

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

**2009**

**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 2009**

### **Introduction**

Since 1969, Baruch Institute research associates have completed more than 650 scientific research projects, and students have completed hundreds of theses, dissertations, and special research projects. All of this work has resulted in the publication of 1,600 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 64 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 51 of the investigators conducting research at the BMFL. In addition, 65 other investigators representing 29 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 grouped in a 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 and SC Sea Grant Consortium), US Department of Energy (US DOE), US Department of Defense, 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 investigator(s) or Dr. Dennis Allen or Dr. Scott Neubauer. Paul Kenny facilitates researcher use of the BMFL and is available for training and assistance. All BMFL staff can be contacted at 843-546-3623. Information may also be obtained from the Institute's web site (<http://www.cas.sc.edu/baruch/>).

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## **Analyses of the 3D structure of salt marsh landscapes and its effect on sediment cycling**

Investigators: Dr. Raymond Torres<sup>1</sup>, Dr. Lew Lapine<sup>2</sup> and graduate students Joseph Bell<sup>1</sup>, Jessica Chassereau<sup>1</sup>, and Si Chen<sup>3</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, USC; <sup>2</sup>SC Geodetic Survey;

<sup>3</sup>Marine Science Program, USC

The purpose of this research is to: 1) Evaluate the 3D structure of a salt marsh landscape, 2) Compare the GPS DEM to a recent LiDAR DEM of the same area, 3) Assess spatial and temporal variability of sediment accretion and composition in the context of 3D island structure, 4) Characterize the temporal and spatial variability of processes controlling tidal creek network development and stability, and 5) Establish a long-term monitoring sites for salt marsh geomorphology and processes.

In the initial phase of this study we established two Order 1 Class B benchmarks for geodetic control (PID numbers AJ5765 and AJ5767). Based on these benchmarks we created a high resolution RTK-GPS DEM of a salt marsh island, Maddieanna Island (map location #16). Island area is 0.4 km<sup>2</sup> and it is approximately 3 km SSW of the Marine Lab building, nominally centered at 33°19'00.00"N, 79°11'52.00"W. The DEM is made of about 77000 GPS points with 0.5 m spacing around the creeks and 5 m spacing on the marsh platform. This DEM serves as a base for current and future research. In summer 2008, we will install nine SETs, and establish fixed positions for measuring sediment accretions with tiles at several more locations. We also installed four observations platforms for auto samplers at 1) 33°19'4.70"N, 79°12'3.72"W, 2) 33°19'11.09"N, 79°11'44.19"W, 3) 33°19'9.75"N, 79°11'40.81"W, and 4) 33°18'42.08"N, 79°12'5.94"W, ISCO 1, 2, 3 and 4 respectively. These samplers were installed to acquire suspended sediment samples in response to low tide rainfall events. The samples will be analyzed for nutrient quality and composition, C isotopes, C transformation.

This research is significant because its goal is not merely to estimate sediment accretion, but to investigate spatial and temporal variability in accretion, and to examine how the 3D marsh landscape structure affects that variability. The overall question driving this part of the research is: How well can we know sediment accretion rates in salt marsh landscapes? The project started in 2003 and there is support to continue these efforts until 2012. Agencies supporting this work include: NSF, NOAA, USGS, and Calfed.

## **Physical controls on benthic fluxes of microalgae and particulate organic matter in estuarine environment**

Investigators: Dr. George Voulgaris<sup>1</sup>, Dr. Jay Pinckney<sup>2</sup>, and Jeff Morin<sup>1</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, USC; <sup>2</sup> Department of Biological Sciences, USC

In estuaries, the flux of particulates between water and sediment is dependent on turbulence generated by tidal and wind-induced flows (including surface waves). The suspended particulates consist of three major components; benthic microalgae, non-living particulate organic matter, and sediment. Quantification of the relative amounts of these three types of particulates under a variety of tidal and wind-induced turbulence conditions is necessary to construct computational models of sediment and particulate fluxes in estuarine habitats. Furthermore, the physical, biogeochemical, and ecological fate of resuspended particulates depends on the type of particle. For example, resuspended benthic microalgae may be a valuable food resource for filter feeders (oysters) as well as zooplankton and juvenile fish. Particulate organic matter demineralization is probably enhanced when resuspended in oxic water column conditions promoting rapid and efficient recycling of nutrients. The size distribution of resuspended sediments under different turbulence conditions has major implications for sediment transport and deposition processes. Thus quantification of the effects of shallow water turbulence on the material fluxes of different particle types will provide insights into the importance of this process in governing the source, transport, and fate of benthic microalgae, particulate organic matter, and sediments across the sediment-water boundary of estuaries. Furthermore, these results can be coupled with existing hydrodynamic models to provide system-wide estimates of benthic-pelagic exchange of particulates.

The overall objective of this study is to create a biogeochemical module that can be integrated with hydrodynamic models to simulate fluxes of benthic microalgae (BMA), non-living particulate organic matter

(POM), and the particle size distribution of suspended sediments (SS) under turbulence conditions of tidal and wind-induced flows. The short-term objectives to be achieved within the 2-year length of the proposed project are:

- 1) Determine experimentally the relationship between physical hydrodynamic forcing and re-introduction of BMA, POM, and SS into the water column, in a tidally dominated environment for different seasons.
- 2) Differentiate the particle dynamics of benthic sediment and BMA.
- 3) Parameterize benthic fluxes of BMA into a geochemical module that can be integrated in physical numerical models.

Experiments will utilize high frequency (>2Hz) flow and BMA (Chlorophyll a) measurements in the benthic boundary layer. These will be accompanied by collection of water column samples for particle characteristic analysis in the laboratory that will be used to verify/calibrate the automated measurements. Experiments will be carried out over full tidal cycles (spring and neap) at North Inlet for two different seasons (winter - summer) with different productivity characteristics. North Inlet is part of the Winyah Bay estuarine system and is composed of many shallow creeks traversing a large salt marsh encompassed by Debidue Island, North Island and the Mainland. The marsh is flooded twice over a 24 hour period and the sediments are generally a mixture of sand and silty clay.

The benthic boundary layer (BBL) measurement system will consist of: (i) Acoustic Doppler Velocimeter (ADV) that measures mean flow and turbulence; (ii) Optical Backscatter Instrument (OBS) that measures bulk material in the water column; (iii) Laser in situ Scattering Transmissometer (LISST) for in-situ particle size measurements; (iv) Acoustic Backscatter Sensor (ABS) for high resolution (<1cm) profiles of inorganic particle size concentrations; and (v) Fluorometer for in vivo Chlorophyll a measurements. The system will be deployed in a tidal creek in North Inlet, SC. See map location #10

This project is funded by South Carolina Sea Grant for the period February 2008 to January 2010.

### **Recent Holocene sea level trends and environmental impacts on a freshwater tidal wetland; Thousand Acre Marsh, SC, USA**

Investigators: Abby Springer<sup>1</sup>, and Drs. Douglas F. Williams<sup>1</sup>, Scott White<sup>1</sup>, Camelia Knapp<sup>1</sup>, Robert Gardner<sup>1</sup>, and Paul Gayes<sup>2</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, USC

<sup>2</sup>Center for Marine and Wetland Research, Coastal Carolina University

The objectives of this investigation are to use the sedimentary record of the Thousand Acre Marsh of the North Inlet-Winyah bay NERR site as an analogue to a "paleo-mud bay system" and to 1) determine the subsurface sequence stratigraphy based on sea level changes 2) produce an age framework for these events; 3) determine previous sediment response to sea level rise; 4) forecast the future sediment response of North Inlet coastal environments to rising sea level; and 5) provide research managers with information needed to deal with future coastal environmental issues related to historical rates of sea level change. The investigation will begin with the construction of a lithological and stratigraphical framework by taking numerous vibracores in grid format across Thousand Acre Marsh (see map location #6C). Ground Penetrating Radar (GPR) profiles and high resolution seismic data will provide correlation with core lithology. The combination of these data types and <sup>14</sup>C dating will allow sequence boundaries to be identified and correlated with facie distribution and event timing, thus providing migration history of this "paleo-mud bay system" due to encroaching sea level.

The significance of this project relies on the sediment response of coastal environments to sea level change. The North Inlet-Winyah Bay NERR site contains barrier island, marsh and hardwood forest environments. These systems are already being affected by sea level rise as evidenced by salt water intrusion under beach ridges and lateral migration of the marsh system into what is present day Mud Bay. Each of these coastal environments are natural resources that can be sustained and managed if resource managers have a better understanding of Holocene sediment responses under similar boundary conditions.

