

# **CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS**

**2006 - 2007**

**Baruch Marine Field Laboratory (BMFL)**

**North Inlet-Winyah Bay  
National Estuarine Research Reserve  
(NERR)**

**University of South Carolina**



**Belle W. Baruch Institute  
for Marine & Coastal Sciences**



**North Inlet-Winyah Bay  
National Estuarine Research Reserve**

## Current Projects 2006-2007

### Introduction

More than 600 scientific research projects and about 355 student theses and dissertations have been completed by Baruch Institute research associates since 1969. This work has resulted in the publication of more than 1,430 scientific articles, reports, and books that contribute new information in subject areas ranging from molecular biology to landscape ecology. The accumulating information provides a fundamental understanding of the structure, function, and condition of coastal ecosystems. Results of research projects are used by educators, coastal resource managers, health and environmental regulators, legislators, and many other individuals and organizations interested in maintaining or improving the health of estuaries in the face of increasing human activities in the coastal zone.

The following annotated list summarizes 88 of the projects currently being conducted at the Baruch Marine Field Laboratory (BMFL) by staff, graduate students, and faculty associated with the University of South Carolina and other institutions. The University of South Carolina is the home institution for 32 faculty, 18 technicians, and 16 student investigators conducting research at the BMFL. In addition, 38 faculty, 4 technicians, 14 students and 7 volunteers representing 20 other institutions are carrying out projects at the BMFL. Dozens of other graduate and undergraduate students assist these scientists throughout the year to obtain hands-on training in field research methods. A wide variety of basic and applied research is represented. This list includes only those projects that make regular use of the site. Most of the studies that involve field measurements and collections are being conducted within the North Inlet-Winyah Bay National Estuarine Research Reserve.

The projects are listed randomly and each project summary includes title, investigator(s), affiliation, and project abstract. Projects that focus on long-term monitoring and research are grouped under the heading Long-term Studies. Education, Outreach, and Data Management Projects are described in another section.

Funds for these research projects are provided by a variety of sources, including the National Science Foundation (NSF), Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA) (National Estuarine Research Reserve System, *NERRS*, and SC Sea Grant Consortium), US Department of Energy (US DOE), the Office of Naval Research (ONR), National Aeronautics and Space Administration (NASA), and the SC Department of Health and Environmental Control (SC DHEC). The Friends of the Institute, an independent organization that supports Baruch Institute activities, also provides assistance and the Belle W. Baruch Foundation provides the long-term stewardship of Hobcaw Barony to maintain it in a natural state for research and education. For more information, please contact the individual investigators, Dr. Dennis Allen, or Dr. Scott Neubauer at 843-546-3623. Information may also be obtained from the Institute's web site ([www.cas.sc.edu/baruch/](http://www.cas.sc.edu/baruch/)), which contains links to many related sites.

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## **Characterization of intertidal zone creek networks**

Investigator: Dr. Raymond Torres  
Department of Geological Sciences, USC

Tidal creeks and channels dissect the marsh landscape and produce discrete islands with well-defined drainage basin networks. Estuarine habitat structure results from the interactions between salt marshes, channel networks and land use. Therefore, any influence on channel network geometry may influence habitat structure and population density of marsh flora and fauna. Hence, channel network form and processes play an important role in estuarine ecology and stability.

Urban and suburban developments encroaching onto coastal environments may cause alterations to the channel platform. These alterations increase shear stress, perhaps negatively impacting habitat structure, thereby requiring rehabilitation. While marsh habitat creation and rehabilitation efforts are an important part of ecosystem stabilization, the critical question is: Restoration to what? Scaling in estuarine channel network geometry may yield useful indices to describe drainage density equilibrium. It may also elucidate controls on spatial variability of biological processes, which in turn can be used to define restoration goals and objectives.

The objectives of this proposed research are to 1) quantify estuarine channel network properties at North Inlet NERRS and 2) test terrestrial concepts for channel network evolution in estuarine systems. I propose to use Hack's law ( $L = m \times A^n$ , where L is total stream length, m is a parameter derived experimentally, A is drainage basin area, and n is a scaling exponent) to test for power law scaling in estuarine channel systems. I expect to reveal the utility of exponential scaling which may serve as an index needed to assess the large-scale health and stability of estuarine systems. It may also be the basis for channel system design in reconditioned coastal landscapes. This project is funded by EPA and will continue through 2007.

## **A high accuracy micro-topographic determination of marsh topography**

Investigators: Drs. Raymond Torres and Xiaobo Zhou  
Department of Geological Sciences, USC

Salt marshes are dynamic environments being modified by every ebb and flood of the tides. Do the incoming tides and their drainage define the creek network or is it the pre-existing topography that determines the form and development of tidal creek networks?

We use relatively new Real-Time Kinematic (RTK) Global Positioning System (GPS) technology within a calibrated network of published geodetic benchmarks to ensure control and accuracy of data. This method of topographic/hydrographic surveying yields approximately 2 cm accuracy data. These data effectively reveal the subtle marsh surface morphology that conventional mapping methods have thus far portrayed as flat.

Preliminary interactive computer visualization and profiling of the micro-topography has shown subtle troughs and ridges on the marsh platform between creek networks that have previously only been suspected to be real geomorphic features. Ongoing analysis of the marsh topography may better define the spatial control of pre-existing topography in the development of creek and channel networks.

Channel network structure, marsh platform and their processes are vital to estuarine ecology. A better interpretation of topographic forces or control (versus tidal forcing) may aid in the overall understanding of marsh surface development and to that of the creeks and channels that dissect it. Understanding development and stability of salt marshes is scientifically valuable for many efforts, these include: biological, environmental, habitat and ecological as well as economical objectives.

Funding for this project is through NSF EAR. The field study was initiated in January 2002 and is ongoing. See [map](#) location #16

### **Long-term and short-term sediment accumulation rates in a salt marsh setting**

Investigators: Drs. Xiaobo Zhou and Raymond Torres  
Department of Geological Sciences, USC

Sediment accumulation rates depend on microtopography and local geomorphology. We are using radiogenic isotopic techniques to estimate long-term sediment accumulation and the filter paper method to assess short-term accumulation. We emplaced 74 filter papers over a salt marsh island and extracted 36 sediment cores of 0.9 to 1.7 meters in length to investigate the spatial and temporal variability of sediment accumulation. The elevation of each location is known to within 0.05m of the geoid. Funding for this project is through EPA. The field study was initiated in January 2004 and will continue until 2007. See [map](#) location #16

### **Morphological controls on marsh creek network flow patterns**

Investigators: Dr. Richard Styles<sup>1</sup>, Dr. Raymond Torres<sup>2</sup>, Kevin White<sup>3</sup>, and Joseph Jurissa<sup>3</sup>  
Department of Geological Sciences and Marine Science Program, USC<sup>1</sup>;  
Department of Geological Sciences, USC<sup>2</sup>; Marine Science Undergraduate Major, USC<sup>3</sup>

An experimental study to investigate flow characteristics and salt marsh morphology was carried out in the North Inlet South Carolina. Acoustic Doppler current meters (ADVs) were placed at the terminus of two abutting creek networks that were separated by a topographic divide. An additional acoustic profiler was placed near the mouth of one of the creeks. Flow patterns observed during spring tide indicated an abrupt switch in current direction during flood tide before vanishing at slack high water. This reversal in flow direction was mirrored during the ebb phase, in which initial ebbing did not drain the creek but rather flowed further onto the marsh surface. This pattern was also seen in the profile measurements at all depths. In contrast, the current moved up both creeks on flood and out on ebb during the neap phase. The marsh surrounding the study site is located within a meander of the main tidal channel. Although the cause of the spring tide flow pattern is not completely understood, it may be related to inundation of the marsh island producing a net fluid transport down the pressure gradient formed by the propagating tidal wave. Therefore, topography exerts the dominant control on the flow over the marsh surface during neap tide, yet topography and hydrodynamics exert control during spring tide.

Funding for this project was provided by NSF to Ray Torres, a Research and Productivity Scholarship (RPS) grant to Richard Styles, and a John Hodges award to Kevin White. This study was initiated in May 2004 and is ongoing. See [map](#) location #3.

### **Integrative acoustic mapping of sedimentary processes and benthic environments**

Investigator: Dr. Scott M. White  
Department of Geological Sciences, USC

The primary goal of this project is a system-wide map of the sedimentary environments within the major channels in the North Inlet estuary. This map will be based on the classification of acoustic geophysical data acquired using a multi-frequency side-scan sonar, 10 kHz sub-bottom profiler, and high frequency depth sounder. Previously published and on-going work in sediment sampling by other investigators will be used to constrain models of sediment type and grain size based on the acoustic data. Maps will be created showing the locations of distinct benthic environments based on integrative GIS maps of bed type, thickness of deposits, and channel structure. These will in turn illuminate the processes leading to the distribution of sediments and the diversity and relative proportions of different benthic environments within the NERR. The data collection phase of this project will be carried out in summer 2006 with subsequent integration, processing, and map production during the following academic year. Funding for this project is provided through the USC College of Arts and Sciences, and the Department of Geological Sciences.



### **Sediment exchange near a tidal node**

Investigators: Dr. Richard Styles<sup>1</sup> and Steven Traynum<sup>2</sup>  
Department of Geological Sciences and Marine Science Program, USC<sup>1</sup>  
Marine Science Program undergraduate major, USC<sup>2</sup>

In October 2004, an observational program to examine flow and sediment transport in a subtidal marsh system was conducted in the North Inlet/Winyah Bay NERRS located near Georgetown, South Carolina. Time series of current and acoustic backscatter profiles were obtained from a moored upward looking ADCP deployed in a tidal channel. The channel serves as a conduit between Winyah Bay, a large brackish estuary, and North Inlet, a saline subtidal marsh system. During flood, tidal waters entering from the two systems converge at a node point separating the two water masses. Spatial and temporal salinity and current measurements suggest that during early ebb, Winyah Bay water is transported into North Inlet. As ebb continues, lateral advection from the marsh surface and tidal creeks leads to an increase in salinity, suggesting that North Inlet water is mixing with the Winyah Bay water. Resuspension is greatest during the latter ebb phase with concentrations exceeding 300 mg/l. These results indicate net particulate transport from Winyah Bay to North Inlet over a tidal cycle.

Funding for this project was provided by a Research and Productivity Scholarship (RPS) grant to Richard Styles, and a Honors College Senior Thesis grant to Steven Traynum. The University of South Carolina Marine and Aquatic Research Experience (MARE) program also contributed funding to support this research. This study was initiated in October 2004 and is ongoing.

### **Sedimentation cycles in relation to underlying subsurface structures on a mesotidal marsh island, North Inlet, South Carolina**

Investigators: Juana M. Montané and Dr. Douglas Williams  
Department of Geological Sciences, USC

Utilizing high-resolution seismic stratigraphy from CHIRP and StrataBox instruments, reflection profiles are correlated with lithostratigraphy derived from 11 cores, revealing new aspects of subsurface structure and depositional history within and around a marsh island. The study site is located within the North Inlet-Winyah Bay NERR site, South Carolina, USA. Reflection surfaces were recorded as shallow as 0.5 m and as deep as 35 m below surface. These data were acquired utilizing innovative methodology to investigate the unconsolidated sedimentary lense from a floating platform.

Little is known regarding the long-term history of sedimentation, stratigraphy, and evolution of salt marsh systems, especially in relation to Pleistocene-Holocene paleo-sedimentation patterns and their intrinsic control on present surficial features. By analyzing the nature and characteristics of these evolutionary processes, both through traditional and innovative remote sensing approaches, the goal of this research is to advance our understanding of the modern geologic marsh system.

Results of this study will yield a detailed description of the shallow geological framework and subsurface stratigraphy including the effects of this subsurface structure on the long-term (Holocene) sedimentation and geomorphology. Defining the shallow-subsurface geologic framework provides a foundation for future process-orientated and ecological studies and offers insight into the evolution of coastal marshes. See [map](#) location #16

### **Saltmarsh hydrology and acute marsh dieback**

Investigators: Drs. Alicia Wilson and Jim Morris  
Department of Geological Sciences and Department of Biological Sciences, USC

The goal of this work is to understand links between salt marsh hydrology and ecological productivity. An important hypothesis for this work is that marsh dieback at the site was caused by rapid changes within the normal range of marsh conditions.

We will install ~20 piezometer nests (3 piezometers in each nest) and ~10 diffusion samplers to monitor groundwater levels and salinity. We will conduct additional measurements (groundwater chemistry, ecological

productivity) during monthly field visits. We will vibracore to ~10 ft depth in 10-20 locations to get detailed stratigraphy and to install some of the deeper piezometers. Shallow piezometers will be jetted in or hand-augered.

We will use data we collect in the field (topography, stratigraphy, well tests, and monitoring data) to construct numerical models of groundwater flow and salinity in the marsh island. Once the models are tested, we will use the models to estimate the hydrologic conditions (and the rate of change in those conditions) during the drought that peaked in 2002. See [map](#) location # 2B

### **Quantifying blue crab predation on periwinkle abundance: Visual and immunological assay of gut contents**

Investigators: Michael Long<sup>1</sup> and Dr. Robert Feller<sup>2</sup>  
Department of Biological Sciences, USC<sup>1</sup>; Department of Biological Sciences and Marine Science Program, USC<sup>2</sup>

Periwinkles will be regularly (biweekly or monthly) censused and measured and crabs will be collected in a stratified random design at four stations along the salt marsh elevation gradient from high marsh to the tidal creek. Area of study will be located to the left of the road leading to Clambank, in the same vicinity Brian Silliman monitored cages in 2004 as a BMFL visiting scientist. Crab gut contents will be analyzed visually and/or immunologically for presence/absence of snail opercula or solubilized tissues using a polyclonal antiserum (Feller et al., 1979). Lab feeding studies (serial sacrifice) will be conducted to determine how long snail meals can be detected in blue crabs. Same size crabs will be fed a known amount of snail mass (operculum still attached but without shell) and sacrificed over specified time intervals to establish a known digestion profile based on numbers of precipitin lines found.

The overall objective is to provide quantitative data with which to measure the predation intensity that blue crabs exert upon the periwinkle snail population. The immunoassays will provide information on the interactions between the predator (crab) and prey (snail). The snail population census will help determine if the snail population increases through time or if it decreases. It will also establish how the size-frequency distribution of the snail population does or does not change through time. Analysis of the data provided by this experiment may provide a basis for assessing the overall strength and ecological significance of the trophic cascade if it is present. Funding is provided by SC Sea Grant.

### **Plant defense by volatile emissions**

Investigator: Dr. David E. Lincoln  
Department of Biological Sciences, USC

Many, perhaps most, plants produce odorous emissions from their leaves. Recent investigations have demonstrated that such emissions of leaves that are stimulated by herbivore wounding can attract the enemies of herbivores and thus initiate a third trophic level defense of plants. The goal of the proposed research is to understand the defensive capacity of such herbivore stimulated leaf emissions through attraction of third trophic level enemies in a native setting. Experiments focus on the relationship of herbivore density and the resulting emissions to plant defense, how qualitative and temporal variation in emissions among plants shift their third trophic level defense, and how plant community context can alter the defensive effectiveness of herbivore stimulated emissions. These studies are taking place in the plant community on the edge of the marsh and the adjacent forest at Goat Island. See [map](#) locations # 3 & 8 for project location.

### **Latitudinal variation in plant-herbivore interactions in Atlantic Coast salt marshes**

Investigator: Dr. Steven C. Pennings  
Department of Biology and Biochemistry, University of Houston

Biogeographic theory predicts that consumer-prey interactions are more intense at lower latitudes, leading to increased defenses of prey. My students and I are testing this hypothesis in Atlantic Coast salt marshes. We are counting predators and herbivores, measuring herbivore damage to salt marsh plants and traits of the plants, and

evaluating plant palatability in multiple sites from Florida to Maine. At Baruch, we work about halfway along Goat Island and at the end of the 3<sup>rd</sup> Boundary Cutoff Road ([map](#) locations # 9 & 9A). This project will test a long-standing biogeographic theory that has received little experimental attention. This project was funded in 2002-2005 by the National Science Foundation and is affiliated with the Georgia Coastal Ecosystems Long-Term Ecological Research program.

### **Latitudinal variation in the top-down control of salt marsh herbivores by invertebrate predators**

Investigators: Dr. Robert F. Denno, Rachel Goeriz, Jessica Hines, Dr. Shannon Murphy, and Dr. Gina Wimp  
Department of Entomology, University of Maryland

This study addresses the top-down and bottom-up control of insect herbivores (planthoppers) inhabiting *Spartina alterniflora* marshes. We are specifically interested in the effects of an extensive spatial subsidy of intraguild predators (Pardosa wolf spiders and other invertebrate predators) from neighboring upland habitats (e.g., *Spartina patens* and other upland vegetation types). In northern marshes, spiders typically move from upland overwintering habitats into *Spartina* marshes where they can suppress herbivore populations during the summer months. Using extensive surveys during the *Spartina* growing season (mid May through Mid September), our initial objective is to examine latitudinal variation in the abundance of invertebrate predators in relation to spatial changes in vegetation structure (the cover of upland habitats, and the standing crop biomass and leaf litter in *Spartina* marshes), factors that are known to influence the abundance of predators. Preliminary data suggest that both upland cover and leaf litter associated with *Spartina alterniflora* decrease along the Atlantic coast from New England to Florida. Associated with this spatial change in marsh vegetation structure is a dramatic decrease in the abundance of the ground-foraging community of predators (mostly hunting spiders) that colonize the low marsh from upland habitats. Thus, our expectation is that predator control of insect herbivores in *Spartina* will diminish from north to south along the Atlantic Coast. We aim to verify this latitudinal expectation by sampling vegetation structure and arthropod community composition in *Spartina* marshes along the Atlantic coast. At each marsh we will sample vegetation structure across the elevation gradient from tall-form *Spartina alterniflora* near tidal creek low marsh habitat to *Spartina patens* in high marsh upland habitat. Furthermore, we will use sweep nets and d-vac vacuum samplers to appraise the density of insect herbivores and their predators in the same salt marsh habitats. Our ultimate goal is to understand how this predator subsidy interfaces with spatial variation in vegetation structure to influence latitudinal changes in predator-prey dynamics and food-web interactions in *Spartina alterniflora*. Toward this end, southern-Atlantic marshes (e.g., Clambank in Baruch, SC) represent critical study areas because they characterize differences in structure between north and south Atlantic areas where invertebrate predators are abundant and rare respectively. Thus, such marshes present an ideal opportunity to elucidate factors underlying the dramatic latitudinal change in predator abundance with extended consequences for herbivore control.

This research is funded by NSF grant DEB-0313903: Ecological Studies Division of Environmental Biology to RFD.

