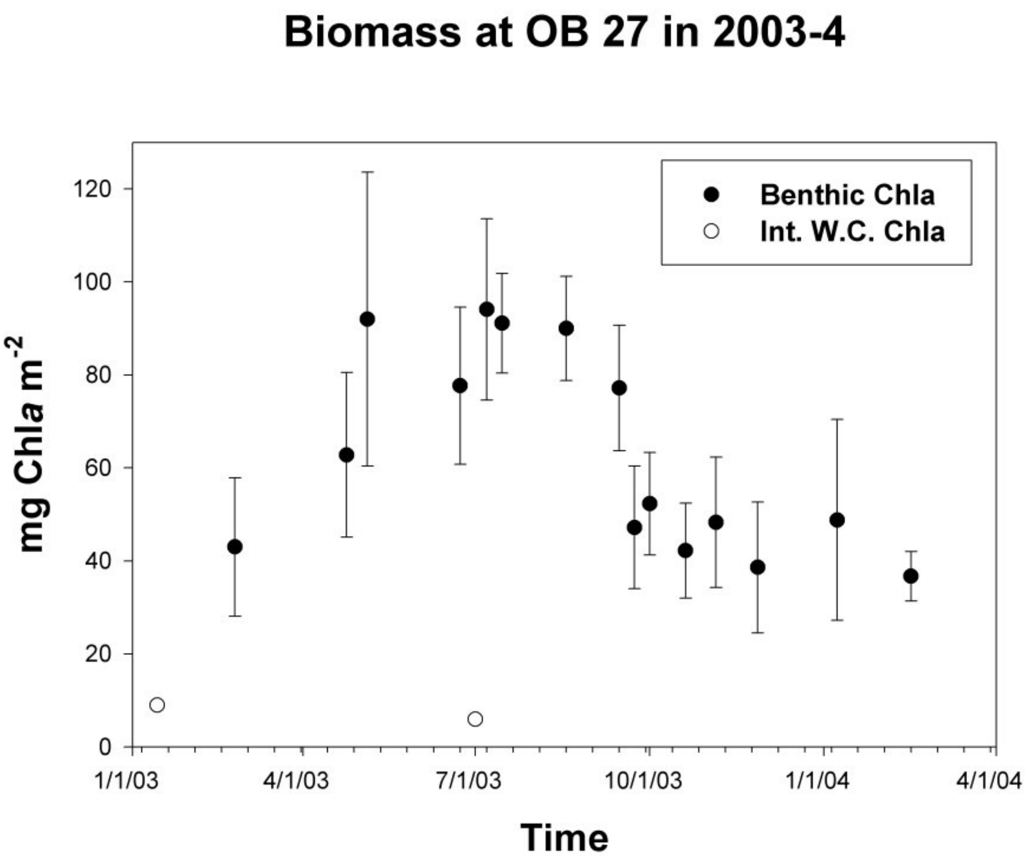


Figure 22. Benthic chlorophyll a (B Chla) vs. integrated water column chlorophyll a (Int WC Chla) at OB 27. Values are means $\pm$ 1 std. dev.



Benthic Infaunal Component (of Section 3.0)