## **Salt marsh hydrology and acute marsh dieback**

Investigators: Dr. Alicia Wilson<sup>1</sup>, Dr. Jim Morris<sup>2</sup>; and Ph.D. students Andrea Hougham<sup>1</sup>, and Weihong Wang<sup>3</sup>  
<sup>1</sup>Department of Earth and Ocean Sciences, <sup>2</sup>Department of Biological Sciences,  
Belle W. Baruch Institute for Marine and Coastal Sciences, <sup>3</sup>Marine Science Program, USC

The goal of this work is to quantify groundwater flow in a salt marsh island, to understand (1) the role of submarine groundwater discharge (SGD) in nutrient cycling and (2) links between salt marsh hydrology and ecological productivity, particularly the cause of salt marsh dieback. An important hypothesis for this work is that acute marsh dieback at the site was caused by rapid changes within the normal range of marsh conditions during drought conditions. We installed 7 piezometer nests (3 piezometers in each nest) to monitor temperature and fluctuations in hydraulic head. Numerical models are currently being calibrated to monitoring data from 2006-2008 to and will be used to reconstruct groundwater flow conditions at the time of the dieback in 2001/2002. During 2009 the wells will be used for ongoing nutrient sampling, and a new study of temporal and spatial variations in Ra activity in the porewater will begin. The Ra studies commonly use single average values for groundwater, which can introduce significant uncertainty into estimates of SGD. See map location #2B. This project is funded from 6/1/2006 until 8/31/2009 by the South Carolina Sea Grant Consortium

## **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, and are examining how latitudinal variation in both bottom-up (plant quality) and top-down (predators) factors affects latitudinal variation in herbivore populations. 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 the BMFL-North Inlet SC site, 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 has been funded by two grants from 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. Steven C. Pennings<sup>1</sup>, Rachel Goeriz<sup>2</sup> and Jessica Hines<sup>2</sup>  
<sup>1</sup>Department of Biology and Biochemistry, University of Houston;  
<sup>2</sup>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 North Inlet, 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 R.F. Denno (deceased).

### **Tidal forcing and geographic variation in top-down and bottom-up control of a salt marsh food web**

Investigators: Brittany DeLoach and Dr. Steven Pennings  
Department of Biology and Biochemistry, University of Houston

My research is looking into geographic variation in bottom-up and top-down effects, and their interaction, on the arthropod communities in coastal salt marshes. The majority of research on salt marshes has been conducted along the Atlantic Coast of the United States; however, the Atlantic and Gulf Coasts may not function in exactly the same ways. There is a major geographic contrast between the two areas driven by tidal range. Specifically, I want to know if the difference in tidal regimes between the Gulf Coast and the East Coast has any effect on the relative importance of nutrients and habitat structure in structuring the *Spartina alterniflora* food web. We will have 20 sites per coast.

To document background patterns at each site, we will measure wrack abundance with quadrats, sample arthropod composition with a D-vac suction sampler, take soil samples for salinity and organic content, and take leaf samples for carbon and nitrogen analysis.

At the same time, we will set up an experiment at each site manipulating thatch/wrack and nutrients. There will be one set of plots per site, which will measure 3x1m and be separated by 3m. There are four treatments:

- 1) ambient control
- 2) wrack addition - mono-layer of wrack around plant stems with bird netting to hold wrack in place
- 3) nitrogen addition - eight 21g slow-release fertilizer pellets (20-10-5) per m<sup>2</sup> placed 10 cm deep in the soil, and
- 4) wrack plus nitrogen addition

In August 2009, we will document the background patterns again with wrack, insect, soil, and leaf samples. The lower 1 x 1 m of the experimental plots will be sampled using the D-vac suction sampler to assess the effects of the treatments on predator and herbivore abundances. Then, the site will be deconstructed and everything from the experiment will be picked up. See map location #9A

### **Tracking variations in *Juncus roemerianus* marshes using a palynomorphic fingerprint to identify former high level salt marsh positions**

Investigators: Dr. Pamela E. Marsh and Dr. Arthur D. Cohen  
Department of Earth and Ocean Sciences, USC

In the southeastern United States, *Juncus roemerianus* is the plant that grows at the most inland extent of salt water influence in many salt marshes. As such, it is an excellent proxy for highest high water and sea level. Marsh and Cohen (2008) identified a palynomorphic fingerprint that distinguishes sediments found in *Juncus roemerianus* zones from sediments found in all other salt marsh zones. The components of this fingerprint include: high palynomorph diversity, an unidentified fungal spore type, and the fungal spore of *Atrotorquata lineata*. Our current research consists of several parts. First, we wish to show that this palynomorphic fingerprint occurs at all locations within *Juncus roemerianus* stands regardless of distance from the ocean or upland areas. To accomplish this, we have collected samples at 50-foot intervals along a 600 foot transect of a *Juncus roemerianus* stand located on the

road to Clambank at the end of Crab Haul Creek, North Inlet. These samples showed that the palynomorphic fingerprint is present in all locations. Second, we hope to show that the palynomorphic fingerprint is present throughout the range of *Juncus roemerianus* (roughly Delaware to Texas). In addition to the previously mentioned samples from North Inlet, we obtained sediment samples from throughout South Carolina as well as North Carolina, Florida and Alabama, with commitments of samples from Texas, Louisiana, Mississippi, and Georgia. All samples analyzed to date have contained the fingerprint. Third, we hope to show that our palynomorphic fingerprint is preserved beneath the surface and can be used to track minor changes in sea level. To date, we have found the *Juncus* fingerprint beneath the surface in South Florida and in cores from James Island, SC, and we have collected cores in a *Juncus* marsh near the intersection of Floating Bridge Road and Old Clubhouse Corner Road that we hope will allow us to trace sea level movement.

The significance of this project lies in the potential to determine what has happened with sea level in the past and, perhaps, to be able to discover whether current changes in sea level are anthropogenically influenced or, rather, part of a larger cycle that has been occurring for millennia.

This project began in 2006 and is expected to be completed in the fall of 2009. Funding for this project has been provided by the Baruch Institute Hodge Summer Fellowship, the Geological Society of America Graduate Research Grant, the Society of Wetland Scientists South Atlantic Chapter Student Research Grant, and the South Carolina Sea Grant Consortium.

Marsh, P.E. and A. D. Cohen. 2008. Identifying high-level salt marshes using a palynomorphic fingerprint with potential implications for tracking sea level change. *Review of Palaeobotany and Palynology* 148(1): 60-69.

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

Investigators: Dr. James Morris<sup>1,2</sup> and Karen Sundberg<sup>2</sup>  
<sup>1</sup>Department of Biological Sciences and Marine Science Program, USC  
<sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, 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. Marsh plots were fertilized from 1996 or 2001 until 2004. Currently we are looking at the effect decreasing eutrophication on the marsh surface elevation, and we hypothesize that there will be a decrease in volume of belowground biomass due to enhanced decomposition now that belowground production is no longer stimulated. 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. Map locations #2A, B, C, D.

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

Investigators: Dr. James Morris<sup>1,2</sup> and Karen Sundberg<sup>2</sup>  
<sup>1</sup>Department of Biological Sciences and Marine Science Program, USC  
<sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, 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 various saltmarsh plants.

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. Currently there are three independent experiments. Each experiment has six treatments ranging from supra optimal elevation (i.e., floods only on spring tides) to completely inundated (i.e., waterlogged) with 15 cm separation between pipes and six replicates per treatment. Two experiments examine the effect of marsh platform on *Spartina alterniflora*, and one focuses on the effect of marsh platform on *Juncus roemerianus*. The experiments are planted at the beginning of the growing season with salt marsh plugs collected near Oyster Landing, North Inlet, South Carolina. Monthly stem

height measurements are obtained each year from April to October as an estimate of standing biomass. Plants are harvested at the end of the growing season, dried and weighed to determine aboveground and belowground productivity. 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.

### **Investigating coastal salt marsh belowground carbon dynamics in North Inlet, SC, USA**

Investigators: Weihong Wang<sup>1</sup> and Dr. James T. Morris<sup>2</sup>  
<sup>1</sup>Marine Science Program, USC; <sup>2</sup>Department of Biological Sciences and Belle W. Baruch Institute for Marine and Coastal Sciences, USC

The preservation and accumulation of organic carbon is thought to be an important mechanism by which coastal wetlands keep pace with rising sea level. The survival of coastal salt marshes is especially challenged nowadays by continuous sea level rise caused by global warming. A fundamental understanding of sediment carbon cycling mechanisms within the salt marsh system will provide a basis for evaluating the capacity of salt marsh to sequester carbon in sediments and the role of this process in maintaining relative elevation. This proposed research addresses (1) the seasonal and annual soil respiration in North Inlet salt marshes; (2) measurement and separation of root respiration from sedimentary organic matter (SOM) decomposition using carbon stable isotopes; (3) measurement of stem CO<sub>2</sub> fluxes and its fate by stable carbon isotope analysis; (4) and measuring the temperature dependence of soil respiration. In this research, three hypotheses will be tested: (1) root respiration and SOM decomposition have different temperature sensitivities; (2) stem CO<sub>2</sub> comes from two sources: CO<sub>2</sub> respired from roots and CO<sub>2</sub> derived from SOM decomposition and is a major pathway for carbon export; and (3) the carbon isotope composition of soil CO<sub>2</sub> is a function of two different carbon sources: root and SOM respiration. Stable carbon isotope analyses, soil respiration and stem CO<sub>2</sub> fluxes measurements, and sediment core incubation experiments will be used in this study to achieve the objectives and test our hypotheses. The results of this proposed research will provide information to policy makers and managers relative to the effects of sea level rise on a vital natural resource, namely our salt marshes. This project will start in Summer 2007 and end in Summer 2009. Support is provided by NOAA NERRS fellowship, the USC Marine Science Program, and the Baruch Marine Field Laboratory.