### **Genetic variation and cryptic speciation in harpacticoid copepod populations**

Investigator: Dr. Jeffrey G. Baguley  
Belle W. Baruch Institute for Marine and Coastal Sciences, USC

We are currently working on projects investigating genetic variation in two estuarine meiobenthic copepods, *Nannopus palustris* and *Microarthridion littorale*. We have previously revealed a genetic basis for morphological variation in female *N. palustris*, suggesting the presence of cryptic species rather than polymorphism within the species. Collections of *N. palustris* will continue in an attempt to find similar variation in the male of the species. Populations of *N. palustris* from North Inlet, SC are also being compared to populations from Massachusetts and Louisiana in order to further investigate the phenomenon of cryptic speciation and genetic variation with geographic distance. Investigations involving *M. littorale* will focus on variation in multiple nuclear gene loci. Previous investigation has found three distinct mitochondrial DNA haplotypes, suggesting a possible cryptic species complex. However, nuclear gene evidence is needed to further support this hypothesis. Both projects will employ DNA extraction, PCR, DNA sequencing, and/or RFLP techniques to determine genetic variation. All collections will be performed around the Oyster Landing Pier ([map](#) location # 3).

### **Phylogeographic patterns in the parchment-tube worm, *Chaetopterus variopedatus* (Annelida)**

Investigators: Adriene Burnette and Dr. Kenneth M. Halanych  
Department of Biological Sciences, Auburn University

*Chaetopterus variopedatus* is often reported as having a cosmopolitan distribution. In the USA, it is commonly found along the East Coast into the Gulf of Mexico. It has also been reported along the Pacific Coast. Many recent molecular studies have demonstrated that organisms with such broad geographic ranges are often cryptic species complexes (invasive species notwithstanding). Because *C. variopedatus* is one of the best studied annelids in terms of developmental mechanisms and because of its ecological importance, the boundaries of genetically distinct populations need to be delineated for comparative purposes. To this end, we are using mitochondrial DNA markers to determine genetic diversity and patterns in Western Atlantic and Gulf populations of this worm.

### **WormNet: Recent advances in Annelid systematics, development, and evolution**

Investigators: Dr. Kenneth M. Halanych, Heather Blasczyk, and Dr. Torsten Struck  
Department of Biological Sciences, Auburn University

Understanding metazoan phylogeny has been confounded by interpretations of the degree and nature of segmentation in body plans. In particular, the Annelida, commonly called segmented worms, has been central to debates on the role of segmentation in animal evolution. Recent evidence suggests that several nonsegmented or partially segmented worm taxa, previously regarded as separate phyla, are within the annelid radiation. Genomic approaches are being used to reconstruct the early phylogenetic events of the “Annelida”, which includes several previously recognized phyla. Interpreting the segmentation, a hallmark of annelids, in the context of the phylogeny will allow novel insights on the role and plasticity of segmentation during animal evolution. We have visited the Baruch Marine Field Laboratory so that we may build a representative collection of annelids from the southeastern USA.

### **Predicting the persistence of coastal wetlands to global change effects**

Investigators: Drs. Glenn R. Guntenspergen, Donald Cahoon, Karen McKee, and J. Grace  
U.S. Geological Survey, National Wetlands Research Center and  
Patuxent Wildlife Research Center

The survival of coastal wetlands in the face of global change impacts will be determined by the ability to maintain wetland surface elevations relative to sea-level rise.

Within the context of this conceptual framework, we will address the following goals in our extensive network study:

1. Understand the linkages and feedback effects that control habitat stability of coastal wetlands, specifically how wetlands maintain surface elevations relative to sea level.
2. Determine how external forcing functions (sea-level rise and nutrients ) interact with these internal processes to affect ecosystem stability.
3. Develop a predictive capacity to forecast future responses of coastal wetlands to changes in external forcing functions.

We will use long-term observations and analyses of wetland elevation dynamics from a geographically broad network of elevation monitoring stations with standard sampling protocols to understand the trends in coastal wetland response to sea-level rise and nutrient addition.

In addressing this objective, we will measure key processes and soil characteristics (Table 1). Predictive models using these relationships will be used to assess and understand coastal wetland elevation response to an interacting set of external drivers. We will use coastal brackish wetlands as our focus because they are dominated by plant species with  $C_3$  and  $C_4$  photosynthetic pathways and are exposed to multiple external stressors.

We will select 15 brackish sites ranging from the Gulf of Mexico to the Maritime Provinces of Canada in a space for time substitution experiment to assess the trends in surface elevation response to different rates of subsidence and tidal range (proxies for SLR). Network sites will be deliberately selected to span a broad range of environmental conditions to provide greater predictive potential. At each of the 15 brackish wetland sites, the full range of process measures (Table 1) will be conducted seasonally for at least two years, then twice per year thereafter.

At each site, we will establish four plots. Each plot will consist of an area with a deep benchmark and four shallow benchmarks (SET) to measure surface elevation, marker horizons to measure sediment deposition, an area for non-destructive plant and soil sampling, and an area for destructive plant and soil sampling (Fig 2). Two plots will be located at a higher elevation and two plots at a lower elevation relative to each other. In each set of two plots, one plot will serve as a control and the other plot will be fertilized.

**Statistical Analyses:** The work conducted in this research program is designed to both test hypotheses and predict effects. To accomplish both of these objectives, we will use structural equation modeling, SEM, (McCune and Grace 2002, Pugsek et al. 2003) as a framework for both multivariate hypothesis testing and for forecast modeling. The results from SEM applications can be readily converted to forecast models capable of producing predictions of system responses to a wide variety of scenarios. This integrated use of SEM and forecast modeling has distinct advantages over conventional modeling in (1) providing input parameters that are statistically partitioned from other effects and (2) by permitting detailed feedback from data to the forecast model structure.

### **Sediment accretion in North Inlet salt marshes**

Investigators: Dr. James Morris and Karen Sundberg  
Department of Biological Sciences and Marine Science Program, USC

The objective of this study is to understand how the elevation of the marsh surface is regulated. A major hypothesis being tested is that eutrophication initiates a sequence of changes in the sediments, beginning with a decrease in volume due to enhanced decomposition of organic matter. In fact, sediment accretion in experimentally fertilized marsh plots has increased. This is probably due to an increase in sedimentation caused by a higher density of plant stems in fertilized plots. Results of a model linking plant production and sedimentation with sea level indicate that the marsh maintains its elevation with respect to mean sea level for a range of rates of sea level rise, up to a threshold. The elevation of the marsh platform with respect to mean sea level is inversely proportional to the rate of sea level rise. See [map](#) locations #2A, B, C, D.

### **Experimental varying of the marsh platform and macrophyte response**

Investigators: Dr. James Morris and Karen Sundberg  
Department of Biological Sciences and Marine Science Program, USC

The objective of this study was to design a simple experiment in order to investigate how varying the marsh platform in relation to mean sea level would affect macrophyte production, stand dynamics, and biomass allocation patterns of *Spartina alterniflora*.

Our goal was to ascertain aboveground and belowground allocation patterns and quantify where the bulk of belowground biomass was located in relation to marsh elevation and sea level. There are six treatments ranging from supra optimal elevation (i.e., floods only on spring tides) to completely inundated (i.e., waterlogged) with 0.013 m separation between pipes with six replicates per treatment. Monthly stem height measurements are obtained each year from April to October. Plants were harvested at the end of both growing seasons from Oyster Landing, North Inlet, South Carolina ([map](#) location #3).

The frequency of inundation results in significant variation in stand densities and plant heights. While macrophyte production may not vary with treatment, these changes in stand densities and macrophyte morphology may have profound effects on the ability of salt marshes to accrete allochthonous sediments and maintain pace with sea level rise. Furthermore, allocation patterns may ultimately influence net annual primary productivity within salt marshes. Funding for this project came from NSF LTER, USGS, and Louisiana DNR for the period April 2002-Spring 2004.

## **Interspecific competition among some salt marsh perennials in South Carolina**

Investigators: Drs. Richard Stalter<sup>1</sup> and John Baden<sup>2</sup>  
St. John's University, NY<sup>1</sup>; US Army Corps of Engineers, Wilmington, NC<sup>2</sup>

Salt marsh vegetation in the United States is characterized by distinct zonation of vascular plants. Zonation is less pronounced in brackish versus high salinity marshes. Previous transplant experiments indicated several species could not tolerate conditions in areas where they are not normally found. These experiments, however, failed to differentiate the effects of abiotic and biotic (namely interspecific competition) factors. Controlled, reciprocal transplant manipulations have been performed. Growth and survival are being monitored to measure the relative importance of interspecific competition and abiotic factors as determinants of zonation patterns between the salt marsh cord grass, *Spartina alterniflora*, and the black needle rush, *Juncus roemerianus*. See [map](#) location # 6A.

## **Effect of wrack accumulation on salt marsh vegetation**

Investigators: Drs. Richard Stalter<sup>1</sup> and John Baden<sup>2</sup>  
St. John's University, NY<sup>1</sup>; US Army Corps of Engineers, Wilmington, NC<sup>2</sup>

The objective of this ongoing study is to investigate the effect of wrack coverage on salt marsh vegetation in five vegetation zones in a South Carolina salt marsh. A second objective will be to monitor seedling establishment and survival in plots in four arrays during the growing season, 2005-2006.

Four arrays consisting of a string of permanent plots were established in the above communities ([map](#) location #9A). A fifth array was established in a pure stand of *Spartina alterniflora* in March, 2005. Each array was 1.8 meters wide and consisted of eight 1m x 1.8m plots in a row roughly parallel to the water's edge. Within each of these plots, a central 0.5m x 1m sample plot was marked off, surrounded by a 0.25m wide buffer zone including a 0.5m buffer between adjacent sample plots within the array. In early March 2004, wrack was collected and placed on each array except for one control plot at a thickness of 15-cm. Fish netting with a 6.5 cm mesh was laid over the wrack covered arrays and held in place with a peripheral rope tied to stakes at the corners of the array and attached to the netting with special snap clips purchased from Forestry Suppliers, Jackson, MS. Wire staples were used to anchor the rope and netting to the ground. In April 2004, one plot in each array was uncovered and sampled. Subsequently, one plot in each array was uncovered in May, August and October, 2004. During mid October, 2004, vegetation within each experimental plot and the control were sampled with three randomly located 20 x 20cm quadrats located within the larger plots. Stems were counted by species. Vegetation of all species within the quadrats was cut at ground level and standing crop (gms of vegetation/m<sup>2</sup>) was determined.

This is the first study of the effect of wrack on the survival of salt marsh vegetation in a South Carolina salt marsh. With the exception of *Spartina patens*, all salt marsh species experienced 100% kill after wrack cover for two months. *Spartina patens* experienced a 50-75 percent reduction in density though some *S. patens* survived wrack cover for a period of one year.

The investigators greatly appreciate the support of the Baruch Institute for providing us with a vehicle, and lodging and for the helpful assistance of staff who removed wrack from one of the arrays during a hurricane surge during the summer of 2004. BMFL staff also provided the investigators with pictures of the vegetation in the arrays during the growing season of 2004, and in March, 2005. The senior investigator thanks St. John's university for providing equipment and travel funds to support this research. See [map](#) location #9A

## **Nekton as processors and transporters of nutrients in intertidal creek basins: Short-term contributions of dissolved nitrogen and phosphorus**

Investigators: Dr. Dennis Allen<sup>1</sup>, Dr. Richard Dame<sup>2</sup>, Kimberly Foley<sup>1</sup>, Dr. Stacy Luthy<sup>2</sup>, and  
Dr. Robert Young<sup>2</sup>  
Baruch Marine Field Laboratory, USC<sup>1</sup>; Marine Science Department, Coastal Carolina University<sup>2</sup>

The role of nekton in nutrient dynamics within salt marsh ecosystems has not been previously addressed, and we believe that their role is significant and underappreciated.

More than 50 species of fishes, shrimps, and crabs (nekton) move in and out intertidal creeks with the tides. They forage in the creek bed, mud flats, and oyster reefs when flooded, and some species move onto the marsh around the highest period of the tide. Foraging in the sediments (bioturbation), handling (crushing) prey, and excreting wastes are primary means by which these animals contribute to the pool of dissolved nutrients. In this study, we are quantifying the amount of ammonium and orthophosphate contributed by the nekton while occupying intertidal creek basins. Our focus thus far has been on contributions by nekton occupying residual pools of water in creek beds at low tide. A series of experiments with multiple treatments has been conducted to quantify levels of nutrient production by nekton, microbial components of the water column, and the biotic components of the sediments. Simultaneous measurements in replicated artificial pools set in natural creeks and in a nearby natural pool (with naturally recruited populations of nekton) are providing an opportunity to determine what proportion of nutrient increase in these isolated water bodies is associated with nekton excretion and feeding. The next phase of the study will compare nutrient fluxes in undisturbed intertidal creeks (with nekton) and other creeks from which the nekton has been excluded.

Additional experiments may be conducted in flow-through artificial creek mesocosms.

The project is supported by the National Science Foundation, through the Ecosystems Studies Program (January 2005–December 2007).

### **Site fidelity and spatial variations in growth and condition of nekton among intertidal creek basins**

Investigators: Dr. Dennis Allen<sup>1</sup>, Dr. Richard Dame<sup>2</sup>, Kimberly Foley<sup>1</sup>, Dr. Stacy Luthy<sup>2</sup>, and Dr. Robert Young<sup>2</sup>  
Baruch Marine Field Laboratory- USC<sup>1</sup>; Marine Science Dept., Coastal Carolina University<sup>2</sup>

Previous studies that we conducted in North Inlet revealed that use of intertidal creeks by fishes, shrimps, and crabs (nekton) varied among sites and that consistent differences in the magnitude of use were related to unique physical features of those intertidal creeks. Variations in the size distributions of some transient species among creeks suggested that there may be differences in the capacity of individual creeks to support nekton growth. Other work, indicating that individuals return to the same creek tide after tide, suggests a mechanism by which groups from the same year class can remain segregated for weeks to months and potentially grow at different rates. Our current work seeks to determine the extent of site fidelity for multiple common species that use intertidal creeks for foraging during the warm season. Regular, simultaneous collections from multiple creeks will determine if patterns of repeated use and differences in season-long growth rates occur. Indices of animal condition (immediate past growth and potential for future growth) will provide an additional measure of habitat quality. Together, these studies will determine: (1) whether growth rates and condition vary spatially for individual species and (2) whether high site fidelity is a possible mechanism for segregation and the expression of different growth responses among locations. In addition to addressing relationships between nekton use and nursery habitat quality, our research will contribute to a broader understanding of the export of living biomass from intertidal salt marsh basins to the lower estuary and ocean. The project is supported by the National Science Foundation, through the Ecosystems Studies Program (January 2005–December 2007).

### **The role of tidal creeks in foraging and growth rate of juvenile Atlantic sharpnose sharks, *Rhizoprionodon terraenovae***

Investigators: Mary K. Maxwell and Dr. Daniel C. Abel  
Coastal Marine and Wetland Studies Graduate Program, Coastal Carolina University

The purpose of this study is to test the hypothesis that estuarine subtidal creeks are critical nursery habitat for juvenile Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, compared to nearshore environments where this species is also found in abundance seasonally. We will analyze gut contents and estimate growth rates using tag-recapture and other methods for sharks caught in North Inlet as well as in the nearby nearshore environment. Sampling will occur from May to October 2006 and will consist of hook-and-line fishing, longlines, and/or gill nets. Gut contents will be sampled throughout the sampling season. Each shark that is not sampled for gut contents will be tagged and released. Upon recapture, animals will be measured and a growth rate will be estimated. This study

will shed light on the relative importance of isolated estuaries as nurseries for *R. terraenovae*, and will help determine whether North Inlet serves as Essential Fish Habitat (EFH) for this species.

This project is supported by the Coastal Atlantic States Shark Pupping and Nursery (COASTSPAN) program, Georgetown Environmental Protection Society, and Coastal Carolina University's Coastal Marine and Wetland Studies Graduate Program.

### **Winyah Bay and nearshore waters as shark habitat and nursery grounds**

Investigators: Samuel J. Gary Jr. and Dr. Daniel C. Abel  
Coastal Marine and Wetland Studies Graduate Program, Coastal Carolina University

Surveys of sharks along the Southeast coast continue to show declines in several species, e.g., sandbar and dusky sharks, although other stocks, e.g. blacktips, may be experiencing recovery. These and other sharks inhabit coastal waters and/or estuaries, and use these as nurseries. We are in the fifth year of a long-term longline study to survey the sharks of Winyah Bay and nearby waters; to determine which sharks use the Bay as a nursery; and to understand habitat selection by selected species in the Bay. Sampling will occur from May through October of 2005 and consist of 500 ft demersal longlines with 25 hooks. 12/0 circle hooks will be used to target neonates, young-of-year and juveniles; and 16/0 circle hooks will be used to sample larger individuals. Longlines will be set in the Lower Bay, Middle Bay and, for the first time, the nearshore environment. Variables including surface and bottom water temperature, salinity, and dissolved oxygen, as well as secchi depth and set depth will be measured. Captured sharks are identified, measured, tagged and released with as little stress to the animal as possible. Early results from this project are in press (Abel, D. C., R. F. Young, J. A. Garwood, M. J. Travaline and B. K. Yednock. 2005. Survey of the shark fauna in two South Carolina estuaries and the impact of salinity structure. Pages x-xx in C. T. McCandless, N. E. Kohler, and H. L. Pratt, Jr., editors. Shark nursery grounds of the Gulf of Mexico and the East Coast waters of the United States. American Fisheries Society, Symposium, Bethesda, Maryland. )

This project is supported by the Coastal Atlantic States Shark Pupping and Nursery (COASTSPAN) program, Georgetown Environmental Protection Society, and Coastal Carolina University's Coastal Marine and Wetland Studies Graduate Program.

### **A comparison of the shark fauna of two S.C. estuaries differing in degree of human impact**

Investigators: Mollie M. McDonough and Dr. Daniel C. Abel  
Coastal Marine and Wetland Studies Graduate Program, Coastal Carolina University

In 2003, as part of a long-term study of the ecology of sharks of northeast South Carolina, we set 196 bottom longlines throughout North Inlet (a relatively pristine estuary), Murrells Inlet (an urbanized estuary otherwise similar to but slightly smaller than North Inlet), and along Garden City Beach (a nearshore ocean environment), and caught 34, 5, and 26 sharks, respectively. Corresponding Catch Per Unit Effort (CPUE, sharks per 25 hooks,  $\mu \pm \text{SEM}$ ) was  $1.83 \pm .06$ ,  $0.07 \pm .002$ , and  $2.64 \pm .09$ . We also caught 5, 19, and 1 batoids, respectively, at the three sites. Because *R. terraenovae* (Atlantic sharpnose sharks) were abundant immediately outside but not in Murrells Inlet, and were plentiful at nearby locations, human impact associated with urbanization may explain their absence in Murrells Inlet, as well as its inability to serve as a nursery for other species of sharks. From May–October 2006 and 2007 we will test this hypothesis by setting 500 ft demersal longlines with 25 12/O and 16/O circle hook gangions at sites in North and Murrells Inlets and correlating CPUE with environmental data from the sites.