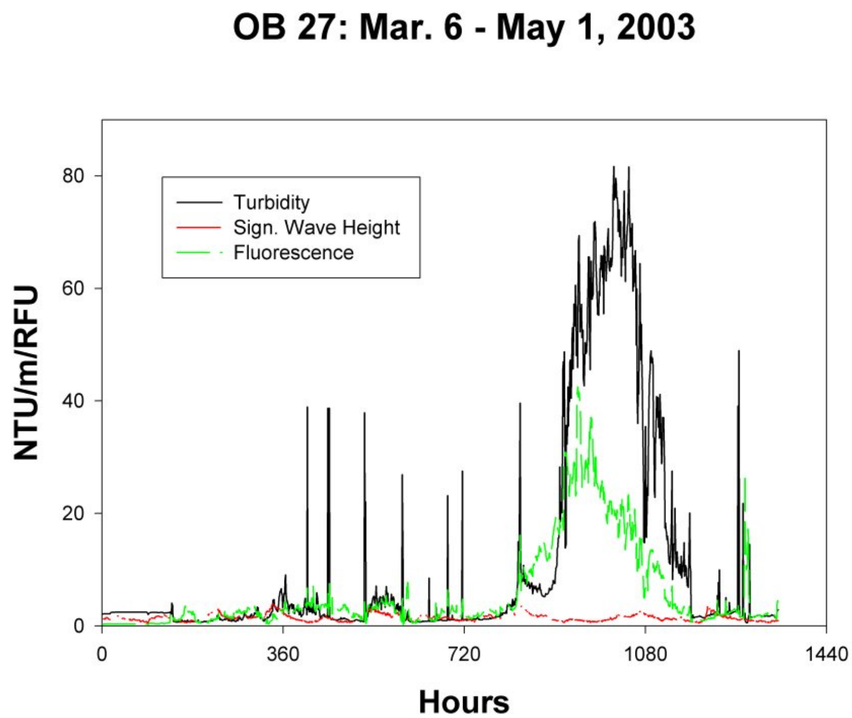
It was proposed to continue quarterly sampling as well as begin sorting of samples and identification of fauna. Analyses and biomass is not to be conducted until summer 2004. Field sampling was conducted in August and November 2003. Sorting and identification of samples is proceeding on schedule.

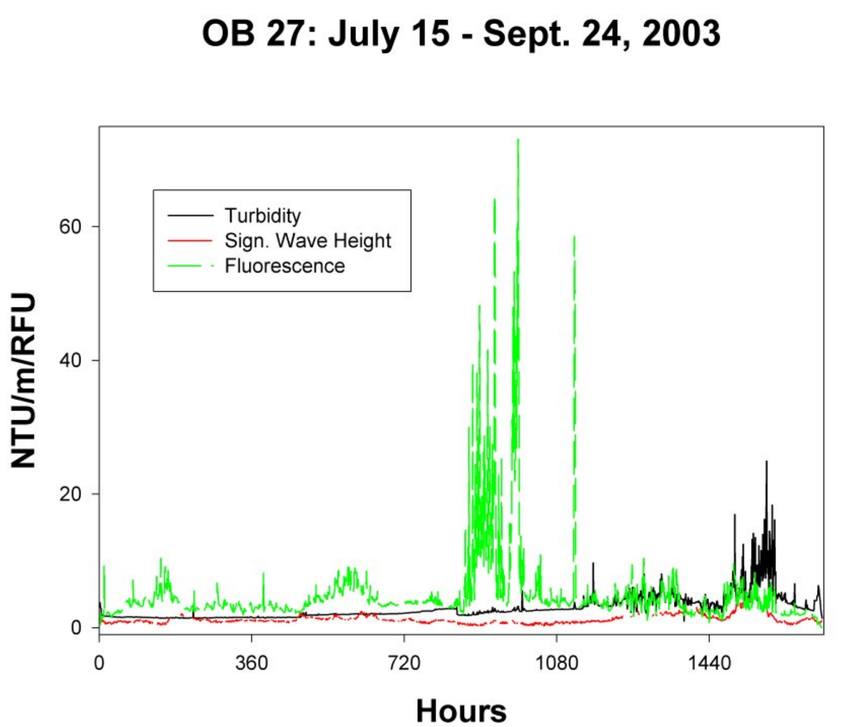
As discussed in previous progress reports the crab trawling project evaluating the utilization of near shore habitats adjacent to the CFR mouth (and other inlet areas) was delayed until June of '04 (covered in this progress report under fisheries). Our current plan is to conduct this sampling beginning June ’04 and continue through September ‘04. If crab densities are high in September, sampling may continue until November. This sampling will be conducted on the new and full moon periods (periods when larval ingress is expected to be the greatest). Agreements have already been made with a local vessel operator to conduct the sampling in targeted areas just outside the Cape Fear River mouth as well as Carolina Beach inlet and, weather permitting, Masonboro Inlet.

Two undergraduate assistants to assist with the processing of benthic core samples from offshore and benthic grab samples from the CFR plume. A technician was hired to assist with data management, sample tracking and analysis. Hiring of an additional technician to assist with the completion of the benthic sampling is planned for early summer, '04.