### **The role of microorganisms in the decomposition of *Spartina* wrack in coastal ecosystems**

Investigators: Morgan Marsh<sup>1</sup> and Dr. Vladislav Gulis<sup>2</sup>  
<sup>1</sup>Coastal Marine and Wetland Studies Graduate Program, Coastal Carolina University;  
<sup>2</sup>Department of Biology, Coastal Carolina University

*Spartina* wrack has not been studied extensively even though the accumulation of material in salt marshes can be considerable. The main questions to be addressed in this study are: (1) what are the decomposition rates of *Spartina alterniflora* wrack along the salt marsh elevational gradient; (2) what is the relative importance of fungi vs. bacteria in *Spartina* wrack decomposition; (3) what are the differences in fungal community structure between standing dead *Spartina* and *Spartina* wrack? This experiment utilizes 4 study sites in the salt marsh at the BMFL, two at Oyster Landing, one at Clambank and one at Tom's Creek. Four sampling stations along the elevational gradient (transect) at each of four sites are: subtidal, low marsh, high marsh and high bank. Decomposition rates of *Spartina* in litter bags, associated microbial respiration, fungal and bacterial biomass (from ergosterol concentrations via HPLC, and epifluorescence microscopy, respectively) will be determined over ten months (March - December 2009; 5-7 sampling dates). Fungal community structure will be assessed either by DGGE, T-RFLP or cloning and sequencing. This study will provide insights into microbial communities associated with *Spartina* wrack, since earlier studies focused primarily on standing dead *Spartina*. See Map locations # 10 & 16)

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

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

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*. Map location #6C.

## **The flora of Indian shell mounds in North Inlet, South Carolina**

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

The objective of this study is to investigate the vascular flora at four Indian clam shell middens in North Inlet. We will investigate the distribution of vascular plant species at the shell middens along an elevation gradient at Clambank and nearby. To accomplish this we will survey the plant species with a surveyor's transit and stadia pole; elevation of each taxon will be recorded above the most flood tolerant species, *Spartina alterniflora*. The primary objective will be to collect and identify all the vascular plant species present at each midden. These will be housed at the herbarium at the University of South Carolina. The species present at these middens will be compared with those found at shell ring sites in South Carolina by Stalter et al (1999). We will sample the middens beginning July 1, 2009. The study will be terminated around June 30, 2011. A small sample of each taxon will be collected, pressed and mounted on a herbarium sheet as voucher material. Only one sample/taxon will be collected as reference material. Soil samples from two of the shell middens will be collected; mineral analysis will be performed by the Nutrient Analysis Laboratory, Cornell University.

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

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

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, 2005-2008.

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. We continue to assess survival of wrack impacted plants and monitor recruitment and growth in specific wrack impacted zones. Map location #9A.

### **Black sea bass (*Centropristis striata*) recruitment, growth, and genetic structure in East and Gulf coast estuaries**

Investigators: Dr. Dennis M. Allen<sup>1</sup>, Dr. Joseph M. Quattro<sup>2</sup>, and Damien Wilkinson<sup>1</sup>  
<sup>1</sup>Baruch Marine Field Laboratory, USC; <sup>2</sup>Marine Science Program and Department of Biological Sciences, USC

Black sea bass is one of the most familiar shallow-ocean bottom fishes from New York to the central Florida and in the eastern Gulf of Mexico; it supports major commercial and recreational fisheries particularly from the Carolinas north. One aspect of this study is to determine genetic stock structure of the species throughout its wide range with emphasis on defining genetically distinct populations. Adults spawn in the ocean and some of the juveniles recruit to high salinity estuaries in the spring and summer. We are also interested in relationships between juveniles in estuaries and adult spawning stocks along the geographic gradient. In addition to genetic characteristics, we are analyzing otoliths from estuarine caught juveniles to determine age, size, and growth rates. This information will reveal how long it took individuals to reach the estuary from the spawning locations and how fast they grew both during transit and once they recruited to the estuary. Combined with the genetic information, these analyses could provide insights into locations of spawning grounds, cross shelf movements, and the extent to which individuals at any one location represent different spawning stocks. The study is funded by the MARFIN Program, NMFS NOAA.

### **Tidal migrations, home ranges, and site fidelity of nekton within and among North Inlet intertidal creek-basins**

Investigators: Dr. Dennis Allen and volunteers  
Baruch Marine Field Laboratory, USC

Our previous studies in salt marsh creek -basins have indicated that: (1) spatial variations in abundance, size distribution, and production of nekton exist, (2) differences among creek-basins are quite stable from season to season and from year to year, and (3) spatial variations can be related to differences in the geomorphology of those creek-basins. These spatial differences in nekton use might be explained by limited among-creek movements by tidal migratory organisms, i.e. fishes and shrimps that are forced to leave the intertidal zone during low tide tend to return to the same creek-basins with the next flooding tide. Preliminary mark-recapture studies within creeks indicate that grass shrimps, *Palaeomonetes spp.*, which often account for the most abundant of the tidal migrants, have high fidelity for creeks. These studies have been conducted during periods when high tides are not high enough to cause a significant amount of mixing of water between adjacent basins. Grass shrimps move onto the flooded marsh during high tides, and we are interested to learn to what extent shrimps that enter one basin tend to remain in that watershed during very high tides or leave with the ebbing tide through another creek-basin. To extend our understanding of the movements, home ranges, and fidelity of grass shrimps, color marks (elastomers and stains) will be used to tag shrimps. Then, attempts will be made to recapture shrimps at different locations and stages of the tide. The long-range plan is to ask similar questions with other shrimps, crabs, and fishes. Combined with information from other ongoing studies, this study will help us to better understand relationships between these keystone salt marsh species and inter-creek variations in habitat quality. The work will also address patterns and mechanisms of biomass transfer within the tidal landscape.

## **An index for estimating abundance of juvenile *Mycteroperca microlepis***

Investigators: Dr. Marcel Reichert and Paulette Mikell  
Marine Resources Research Institute, SC DNR

The gag, *Mycteroperca microlepis*, is a large slow-growing grouper that is believed to make annual migrations to specific locations to aggregate and spawn. Like other groupers that form spawning aggregations, gag are particularly susceptible to overfishing as large numbers of individuals in spawning condition are immediately available to fishing gear.

It has been determined (Collins *et al.*) that gag spawn once a year with peak activity occurring during late March and early April along the southeast coast of the United States. Gag larvae exist in the plankton for extended periods of time (mean=43 days) before entering estuarine waters along the east coast of the United States. Postlarval gag enter South Carolina inlets on flood tides during April and May of each year with a mean size of 14 mm. Juvenile gag are most commonly found associated with oyster banks and shell rubble. Young-of-the-year gag remain in estuarine waters throughout the summer months and move offshore as water temperatures decrease in the fall.

The primary goal of this project is to develop a monitoring program that can provide an annual index of juvenile abundance that can be used to predict future year class strength and serve as a management tool. Other objectives are to develop a method to estimate abundance of juvenile gag in estuarine nursery areas and to describe some factors that might be responsible for recruitment success. Sampling is conducted using witham collectors - air conditioner filter material folded over a PVC frame.

Collectors are deployed at selected locations, on the landward side of the Intracoastal Waterway. Postlarval gag move into the folds of the filter material after entering the estuary. Collectors are anchored in tidal creeks where they float one meter below the surface. Each of two sites will consist of four witham collectors deployed about 30 meters apart. The study site in North Inlet is in Crabhaul Creek (map location #20), east of the Oyster Landing Pier.

Collectors will be sampled three times per week from mid-March through mid-June or until gag no longer recruit to this particular gear type. Water temperature and salinity will be measured for each sampling event. All bycatch organisms will be identified to the lowest taxonomic level and released. Gag will be measured to the nearest mm TL and individuals will be brought back to the lab to confirm identification, as there is the possibility of confusing gag postlarvae with black grouper (*Mycterperca bonaci*).

## **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>  
<sup>1</sup>Belle W. Baruch Institute for Marine & Coastal Sciences, USC  
<sup>2</sup>Department of Biological Sciences and Marine Science Program, USC

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.