This project is supported by the Coastal Atlantic States Shark Pupping and Nursery (COASTSPAN) program, Georgetown Environmental Protection Society, Slocum-Lunz Foundation, National Fish and Wildlife Foundation/Sustainable Universities Initiative.



## **Juvenile white shrimp, *Litopenaeus setiferus*, potential reduction of macrobenthos abundance in southeastern US salt marshes**

Investigators: Jennifer Beseres<sup>1</sup> and Dr. Robert Feller<sup>2</sup>  
Marine Science Program and Baruch Marine Field Laboratory, USC<sup>1</sup>  
Department of Biological Sciences and Marine Science Program, USC<sup>2</sup>

Many juvenile estuarine species rely on the detritally-driven food webs in salt-marsh habitats and are capable of ingesting large numbers of benthic prey. Long-term monitoring conducted by the Baruch Marine Field Lab in North Inlet-Winyah Bay (NI-WB), SC, shows that macrobenthos abundances typically decline in early spring with the recruitment of predatory transient estuarine species such as brown shrimp *Farfantepenaeus aztecus* and many juvenile fishes. This database has also provided correlative evidence that macrobenthos numbers decline more than usual during years when white shrimp (*Litopenaeus setiferus*) are very abundant, leading to the hypothesis that white shrimp predation is capable of significantly reducing macrobenthos abundances.

In order to determine the magnitude of shrimp predation in reducing macrobenthos abundances, we first used manipulative caging experiments in NI-WB, SC (Crabhaul Creek, [map](#) location #3), and Sapelo Island, GA (Factory Creek). Normal and elevated white shrimp densities were held in inclusion cages and allowed to feed on subtidal macrobenthos for 7 days. Macrobenthic organism abundance significantly declined over a 7-day period in the shrimp treatment cages. Follow-up laboratory experiments indicated that shrimp predation reduced macrobenthos abundance to a greater extent than disturbance or emigration. Laboratory measurements of individual shrimp consumption rates on recently settled hard clams indicated maximum consumption rates of greater than 10,000 clams / m<sup>2</sup>/ day. We plan to combine these data with those from the caging and laboratory predation experiments to model seasonal changes in prey abundance as a function of shrimp predation. This project is funded by a NOAA/NERR Graduate Research Fellowship through 2006.

## **Microbial Observatory: The microbial community and distribution associated with the roots of select salt marsh plants**

Investigators: Drs. George Y. Matsui<sup>1</sup> and Madilyn Fletcher<sup>1,2</sup>  
Belle W. Baruch Institute, University of South Carolina<sup>1</sup>  
Department of Biological Sciences and Marine Sciences, University of South Carolina<sup>2</sup>

The root-associated microbial communities directly influence the growth of many plants. This is especially true in plants that are subjected to nutrient limitations or soil constituents that may inhibit growth. Within the salt marsh, nitrogen limitations exist as well as high levels of sulfide that have been shown to limit plant growth. It is believed that microorganisms associated with the roots of salt marsh plants aid in mediating these factors. The purpose of this study is to 1) examine the microbial communities found on the roots of *Spartina alterniflora* and *Juncus roemerianus*, 2) determine how these communities are distributed along the roots, and 3) determine what factors contribute to differences in microbial community and distribution. The roots of *S. alterniflora*, *J. roemerianus* and sediment associated with those plants will be collected and the microbial communities on the roots and within the associated sediments will be examined using fluorescence in situ hybridization (FISH) of 16S rRNA used in conjunction with confocal laser scanning microscopy (CLSM). Oligonucleotide probes targeting specific taxonomic groups of bacteria will be used to determine bacterial distribution and differences within the bacterial communities. Pore water will be collected and analyzed to determine environmental parameters that may affect microbial communities associated salt marsh plant roots. The results of this study will provide a better understanding of factors that affect primary production and the microbial influence on carbon and nitrogen cycling within the salt marsh. [Map](#) location #10. Support is provided by National Science Foundation award MCB-0237854 and the Belle W. Baruch Institute.

### **Adhesion and coaggregation of estuarine bacteria on silica**

Investigators: Drs. George Y. Matsui<sup>1</sup> and Madilyn Fletcher<sup>1,2</sup>  
Belle W. Baruch Institute for Marine and Coastal Sciences, USC<sup>1</sup>  
Department of Biological Sciences and Marine Sciences, USC<sup>2</sup>

Bacteria adhere rapidly to clean surfaces and form biofilms in natural waters. The process by which these complex structures form is not clearly understood. It has been proposed that some biofilm communities are formed from the successive adhesion of bacteria. Successional adhesion may be the result of specific interactions between bacteria, coaggregations, that act as primary colonizers and subsequent colonizers, which interact symbiotically. Such a system is seen in bacteria that form the biofilm found on human teeth and it has been suggested that coaggregation is involved in the formation of freshwater biofilms. Marine biofilms may also form by successional development. Specific groups of bacteria are believed to be involved in early biofilm formation but the relationship between these organisms and bacteria found in older biofilms has not been determined. The purpose of this study is to examine colonizers of silica surfaces in estuarine systems to determine whether primary colonization is characteristic of specific adhering marine bacteria and to determine whether co-aggregation has a role in subsequent adhesion. Short term incubations of cleaned glass slides in estuarine water have been conducted and colonizing bacteria isolated. The ability of these isolates to adhere to silica and to form coaggregates will be tested. Characterization of the organisms will be conducted by 16s rDNA analysis. The results of this study will provide a better understanding of the marine biofilm formation and lead to future studies on factors affecting primary adhesion and co-aggregation of bacteria, as well as relationships between adhering bacteria in estuarine systems. Support provided by the Belle W. Baruch Institute. Site location: Clambank boat landing

### **Carbon dioxide production and dissolved inorganic carbon transport in the North Inlet salt marshes**

Investigator: Dr. Scott Neubauer  
Baruch Marine Field Laboratory USC

This study will describe some of the spatial and temporal patterns in inorganic carbon fluxes in the North Inlet salt marshes. This project will build upon previous work that has shown that a wide variety of factors including the presence/absence of plants, soil composition, and temperature affect rates of heterotrophic metabolism (i.e. CO<sub>2</sub> production) in tidal marsh soils. A fraction of carbon dioxide produced in marsh soils is exported to tidal waters in the form of dissolved inorganic carbon (DIC), but there have been few studies that have robustly documented how and why DIC concentrations vary over the course of the year. Rates of soil metabolism will be measured on soil cores that have been removed from intertidal marsh zones and processed in the lab under anaerobic conditions. Soil subsamples will be incubated anaerobically in sealed bottles at ambient temperatures. Soil respiration and decomposition rates (i.e. the increase in carbon dioxide within the bottle headspace) will be measured over short (hours to days) and longer (~months) time scales. Specific locations for this part of the research have not yet been determined. I will measure the DIC concentrations of water samples collected from the Oyster Landing Pier over tidal and diurnal cycles by acidifying water samples and measuring the total amount of evolved carbon dioxide. Furthermore, the partial pressure of carbon dioxide will be measured using a gas equilibrator connected to an infrared gas analyzer. The timing of these analyses will be coordinated with the NERRS System-Wide Monitoring Program to take advantage of other data that are regularly collected at Oyster Landing (e.g. nutrients, dissolved organic carbon, chlorophyll).

### **Availability and utilization of dissolved organic nitrogen by *Spartina alterniflora***

Investigator: Thomas J. Mozdzer  
Department of Environmental Sciences, University of Virginia

This research is part of my doctoral work determining if a latitudinal gradient exists in the availability and utilization of dissolved organic nitrogen in *S. alterniflora* salt marshes. To accomplish this, I have established eight field sites along the Atlantic coast that are being monitored monthly or bi-monthly for porewater nutrients. At the North Inlet site, I am working with Jim Morris who is collecting porewater samples for my analysis. In addition to

determining porewater nutrients ( both organic and inorganic), I would like to determine if there are differences in how different populations of *S. alterniflora* along the coast of N. America are using available nutrients. My MS research demonstrated the direct utilization of amino acids by *S. alterniflora* and *P. australis*, and I wanted to validate these results in different sites.

To determine DON utilization by *S. alterniflora*, fifteen vegetated 15 cm diameter cores will be withdrawn from the marsh. Porewater will be sampled via a stainless steel probe and frozen for analysis at the University of Virginia. The PVC core plus plant will be placed in individual containers and flooded to a depth of 10cm with ambient creek water. These cores will be subsequently amended with one of three treatments: <sup>15</sup>N-ammonium, <sup>13</sup>C, <sup>15</sup>N-amino acid mix, or a disturbance control. Amino acid treatments are 99% enriched with <sup>13</sup>C and <sup>15</sup>N, and the ammonium is 99% <sup>15</sup>N. Using the stable isotopes as a tracer, I can determine the plant utilization over a 48-hour incubation period. After the 48-hour incubation, above and belowground plant material will be harvested, and shipped on dry ice to the University of Virginia, where it will be freeze dried and analyzed for stable isotope concentrations by the UC Davis Stable Isotope facility. See [map](#) location #14.

### **Chemically mediated interactions in a sedimentary assemblage**

Investigators: Drs. Charles R. Lovell, Sarah Woodin, David Lincoln, and students  
Department of Biological Sciences and Marine Science Program, USC

In this study, investigators are evaluating impacts of toxic chemicals (bromophenols) produced by burrowing polychaetes on marine sediment microflora. Respiration and assimilation rates of bacterial communities are being conducted using radiotracer techniques. Phospholipid fatty acid analysis has provided insights into microbial community ecology and how microbial communities respond to chemical stresses. Field and laboratory measurements indicate that natural microbial communities are adept at mineralizing these compounds and that their modes of growth in the sediments provide them with protection from toxic chemicals. Bacterial species highly active in compound mineralization may be useful in cleaning up chemically impacted sites. See [map](#) location # 17. This project has been supported by NSF, ONR, and EPA.

### **Colonization of man-made surfaces in the marine environment**

Investigators: Dr. Charles R. Lovell and students  
Department of Biological Sciences and Marine Science Program, USC

Microorganisms colonize submerged surfaces very efficiently. This colonization process provides numerous benefits to the microorganisms, including access to surface-bound nutrients and protection from certain types of predators. The accumulation of these organisms and their extracellular products on surfaces ultimately results in the formation of biofilms, which contribute very substantially to the process of biofouling. Biofouling of man-made materials creates numerous problems. The dense accumulation of organisms and polymers impedes thermal transfer in heat exchange pipes, creates drag on ship hulls, and produces unique corrosion processes that can destroy the surface in question. The consequences of surface colonization are clear, but the sequence of events leading to biofouling is poorly understood. We have been studying the early stages of surface colonization and have identified the primary colonists (i.e., the first species to attach to the surface) on a variety of surfaces. We have also tracked the seasonal dynamics of these primary colonists and are now determining their interactions with other types of organisms. In some biofilm systems, the primary colonists greatly facilitate the attachment of other species, leading to biofouling. If the primary colonists in marine systems have this same essential role in the generation of marine biofouling communities, they may hold the key to controlling biofouling. This project has been supported by the Department of Defense.

Recent publications associated with the work:

Dang, H. and C.R. Lovell. 2002. Numerical dominance and phylotype diversity of marine *Rhodobacter* during early colonization of submerged surfaces in coastal marine waters as determined by 16S rDNA sequence analysis and fluorescence in situ hybridization. *Applied and Environmental Microbiology* 68:496-504.

Dang, H., and C.R. Lovell. 2002. Seasonal dynamics of particle-associated and free-living marine Proteobacteria in a salt marsh tidal creek as determined using fluorescence in situ hybridization. *Environmental Microbiology* 4:287-295.

Dang, H., and C.R. Lovell. 2000. Bacterial primary colonization and early succession on surfaces in marine waters as determined by amplified rRNA gene restriction analysis and sequence analysis of 16S rRNA genes. *Applied and Environmental Microbiology* 66:467-475.

### **Infaunal burrows and their impacts on sediment microbiota**

Investigators: Drs. Charles R. Lovell and George Matsui  
Department of Biological Sciences and Marine Science Program, USC

Marine infauna create and maintain burrows in soft sediments. These structures vary in composition, properties, and longevity, but in all cases house abundant and highly active microbiota. The increased surface area provided by burrows greatly enhances diffusive exchange between the sediments and overlying seawater and the irrigation of the burrows by the resident infauna introduces oxygenated seawater into sediments that are otherwise highly anoxic. The microbiota of the burrow linings occur in thick biofilms and consists of both oxygen requiring and oxygen sensitive species. A major focus of this project is the impact of oxygen introduction by irrigation on key species of anaerobic bacteria, particularly the sulfate reducing bacteria. We are performing field sampling and experimental manipulations in the laboratory to determine whether the sulfate reducers in burrow lining biofilms are sensitive to introduced oxygen, or are sheltered through growth in anaerobic microzones. Such microzones could arise from growth of sulfate reducers in association with oxygen consuming species. Another possibility is strong chemical reduction of the surroundings by high levels of sulfate reduction activity, which produces hydrogen sulfide. It is also possible that the sulfate reducers have no special refugia from oxygen and are exposed to oxygen when burrows are actively irrigated. We are using fluorescence in situ hybridization and fluorescent redox potential probes to determine which of these growth strategies are employed by sulfate reducers to maintain activity and viability in the strongly irrigated tubes of the onuphid polychaete *Diopatra cuprea*.

Publications associated with the work:

- Matsui, G.Y., D.B. Ringelberg, and C.R. Lovell. 2004. Sulfate reducing bacteria in tubes constructed by the marine infaunal polychaete *Diopatra cuprea*. *Applied and Environmental Microbiology* 70:7053-7065.
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- Watson, J., G.Y. Matsui, A. Leaphart, F.A. Rainey, J. Wiegel, and C.R. Lovell. 2000. Reductively debrominating strains of *Propionigenium maris* from burrows of bromophenol producing marine infauna. *International Journal of Systematic and Evolutionary Microbiology* 50:1035-1042.
- Phillips, T.M. and C.R. Lovell. 1999. Distributions of total and active bacteria in biofilms lining tubes of the onuphid polychaete *Diopatra cuprea*. *Marine Ecology Progress Series* 183:169-178.

### **Identity, physiological ecology, and toxicity of the red tide dinoflagellate *Kryptoperidinium* sp.**

Investigators: Dr. Susan B. Wilde<sup>1,2</sup>, Krista DeMattio<sup>2</sup>, Raphael Tymowski<sup>1</sup>, and Charles Keppler<sup>2</sup>  
Baruch Marine Field Laboratory and Hollings Marine Laboratory, USC<sup>1</sup>;  
Marine Resources Research Institute, SCDNR<sup>2</sup>, University of North Carolina at Charlotte<sup>3</sup>

*Kryptoperidinium* sp. is a dinoflagellate responsible for red tides in several South Carolina estuaries from Georgetown to Hilton Head in spring 1998-2001 (the first red tides reported to be localized to SC estuaries). These blooms have recently been shown to cause physiological stress to oysters. Given their widespread distribution and potential to adversely affect shellfish, the ecological and economic impacts of these newly observed blooms might be considerable. This study examines the identity of the bloom organism(s), the factors driving bloom dynamics, and potential bloom impacts on shellfish health. The blooms appear to coincide with heavy spring rain events that produce increased run-off of terrestrial humic substances. The use of this dissolved organic matter (DOM) as an energy source may be beneficial for its growth in estuarine waters. Our objectives are to determine *Kryptoperidinium*'s physiological responses to DOM and inorganic nutrient enrichment in order to determine

whether nutrient loading plays a role in bloom stimulation. Furthermore, we are developing molecular tools to enhance bloom species identification and detection, and determining the physiological stress responses of oysters to the SC blooms. This project is supported by ECOHAB (NOAA, NSF, EPA, NASA, ONR) for the period September 2, 2002 to August 31, 2005, and NOAA NOS for the period 1 October 2004 to 30 September 2006.

### **Application of the CHEMTAX model in estuaries. Deriving phytoplankton composition from HPLC pigment profiles**

Investigators: Dr. Susan B. Wilde<sup>1,2</sup>, Raphael G. Tymowski<sup>1</sup>, and Dr. David White<sup>3</sup>  
Baruch Marine Field Laboratory and Hollings Marine Laboratory, USC<sup>1</sup>; Marine Resources Research Institute, SCDNR<sup>2</sup>, NOAA, Hollings Marine Laboratory<sup>3</sup>

CHEMTAX is a modeling program used to derive the abundance and class composition of phytoplankton from HPLC pigment data. Although it has been applied successfully to open-ocean algae, it produced inaccurate results in an estuarine system. Further study indicated that CHEMTAX output is accurate only if the pigment ratios used to calibrate the model are near those of the phytoplankton in the community being examined. Thus, a model calibrated using open-ocean phytoplankton is not applicable to an estuary containing similar taxa. The main goal of the current study was to produce a set of calibration pigment ratios that would allow the model to be used in several SC estuaries. Phytoplankton composition derived using the newly calibrated CHEMTAX model was compared to that determined through microscopic enumeration. The results of the two methods agree closely, although additional research is required to achieve greater resolution between algal classes.

### **Functional relationships (coupling) between epiphytic microalgae and food webs in a saltmarsh estuarine system and their management implications**

Investigators: Dr. Richard Zingmark<sup>1</sup> and Raphael Tymowski<sup>2</sup>  
Department of Biological Sciences, USC<sup>1</sup>, Baruch Marine Field Laboratory, USC<sup>2</sup>

North Inlet Estuary (NIE) is a typical, near-pristine, highly productive, *Spartina alterniflora*-dominated, salt marsh estuary that has been well characterized in recent years with respect to material and energy flow. Numerous subsystems have been identified that vary in direction and magnitude of material flux. One such typical subsystem, the tidally driven Bly Creek basin, is an exceptionally productive area that receives a diel net input of particulate organic carbon (POC) (including phytoplankton) from the coastal ocean. Some of the phytoplankton is sequestered by and becomes incorporated into the epiphytic community on the stems of *S. alterniflora*. Although the net flux of POC into Bly Creek was previously estimated, specific functional mechanisms (e.g., trophic links) responsible for processing it are not understood. This proposed research seeks to describe and quantify linkages between “phytoplanktonic” carbon transported from the coastal ocean through Bly Creek and its various trophic compartments. By identifying and quantifying trophodynamic mechanisms regulating phytoplankton flux through Bly Creek, the proposed research will fill gaps in our understanding of how highly productive salt marshes are linked to and process primary production from the coastal ocean to help fuel estuarine secondary production (including that of commercially and recreationally important fish and shellfish species) in this and other salt marsh estuarine systems. Results of this study will provide a strengthened scientific basis to guide protective management decisions in salt marshes. This study is funded by SC Sea Grant Consortium, 1 March 2005 to 28 February 2007.