Interaction with User Groups. We participated in the development of an Ecopath Model for the South Atlantic Bight being developed under the auspices of the South Atlantic Marine Fisheries Council. The work in Onslow Bay and Long Bay was used to help identify major faunal groups that should be included in the model. We have committed to provide biomass data on deep burrowing and shallow burrowing infauna from our CORMP research for inclusion in the model. In October 2003 a meeting was held with Jeff DeBlieu, Nature Conservancy, to provide input on their conservation areas planning process. The Nature Conservancy is involved with a multi-agency/group process to identify critical areas of fishery conservation concern, and they have targeted river plume habitat as being of potential importance. CORMP data was shared on benthic communities and crab populations in the Cape Fear River plume region. We also presented our data on juvenile crab use of the Cape Fear River plume to the North Carolina Crustacean Advisory Committee as part of their efforts to revise the North Carolina Blue Crab Management Plan. The CORMP data relates to identification and protection of key juvenile fisheries habitat. We were also contacted and asked to provide input on the Coastal Habitat Protection Plan section on offshore soft-sediment communities, relying on the information gathered in CORMP and other offshore projects. This is being done.

Figures 23 & 24. Patterns of near-bottom fluorescence, turbidity and wave action at OB 27.





Program Management Initiatives, Proposal Sections 4, 5 and 6

1. *Outreach and Education* (Proposal Section 5)

- National Weather Service
    - Met and consulted with Wilmington NWS meteorologists, including the Director and the Regional Director (Maine to Georgia) to outline plans for CORMP buoys, met stations, wave data and pier installations (for 2004-05 program) for possible partnerships with NWS
- U.S. Marine Base at Camp Lejeune, Jacksonville, N.C.
    - Met with senior level environmental managers at Camp Lejeune on approximately a monthly basis under auspices of UNCW and CORMP
    - Materially assisted Camp Lejeune with background and introductions to Directors and Associate Directors of the Strategic Environmental R&D Program (SERDP) in Washington
    - Assisted Camp Lejeune in proposal to SERDP
    - Served on Camp Lejeune group (Moss and Ihnat) for liaison with SERDP
    - Played active role in SERDP awarding of Camp Lejeune of a $2M per year for ten years research effort involving, among other things, beaches and the coastal ocean off Camp Lejeune
    - Negotiated with Camp Lejeune a cost shared (50:50) full spectrum real-time, NBDC turn-key buoy to be located 5 miles off Camp Lejeune beaches in Onslow Bay, and to be a part of the CORMP fixed mooring system with sub-surface and surface sensors feeding to the NDBC web site.
- Preliminary to summer 2004, had meetings and discussions and planning sessions with UNCW's Math and Science Education Center for CORMP sponsored summer 2004 teacher programs
- Preliminary to summer 2005, had discussions and planning sessions with NCSU's Science House regarding teachers of grades 6-12 educational partnerships for CORMP sponsored summer 2005
- Augmented above sessions by discussions and planning with Dr. Rich Huber, Professor, UNCW School of Education, about middle/high school teachers and how best to structure classroom/field experiences for maximum benefits
- Plans underway for "user" cooperative visits to Wilmington Ports Authority and to Department of Defense's SunyPoint Federal Munitions Terminal
- Preliminary discussions and plans underway to visit NMFR in Beaufort, N.C. re cooperative programs

2. *Program Management* (Proposal Section 6 & Management Issues of Section 4)

- Advertised and interviewed candidates for a CORMP Administrative Assistant, hired full-time person (for last half of program year) with significant experience (retired GS-14 GSA career)
- Met with NOAA's Coastal Service Center re Ocean.US hire through UNCW/IPA