## **Understanding the effects of sea level rise on coastal freshwater wetlands**

Investigator: Dr. Scott Neubauer  
Baruch Marine Field Laboratory, USC

Coastal wetlands are important habitats that buffer terrestrial-aquatic interactions and can exert a significant influence on processes in adjacent coastal waters. One of the more certain impacts of global climate change is sea level rise, which will move the salt gradient upriver into historically freshwater wetlands. The overall focus of this project is on tidal freshwater wetlands, greenhouse gas emissions, and interactions with future climate change (i.e., sea level rise and salt water intrusion). Since June 2008, experimental plots in a tidal freshwater marsh on the Waccamaw River have been dosed with diluted seawater, with porewater salinities in the +salt plots ranging from 2 to 5, versus  $>0.2$  for control plots. To date, calculations based on measured  $\text{CO}_2$  and  $\text{CH}_4$  fluxes from the marsh suggest that net ecosystem production (NEP) is likely to decline as salt water moves into tidal freshwater regions, but that the driving factor in decreasing NEP is lower plant production rather than increased ecosystem respiration. This research will build upon and contribute to the growing expertise of the University of South Carolina in areas of climate change. The research was funded for 2007-2008 by a grant from the University of South Carolina, Office of Research and Health Sciences Research Funding Program; measurements will continue into 2009.

## **Exploration of the mechanistic basis and biogeochemical implications of differential nutrient limitation among trophic levels**

Investigators: Drs. Curt Richardson<sup>1</sup>, Scott Neubauer<sup>2</sup>, and P.V. Sundareshwar<sup>3</sup>  
<sup>1</sup>Duke University, Durham, NC, <sup>2</sup>Baruch Marine Field Laboratory, USC;  
<sup>3</sup>South Dakota School of Mines and Technology, Rapid City, SD

The structure and function of ecosystems is governed by the patterns of nutrient limitation of the primary producers (e.g., plants) and heterotrophs (e.g., soil microbes). Often, these groups of organisms are limited by the same nutrient. However, an increasing body of evidence indicates that different nutrients can limit primary producers and heterotrophs in some ecosystems; this is known as differential nutrient limitation (DNL). This study examines why DNL occurs in some ecosystems (but not others), and what the consequences of DNL are with respect to the utilization vs. storage of carbon. These questions will be tested in four wetlands ranging from Rhode Island to Georgia and including both freshwater and saline systems. One of our study sites is in North Inlet, where DNL has previously been documented. At each site, a network of field-fertilized experimental plots will be utilized to influence the nature of nutrient limitation. A standardized sampling approach at all sites will emphasize measurements of plant and microbial productivity, phosphorus cycling, and ecosystem metabolism. It is expected that DNL will occur in ecosystems with higher rates of phosphorus mineralization and that DNL will result in less storage of carbon. This study has implications for ecosystem management and theories of ecosystem development. The research provides a conceptual framework to integrate ecological studies at multiple scales by understanding how ecological stoichiometry (i.e., nutrient ratios) affects the biogeochemical cycles that govern ecosystem energetics. This project includes a commitment to students from under-represented groups (including American Indians) through a field research-mentoring program that will advance the participation of these groups in ecosystem studies. The project will be supported by the National Science Foundation from 2008-2011.

## **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. The site of this and associated marsh microbial studies in Crabhaul Creek basin near the BMFL (map location #19). 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 and surrounding sediment 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, fluorescent redox potential probes, and microelectrodes to determine which of these growth strategies are employed by sulfate reducers to maintain activity and viability in strongly irrigated burrows and tubes of marine infauna.

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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- Noble, P.A., J.S. Almeida, and C.R. Lovell. 2000. Application of neural computing methods for interpreting phospholipid fatty acid profiles of natural microbial communities. *Applied and Environmental Microbiology* 66:694-699.
- 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.



## **Infaunal burrows are sites of *Vibrionaceae* enrichment within the estuary**

**Investigators:** M. Megan Dantzler Gamble and Dr. Charles R. Lovell  
Department of Biological Sciences and Marine Science Program, USC

Sampling initially aimed towards identifying routes of bacterial transport within the North Inlet-Winyah Bay estuary introduced the finding that infaunal burrows are sites of *Vibrionaceae* enrichment. For the transport study, *Vibrionaceae* were originally chosen as a model assemblage due to their prevalence in marine systems, their ability to grow quickly and distinctively on a well-established indicator medium, thiosulfate citrate bile salts sucrose (TCBS) agar, as well as their capacity to employ numerous metabolic pathways and growth strategies that could promote their survival and propagation. *Vibrio parahaemolyticus* is of substantial interest to management of local shellfisheries and was used in this study as an individual species indicator. *V. parahaemolyticus* occurs naturally in temperate coastal waters and is an opportunistic human pathogen, capable of causing illness or death as a result of consuming raw or undercooked shellfish. Seasonal variation in water temperature is known to affect *Vibrio* population dynamics, with highest numbers and greatest potential for epidemic outbreaks occurring in the warmer months, though data from NI-WB indicate that local *Vibrionaceae* assemblages are maintained year-round, primarily in infaunal burrows.

Identification of infaunal burrows enrichment zones has led to further questioning as to why burrows maintain these enrichments. For the upcoming 2009 sampling, I plan to determine if burrows are “hot spots” for *Vibrionaceae* or all marine heterotrophic bacteria by using dual probe fluorescent in situ hybridizations (FISH). It is also hypothesized that the enrichments could be a result of physical dynamics related to burrow structure and tidal flushing or introduction by macrofauna. Lastly, burrow water will be monitored for its chemical constituents to determine if particular conditions provide an improved habitat for *Vibrionaceae* or other marine heterotrophic bacteria. Identification of an enrichment zone has significant implications for transport studies as well as total bacterial community profiles.

This project, initiating in March 2007 and concluding in summer 2010, will be conducted in the current NSF funded North Inlet Microbial Observatories site (map location #10).

## **The relative influence of underwater light and oyster grazing on phytoplankton community composition in North Inlet Estuary, South Carolina**

**Investigators:** Evelyn Lawrenz and Dr. Tammi Richardson  
Department of Biological Sciences and Marine Science Program, USC

Our research focuses on environmental factors influencing phytoplankton community composition in Winyah Bay and North Inlet. As part of this research we will focus on the effects of underwater light and oyster grazing on phytoplankton community structure. The primary determinants of underwater light are particulate matter (non-algal particles and phytoplankton) and colored dissolved organic matter (CDOM). Whereas particulate matter reduces light intensity, CDOM also shifts the spectral quality of the underwater light by strongly absorbing ultraviolet and blue wavelengths. Meteorological forcing and/or seasonal cycles cause large temporal and spatial changes in turbidity and water color in North Inlet with unknown effects on phytoplankton community composition. Because phytoplankton taxa differ in their pigment composition, they harvest different colors of light with varying efficiencies. The response of different taxa to alterations in the light environment will determine estuarine phytoplankton community composition and hence their suitability as a food source for grazers.

Autotrophic nanoflagellates are important to the diet of the Eastern oyster *Crassostrea virginica*, which dominates the benthic grazer community in North Inlet. However, nanoflagellates are pre-dominant only in the summer. What oysters graze on when the phytoplankton community consists of large diatoms or of a mixture of various sizes and taxa, and how oyster feeding affects phytoplankton community composition are unknown. *Thus, the objective of this project is to better understand the relative importance of light availability and oyster grazing to phytoplankton community composition.* Relationships between light and phytoplankton community composition will be derived from monthly assessments of spectral irradiance and community composition (by pigment-based chemotaxonomy and microscopy) at Oyster Landing and Clambank. Effects of oyster grazing will be investigated by seasonal measurements of clearance rates and dietary composition of sub-tidal oyster populations. Research will last from June 2009 to September 2010, and will be funded through the National Estuarine Research Reserve Graduate Research Fellowship Program.

## **Understanding the invasion of the Charru mussel, *Mytella charruana***

Investigators: Dr. Eric Hoffman and Dr. Linda Walters  
Department of Biology, University of Central Florida

Although many genera are classified as belonging to the mussel family Mytilidae, the evolutionary relationships among these genera are poorly understood. Here, we seek to better understand the phylogenetic relationships among these species. Specifically, this project seeks to determine the relationship between *Mytella charruana*, a species that has recently been described along the southeastern coast of the United States, well outside its native range of Atlantic and Pacific Central and South America, and other species within the family. In this study, we plan to include at least one species within each of the following genera: *Perna*, *Geukensia*, *Brachiodontes*, *Mytella*, *Mytilus*, and *Modiolus*. Genetic variation within these genera will be used to resolve the phylogeny of Mytilidae. To estimate the phylogenetic relationships, we will sequence approximately 900 base pairs (bp) of the mitochondrial Cytochrome Oxidase subunit 1 (COI) gene and approximately 900 bp of the nuclear 28S ribosomal RNA gene. Variation among these genes should provide the genetic diversity we need to resolve the phylogeny of the genera of interest. We greatly appreciate Paul Kenny providing us with samples of *Brachiodontes* from North Inlet.