### **Zooplanktivory by the burrowing brittlestar *Hemophilic elongata*: Tests on natural plankton assemblages**

Investigator: Dr. Stephen Stancyk  
Department of Biological Sciences and Marine Science Program, USC

Most burrowing brittlestars are in the family Amphiuridae, and obtain nutrition from surface and subsurface deposit-feeding on detritus. *Hemophilic elongata*, however, is in a different family (Ophiactidae) and has been shown to readily feed on brine shrimp and copepods. Because most zooplanktivorous brittlestars are found in the deep sea or Antarctica, the presence of *H. elongata* in North Inlet provides an opportunity to learn more about

feeding responses and prey selection in ophiuroids. To develop feeding response curves and prey preference information, individual brittlestars are placed in cores and allowed to feed on known densities and mixtures of unnatural (brine shrimp, *Artemia*) and natural (field-collected copepods, larvae, etc) prey assemblages. *H. elongate* is uncommon in North Inlet and lives around tube-caps of the polychaete, *Diopatra cuprea*, only in muddy sands. See [map](#) location #17.

### **Environmental impacts of gelatinous zooplankton (hydromedusae) on carbon dynamics of the North Inlet ecosystem**

Investigators: Dino Marshalonis, Dr. James L. Pinckney, and Dr. Tammi L. Richardson  
Department of Biological Sciences, USC

Hydromedusae (thimble jellyfish) are gelatinous zooplankton that are major predators of other zooplankton species. Their ability to reproduce rapidly coupled with their extremely high prey consumption rates enables them to exert control over energy flow and nutrients in estuarine waters. Gelatinous zooplankton are major components in a trophic cascade in which they consume microzooplankton and the microzooplankton are primary grazers on nanophytoplankton. Therefore, gelatinous zooplankton can affect phytoplankton community composition indirectly by consuming phytoplankton herbivores. Seasonal abundances of Hydromedusae have been recorded for North Inlet, South Carolina during the last 15 years as a part of their LTER and NERRS Programs and have been shown to be the dominant gelatinous predator in this system in terms of numerical abundance.

The study location for the proposed research will be Clambank Creek in North Inlet, South Carolina ([Map](#) Location 6B). There are three main testable hypotheses for this project. First, we will examine whether grazing by hydromedusae stimulates a shift in phytoplankton community composition from small to large phytoplankton. Secondly, we will evaluate the effects of temperature and species on ingestion rates and assimilation efficiencies for hydromedusae in North Inlet. Third, we will compare respiration rates for oblate and prolate hydromedusae species, as well as actively feeding and non-feeding organisms. In situ bioassays will examine relationships between gelatinous zooplankton and the rest of the estuarine plankton in this system. These results will be compared to our determination of species specific metabolism through respiration rates. Determination of ingestion and assimilation rates will quantify the grazing impacts hydromedusae in North Inlet will impart on the rest of the plankton. Collectively, these values can be scaled up for the entire estuary using long term data for gelatinous animal abundance in North Inlet. The sum result of these experiments will be incorporated into a carbon based food web model to demonstrate how and to what degree gelatinous animals influence carbon flows for the North Inlet plankton system, as well as the potential impact of increased gelatinous animals in the future. This project is funded by NOAA's National Estuarine Research Reserve System (NERRS) Graduate Research Fellowship Program from June 1, 2005–May 2008.

### **Ecotoxicology of benzalkonium chloride, a common antimicrobial surfactant**

Investigators: Jean Marie Buschur and Dr. James L. Pinckney  
Marine Sciences Program, USC

Pharmaceuticals and personal care products (PPCPs) are a relatively new class of chemicals of which little attention has been paid to their long-term environmental effects. One PPCP is benzalkonium chloride (BAC), which has been used as an antimicrobial agent in many products such as pharmaceuticals and household cleaners. BAC is released in high concentrations in wastewater effluent. However, few studies have determined the effect of BAC on phytoplankton.

In this research the affect of BAC natural phytoplankton communities at Clambank Creek, North Inlet, South Carolina will be studied. There are four specific hypotheses. First, a low concentration of BAC ( $0.6 \mu\text{g L}^{-1}$ ) will have no impact on biomass and community composition. Second, an intermediate low concentration of BAC ( $1.0 \mu\text{g L}^{-1}$ ) will lower biomass and community composition for cyanobacteria, cryptophytes, and diatoms; it will have no impact on chlorophytes and dinoflagellates. Third, an intermediate high concentration of BAC ( $1.5 \mu\text{g L}^{-1}$ ) will be lethal for diatoms, cyanobacteria and cryptophytes; and will result in lowered biomass and community composition on for chlorophytes, dinoflagellates. Finally, a high concentration of BAC ( $2.5 \mu\text{g L}^{-1}$ ) will be lethal for all species.

Each unialgal culture underwent a 7 day EC<sub>50</sub> laboratory toxicity test with exposure to BAC in the following different geometrically spaced concentrations: 0.0, 0.10, 0.15, 0.25, 0.40, 0.60, 1.00, 1.50, 2.00, and 2.50 µg L<sup>-1</sup>. The EC<sub>50</sub> was evaluated at 48, 72, and 168 hours. Short-term phytoplankton bioassays will be used to measure phytoplankton response to BAC in situ. Photosynthetic pigments, algal species identification/enumeration by microscopy, and primary productivity will be determined at the initiation of the experiment and daily for the 3 day incubation period. Bioassay results will be analyzed using a multivariate analysis of variance procedure. A repeated measures design will be used to determine experimental effects within replicates and between different treatment levels for each bioassay. High performance liquid chromatography (HPLC) will be used to quantify photopigment concentrations in water samples collected from the bioassays and the laboratory EC<sub>50</sub> tests. ChemTax (CHEMical TAXonomy), a matrix factoring program, will be used to calculate algal class abundances based on the concentrations of algal photopigments. Microscopy will be used to count phytoplankton species and abundances to confirm results of phytoplankton taxa from HPLC.

These results will assess the effects of BAC on phytoplankton. Intermediate effects of BAC will be seen through the shift in community composition of the phytoplankton, determined from HPLC and ChemTax analysis. This is a start to understanding the effect of PPCP's on the environment, and may lead to regulations against their disposal in the environment.

This project is funded by South Carolina SeaGrant and will run from May 2006 – May 2007.

### **Effects of sublethal concentrations of agricultural herbicides on the structure and function of estuarine phytoplankton communities**

Investigators: Dr. James L. Pinckney and Jean Marie Buschur  
Marine Sciences Program and Department of Biological Sciences, USC

Habitat alteration and loss of biodiversity due to pesticide contamination is rapidly emerging as major ecological threat for wetland and estuarine ecosystems. In aquatic ecosystems, phytoplankton are usually the most atrazine-sensitive biotic components. The proposed research will directly address SC Sea Grant Strategic Goal 3 under the Priority Topic "Investigations of the cumulative effects on key indicator marine organisms of low level, sub-chronic exposure to chemical contamination due to increasing human activities". In this project, the key indicator species will be phytoplankton and the ecological indicators will be phytoplankton community composition and primary productivity. The chemical contaminants will be a common herbicide (atrazine) in waters entering many South Carolina estuaries, growth-limiting nutrients (nitrate & phosphate), and the interactive effects of atrazine and nutrients to simulate pulsed river discharge events.

The experiments are designed to determine the short-term sublethal effects of environmentally-relevant concentrations of atrazine (under high and low nutrient concentrations) on estuarine phytoplankton community structure and function. The specific hypotheses that will be tested are

- a. Short-term exposure of estuarine phytoplankton to low atrazine concentrations (1.00 µg liter<sup>-1</sup>) under low nutrient conditions promote shifts in the relative abundance of phytoplankton taxonomic groups and species and a reduction in primary productivity.
- b. Under high (non-limiting) nutrient conditions, the effects of sublethal concentrations of atrazine (1.00 µg liter<sup>-1</sup>) on phytoplankton biomass, community composition, and primary productivity are less severe (i.e., are significantly different) than the effects under nutrient-limiting conditions.
- c. Trace concentrations of atrazine (0.10 µg liter<sup>-1</sup>) have no effect on estuarine phytoplankton biomass, community composition, or primary production.

Short-term Phytoplankton Bioassays will be used to measure initial phytoplankton responses to different levels of atrazine and nutrient exposure. The purpose of these experiments is to determine the effects of a range of atrazine/nutrient concentrations on phytoplankton primary productivity and biomass of specific algal groups (i.e., diatoms, cyanobacteria, dinoflagellates, cryptophytes, etc.) in natural estuarine phytoplankton assemblages. These data will be used to assess "who" responds to the different levels of atrazine treatments under ambient (light, nutrient, temperature, etc.) conditions. This experimental approach is critical for understanding the mechanisms underlying phytoplankton community responses and dynamics in estuarine ecosystems.

This project is funded by South Carolina SeaGrant and will run from May 2006 to May 2007.

## **An evaluation of antimicrobial activity in the western Atlantic octocoral *Leptogorgia virgulata* (Lamarck)**

Investigators: Jacqueline Shapo<sup>1,2</sup> and Dr. Sylvia Galloway<sup>2</sup>  
Graduate Program in Marine Biology, College of Charleston<sup>1</sup>  
NOAA/NOS/CCEHBR<sup>2</sup>

Unlike vertebrates, which possess both an innate and an acquired immune system, corals possess a non-adaptive immune response only, about which little has been studied. Antimicrobial activity, a rapid, nonspecific response by the innate immune system of a multicellular organism to damage, stress, or antigen exposure, was examined in the common seawhip, *Leptogorgia virgulata* (Lamarck), from South Carolina waters. Extraction and assay protocols were developed to permit identification of antimicrobial activity in crude methanol/water extracts of *L. virgulata*. Detection was determined by liquid growth inhibition assays using *Escherichia coli* BL21, *Vibrio harveyi*, *Micrococcus luteus*, and a *Bacillus* sp. isolate from a scleractinian coral (*Acropora cervicornis*). This research represents the first report of antimicrobial activity in *L. virgulata* and, of equal note, in a sub-tropical coral of the western Atlantic Ocean.

Variability in the antimicrobial activity in *L. virgulata* at and among seven reference and anthropogenically impacted sites in South Carolina was measured between May and October 2005. Only *L. virgulata* at the Charleston City Marina in Charleston County, SC, failed to exhibit antimicrobial activity against selected bacteria during the 6-month study period. Variability in antimicrobial activity, as demonstrated by growth inhibition of selected bacteria, differed significantly at Cherry Point Seafood Company, Wadmalaw Island; Patriots Point Marina, Charleston Harbor; Kiawah River Bridge; Huntington Beach State Park–South Jetty; and upper 60 Bass Creek–North Inlet at different points throughout the summer season.

Highly-sensitive, analytical chemical techniques, including reverse-phase high performance liquid chromatography (HPLC), HPLC coupled to mass spectrometry (LC-MS), and <sup>1</sup>H- and <sup>13</sup>C-nuclear magnetic resonance (NMR) spectroscopy were coupled to a liquid growth inhibition assay system and permitted the development of a bioassay-guided fractionation scheme. This methodology allowed us to isolate, purify, and characterize unknown metabolites in antimicrobial fractions of *L. virgulata*. Corroborative MS/NMR evidence validated the presence of the molecular weight and chemical shifts of homarine, a well-known emetic metabolite isolated from *L. virgulata*, as well as a homarine analog. These molecular signatures were isolated from combined HPLC fractions 14-21 and 22-24, obtained from crude *L. virgulata* extracts containing documented antimicrobial activity. In subsequent liquid growth inhibition assays, replicates of fractions 14-21 inhibited the growth of *M. luteus* and *V. harveyi*, suggesting that these partially purified fractions contained active compounds responsible for the antimicrobial activity in *L. virgulata*. It was not determined whether homarine and/or a homarine derivative are solely responsible for the antimicrobial activity in *L. virgulata*. The findings of this study suggest that homarine is, in part, an active constituent of the innate immune system in *L. virgulata*, which may act synergistically with cofactors and/or congeners in the octocoral to mount a rapid response to stressors, such as microbial invasion and disease.

This project is supported by base funding for Coral Health and Disease Investigation from the National Oceanic and Atmospheric Administration, National Ocean Service, and the Center for Coastal Environmental Health and Biomolecular Research from October 2004 to October 2006. Additional support came from the South Carolina Department of Natural Resources Artificial Reef Program and the College of Charleston Teaching Assistantship Program. See [map](#) location #18.

## **Phylogeography and evolution of chemosynthetic endosymbioses in protobranch bivalves of the Family Solemyidae**

Investigators: Dr. Coleen Cavanaugh and Frank Stewart  
Department of Biology, Harvard University

Studies of mutualistic associations between sulfur-oxidizing chemosynthetic bacteria and marine invertebrates have yielded tremendous insight into the physiology and evolution of bacteria-eukaryote interactions, as well as the ecology and primary production of marine reducing environments (e.g., deep-sea hydrothermal vents, coastal muds). However, for most chemosynthetic symbioses, intraspecific patterns of genetic and phenotypic variation in both host and symbiont have yet to be described, despite the relevance of these processes to symbiont-host diversification, local adaptation, and speciation. The proposed research aims to reduce this knowledge gap by critically examining



the population genetic structure, phenotypic variation, and evolutionary history of chemosynthetic endosymbioses within the protobranch clam Family Solemyidae.

Specifically, we propose a multi-locus analysis of symbiont and host genetic variation among populations of the Atlantic protobranch clam *Solemya velum*. This will be done concurrent with analyses of the kinetic and structural properties of key symbiont and host proteins to assess the potential for adaptive differences in response to temperature variation across the range of the species (Florida to Nova Scotia). We propose using the Baruch Institute as a base for collecting *S. velum* clams from the North Inlet estuary and for processing samples for genetic and protein analyses. Collection of *Solemya velum* from the North Inlet estuary will involve accessing tidal marshes by boat, retrieving and sieving sediment samples, and preserving clam tissue for genetic and protein analyses

The North Inlet is an ideal site for the purposes of this study. *Solemya velum* clams have been collected previously from North Inlet (from the DeBordieu flat area by Dr. Rick Fox, Lander University). Furthermore, the habitat and temperature regime of this southern site provides an interesting contrast to that of the Woods Hole MA region from which *S. velum* clams have been collected for prior physiological and genetic analyses. Comparison of clams from the North Inlet region and from northern sites (e.g., Woods Hole) will provide insight into adaptation to distinct temperature regimes, as well as into the rates of gene flow among geographically isolated populations of estuarine bivalves. See [map](#) location #17.

### **The effects of microhabitat and mussel body position on survivability and growth of *Geukensia demissa***

Investigators: Jennifer Jost and Dr. Brian Helmuth  
Department of Biological Sciences, USC

With global climate change becoming an ecologically pressing issue, there has been a recent interest in the ability to predict the effects of climate change on the earth's ecosystems. This requires that we first understand the effects of temperature on organisms within their habitat, in terms of what range of body temperatures are experienced by the organism and what aspect of this body temperature (maximum temperature, minimum temperature, or the cumulative effects of temperature over time) has the greatest effect on survival and growth rates in the field.

Past research has examined the effects of body size, marsh site, and mussel body position on mussel body temperature of *Geukensia demissa*. Thermally matched temperature loggers (empty mussel shells filled with silicone and equipped with an iButton temperature logger) with an accuracy of  $\pm 1^\circ\text{C}$ , were placed in the field near Oyster Landing at three marsh microhabitats. Three body sizes (4-6cm, 6-8cm and 8-10cm shell length) and three body positions (0cm, 3cm, and 6cm shell length exposed above sediment surface) were examined beginning March 2004. The data suggest that body position is highly significant, marsh microhabitat is somewhat significant and body size has no effect on mussel body temperature. Based on these preliminary results, mussel loggers are still in position to continue to record and monitor estimated mussel body temperature. However, the variable body size has been eliminated.

Currently, I am setting up both a field and seawater laboratory experiment to run from May to September 2006. In the field I plan to set up two temperature experiments. One will be a control with no material over the mussels, one will be shade cloth. For each treatment, I will select 10 clumps of *G. demissa* in the field. Within each clump, I will notch mussels at the start of the summer, and place iButton temperature loggers (at three vertical body positions) near the living mussels to estimate mussel body temperature in the area. At the end of the summer, I will return to the marsh, record the level of growth for each mussel and remove the mussels to be dissected. Once dissected, mussel shell length, mussel body dry weight and mussel gonad dry weight (if applicable) will be measured and recorded. I expect to see an increase in both growth and gonad weight in the treatment with shade cloth.

The seawater lab experiment also plans to examine the effects of various body temperatures on mussel body growth and survivability. I will house mussels in artificial marsh tanks with a set tidal cycle of 4 hours high tide per day. During low tide, mussels will be heated to one of 4 treatment temperatures: 40, 45, 50 or  $55^\circ\text{C}$ . Mussels will be heated in a manner similar to that seen in the field, with halogen heat lamps turning on at 6AM and off (following peak temperature) at 3PM. Mussels will be cooled in air, and will experience high tide conditions only during the night. This corresponds to the typical conditions seen on hot days at Oyster Landing marsh sites. A similar study conducted in the summer of 2005 found that there was an increase in mussel mortality at temperatures over  $45^\circ\text{C}$  when exposed to that temperature maximum daily. In a similar manner, we will heat mussels to the goal maximum temperatures. However, the max temperature will not occur on a daily basis. There will be 3 regimes: exposure to

max temperature daily, exposure to max temperature every 3 days, and exposure to max temperature every 7 days. On the days that there is no heating regime, the tidal cycle will continue as normal, but the heat lamps will not turn on. There will be 20 mussels for each treatment, with a total of 12 treatments in two identical tanks. Initial measurements will include shell length, width and height. Final measurements include shell size, dry weight and dry gonad weight. Again, I expect to see an increase in mortality with increase in treatment temperature as well as a decrease in growth with an increase in treatment temperature. See [map](#) location #8, 10

### **Urbanization and Southeastern Estuarine Systems (USES)**

Investigators: Drs. Dwayne E. Porter<sup>1,2</sup>, Susan Wilde<sup>1</sup>, Tom Chandler<sup>1,2</sup>, Marj Aelion<sup>1,2</sup>, Marie DeLorenzo<sup>3</sup>, Geoff Scott<sup>2,3</sup>, John Ferry<sup>1</sup>, Mike Fulton<sup>2,3</sup>, Tom Siewicki<sup>2,3</sup> and Angela Halfacre-Hitchcock<sup>4</sup>  
Belle W. Baruch Institute for Marine and Coastal Sciences, USC<sup>1</sup>; Norman J. Arnold School of Public Health, USC<sup>2</sup>; NOAA's Center for Coastal Environmental Health and Biomolecular Research<sup>3</sup>; College of Charleston<sup>4</sup>

Left unmanaged, anthropogenic activities threaten the environmental health and economic vitality of coastal estuaries. Historically, the dynamic and complex nature of critical estuarine ecosystems inhibited the successful development of models that could effectively be used by coastal zone and fisheries managers. In response to these concerns and the identified need for spatial models to support sustainable coastal development, a long-term study was initiated in 1990 to define, measure and model the impacts of urbanization on coastal estuaries of the southeastern United States. The Urbanization and Southeastern Estuarine Systems (USES) project began 1 June 1990. The primary objectives of this long-term study are: to delineate the impact of multiple stresses resulting from urbanization on high-salinity estuaries; and to develop models that will provide a scientifically valid basis for land-use management decision-making in the coastal zone.