- Developed and wrote with input from NOAA/CSC a detailed proposal serving as basis for eventual hire at UNCW transitioning to a IPA to Oceans.US
- Hired Dr. Lee Dantzler as senior Research Professor at UNCW's Center for Marine Science, including creating position at UNCW, filing necessary forms and procedures for hire at a most advanced level, both academically and salary wise
- To further develop the CORMP data management strategy, established Data Management Consulting Agreement Contract with senior data manager in the Caro-COOPS program in order to be compatible with and leverage Caro-COOPS' experience and expertise in this area
- Developed CORMP's first dedicated data management position
    - UNCW PD 102 filed
    - UNCD HR330 filed
    - Position description compatible and complimentary with CORMP's Data Management Plan, which itself is compatible with the Caro-COOPS data management plan
    - Advertisement for position developed
- Due to disability, hired behind director of CORMP operational staff on part time basis, including operational experience in diving, data management and instrumentation processing
- Drafted position description for CORMP's first dedicated data manager position, description complimenting CORMP's Data Management Plan (developed during Sept 03-Dec 04). Position advertised in late Jan 04, and to be filled in spring 04.

3. *CORMP Operations for* 8/1/03-01/31/04

The operations component of the Coastal Ocean Research and Monitoring Program (CORMP) is responsible for the planning, preparation, and execution of all research cruises, moored instrument recoveries/redeployments and a large portion of the sample and data processing from the research cruises. CORMP operations has spent a total of 28 days at sea (in excess of some 150 person days) during this 6 months reporting period in support of CORMP monitoring and research objectives.

Research cruises: Onslow Bay and Cape Fear River Plume. Onslow Bay cruises were conducted during the months of September, November and January. An additional cruise was conducted in late September to measure post-storm effects resulting from the passage of Hurricane Isabel on September 18, 2003.

The sampling effort in the Cape Fear River Plume was expanded to include bimonthly cruises aboard the R/V Cape Fear. The use of the larger vessel allows for more thorough analysis of the water column properties in the plume with the CTD/rosette. In addition, the R/V Cape Fear has recently been outfitted with an ADCP and flow-thru seawater system to allow for underway measurements of currents, temperature and conductivity during both Onslow Bay and Cape Fear River Plume cruises. Water sampling from a smaller boat continued in the plume for the months of August, October and December.

UNCW Moorings: OB27 and OB3M. The operations group continued operations and dive support of the underwater moorings at OB27 and OB3M. Instruments were recovered and redeployed on a six-week interval. During this period, CORMP divers made a total of 95 dives for recovery, redeployment and general maintenance of the mooring arrays. In addition, divers collected a number of samples for biological (primarily chl a) and geological (sediment turnover and movement) analysis. Preparations were also made to move the instrument mooring at OB27 to a new location. This new position will move the "quad" away from a hard-bottom ledge and onto a large sand plain. This will hopefully remove any artifacts to measurements of currents and biota that may have been a result of the moorings proximity to the ledge.

UNCW/NCSU Moorings: OB1M, OB2M, OB3M and OB4M. Operations completed two scheduled recoveries and redeployments of the instruments installed at the four offshore moorings during the months of October and January. With NURC assistance, CORMP divers recorded 44 dives in successful recovery and redeployment of all instruments (ADCPs, CT loggers). January also marked the first 3 month turnaround of CT loggers. On the advice of the NCSU technicians, the original 6 month schedule for CT logger turnaround was determined to be too lengthy and thus shortened to 3 months.

Sampling Processing and Data Analysis. A total of 2087 samples (chlorophyll *a*, nutrients, infauna, zooplankton, sediment stratigraphy, light partitioning) have been collected by CORMP operations staff during this 6 month period. Operations personnel continue to process nutrient and chlorophyll *a* samples from the Onslow Bay cruises. In addition, CTD data from all the cruises have been collected and processed by CORMP operational personnel.

4. *Budgetary* (Proposal Section 8)

- Provided day-to-day program management across a diverse set of objectives, from physical to biological to geophysical to operations
- Provided day-to-day management of the CORMP Operations Group
- Provided day-to-day financial management, spread sheet analysis, and correlations of CORMP expenditures with UNCW's financial management tracking system and the UNCW Office of Sponsored Programs
- Provided salaries and benefits for 24 CORMP persons (full-time, part-time, undergraduate/graduate students and temporary employees)
- Drafted, initiated and processed three separate CORMP sub-contracts (to N.C. State University, the University of South Carolina, Columbia, and to the University of S.C. Baruch Marine Laboratory