## **Quantitative analysis of coordinated movement in animal groups**

Investigators: Dr. Steven Viscido and students Alyson Anthony and Amanda Lee  
Department of Life Sciences, Department of Life Sciences, Winston-Salem State University,  
Winston-Salem, NC

Gregarious behavior occurs throughout the animal kingdom, and the startling array of coordinated group movements has been the subject of much study. However, although many models explain how individual behaviors result in coordinated group movements, quantitative empirical tests of these models are rare. Testing aggregation models requires detailed quantitative data on the movements of all individuals within the group. Collecting such data is the goal of this project. We plan to use fiddler crabs (*Uca pugilator*) that live in burrows along the creek beside the road to Oyster Landing, as our model organism, because they have been used successfully by the P.I. for this purpose in the past (see Viscido and Wethey 2002). At low tide in the summer, these crabs form large feeding aggregations, and during the month of June are preyed upon by shore-birds such as Willets and Clapper Rails. Using a blind, we will set up video cameras and record the feeding and pre-response movements of fiddler crabs during low tide for a period of 1 week, and then use the data back in our lab at WSSU to conduct computer motion analysis. This project will begin in the summer of 2009 and is supported by the Winston-Salem State University Summer Undergraduate Research (SURE) program.

## **The effects of trophic interactions on oyster spat survival: A comparison of subtidal vs. intertidal habitats in the North Inlet-Winyah Bay National Estuarine Research Reserve**

Investigators: Laura L. Canton<sup>1</sup> and Dr. Keith Walters<sup>2</sup>  
<sup>1</sup>Coastal Marine and Wetland Studies Program, Coastal Carolina University,  
<sup>2</sup>Department of Marine Science, Coastal Carolina University

There have been few studies that look directly at the effects of mud crab predation on oyster spat growth and survival. There is also a lack of data on the differences in predation pressures between subtidal and intertidal locations. Subtidal reefs are rare in South Carolina; however previous studies have shown that spat can settle subtidally. I propose to test the effects of mud crab, *P. herbstii*, predation on the growth and survival of eastern oyster spat, *Crassostrea virginica*, in both subtidal and intertidal locations in the North Inlet-Winyah Bay National Estuarine Research Reserve. I will conduct a preliminary aquarium experiment, followed by a series of manipulative field experiments using mud crabs. Oyster spat will be collected on settlement tiles throughout the month of May. The experiment will consist of three subtidal and three intertidal locations within North Inlet. Caged

treatments and controls will be deployed at each site, as well as uncaged settlement tiles to monitor natural predation. Cages will be monitored biweekly from June through September 2009. Results should provide a basis for determining whether predation pressure is greater at subtidal elevations, due to permanent tidal inundation.

### **Characterization of oyster cement**

Investigators: Dr. Jonathan Wilker<sup>1</sup>, Lauren Hight<sup>1</sup>, Jeremy Burkett<sup>1</sup>, and Paul Kenny<sup>2</sup>  
<sup>1</sup>Department of Chemistry, Purdue University, West Lafayette, IN  
<sup>2</sup>Baruch Marine Field Laboratory, USC

Marine species such as mussels, barnacles, and oysters produce adhesive and cement materials for affixing themselves to surfaces. The strong bonding, wet adhesion capabilities, and biological origin of these materials indicate promise for developing new biomedical materials such as surgical glues and dental cements. In an effort to develop such applications, we are beginning by characterizing adhesive materials produced by marine organisms. Prior studies have determined some of the key chemical reactions and bonding motifs used by mussels for production of their adhesive. For the current project, our main objective is to characterize the chemistry within the cement of the Eastern or Atlantic oyster *Crassostrea virginica*. Oysters are collected near the Baruch Marine Field Laboratory and then grown in laboratory aquaria. Chemical methodologies are used to analyze the cement, including wet chemistry and spectroscopic techniques. Insights gained will provide both fundamental understanding of how a marine biological material functions as well as providing insights for the design of new biomedical adhesives. This project is currently supported by the Office of Naval Research (October 2006-September 2009).

### **Comparative studies demonstrate the effects of changing land use on tidal creeks**

Investigators: Drs. Guy T. DiDonato<sup>1</sup>, Derk Bergquist<sup>2</sup>, A. Frederick Holland<sup>1</sup>, Denise M. Sanger<sup>3</sup>, Jill Stewart<sup>4</sup>, Robert Van Dolah<sup>2</sup>, and Ed Wirth<sup>1</sup>  
<sup>1</sup>National Ocean Service, Hollings Marine Laboratory, Charleston, SC; <sup>2</sup>SC Department of Natural Resources, Charleston, SC; <sup>3</sup>SC Sea Grant Consortium, Charleston, SC; <sup>4</sup>National Ocean Service, Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC

The human population of South Carolina's coastal counties has increased over 30% since 1990, and this influx of people is predicted to continue well into the future. The population boom has been marked by the conversion of forested and agricultural watersheds to suburban and urban ones. Impacts of these landscape changes on South Carolina's tidal creeks were evaluated in winter and summer, 2005. Creeks in the pristine North Inlet-Winyah Bay (NIWB) NERR served as a valuable reference systems for these studies. Creeks from urban, suburban, and forested watersheds were sampled from the upper intertidal reaches down to the subtidal zone. Results demonstrate that the conversion of forested watersheds to suburban and urban ones modifies water and sediment quality. Tidal creek NOx levels increased with urbanization during both seasons; PO4 also showed a land use signal and was highest in suburban watersheds in summer. Pathogen indicators were highest in urbanized watersheds regardless of season. Sediment contaminants also increased with urbanization. These results demonstrate that changing land use alters the ecological character of tidal creek ecosystems, and sites like those in NIWB and other NERR reserves provide a critical reference for ongoing comparative studies and regional assessments.

## **Coastal Integrated Demographic-Economic-Environmental Prediction Program: Public health and environmental health**

Investigators: Dr. D.E. Porter<sup>1,2</sup>, Dr. G.T. Chandler<sup>2</sup>, Dr. V.R. Shervette<sup>1</sup>, K. Gaertner<sup>2</sup>, C.H. Scott<sup>2</sup>, S. Powell<sup>2</sup>, Dr. B. Kingmore<sup>1</sup>, Dr. M. DeLorenzo<sup>3</sup>, Dr. M. Fulton<sup>3</sup>, Dr. T. Siewicki<sup>3</sup>, and T. Pullaro<sup>3</sup>  
<sup>1</sup>Belle W. Baruch Institute for Marine and Coastal Sciences and the Baruch Marine Field Laboratory, USC; <sup>2</sup>Arnold School of Public Health, USC; <sup>3</sup>NOAA Center for Coastal Environmental Health and Biomolecular Research

Over half (53%) of all U.S. residents now live within 50 miles of the coast (NOAA, 2005). Estuaries provide people with basic commercial and recreational services, but also provide invaluable ecosystem services such as nutrient cycling, flood control, waste treatment, and species habitat (Scavia et al., 2002). Stormwater pond density has been increasing with coastal development. A 1999 survey identified 7,309 ponds within the S.C. coastal zone (inland approximately to the level of river tidal influence), which represented an approximately 65 percent increase in the number of ponds during five years (USES, 2004). Stormwater ponds are used to receive runoff from residential and commercial areas, thereby collecting non-point source contaminants and controlling flooding. The majority of the stormwater ponds in the S.C. coastal zone have tidal exchange with the estuarine environment (Lewitus et al., 2003).

Low water circulation and high pollutant loading from urban areas have contributed to a number of water quality problems in stormwater ponds (Novotny, 1995). Eutrophication can be induced in these ponds by runoff after fertilizer applications, fecal material input, and additional urban runoff from domestic wastewater, driveways, and roads (Bricker *et al.*, 1999; WHO, 1999). High nutrient levels can lead to excessive algal growth (e.g. Glibert *et al.*, 2001) and the potential development of harmful algal blooms. High bacterial levels are another health concern in coastal pond systems. Sources of bacterial contamination in stormwater ponds include wastewater discharges, septic tank leaks, agricultural or stormwater runoff, wildlife and domestic animal waste (An *et al.*, 2002; Novotny, 1995; Ritter *et al.*, 2002). Finally, chemical contaminants entering stormwater ponds (e.g. pesticides, PAHs, and metals) may cause direct toxicity to aquatic organisms or indirect effects such as algal bloom induction, bioaccumulation, and trophic transfer (e.g. Baier-Anderson and Anderson, 2000; DeLorenzo and Serrano, 2003; Moore *et al.*, 1998; Okay and Gaines, 1996; Phyu *et al.*, 2005). Chemical contaminants can reach stormwater ponds via runoff from urban areas (e.g. golf courses and residential lawns after pesticide application and PAHs from roadways). Pharmaceutical compounds are an emerging concern for both environmental and public health. Toxic effects and increased incidence of pathogens resistant to anti-bacterial agents are potential impacts of pharmaceutical inputs to coastal waters from wastewater treatment facility discharges and irrigation using secondarily-treated sewage effluents.