Emphasis has been placed on watershed dynamics, including an examination of land-use patterns and the impacts associated with watershed loadings. By comparing the short-term trends and long-term variability in system responses at the North Inlet-Winyah Bay NERR with those of an adjacent developed estuary, a clearer assessment of the impacts of development can be made than basing management strategies on one estuarine system. The models incorporate land-use patterns and practices, integrated toxicological and risk assessment modeling, and Geographic Information Processing (GIP) approaches. A strength of the USES project is that it is a long-term monitoring and research project focusing on current issues of both ecosystem health and public health. As proposed in the multi-year plan, out years are extremely crucial to the continuing success of the project. It is during this time that the integration of sub-study components via data syntheses; modeling development, testing and calibration; and outreach to coastal zone managers take place. In addition to the two primary study sites, associated researchers have expanded into additional estuarine systems of the Southeast to conduct similar experiments and compare results and test developed models. As driven both by our science and the needs of natural resource and public health managers, we are able to adjust our research thrusts to focus on those issues most critical to the Southeast.

This project is funded by the Coastal Oceans Program/NOAA/Department of Commerce from 08/01/05 through 07/31/07 ([www.urbanestuary.org](http://www.urbanestuary.org)).

### **Development of a GIS-based database management program to characterize sources and effects of natural parameters and anthropogenic impacts on coastal ecosystems**

Investigators: Drs. Dwayne E. Porter<sup>1,2</sup>, Tom Siewicki<sup>2,3</sup>, Jeff Allen<sup>4</sup>, Marj Aelion<sup>1,2</sup>, and Heath Kelsey<sup>2</sup> and Sam Walker<sup>2</sup>  
Belle W. Baruch Institute for Marine and Coastal Sciences, USC<sup>1</sup>; The Norman J. Arnold School of Public Health, USC<sup>2</sup>; NOAA's Center for Coastal Environmental Health and Biomolecular Research<sup>3</sup>; The Strom Thurmond Institute, Clemson University<sup>4</sup>

According to a 1995 NOAA report, the top priorities for coastal resource managers were to acquire 1) information on nonpoint sources of pollution and preventing wetland habitat loss; 2) scientific data linking development activity to adverse resource impacts; and 3) techniques for managing development impacts and mediating multiple use conflicts.

The advent of database management programs, the Internet and the World Wide Web (WWW), and Geographic Information Systems (GIS), particularly when coupled to statistical modeling, allow new approaches to managing development of our coastal ecosystems. The South Atlantic Bight Land Use - Coastal Ecosystems Study (LU-CES) will combine existing and newly gathered data into a single (virtual) archive for use in forecasting impacts to coastal and estuarine ecology in the SC&GA region. The project will then be able to devise alternative development strategies to minimize these impacts. This project also seeks to predict human source fecal coliform contamination and nutrient levels in the surface and groundwaters of golf course associated developments, based on land use characteristics in the vicinity of monitoring points. The project is testing the hypothesis that fecal coliform levels from human sources are significantly higher in areas close to certain land use characteristics, and determining whether the source of the bacterial contamination is from human or non-human sources.

The South Carolina Department of Health and Environmental Control (DHEC) uses fecal coliform levels measured in surface waters to classify shellfish harvesting areas based on the Interstate Shellfish Sanitation Conference (ISSC) guidelines. Under the ISSC guidelines, shellfish harvesting areas can be classified as approved, conditionally approved, restricted, conditionally restricted, or prohibited based on the fecal coliform concentrations measured by DHEC. Shellfish in areas with high fecal coliform levels in the surface water are assumed to have potentially dangerous levels of fecal coliforms (and human pathogens) as well. However, fecal coliforms can be deposited in surface waters from both human and wildlife sources, and it may be important to differentiate between these sources. The transport of fecal coliforms to surface waters from human sources and wildlife sources may be very different, and their differentiation could lead to changes in the classification of some shellfish harvesting areas. Additionally, if the prediction of fecal coliform from human and animal sources is possible using land use characteristics, it may be possible to develop a land use based classification system of harvesting areas.

This project will differentiate the fecal coliform levels measured in Murrells Inlet into fecal coliforms from human and animal sources. This will be accomplished by comparing patterns of Multiple Antibiotic Resistance (MAR) in *E. coli* obtained from human sources and from surface water samples. In general, bacteria from human sources exhibit more antibiotic resistance than from animal sources, and have different patterns of multiple resistance. The MAR technique will help to determine if fecal coliforms measured in an area are from human or wildlife sources.

Geographic Information Systems (GIS) are used to characterize various land uses within the study areas. Data from the fecal coliform classification are incorporated into the GIS to examine the spatial distribution of human and animal source fecal coliforms. Using the land use characterizations and the fecal coliform distribution, GIS and statistical procedures will be used to attempt to predict the fecal coliform levels from human and animal sources based on the land use characteristics. Specific land use characteristics characterized include septic tank density, population density, housing density, vegetation, impervious surfaces, sewage treatment outfalls, and stream locations and volumes. Additional variables include rainfall, salinity, temperature, and tidal fluctuation. Statistical procedures include kriging, multiple regression and logistic regression. This project is funded for the period from 07/01/04 to 06/30/06 by SC Sea Grant Consortium.

### **Advanced Laser Fluorescence (ALF) technology for estuarine and coastal environmental biomonitoring**

Investigators: Drs. Alexander Chekalyuk<sup>1</sup>, Kenneth Moore<sup>1</sup>, David White<sup>2</sup>, and Dwayne Porter<sup>2</sup>  
Virginia Institute of Marine Science<sup>1</sup>; The Norman J. Arnold of the School of Public Health, USC<sup>2</sup>

The project objective is to develop an advanced laser fluorescence (ALF) technology for environmental biomonitoring estuarine and coastal areas from a small vessel and sample analysis. The ALF technique should be capable of providing high-resolution real-time data for:

1. Quantitative assessment of major photosynthetic pigments, phytoplankton physiological and nutrient status and their photosynthetic activity
2. Detection of taxonomic changes in phytoplankton populations and dominant algal groups
3. Fluorescence measurement of chromophoric dissolved organic matter (CDOM)

These critical variables will provide valuable, currently missing information, which can be utilized along with standard water quality data for detailed bio-environmental characterization of estuarine and coastal areas. In particular, variable fluorescence has been shown to be a sensitive indicator of phytoplankton physiological status and nutrient supply, and can therefore be utilized for monitoring impacts of nutrient enrichment and as an indicator of potential contamination. Monitoring phytoplankton taxonomic variability will allow detection of habitat changes,

including potential for detecting toxic algal blooms. In addition, the concentration of CDOM is a useful parameter for further characterization and biomonitoring of estuarine areas.

The ALF technique will utilize the latest advances in laser technology and active fluorescence spectroscopy. Assessment of photosynthetic pigments and CDOM will be conducted by fluorescence spectral analysis with excitation at several wavelengths coinciding with absorption bands specific to these pigments. The fluorescence pigment assessment will also allow detection of taxonomic changes in phytoplankton populations and identification of dominant algal functional groups. Phytoplankton physiological status and photosynthetic activity will be assessed from variable fluorescence, Fv/Fm, measured with pump-during-probe (PDP) fluorescence induction protocols. The application of this technology to estuarine waters with high turbidity, large suspended sediment and detritus loads, elevated concentrations of pigments and dissolved organic matter, and complex phytoplankton taxonomic composition presents significant challenges. A unique house-made Laser Pigment Analyzer will be utilized as a flexible research platform for optimizing ALF technological solutions. The proposed ALF technology will be optimized through research and extensive tests to be conducted at participating NERR sites (North Inlet – Winyah Bay) with contrasting bio-environmental conditions.

The ALF surveys will provide valuable, currently missing information, which can be used along with standard water quality data for detailed bio-environmental characterization of estuarine and coastal areas. Variable fluorescence has been shown to be a sensitive indicator of phytoplankton physiological status and nutrient supply, and can therefore be utilized for monitoring impacts of nutrient enrichment and indication of potential contamination. Monitoring phytoplankton pigment and taxonomic variability will allow detection of habitat changes, including potential for detecting toxic algal blooms. The concentration of CDOM will provide additional useful information for characterization of bio-environmental situation. Utilization of a small vessel as a platform will allow periodical ALF surveying in NERR sites and adjacent areas. Real-time data analysis will allow flexible, ‘observation-driven’ sampling and will provide coastal managers with rapid feedback in the regions with strong socio-economic activity and heavy urban population in the event of rapid bio-environmental changes caused by external sources, including potential eco-terrorism events.

This project is funded from 1/1/2004 through 12/31/2006 and is funded by The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

### **Testing an alternative oyster reef restoration strategy**

Investigators: Dr. David Bushek<sup>2</sup>, Paul Kenny<sup>1</sup>, Laura Schmidt<sup>1</sup>, and Dr. Anna Toline<sup>1</sup>  
Baruch Marine Field Laboratory, USC<sup>1</sup>; Haskin Shellfish Research Laboratory, Rutgers  
University<sup>2</sup>

During a recent dredging project, oyster reef habitat was inadvertently destroyed when dredge pipes drifted over oyster reefs during high tide and settled on them during low tide. In a collaborative effort between residents from the local residential community and staff from the Baruch Marine Field Laboratory, oyster recruitment stakes were planted to attract settling oyster larvae to the site. Half of the stakes were coated with a thin layer of concrete, which has been anecdotally reported to increase recruitment. Stakes were planted in June 2003 (see [map](#) location # 11). Recruitment during 2003 and 2004 was low indicating that the populations in the upper reaches of the canal system may be slow to recover. Oysters that did settle on stakes, however, were 100 times more likely to settle on cement coated stakes than bare stakes. Support for this project was provided by the Debordieu Colony Community Association, the North Inlet-Winyah Bay NERR, and the Baruch Marine Field Laboratory.

### **LIDAR-based watershed modeling of North Inlet**

Investigator: Laura Schmidt  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

The goal of this project is to model sediment and surface water movement in the North Inlet watershed. The project started in 2002 with the acquisition of LIDAR data. We are developing parameters suitable for input in the AGNPS model. Using the AGNPS model, we will predict problem areas for non-point source pollution (sediment). This project requires several sources of ancillary data, including a LIDAR-derived elevation model, and a current land cover map. The LIDAR data were used to delineate the North Inlet watershed. The land cover map will be

developed from various sources of digital imagery, including IKONOS satellite imagery and digital orthophoto quads. This work will give the North Inlet-Winyah Bay NERR staff a better understanding of the development pressures influencing North Inlet.

### **Settlement and metamorphosis of three species of fiddler crabs in a South Carolina salt marsh**

Investigators: Drs. Renae Brodie and Marcel Reichert  
Marine Science Program and Department of Biological Sciences, USC

South Carolina has three species of estuarine fiddler crabs: *Uca pugilator* and *Uca pugnax*, which are high salinity crabs and *Uca minax*, which occupies low salinity and freshwater habitats as an adult. All three of these undergo larval development in offshore waters, then return to the estuary at the end of the larval period where they metamorphose and remain as juveniles and adults. We would like to understand this reinvasion process better. Namely, we would like to know if the three species target specific areas for settlement and metamorphosis as they move into tidal creeks, or if they settle randomly. To this end, we will be sampling returning fiddler crab larvae along the creek that runs past Oyster Landing, using light traps (see [map](#) location #3). Larvae caught by the traps will be brought back to the lab, where they will be counted and identified to species using a molecular analysis (the larvae look identical and hence can only be identified genetically). Collections will be made in the Oyster Landing Basin (see [map](#) location # 3)

### **The role of bioturbating infauna on porewater transport within intertidal permeable sediments**

Investigators: George Waldbusser and Dr. Roberta Marinelli  
Chesapeake Biological Laboratory, Solomons, MD

The goal of this project is to continue ongoing investigations of the role large bioturbating infauna play in modifying porewater transport within permeable intertidal sediments. Previous investigations from False Bay, WA and Cedar Island, VA indicate that large infauna modify rates of porewater transport and associated biogeochemistry independent of sediment parameters typically used to estimate transport such as grain size, porosity, and organic content. Furthermore, these effects appear to be closely linked to the behavioral or functional characteristics of the organisms and species interactions also seem to further modify transport and biogeochemistry. Thus far our findings build a case for the importance of benthic infauna in permeable sedimentary habitats on ecosystem level type processes such as nutrient and organic matter cycling. To date very few investigations have considered the role of infauna on transport and biogeochemical processes in near shore permeable sediments, other than one previous investigation on the Debidue Flat by Dr. Anthony D'Andrea.

In order to examine the effects of large bioturbating infauna on porewater transport, both non-destructive photographic surveys of surface features associated with infauna and gel diffusers with a photodegradable tracer are used. Plots of various densities of 1 to 3 different bioturbating infauna are established in areas having similar granulometry and physical characteristics. These sites are 0.5m x 0.5m and are photographed daily for at least 3 days. Within each site 5 replicate acrylamide gel diffusers with a 1mg/ml concentration of fluorescein are placed along a transect perpendicular to the direction of porewater transport as determined by local topography. The gels are 1.1cm in diameter and roughly 11cm in length, and inserted into the sediment by core replacement. The gels are deployed for 2 days, retrieved from the sites, and 0.5cm sub-sections are taken from roughly 1cm from the top and bottom of the gel. The sub-sections are placed in a known volume of deionized water to back equilibrate and then the concentration of fluorescein in the diluent is measured. Based on the weight and density of the gel, and diluent volume the concentration of fluorescein remaining in the gels is calculated. The concentration of fluorescein remaining in the gels provides a proxy for porewater flow, as flow increases more tracer is lost from the gel, and vice versa. A limited number of sediment samples will be taken at the end of the experiment from sites used in order to measure granulometric properties.

### **Examine the potential differences in spawning/larval release behavior of *Uca minax* from upriver areas**

Investigators: Stephen Borgianini<sup>1</sup> and Dr. Renae Brodie<sup>1</sup>  
Department of Biological Sciences, USC

In May, July, and September ovigerous *U. minax* individuals will be collected from natural populations of fiddler crabs at three freshwater locations within the Winyah Bay estuary; a riverine area near Bates Hill Plantation, a tidally isolated population from an abandoned rice impoundment near Samworth Wildlife Management Area, and a downriver population under the old Highway 17 bridge. I will also measure the percentage of ovigerous females captured at each location relative to non-ovigerous females captured. The females will be incubated in fresh water until the zoeae hatch. The time of larval release will be recorded for each female relative to the time of the local slack flood tidal current. Project period: May 15-September 30, 2006.

### **Recruitment of megalopae to freshwater, upriver areas**

Investigators: Stephen Borgianini<sup>1</sup>, Dr. Richard Styles<sup>2</sup>, and Dr. Renae Brodie<sup>1</sup>  
Department of Biological Sciences, Department of Biological Sciences, USC<sup>1</sup>

We will develop a data base for all available flow data vs. tidal data for the Little Pee Dee River and the Black River. Data will be acquired through available data bases maintained by the South Carolina Department of Health and Environmental Control (SCDHEC), North Carolina Department of Natural Resources (NCDNR), and the U.S. Geological Survey (USGS).

Field sampling will be conducted every two weeks from June through September. The sampling regime will include: 1. surface light trap; 2. current flow profiles; 3. pump sampling at three depths (surface, mid-depth, 2ft. from bottom).

The data generated will be compared to distribution data, physiography, and flow data to attempt to highlight any trends in recruitment when compared to adult distribution. Project period: May 15- September 30, 2006.

### **Groundwater flow and its effects on the distribution of *Uca minax* and plant zonation**

Investigator: Stephen Borgianini<sup>1</sup> and Dr. Renae Brodie<sup>1</sup>  
Department of Biological Sciences, USC<sup>1</sup>

Within the North Inlet estuary we will be investigating the dynamics of groundwater flow and salinity distribution along ten (10) forest/upland-salt marsh transects. Five (5) groups of nested transects (two transects each) will be located at locations in the estuary that have unique physiographic characteristics. Groundwater level elevations and salinity will be collected every 2 to 5 days from piezometers located along each transect. In addition, salinity data loggers will be installed at three (3) of the nested transects. At the time the groundwater data are collected observations will be made regarding the distribution of *Uca* congeners and plant species distribution across each transect.

These data will be collected in order to determine how groundwater flow from forest/upland to marsh to tidal creek effects the distribution of *U. minax* as well as plant zonation. Additionally, the affects of changes in groundwater salinity caused by natural events such as rainfall and tides will be compared to the biodistribution measurements collected. Project period: May 15- September 30, 2006.

### **Conduct *Uca minax* megalopal metamorphosis experiments to determine the rate at which field caught *Uca minax* megalopae metamorphose to juveniles**

Investigators: Stephen Borgianini<sup>1</sup> and Dr. Renae Brodie<sup>1</sup>  
Department of Biological Sciences, USC<sup>1</sup>

In June and August *U. minax* megalopae will be collected in surface light traps from the Waccamaw River at Hagely Landing. Individual megalopa will be placed in separate incubation chambers in such a way that they share a

common source of river water (to account for the possibility of quorum sensing among megalopae) that will be changed daily. The metamorphosis rate will be calculated for each batch of megalopae. These data will be used to develop a metamorphosis function that will be used to calibrate a *U. minax* megalopae transport model. Project period: May 15-September 30, 2006.

### **Examine the mechanisms for the recruitment of *Uca minax* megalopae to freshwater, upriver areas**

Investigators: Stephen Borgianini<sup>1</sup>, Dr. Richard Tankersley<sup>2</sup>, and Dr. Renae Brodie<sup>1</sup>  
Department of Biological Sciences, USC<sup>1</sup>, Department of Biological Sciences,  
Florida Institute of Technology<sup>2</sup>

In order to field validate the model described above I will conduct field sampling that consists of nocturnal pump sampling at two locations within the Pee Dee river that will be conducted with the simultaneous deployment of two ADCP (Acoustic Doppler Current Profilers). The sampling regime will include: 1. surface light trap 1 hour before flood current, mid-point of current duration, and 1 hour after flood current; 2. pump sampling at surface for the duration of flood tidal current; 3. an epibenthic sled sampler will be used to collect megalopae on the river bottom on diurnal ebb tide at several locations on the river.