Coastal stormwater pond water quality is important for wildlife, pet, and human health, as well as the health of adjacent aquatic habitats such as estuaries and open water systems. Water discharge from a poorly designed or malfunctioning stormwater pond may serve as a source of contaminants to estuaries. Increases in the occurrence and concentrations of many pollutants are directly linked to human population growth and associated land-use changes. Effective stormwater and wastewater management is critical to reduce the severity of these public and environmental health threats; however, quantitative models are needed to forecast probable outcomes associated with different management strategies.

The purpose of this project is to summarize the current status of water quality indicators such as harmful algal blooms, biological, and chemical contaminants as they relate to coastal environmental and human health issues that may be associated with coastal stormwater ponds. The project also identifies gaps in our understanding of contaminant inputs, fate and effects that may be used to implement future research programs.

This project is funded from 09/01/08 to 02/28/10 by SC Sea Grant/NOAA/Department of Commerce.

## **Center for Integrated Information Systems: Establishment of a Southeast Regional Integration Testbed**

Investigators: Dr. M. Fletcher<sup>1,3</sup>, Dr. D.E. Porter<sup>1,2</sup>, C. Hood<sup>4</sup>, Dr. V.R. Shervette<sup>1</sup>,  
Dr. H. Kelsey<sup>5</sup>, and D. Ramage<sup>3</sup>

<sup>1</sup>Belle W. Baruch Institute for Marine and Coastal Sciences and the Baruch Marine Field Laboratory, USC; <sup>2</sup>Arnold School of Public Health, USC; <sup>3</sup>School of the Environment, USC; <sup>4</sup>Raytheon; <sup>5</sup>NOAA Chesapeake Bay Office

Many federal and state agencies, universities, and local governments have programs that monitor environmental data and have established a vast array of environmental databases. Most of these programs have arisen separately to address specific needs; for example, for coastal monitoring programs, applications include weather forecasts, beach contamination monitoring, and fisheries resource management. Because of their separate origins, such programs tend to use different data management infrastructures, and the barriers to integration of information are formidable. The capacity to access and integrate such distributed data would increase their value and application potential enormously.

Recent research has demonstrated that predictive models can serve the essential purpose of providing a decision support tool for preemptive advisory issuance. Such models use a variety of input data -- most important being rainfall and salinity -- to assess the probability of beach contamination by enterococcus. The application of new predictive models can clearly be extremely useful in improving the timeliness and accuracy of closure decisions. Thus the current focus is the development of a user application related to beach hazards, particularly as they relate to the activities of the South Carolina Department of Health and Environmental Control (SCDHEC). The initial demonstration will incorporate data required for decisions on beach advisories, including the utilization of real-time and delayed mode data, use of predictive models, and the dissemination of information to potential users, including SCDHEC and local government officers. Extensive data management infrastructure will be developed and/or adapted to accommodate multiple streams of monitoring data, which in turn will be utilized in predictive models. The deliverable will be GIS-based tools that utilize monitoring data, predictive models, and user (SCDHEC personnel)-friendly presentations to provide information required for making beach closure decisions.

This project is funded from 09/01/08 to 08/03/09 by Geodetic Survey/NOAA/Department of Commerce.

## **Habitat Mapping and Change Plan for North Inlet-Winyah Bay NERR**

Investigator: Dr. Jennifer Plunket  
North Inlet -Winyah Bay National Estuarine Research Reserve

A Habitat Mapping and Change Plan will be developed for the North Inlet-Winyah Bay NERR that will outline the methodology and standards for future habitat mapping of the reserve. This plan will include a timeline for mapping and will address imagery, technological, and staff time needs. Research needs that can be addressed through habitat mapping and a vertical control plan to monitor elevations will be integrated into the Habitat Mapping and Change Plan. The baseline habitat map will be completed for the area within the North Inlet-Winyah Bay NERR and a land use map will be created for the North Inlet watershed using the NERRS Habitat and Land Use Classification System. The North Inlet habitat map will serve as a baseline for temporal studies that examine trends in land use and land cover change and will also be used to examine habitat distribution and availability for key species in the Reserve.

## **Baruch 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>.

### **Comparison of nekton migration patterns in managed and unmanaged salt marshes using DIDSON acoustic imaging**

Investigators: Dr. Matt Kimball<sup>1,3</sup>, Dr. Dennis Allen<sup>2</sup>, and Dr. Lawrence Rozas<sup>3</sup>  
<sup>1</sup>Louisiana State University Agricultural Center, School of Renewable Natural Resources  
<sup>2</sup>Baruch Marine Field Laboratory, USC  
<sup>3</sup>NOAA/NMFS/SEFSC Estuarine Habitats and Coastal Fisheries Center

Water control structures (WCSs) installed to regulate water levels can alter both the hydrology and ecology of salt marshes. WCSs are thought to limit nekton ingress into, and egress from, managed marshes, but little research has directly examined how WCSs affect nekton migration patterns and behavior. We propose to examine the effects of WCSs on nekton migration using dual-frequency identification sonar (DIDSON) acoustic imaging. Our specific research objective is to elucidate the role of tide stage and diel periodicity on fine scale temporal and spatial patterns of nekton movement through WCSs. Operating as an acoustic movie camera, the DIDSON produces high resolution images in shallow, turbid waters. These observations will be supplemented with gill and cast net surveys to groundtruth acoustic data and produce a more complete picture of nekton habitat use. Sampling will take place in late summer (August – September 2009) and focus on subtidal and intertidal habitats in managed (i.e., WCSs present) and unmanaged salt marshes of the Yawkey Wildlife Center Heritage Preserve and the North Inlet estuary. Focusing on the meso/polyhaline portions of the North Inlet estuary and the Yawkey Preserve will ensure that we include in our study a diverse array of coastal and estuarine nekton species. The results of this study and ongoing research we are conducting in Louisiana will allow comparisons of nekton behavior and movement at WCSs and within salt marshes between regions (US Atlantic and Gulf coast, i.e., semi-diurnal vs. diurnal tidal cycles), salt marsh habitats (intertidal and subtidal), and types of WCSs (gated trunks in SC and slotted weirs in LA).

### **Organic geochemical characterization of DOM in North Inlet**

Investigators: Dr. Ralph Mead<sup>1</sup> and Dr. Erik Smith<sup>2</sup>  
<sup>1</sup>Department of Chemistry, University of North Carolina, Wilmington  
<sup>2</sup>Baruch Marine Field Laboratory, USC

The goal of this research is to characterize the chemical nature of the DOM pool exported from the marsh, its diagenetic state and the relative contributions of *Spartina*, algal (microphytobenthos and phytoplankton) and sediment/soil sources to heterotrophic bacterial metabolism. Water will be sampled during falling tide to chemically characterize the dissolved organic matter present and to relate back to microbial metabolism rates. The methods I will be using involve initial water filtration at Baruch with subsequent organic characterization (fluorescence, NMR and mass spectrometry) in my laboratory at UNCW.

The knowledge gained from these experiments will aid in understanding the nature of DOM exported from the marsh by different sources such as *Spartina*, algal and sediment/soils, as well as how diagenetically altered it is. This is crucial for linking the role of coastal salt marshes in near-shore carbon biogeochemistry.

### **Assessing the impact of salinity alterations on the amount, age and lability of OC desorbed from fresh and saltwater marsh sediments**

Investigators: Dr. Leigh McCallister and Lindsey Koren  
Department of Biology, Virginia Commonwealth University

This project seeks to address a fundamental gap in our understanding of C cycling in terrestrial aquatic systems by applying a multidisciplinary approach to characterize the age of soil/terrestrial OC transferred to the

aquatic environment and its respiratory fate. This project will be coordinated with current ongoing research with Dr. Scott Neubauer. The primary research objectives are

- 1) To measure the amount and natural abundance stable and radiocarbon isotopic signatures of OC desorbed from both fresh and salt marsh sediments exposed to water of varying salinities.
- 2) To determine the total lability of the desorbed OC and the natural stable and radiocarbon isotopic signatures of the respired C.

*Sample collection and desorption* - Tidal marsh sediments will be collected from two locations representing a tidal fresh (Brookgreen) and saltwater marsh (North Inlet). The organic C will be desorbed following the protocol outlined in Butman et al. (2007) where a soil/sediment sample is shaken with an extractant solution (fresh or salt water) for 12 h. Salinity treatments will include 0, 5, 10, 20 and 35 salinity units.

*Isotopic Analyses* - Stable carbon isotope ratios will be measured using FinniganMAT Deltaplus dual-inlet continuous flow isotope ratio mass spectrometer with on-line sample combustion at UCI AMS Keck facility. Radiocarbon measurements will be performed at the Accelerated Mass Spectrometry Center at Lawrence Livermore National Lab.

*Dissolved organic carbon (DOC) lability, bacterial respiration and production* - DOC lability will be determined from long-term parallel (14 day) duplicate re-growth incubations of filtered water as per McCallister et al., (2006). DOC samples will be taken at multiple time points and analyzed in my lab at VCU. Bacterial respiration will be determined from O<sub>2</sub> consumption via the Winkler method. Rates of bacterial production will be estimated from the incorporation of <sup>3</sup>H-Leucine following the centrifugation method of Smith and Azam (1992).

### **Belowground structure and soil respiration rates among salt marsh plots with varying nutrient status**

Investigators: Drs. Cathy Wigand<sup>1</sup>, Earl Davey<sup>1</sup>, Erik Smith<sup>2</sup>, and Jim Morris<sup>2</sup>, and Karen Sundberg<sup>2</sup> and Paul Kenny<sup>2</sup>

<sup>1</sup>US Environmental Protection Agency, NHEERL Atlantic Ecology Division, RI

<sup>2</sup>Baruch Marine Field Laboratory, USC

We propose that the combination of computer-aided tomography (CT) and soil respiration measures may be a practical and useful approach to monitor condition and assess impairment in coastal salt marshes. CT imaging will be used to examine macro-organic matter and belowground structure in cores collected from long-term fertilized plots, control plots, and salt marsh areas with varying nutrient status. The CT imaging will allow for an estimate of the plant tissue-gas and peat-water volumetric fractions of the salt marsh cores. Coupled with these measures of belowground structure in the salt marsh plots, *in situ* measures of CO<sub>2</sub> efflux, as an indicator of soil respiration, will be determined. We expect an increase in the soil respiration rates in the fertilized plots compared to the control ones, and a decrease in the below-ground macro-organic matter, in particular, the peat-water fraction. We will also report on the belowground structure and soil respiration in natural plots with varying nutrient status in the North Inlet-Winyah Bay NERR. Partial funding for summer sampling (2007, 2008) was provided to visiting scientist C. Wigand from the Baruch Marine Field Laboratory, USC and additional funding by the US EPA, Atlantic Ecology Division.

### **Baruch Wind Assessment: Project Summary**

Investigators: Ralph Nichols<sup>1</sup>, Eric Bosseneck<sup>2</sup>, Dr. Dennis M. Allen<sup>3</sup>, and George Chastain<sup>4</sup>

<sup>1</sup>Savannah River National Laboratory; <sup>2</sup>Renewable Energy Department,

Santee Cooper; <sup>3</sup>Baruch Marine Field Laboratory, USC; <sup>4</sup>Belle W. Baruch Foundation

Wind power is a clean, indigenous energy resource that is rapidly growing in the United States and worldwide. Preliminary research has shown that the Mid-Atlantic seaboard possesses a large untapped wind energy resource lying in its offshore, near-shore, and coastal areas. South Carolina's most promising wind resources lie along these same areas in Horry, Georgetown, and Charleston County. Development of this resource will diversify the state's energy portfolio, increase energy security, reduce imports of fossil fuels, promote local economic growth, and reduce green house gas emissions.

Coastal, near-shore, and offshore winds are stronger and steadier than land based winds and are often located near growing demand centers. Development of near-shore and offshore wind power requires a higher capital investment than land based wind power due to foundation requirements, cabling back to shore, higher operations and maintenance costs and a need for equipment that is resilient to marine conditions. Lack of fuel costs offsets some of these higher operations costs. The capital cost of offshore wind power increases with distance from the coast while the aesthetic concerns voiced by some citizens decreases as the turbines become less visible from shore. Siting of a near-shore or offshore wind farm must take these and other factors into account to ensure an economically viable project while minimizing the impact to the local environment.

Much of the wind modeling that has been done in the Southeast and Mid-Atlantic has been done using mesoscale models. South Carolina's wind potential has been mapped using these models by AWS Truwind. Although these models are very useful in doing a preliminary wind assessment of a large geographic area, detailed wind speed data at the proposed development site is needed in order to develop cost/benefit models and obtain financing for projects. Furthermore, detailed understanding of the wind characteristics in the transitional areas between offshore, near-shore and the coast is needed and will drive future wind power development in these areas.

Detailed wind assessments are currently done using 50 and 60 meter mobile meteorological (met) towers at or near the proposed project sites. This technology is presently being used by Clemson University, Coastal Carolina University and Santee Cooper to assess the wind potential at Waites Island in Horry County. Turbine technology has progressed significantly over the past 20 years and current hub heights are 70 meters or higher with offshore turbines being developed with hub heights of 100 meters. Wind speed data from these mobile towers has to be empirically extrapolated to these higher turbine hub heights to determine energy generation since obtaining data at these heights using stationary met towers becomes costly and difficult. Placement of tall met towers in marine environments is very expensive due to platform and construction costs. New technology to cost effectively measure wind conditions at increasing heights is needed to access the wind potential of a proposed site.

New technology has emerged including light detection and ranging (LIDAR) and sonic detection and ranging (SODAR) that provide a less intrusive and in some cases a lower cost option to obtaining wind speed data from 10 to 200 meters. For these technologies to become commercially competitive with existing met towers, understanding their performances in all kinds of environmental condition is required. Applying these technologies to assessing offshore and near-shore wind conditions will support the development of coastal wind power.

Development of South Carolina's wind energy resource will require, among other things, a detailed assessment of the wind characteristics along its coast. Assessment of coastal wind conditions is seen as the first step in studying coastal and offshore wind potential. This project proposes to assess wind conditions near the North Inlet (map location #8) while studying the viability of SODAR technology in coastal applications. As Santee Cooper's contribution, they will install the 50m met tower on Clambank Landing on Goat Island. Savannah River National Laboratory and Clemson University will install the SODAR equipment near the tower and analyze the data taken from both sets of instrumentation. Santee Cooper and SRNL will coordinate the equipment's installation and ensuing study with authorities from the Belle W. Baruch Foundation and also USC's Baruch Marine Field Laboratory.



## **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), The Baruch Institute's archives, or the National Science Foundation's Long-Term Ecological Research (LTER) site.

### **Ecology of diamondback terrapins (*Malaclemys terrapin*)**

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

A mark-recapture study of diamondback terrapins is in progress in North Inlet. As of August 2008, 233 terrapins have been marked, mainly from tidal creeks off Town, Old Man, Debidue and Jones Creeks. There have been 37 recaptures involving 34 individuals. Recaptures to date indicate high site fidelity to feeding areas in the marsh. Remote sensing of acoustic tags attached to 3 terrapins supports this finding. Nesting areas have been identified on the east and western banks of Debidue Creek with high rates of nest depredation by predators. To date no juveniles have been found. The study will continue to investigate habitat use, movement within the Inlet, and diet of terrapins.

This project is supported by Francis Marion University and a Belle W. Baruch Foundation, Harry M. Lightsey visiting scholars program.

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

Investigators: Dr. James Morris<sup>1,2</sup> and Karen Sundberg<sup>2</sup>  
Department of Biological Sciences<sup>1</sup> and Belle W. Baruch Institute for Marine & Coastal Sciences<sup>2</sup>, USC

Salt marsh grass, *Spartina alterniflora*, dominates the intertidal marsh in North Inlet Estuary. Regular measurements of grass density and height allow for estimates of growth and primary production rates in both control and fertilized plots. Abiotic conditions that are measured include pore water salinity, phosphate, ammonium and sulfide concentrations to provide 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. This time series was initiated in 1986. Map locations # 3 and 8.

### **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>  
<sup>1</sup>Baruch Marine Field Laboratory, USC; <sup>2</sup>Department of Earth and Ocean Sciences, USC  
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 and most web products. View real-time data for North Inlet on NOAA's website at <http://tidesonline.nos.noaa.gov/geographic.html> [Select SC on the state map and then Oyster Landing, SC (North Inlet Estuary)]. Verified historical data for North Inlet's tide gauge Station ID (8662245) are available at [http://tidesandcurrents.noaa.gov/station\\_retrieve.shtml?type=Historic+Tide+Data](http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Historic+Tide+Data). Monthly plots, site photographs, and documentation can be viewed on Baruch's website at <http://links.baruch.sc.edu/Data/NIWaterLevel/index.html>.

The updated elevations for the Oyster Landing tide gauge are available on the CO-OPS website: [http://co-ops.nos.noaa.gov/data\\_menu.shtml?stn=8662245%20Oyster%20Landing%20\(North%20Inlet%20Estuary\),%20SC&type=Datums](http://co-ops.nos.noaa.gov/data_menu.shtml?stn=8662245%20Oyster%20Landing%20(North%20Inlet%20Estuary),%20SC&type=Datums).

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 Willman  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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. Data are telemetered via the NOAA GOES satellite system to the NERR Central Data Management Office, and made available in near real time at <http://cdmo.baruch.sc.edu>. 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. Map location #3.

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

Investigators: Dr. Erik Smith and Amy Willman  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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. 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/>. 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 and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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 locations #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 and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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>. Map locations #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>.