Stranding of megalopae (rather than preferential settlement) may account for a significant proportion of settlement rate on *U. minax* megalopae along the Great Pee Dee River. I plan to conduct a megalopal stranding/settlement study that examines the flux of megalopae being transported into, and out of, impoundments adjacent to the Great Pee Dee River on spring flood and ebb tides.

The data generated will be compared to distribution data, physiography, and flow data to attempt to highlight any trends in recruitment when compared to adult distribution. Project period: May 15- September 30, 2006.

### **Application and evaluation of ADAR-based habitat suitability modeling for *Uca minax* and *Uca pugnator* in North Inlet**

Investigators: Simone Williams and Dr. Renae Brodie  
Department of Biological Sciences, USC

Advances in remote sensing technologies allow new complimentary approaches to large scale assessment of biodiversity. Within the North Inlet we will integrate remote sensing techniques, statistics and auxiliary data to assess the habitat and population distribution of two adult fiddler crabs, *Uca minax* and *Uca pugnator*.

Habitat parameters such as land cover type will be derived from ADAR imagery. Nine sample sites will be selected within North Inlet and in situ data, such as salinity, will be collected fortnightly along transects between February 15, 2006 and August 31, 2006. Population density will be determined from quadrat counts at sample sites. Both derived and in situ data will be used to build a habitat suitability model that estimates likely variations in habitat and population distribution of adult *U. minax* and *U. pugnator*. We will also evaluate the usefulness of the applied integrated remote sensing, statistics and field approach in large scale assessments of adult *U. minax* and *U. pugnator* habitat and population distribution. See [map](#) location #10

### **Ecology of diamondback terrapins**

Investigator: Dr. Peter King  
Department of Biology, Francis Marion University

The goal of the project is to establish baseline data on the population of diamondback terrapins in waters bordering Hobcaw Barony. Initial population characteristics would be population size, sex ratios and age (size) distribution. Other aspects that may be determined are home range and habitat use. Turtles will be caught by nets or traps. Morphometric data will be collected on individuals; they will be tagged and released at the site of capture. Turtles will be tagged with PIT (passive integrated transponders) tags. These are small (about 10mm x 2 mm) inert objects that are placed under the skin. They are used by veterinary surgeons to mark domestic dogs and cats and I (and others) have used them on similar sized freshwater turtles. They are long lasting and have a life of at least 25

years. They reflect a signal much like a bar code on an item in a supermarket checkout. Each PIT tag has a unique number that can be read by a hand held scanner. They are ideal for long-term studies allowing information to be used by researchers of this population in the future. There are few population studies of Diamondback terrapins in SC. A group from SREL monitors a population near Kiawah Island (Gibbons et al., 2001), and has been doing so for about 20 years. Diamondback terrapins inhabit brackish water on the coast from Maine to Texas. Although they are widely distributed their habitat is threatened by coastal development, through outright destruction and/or fragmentation and they are susceptible to toxins in the water or accumulated in the food chain. I would like to investigate this viability of the population in Winyah Bay and establish some baseline data for long-term monitoring of the population.

Gibbons, J. W., J. Lovich, A. Tucker, N. FitzSimmons and J. Greene. 2001. Demographic and ecological factors effecting conservation and management of the diamondback terrapin (*Malaclemys terrapin*) in South Carolina. *Chelonian Conservation and Biology* 4(1) 66-74.

### **Breeding biology of Wilson's plovers in South Carolina: Population status, breeding success, and effects of human disturbance**

Investigators: Kerri Dikun and Dr. Chris Hill  
Department of Biology, Coastal Carolina University

I intend to study the breeding population of Wilson's plover in South Carolina, where the species is listed as threatened. I would like to determine the size of the breeding population within the state and map the locations where the plovers are breeding. Additionally I will study aspects of nesting biology including nest site selection, nest attentiveness and behavior of the adults at the nest, to determine if these are similar to what has been observed in other locations. Establishing the dates on which critical nesting events take place, and determining the age at which these birds fledge will also be a portion of my project. By collecting pertinent data throughout the breeding season I will determine nesting success and productivity, and establish the factors that impact these the most. Finally, I will pay special attention to the impact that human activity has on the nesting success and behavior of Wilson's plovers. I intend to use North Inlet as one of my study sites because it is relatively pristine and has a low human presence.

To locate nests, the southern portion of North Island will be surveyed on foot, twice a week. When nests are located they will be documented and measurements at the nest will be taken (distance to closest vegetation, slope, distance to water, egg flotation etc.). Signs of human activity, such as tracks, or the presence of humans will be documented as well.

When the clutch is complete and the adults have started incubating I will set up a drop trap at the nest to capture adults for color banding. I will also attempt to band chicks by locating them before they leave the nest on their hatching date. Nest success and productivity will be tracked by checking the nest for eggs once a week until the nest is lost, or until the nest hatches. After the nest hatches, I will survey the area near the nest and potential foraging areas to locate the chicks. If the chicks are located I will continue to survey weekly until they fledge.

Little study has been done on the Wilson's plover throughout its breeding range, and the breeding biology and population status of the Wilson's plover is relatively unknown in South Carolina. It is important to determine the breeding population in the state, how successful these birds are at producing young and what factors contribute to or hinder nest success.



## **Visiting Scientist Awards**

The University of South Carolina's Belle W. Baruch Institute for Marine and Coastal Sciences encourages scientists from other institutions to conduct research at the Baruch Marine Field Laboratory. Each year, funds are awarded competitively to several investigators to support travel and other expenses related to their research activity on site. Faculty level investigators who would benefit from the close proximity of a variety of salt marsh/estuarine habitats and a modern research facility are encouraged to apply for a Visiting Scientist Award. We especially encourage scientists with interests in establishing long-term research programs in the area. Proposals for field-based studies that can be supported by existing infrastructure and extant databases are favored. Additional information about the Visiting Scientist program and a list of previous awardees can be found at <http://links.baruch.sc.edu/visitingscientist.html>.

## **Role of salinity and dissolved organic matter source in shaping the biogeography of estuarine bacterioplankton communities**

Investigator: Dr. Jude K. Apple  
NRC Postdoctoral Fellow, US Naval Research Lab, Washington DC.

Bacterioplankton community composition and terrestrial dissolved organic matter (DOM) change dramatically along estuarine gradients, yet factors driving changes in community composition and the relationship with transformation of terrestrial DOM remain poorly understood. My project will quantify changes in bacterioplankton community composition at 4-step intervals along the salinity gradient (0-32 psu) in the major tributaries of Winyah Bay. Shifts in bacterioplankton community composition will be identified by denaturing gradient gel electrophoresis (DGGE) of PCR-amplified 16S ribosomal DNA and related to environmental parameters using multidimensional scaling (MDS) and canonical correspondence analysis (CANOCO). Dissolved organic matter will be concentrated from freshwater, estuarine and marine regions by tangential flow ultrafiltration. Cross-inoculation experiments will be conducted to investigate the effects of salinity and source of high-molecular weight ultrafiltered DOM (UDOM) on community composition and UDOM degradation capacity. Native bacterioplankton communities from each region of the estuary will be incubated with UDOM, such that each is exposed to UDOM from freshwater, estuarine, and marine sources. This experimental approach will be used to identify differences in the capacity of bacterioplankton to degrade DOM from different sources as well as changes in degradability of high molecular weight DOM along the salinity gradient. Measures of bacterioplankton community composition and water column chemistry will be evaluated using multivariate statistics to identify potential drivers of community composition in estuarine and coastal. This research will be conducted during the summer 2006 and supported by the Belle Baruch Visiting Scientist Award.

## **Biogeography of inducible defenses in *Spartina alterniflora***

Investigators: Dr. Jeremy Long<sup>1</sup>, Dr. Erik Sotka<sup>2</sup>, and Dr. Brian Helmuth<sup>3</sup>  
Marine Science Center, Northeastern University<sup>1</sup>, Grice Marine Laboratory, College of Charleston<sup>2</sup>, Department of Biological Sciences, USC<sup>3</sup>

Defense Theory predicts that inducible defenses should evolve in populations where the impact of consumers is more unpredictable or variable in space and time, whereas constitutive defenses should evolve as consumer impacts become more uniform or predictable. Thus, predictions of Defense Theory cannot be rigorously evaluated within a single plant population that is uniformly exposed to a particular consumer guild or when inducible defenses are not explicitly tested. Rather, a biogeographic approach is needed that will compare the evolutionary response of geographically-separated plant populations exposed to locally distinct levels of consumer pressure. Smooth cordgrass, *Spartina alterniflora*, occurs across a large geographic range across which environmental features vary dramatically and, therefore, provides an excellent model system to examine biogeographic patterns in plant defenses. We hypothesize that: inducible defenses are stronger in northern than in southern *Spartina* populations. Our proposed research tests this hypothesis by examining spatial variation in the induced defenses of *Spartina alterniflora* in response to herbivory. We will simultaneously compare the induced defenses of northern and

southern *Spartina* populations using field manipulations followed by laboratory bioassays. Our results will provide unique insight into the ecology and evolution of plant-herbivore interactions in salt marsh ecosystems.

### **Selective Tidal Stream Transport (STST) behavior of fiddler crab larvae in the Winyah Bay Estuary**

Investigator: Dr. Richard Tankersley and Paola Lopez-Duarte  
Department of Biological Sciences, Florida Institute of Technology

Larvae of many estuarine crabs develop in coastal waters before they return and settle in juvenile nursery areas. Tidal currents often facilitate seaward transport of larvae that are spawned within marshes and develop in the high salinity coastal ocean. By coupling vertical migration to the phases of tidal currents, a behavioral mechanism referred to as selective tidal stream transport (STST), larvae may enhance their export from the estuary. By timing periods of active swimming and passive sinking relative to flooding and ebbing tides, larvae can move between the upper and lower estuary. Their behavior may be in response to environmental factors (e.g., salinity, temperature, turbulence) and/or endogenous rhythms with a circatidal period. During the Summer 2006, we will examine the role of circatidal rhythms in the STST behavior of fiddler crab larvae. We will compare the vertical migratory behavior of *U. minax* zoeae and megalopae in the field to patterns observed under constant laboratory conditions. We will also collect zoeae and megalopae at different phases of the tide and different locations in the estuary to test the hypothesis that larvae are entrained to local tidal conditions (i.e., phase) as they move up- or down-estuary. This project is funded, by a Visiting Scientist Award from BMFL

### **Nitrogen fixation rates in a coastal ecosystem under different nutrient addition regimes**

Investigator: Dr. Melody J. Bernot  
Department of Biological Sciences, University of Notre Dame

The proposed study consists of two primary components to measure nitrogen fixation rates. First, a survey of <sup>15</sup>N natural abundance will be conducted in organic pools (sediments, plants) of existing experimental nutrient amendment plots. Second, laboratory assays for dinitrogen fixation rates will be conducted for independent verification of nitrogen fixation rates. The proposed research will aid in development of new collaborations while addressing a fundamental ecological question of broad interest. Data collected via the proposed research will allow me to test a firm hypothesis and, in combination with existing data on sediment chemistry, produce a publishable result. Additionally, the proposed research will provide background data needed to go forward with future research proposals. This project is funded by a Visiting Scientist Award from BMFL.

### **Top-down grazer effects on marsh grass growth and marsh die back**

Investigator: Dr. Brian Silliman  
Department of Zoology, University of Florida

Large expanses of southeastern salt marsh (100's of km<sup>2</sup>) are currently experiencing unprecedented die-back. I have surveyed four die-off areas in Georgia and found snail densities to exceed 2000/m<sup>2</sup>. No studies currently investigating marsh die-off, however, incorporate top-down effects into their experimental framework. Therefore, I am examining the extent to which snail grazing contributes to marsh die-off in GA, FL, LA, and here in SC. To address this goal, I am excluding snails from die back and non affected areas to examine their relative contribution to marsh die back. The consequences of marsh die-off are far-reaching for the ecology and economy of Southeast shoreline communities, since marsh grasses provide essential habitat and nutrients for almost all associated fauna (e.g., oysters, drum, trout, spot and shrimp). Results from this and other current investigations will allow marine managers to predict potential effects of eutrophication and predator depletion (e.g., blue crab declines) and to formulate effective multi-site strategies for marsh conservation. The study sites are located on the marsh in front of the main laboratory complex and adjacent to the lookout tower at Clambank ([map](#) locations # 8 & 10. This project is funded from March 2004 to October 2006 and is supported by a Visiting Scientist Award from the BMFL.

Silliman, Brian R., Johan van de Koppel, Mark D. Bertness, Lee E. Stanton, Irving A. Mendelsohn. 2005. Drought, snails, and large-scale die-off of southern U.S. salt marshes. *Science* 16 December 2005 Vol 310: 1803-1806  
www.sciencemag.org

### **Effects of global warming and marsh grass growth**

Investigator: Dr. Brian Silliman  
Department of Zoology, University of Florida

Marshes, like other coastal communities, will be increasingly exposed to global climate change. To examine potential consequences of global warming to marsh primary production and extent of salt pans in high marsh habitat, I will be deploying mini-greenhouses in the short *Spartina* zone and on the edges of salt marsh pans. Grass productivity and pan border movement will be monitored in greenhouse and control areas over two years. Results will help predict how marsh structure and function will respond to increasing temperatures as a result of global warming. The study sites are located on the marsh in front of the main laboratory complex and adjacent to the lookout tower at Clambank ([map](#) locations # 8 & 10). This project is funded from March 2004 to October 2006.

### **Maymester Course**

#### **Topographic survey and flux determinations at Oyster Landing Basin**

Investigators: Drs. L. Robert Gardner<sup>1</sup>, Dennis Allen<sup>2</sup>, and Ray Torres<sup>1</sup>  
Department of Geological Sciences<sup>1</sup> and the Baruch Marine Field Lab<sup>2</sup>

This course is intended to give students experience in the use of field equipment and instruments in the conduct of research in marine science. Students will receive instruction in the theory and operation of DO, CTS and current meters and in surveying equipment (GPS and Total Station). This equipment will be used in the context of evaluating the "Outwelling Hypothesis." Students will use current meters to measure the tidal discharge into and out of the Crabhaul Creek basin at half hour intervals over a tidal cycle. During each tidal cycle they will also measure DO, temperature and salinity and collect water samples, which will be analyzed for dissolved nutrients, chlorophyll, and suspended sediments. From this data they will compute the net tidal fluxes of DO, salt, heat, sediments, chlorophyll and nutrient. The current data will also be used to calculate a discharge based storage curve for the basin. Separate curves for flood and ebb flow will be computed. The students will also use the surveying equipment to make a topographic map for the basin, from which they will compute a topography based storage curve for comparison with the discharged curves. Later these curves will be used to hind cast material fluxes from previously collected NERRS water chemistry data. Each student will be required to write several papers on the results obtained from this work.

## **Long-Term Studies**

The summaries listed below describe ongoing long-term studies being conducted in North Inlet Estuary. One of the valuable resources provided by the BMFL is the long-term ecological monitoring data of the relatively pristine North Inlet Estuary. These data enable scientists to distinguish natural cycles that may span decades or more from anthropogenic impacts. They can also be used to facilitate interpretation of data from shorter-term research projects. Moreover, this information allows scientists to develop hypotheses and design experiments to identify mechanisms that control the world around us. In many cases, BMFL data sets are either the longest continuous data sets or the most comprehensive data sets available. Many of these data may be obtained via our web site ([www.baruch.sc.edu](http://www.baruch.sc.edu)) using links to the National Estuarine Research Reserve Centralized Data Management Office (CDMO) or the National Science Foundation's Long-Term Ecological Research (LTER) site.

### **Long-term measurements of production and physiological ecology of *Spartina alterniflora***

Investigators: Dr. James Morris and Karen Sundberg  
Department of Biological Sciences and Baruch Institute, USC

Salt marsh grass, *Spartina alterniflora*, dominates the intertidal marsh in North Inlet Estuary. Regular measurements of grass density, height, stem width, and other characteristics allow for estimates of growth and primary production rates. Manipulative field experiments and long-term measurements of abiotic conditions including pore water salinity are providing insights into factors that affect production. Large monthly and interannual variations in the amount of organic material produced by the cordgrass are related to such factors as sea level and precipitation patterns. See [map](#) locations # 3 and 8. This time series was initiated in 1986.

### **Tide level: Long-term monitoring at Oyster Landing Pier in Crabhaul Creek**

Investigators: Virginia Ogburn-Matthews<sup>1</sup> and Dr. L. Robert Gardner<sup>2</sup>  
Baruch Marine Field Laboratory, USC<sup>1</sup>; Department of Geological Sciences, USC<sup>2</sup>  
Partners: Tom Mero, NOAA/NOS/OPSD, and Lewis Lapine, SC Geodetic Survey

Begin and End Date of database: May 2001 to present (ongoing)

The tide gauge measures water level in reference to MLLW in Crabhaul Creek (Oyster Landing Pier) every six minutes. The data are transmitted to NOAA via NOAA's Geostationary Operational Environmental Satellites (GOES), making the data available on-line in near real-time (one hour delay). Data are available to the public, and are useful in showing tidal anomalies, observing sea level rise, and modeling local phenomenon in North Inlet Estuary.

This state-of-the art tide gauge is accurate to  $\pm 3$  mm with a resolution of  $\pm 1$  mm. The gauge is part of the NOS's (National Ocean Service) National Water Level Observation Network (NWLON); NOS oversees all data management. The National Tidal Datum Epoch has been updated to the 1983-01 epoch on April 21, 2003. The updated bench mark sheets are available on the CO-OPS website: [http://co-ops.nos.noaa.gov/datum\\_update.shtml](http://co-ops.nos.noaa.gov/datum_update.shtml).

For viewing the on-line near real-time data for North Inlet, visit NOAA's website at <http://tidesonline.nos.noaa.gov/geographic.html> [Select SC on the map and then Oyster Landing, SC (North Inlet Estuary)]. Historical data are also available at [http://co-ops.nos.noaa.gov/data\\_res.html](http://co-ops.nos.noaa.gov/data_res.html) under Verified/Historical Water Level Data, select Unlisted Station, type in 8662245 for Station ID. Baruch's web link indicates the availability of the data: <http://links.baruch.sc.edu/Data/NIWaterLevel/DataAvailabilityTableJun01-Dec05.pdf>.

Support: National Science Foundation (NSF) Grant No. 9907650. NOAA/NOS/OPSD and the SC Geodetic Survey also supply technical services. See [map](#) location #3.

### **Weather and climate measurements: Long-term monitoring at Oyster Landing Pier**

Investigators: Dr. Erik Smith and Amy Cook  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

As part of the North Inlet – Winyah Bay National Estuarine Research Reserve (NERR), a fully functional meteorological station (National Weather Service installation) is located on the Oyster Landing Pier at North Inlet. Wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation are recorded at 15 minute intervals. A computerized data acquisition system provides regular uploads of data to the laboratory via a short haul modem. For most parameters, records have been collected for more than 13 years. Long-term, continuous weather records provide data for determining the effects of climatology on the various biological and physical processes being studied in the North Inlet estuary. Weather data in real time is available over the Internet at <http://www.baruch.sc.edu/weather/>. See [map](#) location # 3

### **National Atmospheric Deposition Program (NADP)**

Investigators: Dr. Erik Smith and Amy Cook  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

The North Inlet-Winyah Bay NERR established a precipitation chemistry monitoring site in North Inlet Estuary in January 2002. Atmospheric deposition data are collected according to NADP/National Trends Network (NTN) protocols. The work is conducted in partnership with the US EPA National Estuary Program and the SC Department of Health and Environmental Control. This monitoring program increases representation of coastal areas in our nation's deposition monitoring network and also provides a better understanding of the atmospheric deposition in the North Inlet estuary. The site is equipped with an automated collector that ensures sample collection occurs only during precipitation events (wet-only sampling). Precipitation is collected weekly and sent to the NADP Central Analytical Laboratory, where it is analyzed for pH, sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). North Inlet NADP data can be obtained from the following web address: <http://nadp.sws.uiuc.edu/>. See [map](#) location #3.

### **Physical characteristics of estuarine waters: Long-term monitoring at four sites in North Inlet Estuary**

Investigators: Dr. Erik Smith and Tracy Buck  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

As part of the NERRS System-Wide Monitoring Program, the physical characteristics of the water in four tidal creeks of the North Inlet-Winyah Bay NERR are monitored using YSI 6600 ESD data loggers. These data loggers are deployed at 0.5 m above the sediment surface and record water depth, temperature, salinity, pH, dissolved oxygen, and turbidity at 30 min intervals throughout the year. The instruments are calibrated and deployed according to strict NERRS protocols. The consistent, long-term collection of this physical data allows for the characterization of short-term variability and long-term change in North Inlet waters, and provides base-line data critical for various studies of biological and physical processes in the North Inlet estuary. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control. Data can be accessed via the CDMO website: <http://cdmo.baruch.sc.edu/>. [Map](#) location #'s 6A, 6B, 3, 2C.

### **Chemical characteristics of estuarine waters: Long-term monitoring at four sites in North Inlet Estuary**

Investigators: Dr. Erik Smith and Benjamin Lakish  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

As part of the NERRS System-Wide Monitoring Program, water chemistry sampling was initiated in June of 1993 to monitor concentrations of suspended solids, dissolved organic carbon, total nitrogen, ammonium, nitrate, nitrite, total phosphorus, orthophosphate, and chlorophyll a at four locations within the North Inlet–Winyah Bay

NERR. Water samples are collected every 20 days with ISCO automated water sampling devices at intervals of 2 hours and 4 minutes over two complete tidal cycles. Sampling and chemical analyses adhere to strict national protocols developed as part of the NERRS System-Wide Monitoring Program. The consistent, long-term collection of water chemistry variables allows for the characterization of short-term variability and detection of long-term change in key water quality parameters. These data also provide critical information for various studies of biological and physical processes in the North Inlet estuary. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control, and then made available via the CDMO website: <http://cdmo.baruch.sc.edu>. See [map](#) location #'s 6A, 6B, 3, 2C. Water chemistry data collected in North Inlet prior to the initiation of the NERRS SWMP sampling (some dating back to 1978) are available via the BMFL Data Archives web site: <http://links.baruch.sc.edu/Data/index.html>.

### **Long-term monitoring of emergent salt-marsh vegetation in the North Inlet Estuary**

Investigators: Dr. Erik Smith and Tracy Buck  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

As part of a NERRS system-wide initiative in biological monitoring, the North Inlet – Winyah Bay NERR is conducting biological monitoring of salt-marsh emergent vegetation. The long-term goal is to assess the effects of rising sea level on the community dynamics of emergent salt marsh vegetation in the North Inlet – Winyah Bay NERR. Specifically, this project seeks to quantify how salt marsh macrophyte community structure (species composition, relative abundance, and biomass) varies along an elevation gradient, from creek bank to upland forest edge, in response to long-term changes in tidal height and flooding frequency due to sea level rise. In accordance with established NERRS protocols, a stratified sampling approach using fixed transects and repeated measures within permanent sample plots is employed. Two segments have been established along the central axis of upper Crabhaul Creek ([map](#) location #14). Within each segment, 3 fixed transects were randomly established from creek bank to the western, upland edge of the marsh platform. Each segment delineates a total 20 permanent sampling plots. Groundwater wells are installed adjacent to each permanent plot. Sampling includes: percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by non-destructive sampling techniques; and porewater salinity. See [map](#) location #10

### **Plankton community respiration in the North Inlet estuary**

Investigators: Dr. Erik Smith, Amy Cook, and Tracy Buck  
Baruch Marine Field Laboratory, USC and North Inlet-Winyah Bay NERR

Respiration is the fundamental counterpart to primary production (photosynthesis) and represents the largest sink for organic carbon in the biosphere. Although it is at the center of ecosystem functioning, respiration represents a major area of ignorance in our understanding of the marine carbon cycle. Since respiration is the process by which energy is acquired at the cellular scale, and all organisms (save a few obligate fermenters) respire, measures of respiration have the potential to be used as an integrative indicator of energy flow, and thus ecological functioning, at the ecosystem scale.

With support from the NI-WB NERR, this study, initiated in July 2005, seeks to quantify and understand the short-term variability and potential for long-term change in water column respiration rates through a combination of routine field measurements and manipulative experiments. Our focus is on the tidal creeks and open-water portions of the estuary as these represent the conduit for material exchanges between the land-margin and coastal ocean. Routine sampling is conducted on both ebbing and flooding tides at the Oyster Landing site (see [map](#) location #3) in conjunction with the NERR 20-day water quality and water chemistry monitoring program. Respiration rates are derived from the consumption of dissolved oxygen during short-term (3 – 5 h) incubations of creek water contained in replicate 300 ml borosilicate glass BOD bottles, which are maintained at in situ temperatures with a flow-through seawater incubator. Oxygen concentrations are measured by automated Winkler titration employing potentiometric end-point detection. Our goal is to determine the factors that control the magnitude and variability of plankton community respiration rates in this ecosystem, and thus improve our understanding of how carbon flow through the ecosystem may respond to long-term changes associated with coastal land-use and climate alterations.

## **Diversity of plant-associated diazotrophic bacteria and their distributions within specific vegetation zones along an environmental gradient - The North Inlet Microbial Observatory**

Investigators: Drs. Charles R. Lovell<sup>1</sup> and Madilyn Fletcher<sup>1,2</sup>, and students  
Department of Biological Sciences, USC<sup>1</sup>  
Belle W. Baruch Institute for Marine and Coastal Sciences, USC<sup>2</sup>

The diazotrophic (nitrogen fixing) bacteria are extraordinarily diverse, and apart from a few select groups, such as cyanobacteria and rhizobia, are very poorly characterized. Diazotrophs associated with the roots of non-crop plant species are particularly understudied. The North Inlet Microbial Observatory (NIMO) focuses on diazotrophs in a salt marsh ecosystem, which is characterized by strong zonation patterns of a very limited number of plant species growing along distinct environmental gradients, and a great diversity of plant root-associated diazotrophs, many of which appear to be novel taxa. The zonation patterns and biota of salt marshes provide a unique opportunity to explore the diversity and distribution patterns of this key bacterial functional group and to evaluate the underlying effectors that control these parameters. The objectives of this program are 1) To build an extensive collection of culturable diazotrophs, including both O<sub>2</sub> utilizing and anaerobic bacteria. 2) To determine the phylogenetic affiliations of culturable diazotrophs through 16S rRNA and nifH sequence analysis, to determine relevant phenetic characters, and to formally describe new taxa. 3) To determine which taxa actively express nifH in association with salt marsh plants. 4) To determine numerical representations of taxa which express nifH in situ and are isolated into pure culture in the course of this study. 5) To examine the microscale distributions and specific associations of selected diazotrophs on the roots of salt marsh plants. 6) To investigate the macroscale distributions of the diazotrophs by relating their occurrence to host plant distributions and local environmental gradient conditions. Vegetated sediments and plant roots will be collected from 6 specific vegetation zones and diazotroph species diversity will be assessed on the basis of differences in nifH genes that are both characteristic of and exclusive to these organisms. Culturable diazotrophs will be isolated using both classical and novel strategies, and collections of aerobic and anaerobic strains will be established. Diazotrophs that actively participate in N<sub>2</sub> fixation will be identified from nifH mRNA sequences and comparison of these sequences with the growing nifH database. The numerical representations of these organisms will be determined by quantitative DNA-DNA hybridization. The associations of selected diazotrophs with plant roots will be characterized by localization on root surfaces using specific fluorescent oligonucleotide probes and confocal laser scanning microscopy. Through this work, the diversity of diazotrophs and the distributions of specific taxa will be determined, providing information on diazotroph ecology, including diazotroph-plant host interactions and host colonization at the microscale level. Moreover, by analyzing the distributions of specific diazotroph phylogenetic and physiologic groups with respect to the different vegetation zones, new understanding of diazotroph diversity and distribution at the macroscale will be obtained.

The importance of the diazotrophs to the productivity of both natural and agricultural systems provides a strong motivation for this project. The project will produce a detailed phylogenetic and phenetic examination of plant associated diazotrophic bacteria in a system where these bacteria are very important, very diverse, and, so far, mostly unknown to science. Many novel species of diazotrophs will be discovered and, through examination of host specificity and key ecological effectors, a far better understanding of the types of diazotrophs that interact with plants and actively fix N<sub>2</sub> in these associative interactions will be gained. Salt marsh and other wetlands restoration projects are often unsuccessful, at least within the 5-10 year expected duration of many projects, and the interactions of the dominant plant species with essential microbial “hidden players” have not been adequately considered. The interactions between marsh plants and diazotrophs may be particularly important since nitrogen is a key nutrient and a focus of interspecific competitive interactions. Greater understanding of the diversity of salt marsh diazotrophs, their specificity for host plants, and of their responses to environmental variables may contribute to more consistent success of restoration and conservation efforts.

This project is a continuation of work pursued over the last ten years and is supported by the National Science Foundation (1994-2008, so far). See [map](#) locations 8 and 10.

Some of the most recent publications associated with the work:

Bagwell, C.E. and C.R. Lovell. 2004. A DNA-DNA hybridization method for the detection and quantification of specific bacterial taxa in natural environments. In: J.F.T. Spencer and A.L. Ragout de Spencer (eds.) *Environmental Microbiology*, pp. 169-174. Methods in Biotechnology Series, Humana Press, Totowa, NJ.

- LaRocque, J., P.W. Bergholz, C.E. Bagwell, and C.R. Lovell. In press. Influence of host plant-derived and abiotic environmental parameters on the composition of the diazotroph assemblage associated with roots of *Juncus roemerianus*. *Antonie van Leeuwenhoek*.
- Lovell, C.R. In press. Belowground interactions among salt marsh plants and microorganisms. In: E. Kristensen, J.E. Kostka, and R.H. Hease (eds.) *Interactions Between Macro- and Microorganisms in Marine Sediments*, Coastal and Estuarine Studies Series. American Geophysical Union, Washington, D.C.
- Brown, M.M., M.J. Friez, and C.R. Lovell. 2003. Expression of nifH genes by diazotrophic bacteria in the rhizosphere of short form *Spartina alterniflora*. *FEMS Microbiology Ecology* 43:411-417.
- Leaphart, A.B., M.J. Friez, and C.R. Lovell. 2003. Formyltetrahydrofolate synthetase sequences from salt marsh plant roots reveal a diversity of acetogenic bacteria and other bacterial functional groups. *Applied and Environmental Microbiology* 69:693-696.
- Beeson, K., D.L. Erdner, C.E. Bagwell, C.R. Lovell, and P.A. Sobecky. 2002. Differentiation of plasmids in marine diazotroph assemblages determined by randomly amplified polymorphic DNA analysis. *Microbiology* 148:179-189.
- Lovell, C.R. In press. Plant-microbe interactions in the marine environment. In: G. Bitton (ed.) *Encyclopedia of Environmental Microbiology*. Wiley, New York, NY.
- Bergholz, P.W., C.E. Bagwell, and C.R. Lovell. 2001. Physiological diversity of rhizoplane diazotrophs of the saltmeadow cordgrass, *Spartina patens*. Implications for host specific ecotypes. *Microbial Ecology* 42:466-473.
- Bagwell, C.E., M. Dantzler, P.W. Bergholz, and C.R. Lovell. 2001. Host specific ecotypic diversity of rhizoplane diazotrophs of the perennial glasswort, *Salicornia virginica* and selected salt marsh grasses. *Aquatic Microbial Ecology* 23:293-300.
- Leaphart, A.B., and C.R. Lovell. 2001. Recovery and analysis of formyltetrahydrofolate synthetase gene sequences from natural populations of acetogenic bacteria. *Applied and Environmental Microbiology* 67:1392-1395.
- Lovell, C.R., M.J. Friez, J.W. Longshore, and C.E. Bagwell. 2001. Recovery and phylogenetic analysis of nifH sequences from diazotrophic bacteria associated with dead aboveground biomass of *Spartina alterniflora*. *Applied and Environmental Microbiology* 67:5308-5314.
- Lovell, C.R., C.E. Bagwell, M. Czako, L. Marton, Y.M. Piceno, and D.B. Ringelberg. 2001. Stability of a rhizosphere microbial community exposed to natural and manipulated environmental variability. *FEMS Microbiology Ecology* 38:69-76.

### **The South Carolina Harmful Algal Bloom Program**

Investigators: Dr. Susan Wilde<sup>2</sup>, Azal Amatyia<sup>2</sup>, Lara Brock<sup>2</sup>, Dr. Patrick Brown<sup>1</sup>, Krista DeMattio<sup>2</sup>, Kenneth Hayes<sup>1</sup>, Chuck Keppler<sup>2</sup>, Jiqing Liu<sup>1</sup>, Andrew Shuler<sup>1,2</sup>, Elizabeth Symon<sup>2</sup>, Raphael Tymowski<sup>1</sup>, Patrick Williams<sup>2</sup>, Sarah Williams<sup>2</sup> and collaborators from NOS-Charleston, SC Sea Grant, SCDHEC, SCDNR, Clemson University, MUSC, USGS Baruch Marine Field Laboratory and Hollings Marine Laboratory, USC<sup>1</sup>, Marine Resources Research Institute, SCDNR<sup>2</sup>

The SC Task Group on Toxic Algae was formed in late 1997, with the goal to develop a coordinated state strategy to cope with the possible consequences of a *Pfiesteria* toxic outbreak. The Task Group has since expanded to include assessments of harmful algal blooms in general. One of the first accomplishments of the group was to implement a program to respond to fish kills or lesion events in SC estuaries, and determine the potential association with harmful algal blooms. Efforts of the Task Group led to NOAA funding in support of the South Carolina Harmful Algal Bloom Program (SCHABP), the first statewide effort to assess the distribution and potential adverse effects of HABs in South Carolina estuaries. This study will 1) determine the present distribution of harmful algae in SC estuaries; 2) determine environmental factors that favor HAB formation in SC estuaries so future effects can be predicted; and 3) establish a statewide HAB surveillance system. The monitoring effort consists of an intensive statewide spatial monitoring (on a monthly to annual basis) to determine existing physical, chemical and biological parameters (including algal distribution) throughout the state. Sites that are routinely monitored from the Baruch field laboratory will include North Inlet (Clambank Bridge), Murrells Inlet (forested and urban creek), Debordieu ponds and Debidue Creek. In addition, known "hot spots", which are areas with previous algal blooms and/or lesioned fish, are monitored on a more frequent basis (biweekly), in order to document the physical, chemical, and biological factors which exist previous to a bloom event, should one occur. In the event of a potentially harmful



algal bloom, an event response method was formulated to standardize the measurement of environmental parameters that exist at the time of the bloom. Additional water samples are collected for the purposes of identification, isolation, and culturing of the bloom species. These cultured algal species will be used for bioassays to determine the role of nutrient quantity and quality in HAB stimulation. NOAA NOS. 1 October 2004 to 30 September 2006.

#### **North Inlet benthos program: Long-term monitoring of meiofauna and macrobenthos**

Investigators: Dr. Robert Feller  
Marine Science Program, USC

Regular (biweekly or monthly) collections of two size fractions of animals that live in the sand or mud have been made at the same locations in the North Inlet Estuary since 1972 (meiofauna) and 1981 (macrofauna). Small invertebrates, less than 0.5 mm in size, comprise the meiofauna. The meiofauna study is the longest estuarine meiofauna time-series in the world. Although collections of both meiofauna and macrobenthos continue to be collected, sample processing has lagged behind. Although these benthic communities contain hundreds of different species, only dominant taxa are identified regularly. The meiofauna are dominated by nematodes and harpacticoid copepods, while the macrobenthos consists mostly of polychaete and oligochaete worms, bivalves, and small crustaceans. Both size groups of organisms demonstrate annual cycles of abundance, peaking in winter. Simultaneous measurements of physical conditions in the water, sediment, and air help investigators to determine causes of variations over time. Data from undisturbed North Inlet habitats provide a baseline to which other areas, including contaminated areas, can be compared. These studies also provide an opportunity to examine the recruitment dynamics of soft-bottom benthos. See [map](#) location # 7.

#### **Interannual and seasonal patterns of use of flooded marshes and creeks by migratory fishes and crustaceans**

Investigators: Dr. Dennis Allen, Tracy Buck, Paul Kenny, and Ginger Ogburn-Matthews  
Baruch Marine Field Laboratory and NI-WB NERR, USC

Begin and End Date of database: January 1984 to present (ongoing)

In this study, the timing and the magnitude of nekton migrations onto the vegetated marsh surface are measured by enclosing a one acre area of flooded marsh at high tide and determining the taxonomic and life stage composition of the fauna leaving the area with the ebbing tide. These biweekly high tide collections in Oyster Landing Basin relate short-term, seasonal, and interannual changes in the abundance and composition of resident and transient species to flooding depth (sea level), freshwater runoff, and other environmental conditions. Comparisons of high tide collections at this site with same-day seine collections from the adjacent creek from 1996 to 2002 revealed that the composition and abundance of nekton remaining in the low tide pool was representative of the nekton using the flooded marsh. Low tide collections (1984-2003) showed long-term stability in the composition and production of the nine dominant transient fishes and shrimps that occupied the intertidal habitat. Relationships between OL Basin nekton and larval fish catch data from the long-term zooplankton series indicate the importance of recruitment success in determining annual production of some taxa. This information is providing a foundation for the development of new experimental approaches to understanding habitat requirements and interactions among co-occurring tidal migrants. Results have implications for the management of marsh creeks and watersheds proximal to nursery habitat. See [map](#) location #3.

### **Long-term zooplankton time series: Tracking and interpreting changes in the occurrence of larval and permanent taxa in the North Inlet Estuary**

Investigators: Dr. Dennis Allen<sup>1</sup>, Dr. Steve Stancyk<sup>2</sup>, Paul Kenny<sup>1</sup>, Tracy Buck<sup>1</sup>, Ginger Ogburn-Matthews<sup>1</sup>, and Dr. Erik Smith<sup>1</sup>  
Baruch Marine Field Laboratory and NI-WB NERR, USC<sup>1</sup>;  
Department of Biological Sciences and Marine Science Program, USC<sup>2</sup>

Collections have been made at the same location, stage of tide, and time of day using the same sampling technique every two weeks since 1981. Oblique tows with 153 micron mesh nets collect copepod and small invertebrate larvae, and 365 micron epibenthic sled collections take larval fishes, shrimps, and crabs and other large zooplankton species. Seasonal and interannual changes in abundance and species composition of the assemblages are documented and correlated to fluctuations in the physical characteristics of the estuary. These data sets are among the most complete and longest running in the world. They reveal rates and directions of change in an undisturbed estuarine ecosystem. A high level of stability in species composition and relative abundance has been demonstrated over the period, but effects of extended periods of low salinity such as those that occur in the winter-spring seasons of ENSO (El Nino) events are apparent. Over the past 22+ years, we have observed steady increases in the duration of the period of larval production for resident grass shrimp and goby species. This pattern coincides with significant increases in winter water temperatures over the time period and may indicate local responses to global climate change. Since many of the zooplankton species are developmental stages of larger animals, the study provides indications of the reproductive and potential recruitment success of several commercially and/or recreationally important species. See [map](#) location #10.

### **Ecological role and habitat utilization patterns of bottlenose dolphins in the North Inlet Estuary and adjacent waters**

Investigator: Dr. Rob Young  
Department of Marine Science, Coastal Carolina University

This project, began in September 1997, seeks to identify resident populations of bottlenose dolphins in the North Inlet and Winyah Bay systems and to identify their patterns of habitat utilization. This information is used to model the trophic role of dolphins within the system, to model the potential impact of dolphins upon prey populations, and to examine resident dolphin bioenergetics, social structure, and behavior. Photo-identification is used to identify and catalog individual dolphins based on the shape of the dorsal fin, and focal follows are used to establish habitat utilization patterns. Our initial studies have determined that the dozen or so resident dolphins in the North Inlet system consume a significant proportion of the prey fish populations (11-14 metric tons per year) and that 3 - 7% of the annual primary production in North Inlet is required to support them. Due to their changing seasonal patterns in North Inlet, dolphins may serve as a highly visible indicator species for changes and movements in the prey community. This research also contributes to the NMFS Mid-Atlantic Bottlenose Dolphin Catalog whose aim is to determine the stock structure of coastal migratory dolphins between New Jersey and Florida. Young, R.F. and H.D. Phillips. 2002. Primary production required to support bottlenose dolphins in a salt marsh creek system. *Marine Mammal Science* 18(2):358-373.

### **Sea turtle nest monitoring on Debidue Beach/Hobcaw Barony**

Investigators: Betsy Brabson<sup>1</sup> and Robin Baughn<sup>1</sup> (Debidue Beach Coordinators), Wendy Allen<sup>2</sup>, Tracy Buck<sup>2</sup>, Kimberly Foley<sup>2</sup> and other volunteers  
DeBordieu Colony<sup>1</sup>; Baruch Marine Field Laboratory, USC<sup>2</sup>

Nesting activity of the threatened loggerhead sea turtle, *Caretta caretta*, on the Hobcaw Barony portion of Debidue Beach is monitored by trained volunteers, May-October. This beach, owned by the Belle W. Baruch Foundation, is undeveloped and is about 2.2 miles in length. Staff from the Baruch Marine Lab, residents of DeBordieu Colony, and members from surrounding communities participate in the monitoring program. Volunteers walk the beach early in the morning during the nesting and hatching season, record information on false crawls and

nests, and protect nests from predators with screening. Nests laid in areas subject to flooding by tides are carefully relocated to higher areas. Volunteers also monitor the hatching success of the nests. Nest inventories are conducted 72 hours after the major hatch, indicated by dozens of baby turtle tracks in the beach sand. Volunteers excavate the nest chamber and record the number of empty shells, number and stages of development of unhatched eggs, and number of live hatchlings in the nest, if any. Nest inventories are conducted near dark and usually draw a crowd of interested visitors, providing an excellent opportunity to share information about the natural history and conservation of sea turtles. The volunteers are members of a larger volunteer group, the South Carolina United Turtle Enthusiasts (SCUTE), which covers the northern beaches of the state from the southern, undeveloped end of Debidue Beach known as Hobcaw, to North Myrtle Beach. Debidue Beach that includes the Hobcaw Beach plus the middle and north sections to Pawley's Inlet typically accounts for 30-50% of all nests in the Waccamaw region. A final report summarizing nesting activity and success for the SCUTE region is prepared and submitted to the SC Department of Natural Resources that oversees the volunteer sea turtle program for the state. [Map](#) location #1.

### **South Carolina Estuarine and Coastal Assessment Program**

Investigators: Drs. R.F. Van Dolah, P.C. Jutte, G. Riekerk, M.V. Levisen, and D.E. Chestnut  
SC Department of Natural Resources, SC Department of Health and Environmental Control

In 1999, the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) initiated a major new collaborative coastal monitoring program. The goal of the South Carolina Estuarine and Coastal Assessment Program (SCECAP) is to monitor the condition of the state's estuarine habitats and associated biological resources on an annual basis. This program significantly expands current ongoing monitoring efforts being conducted by each Department by drawing upon the expertise of both in a cooperative effort. SCECAP integrates measures of water and sediment quality with multiple measures of biological condition at a large number of sites throughout the state's coastal zone. It also expands historical monitoring activities that have primarily focused on open water habitats (e.g., bays, sounds, tidal rivers) to include an assessment of conditions in tidal creeks, which serve as important nursery habitat for most of the state's economically valuable species. Many of these tidal creeks are also the first point of entry for non-point source runoff from upland areas and therefore can provide an early indication of anthropogenic stress. The SCECAP program, combined with the other cooperating programs, provides a number of direct and indirect benefits to the citizens of South Carolina. These include:

- 1) The ability to identify areas of South Carolina's estuarine habitat that are impaired or degraded with respect to a suite of sensitive biological, chemical, and physical measures.
- 2) A standardized protocol that is used by both the SCDNR and SCDHEC that is cost-effective and consistent with protocols common among other U.S. coastal states. This will allow South Carolina managers to relate conditions in our coastal waters relative to the overall southeastern region, and it will allow better regional prioritization of stressors and impacts.
- 3) More comprehensive periodic reports on the condition of water quality and habitat condition throughout the state's coastal zone than could be accomplished by the individual programs alone.

To date, three sites have been sampled in the North Inlet estuary as part of the program and another is planned for sampling in 2005. Many more stations have also been sampled in the adjacent Winyah Bay system. The relatively small size of the North Inlet estuary limits the number of sites that would be identified through the random, probability-based sampling approach, but it does provide an opportunity to compare conditions within North Inlet to other locations in the state.

## **Education, Outreach, and Data Management**

### **High School Water Quality Program – National Estuarine Research Reserve**

Investigators: Beth Thomas, Education Coordinator, and Stowe Beam, Education Specialist  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

Education and outreach focusing on water quality is targeted to local high schools in Georgetown and Horry Counties to teach high school students and others about the importance of healthy water quality and the value of watersheds and estuaries. This program is an offshoot of the former Estuary-Net volunteer water quality monitoring project (<http://www.northinlet.sc.edu/estnetweb/estnet.html>) developed by the National Estuarine Research Reserve System (NERRS). It includes a complete curriculum with both classroom and field activities that provide a hands-on approach for investigating non-point source pollution and its impacts on estuaries. Teachers and students from local school districts work with Reserve staff to study water chemistry and quality, sample bodies of water near their schools, and compare their findings with local and national estuarine data collected from the NERRS' System-Wide Monitoring Program (SWMP). Participating schools work closely with the Reserve's Education staff and receive introductory classroom visits highlighting the Reserve System and the North Inlet Winyah Bay NERR, the water quality project, and instruction on monitoring equipment and sampling protocols for a variety of sampling variables. Reserve site visits, estuarine ecology, follow-up school visits and sampling assistance (including testing equipment) are also offered.

### **Education Activities – National Estuarine Research Reserve**

Investigators: Beth Thomas, Education Coordinator, and Stowe Beam, Education Specialist  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

Educational activities that integrate findings from research are offered throughout the year. The Hobcaw Seminar series provides an informal means for people of all ages to learn about current and ongoing research programs conducted on Hobcaw Barony. Other regular offerings include programs on estuarine and beach ecology, open houses, "Bike to the Boardwalk", and the monthly 'Fishes of North Inlet Estuary' program in which participants help Reserve scientists sample and process collections of fishes, shrimps and crabs made on a bi-weekly basis. Field trips for high school students, homeschool students, and special groups such as Elderhostel, Boy and Girl Scouts, and 4H clubs are also available. Contact the Reserve for a schedule of events at (843) 546-6219 or visit the Reserve's web site at: [www.northinlet.sc.edu](http://www.northinlet.sc.edu).

### **Community Enhancement Activities – National Estuarine Research Reserve**

Investigators: Beth Thomas, Education Coordinator, and Stowe Beam, Education Specialist  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

The Reserve currently participates in several community enhancement and stewardship activities in partnership with Keep Georgetown Beautiful, the local chapter of Keep America Beautiful. Reserve and BMFL staff assist in semi-annual river and marsh cleanups, lead recycling programs for elementary students and YMCA afterschool programs, and assist with a new county-wide monofilament recycling program. Reserve staff participates in school and beautification subcommittees within the organization.

### **South Carolina Chamber of Commerce High Performance Partnership**

Investigators: Beth Thomas, Education Coordinator; Stowe Beam, Education Specialist  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

The South Carolina Chamber of Commerce's High Performance Partnership (HPP) includes the Belle W. Baruch Foundation/Hobcaw Barony, Clemson University's Belle W. Baruch Institute for Coastal Ecology and

Forest Science, and USC's North Inlet-Winyah Bay National Estuarine Research Reserve, all partnering to provide educational opportunities to our selected partner school, Pleasant Hill Elementary in Georgetown, SC. The HPP was established as part of a federal GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) grant that also includes state funding and business contributions. The program identifies eligible K-12 schools and pairs them with community businesses to provide unique opportunities for improving academic achievement. The Baruch Foundation and Institutes' goals are to provide environmental education programs on site and in the classroom, open houses and training opportunities for teachers, and special programs to increase parent and community involvement in the school.

### **Coastal Training Program for local decision-makers**

Investigator: Jeff Pollack  
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

The Coastal Training Program (CTP) offers science-based information, tools, and training to coastal decision makers in order to promote informed, forward-thinking decision-making related to coastal resources. A coastal decision maker is anyone whose professional or personal decisions impact the health of coastal resources. Local planners, town and county council members, public works officials, and developers are among the target audiences of the North Inlet-Winyah Bay CTP. Training topics encompass a wide range of timely coastal issues; recent training events have addressed stormwater management, shoreline management, and development and planning alternatives for watershed protection.

CTP training can be conducted in a variety of settings and formats, and training is always tailored to the specific needs of the audience. All training sessions include take-home reference materials and digital access (through the CTP website: [www.northinlet.sc.edu/training](http://www.northinlet.sc.edu/training)) to training materials. CTP training events typically involve a variety of instructors, such as university professors, industry practitioners, and technical experts. Training is designed to be practical and is based on local case examples in the North Inlet-Winyah Bay NERR watershed whenever possible. Technological exhibitions, participatory field activities, and panel or round table discussions are included when appropriate to create an open, cooperative learning environment.

The four central partners of the North Inlet-Winyah Bay CTP are the ACE Basin NERR, SC DHEC - Office of Ocean and Coastal Resource Management (OCRM), South Carolina Sea Grant Consortium, and the NOAA Coastal Services Center (NOAA CSC). These agencies constitute the South Carolina CTP Coordinating Committee that provides oversight, guidance, and statewide coordination for the Coastal Training Programs that are administered by the two South Carolina NERRs.

### **Long-term coastal data and metadata rescue and product dissemination by USC's Baruch Institute**

Investigators: Ginger Ogburn-Matthews and Melissa Ide  
Baruch Marine Field Laboratory, USC

Baruch Institute has many valuable ecological and environmental coastal long-term databases that date from the late 1970s through the early 2000s that are not readily accessible to the public and researchers. Technology and information management has changed dramatically just in the last 5 years with the growth and availability of the Internet. The goal of this project is to verify, rescue, organize, archive, and disseminate each database and its documentation (metadata) in a variety of forms (paper, Compact Disk (CD), and web).

First the data and the documentation for each database is assessed. All data are graphed, verified, and documented for missing data and outliers. All previous documentation, programs, summary data, and processed files are organized and documented. After the data are verified error-free, final graphics are created and exported in a .jpg (image) format. All documentation is verified with the data, and summarized in a standardized form, using the Federal Geospatial Data Committee (FGDC)/National Biological Information Infrastructure (NBII) format. All raw datasheets are scanned and saved as .jpg formatted images. Raw data images, processed data (including programs and earlier documentation), and final data are archived to a CD. All final data, metadata, and graphics are printed out; these hardcopy versions along with the CDs are placed in a three-ring binder notebook that is kept in the computer lab at the Baruch Marine Field Laboratory. The final data, graphics, and metadata are also posted to Baruch's Website (<http://links.baruch.sc.edu/data/>) and the metadata is posted to Baruch's Isite Node that is

registered with the NOAA CSC (<http://www.csc.noaa.gov/CID/>), NBII (<http://mercury.ornl.gov/nbii/>), and FGDC (<http://clearinghouse2.fgdc.gov/>) clearinghouses. This project was supported by NOAA's Coastal Services Center and is presently funded by NOAA's National Coastal Data Development Center (NCDDC). This project began August 1, 2002 and is ongoing.

### **The National Estuarine Research Reserve System Centralized Data Management Office**

Investigators: Dr. Dwayne E. Porter<sup>1,2</sup>, Tammy Small<sup>1</sup>, Ashly Burmeister<sup>1</sup>, Jesse Friedmann<sup>1</sup>, Scott Lail<sup>1</sup> and Kirk Yedinak<sup>1</sup>  
Belle W. Baruch Institute for Marine and Coastal Sciences and the Baruch Marine Field Lab, USC<sup>1</sup>; The Norman J. Arnold School of Public Health, USC<sup>2</sup>

NOAA's National Estuarine Research Reserve System (NERRS) acknowledges the importance of both long-term environmental monitoring programs and data and information dissemination through the support of the NERRS System-wide Monitoring Program (SWMP). The goal of the SWMP is to "identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purpose of contributing to effective national, regional and site specific coastal zone management". This comprehensive program consists of three phased components: estuarine water quality monitoring (phase I), biodiversity monitoring (phase II), and land-use and habitat change analysis (phase III).

The Centralized Data Management Office (CDMO) was established in support of the System-wide Monitoring Program involving 25 sites around the US and Puerto Rico. The purpose of the CDMO, housed at the North Inlet-Winyah Bay NERR, is the management of the infrastructure and data protocol to support the assimilation and exchange of data, metadata and information within the framework of NERRS sites, coastal zone management (CZM) programs, and other education, monitoring and research programs. The CDMO and the CDMO Data Management Committee (comprised of representation from the Managers, Research Coordinators, Education Coordinators, NOAA, and state CZM programs) have established six priority areas in support of the System-wide Monitoring Program.

- 1) The continuation and advancement of the System-wide Monitoring Program data and information management program. This priority area will support data management protocols for water quality and meteorological data and associated metadata, documentation, data archival, development of software-specific programs to assist with data QA/QC procedures, and data and information dissemination. The CDMO will continue efforts to (a.) improve the process for making SWMP monitoring data and associated metadata available via the SWMP/CDMO web presentation; and (b.) support applications and programs to assist with the processing, quality control, management and metadata of data collected using the water quality data loggers and meteorological stations. Once operational, the CDMO will also be responsible for the data assimilation, management, and documentation as related to expanded phase I data collection efforts.
- 2) Maintain the on-line data and information server. Via an on-line information server (<http://cdmo.baruch.sc.edu/>), the CDMO will continue to provide access to data and metadata collected as part of the SWMP program. The CDMO will also continue to support listserves for the Reserve program, for Research Coordinators, and for the SWMP.
- 3) To continue to provide technical support services via telephone, e-mail, and individual and group training. The CDMO has taken a leadership role in providing technical support for issues not only related to data management but also computer hardware and software technology, telecommunications, connectivity, and training. On-site training and support will be on a limited basis contingent upon available funds.
- 4) The continuation of the CDMO Data Management Committee annual workshop to provide an additional avenue for the exchange of ideas and information related to database management, technological advances, and other data collection and monitoring program. This dynamic group is also responsible for the identification of ways to improve and enhance individual NERRS site data management capabilities and the CDMO. A two-day workshop will be held in the summer of 2006 at the North Inlet-Winyah Bay NERR.
- 5) The continuation of the CDMO Technicians' Training Workshop series to provide training for NERRS research technicians working on SWMP initiatives. The CDMO will again conduct a multi-day workshop series to provide hand-on assistance to research technicians in support of SWMP equipment setup,

operation and maintenance; data collection and management; and QA/QC activities. The workshops will be held in the late winter 2006.

- 6) Provide technical support for special NOAA projects and provide for information management and outreach support for NOAA, Reserve Managers, Educators, and Research Coordinators, and state CZM agencies. Attention will be focused on providing support to NERRS research and educational activities for group communications, technology upgrades and implementation, and the assimilation and dissemination of data, standard products, and other identified information. In addition, the CDMO will continue to participate in OceanUS activities to promote the role of the NERRS SWMP and the CDMO in support of developing a national integrated coastal ocean observing system.

This project is funded from 09/01/04 to 02/28/06 by NERRS/NOAA/Dept. of Commerce. The CDMO website is [cdmo.baruch.sc.edu](http://cdmo.baruch.sc.edu)

# Research Locations in North Inlet





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