### **NERR emergent vegetation bio-monitoring: Effects of sea level on the spatial dynamics of salt marsh vegetation communities in North Inlet**

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

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 sea level on the spatial dynamics of salt marsh emergent salt marsh vegetation and its ability to migrate in the face of rising sea levels. Previous studies have shown annual net aboveground production of *Spartina alterniflora*, the dominant emergent vegetation in North Inlet, to be positively correlated with annual anomalies in mean sea level. However, the effects that interannual variation and long-term change in sea level have on the spatial dynamics of salt marsh macrophyte communities remain unclear. Thus, this project specifically seeks to address how salt marsh macrophyte community spatial structure (species composition, relative abundance, and biomass) varies along an elevation gradient, from creek bank to upland edge, in response to 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 the upper Crabhaul Creek basin. 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. Surface Elevation Tables (SETs) have also been established adjacent to the lower and higher elevations of the creek-bank to forest-edge transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in and vegetation and tidal dynamics. Sampling within each permanent plot 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; water table height at low tide; porewater salinity, and nutrient and sulfide concentrations. Soil organic content and bulk density adjacent to each plot were determined in 2008 and will be resampled at 3 year intervals. Elevation data (mm scale vertical resolution) for each plot was established in summer of 2008, allowing for the determination of duration and frequency of tidal inundation at each plot along the elevation gradients of each region. Plot elevations will be resampled at 3 year intervals. The project is being conducted in partnership with NOAA's National Geodetic Survey (NGS) and Center for Operational Products and Services (COOPS) to link the ecological monitoring (vegetation community metrics, sediment chemistry and accretion rates) to local and national geospatial infrastructure. See map location #10

### **Microbial heterotrophy in salt marsh tidal creeks**

Investigators: Dr. Erik Smith, Tracy Buck, Amy Willman, and Benjamin Lakish  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

Tidal creeks represent the conduits for organic matter exchange between salt marshes and the coastal ocean. They are also areas of substantial net heterotrophy (total respiration > in situ primary production), which is fueled by organic matter produced by the adjacent marshes. This study seeks to quantify how microbial metabolism in tidal creek waters responds to variability in the magnitude and form of salt marsh exports over tidal, seasonal, and interannual time-scales, the consequences this has on organic matter export to the coastal ocean, and thus improve our understanding of how carbon flow through the ecosystem may respond to long-term changes associated with predicted climate alterations and sea level rise.

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. Microbial metabolic responses are determined by quantifying rates of microbial production ( $^3\text{H}$  leucine incorporation rate) and respiration (in vitro  $\text{O}_2$  consumption rates) in both whole water and size-fractionated samples. Independent variables include particulate organic carbon and nitrogen, dissolved organic carbon, nitrogen and phosphorus, inorganic nitrogen and phosphorus, total nitrogen and phosphorus, inorganic and organic suspended sediments, and chlorophyll *a*. Sampling began in 2005 and is on-going.

Seasonal variability in microbial metabolism, particularly respiration, is strongly linked to water temperature. Pronounced ebb versus flood tide differences in respiration and bacterial production clearly indicate the importance of salt marsh exports in fueling tidal creek heterotrophy. Significant relationships between ebb-flood differences in metabolic rates and the time of day at which sampling occurred would suggest that a substantial portion of the organic matter fueling this heterotrophic metabolism is being produced on very short time scales. That this material is highly bioavailable is further supported by the high bacterial growth efficiencies observed throughout this study. Although previous studies indicate that organic matter export from the Crabhaul Creek basin occurs entirely in dissolved form, results of this study indicate particulate matter concentration is an important driver of microbial metabolism in tidal creek waters.

## **Nutrient, net ecosystem metabolism and dissolved oxygen dynamics in stormwater ponds of the North Inlet watershed**

Investigators: Dr. Erik Smith, Amy Willman, and Benjamin Lakish  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

Stormwater ponds, especially detention ponds, are a prevalent feature of the coastal zone in South Carolina. While these ponds are effective at minimizing localized flooding, they are often ineffective at sequestering the high nutrient loadings associated with residential area runoff. Despite reports that stormwater ponds commonly exhibit signs of eutrophication (high nutrient concentrations, phytoplankton blooms, and fish kills resulting from oxygen depletion), research examining how stormwater ponds respond, as integrated ecosystems, to nutrient enrichment is currently lacking. Further, high net production in these ponds, in addition to fueling bottom water depletion within ponds, may also represent a significant source of highly labile organic matter available for export to the downstream marine environment. The purpose of this study, conducted in several residential ponds within the North Inlet watershed, is therefore to quantify the relationship between nutrient input, net ecosystem metabolism (gross primary production and total respiration), organic matter concentrations and dissolved oxygen dynamics in representative residential stormwater detention ponds.

## **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  
<sup>1</sup>Department of Biological Sciences, USC  
<sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, USC

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). 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.

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

Investigators: Dr. Robert Feller<sup>1</sup>, Dr. Bruce Coull<sup>1</sup>, and Ginger Ogburn-Matthews<sup>2</sup>  
<sup>1</sup>Marine Science Program and <sup>2</sup>Baruch Marine Field Laboratory, 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). For logistical reasons, we switched to quarterly sampling in 2002, however. Small invertebrates, less than 0.5 mm in size, comprise the meiofauna. The meiofauna collection is the longest estuarine meiofauna time-series in the world. Although collections of both meiofauna and macrofauna continue to be collected, sample processing, predictably, lags behind, with only 4 of 8 replicate samples counted since 1992. 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 macrofauna consists mostly of polychaete and oligochaete worms, bivalves, and small crustaceans. Both size groups of organisms demonstrate annual cycles of abundance, peaking in late winter/early spring, with lows in late summer/early fall. Simultaneous measurements of physical conditions in the water, sediment, and air help investigators determine causes of these variations in abundance over time. We also have noticed that the macrobenthos appears to increase and decrease on a cycle of between 9 and 11 years, but the time-series must become longer before this cycle can be confirmed. 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 benthic organisms. Map location #7.

### **Fish and crustacean use of marshes and creeks: Population and community level changes in relation to weather and climate driven changes in conditions within the nursery**

Investigators: Dr. Dennis Allen, Ginger Ogburn-Matthews, Paul Kenny, and Tracy Buck  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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 2003 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. However, during the 20-year period, overall abundance increased, evenness decreased, and water temperatures increased (especially in winter). For spot; increasing abundance, earlier arrival in the spring, and decreasing size at arrival and a decreasing growth rate were observed through 2003. Larval fish catch data from the long-term zooplankton series accurately predicted densities of young fish in the creeks early in the growing season, but the proportion of the year class that survived to emigrate to the ocean 4-6 months later varied from 1- 19%. High tide collections continue to provide data on nekton use of the Oyster Landing Basin. This long-term time series is unique for the Southeast region and is becoming increasingly important as we interpret impacts of global climate change on nekton populations and the shallow water habitats that are essential to their development. Results have implications for the management of salt marsh-estuaries, watersheds, and fisheries. See map location #3.

## **Geographic variations in speckled worm eel larvae: Can long-term studies be used to determine large-scale changes in recruitment patterns of oceanic larvae to estuaries?**

Investigators: Drs. Ken Able<sup>1</sup>, Dennis M. Allen<sup>2</sup>, Donald Hoss<sup>3</sup>, Stanley Warlen<sup>3</sup>, Gretchen Bath-Martin<sup>3</sup>, and Perce Powles<sup>4</sup>  
<sup>1</sup>Rutgers University Marine Field Station; <sup>2</sup>Baruch Marine Field Laboratory, USC; <sup>3</sup>NOAA NOS Beaufort, NC; Biology Department, <sup>4</sup>Trent University, Ontario, Canada

The speckled worm eel, *Myrophis punctatus*, is a common and widely distributed fish in Atlantic and Gulf estuaries, but, because of its cryptic habit of remaining buried in shallow muddy substrates, little is known about its life history and ecology. It appears to be an estuarine resident that migrates to unknown ocean areas to spawn. Large and morphologically unique leptocephalus larvae arrive in estuaries during the coldest months. The 25 year mesozooplankton (365 micron net) time series in North Inlet, SC has revealed large within and among year variations in the occurrence of these planktonic leptocephali. Comparisons of temporal patterns of abundance and the stage and age of larvae at the time of ingress are being made between North Inlet, SC, Beaufort, NC and Little Egg Inlet, NJ. Recently, more datasets and collaborators have been identified. Protocols for making morphometrical measurements, determining stages of development, and aging based on sagittal otoliths have been established. This information will provide insights into the time and perhaps locations of larval production. We plan to relate variations in environmental conditions in the estuaries and ocean to the characteristics of the recruiting larvae. Being dependent on both ocean currents and estuarine habitats to complete its life cycle, the speckled worm eel may be a good candidate species for understanding potential impacts of climate change on species that use both estuaries and the ocean to complete their life cycles. Similar questions can be asked of other wide-ranging species such as spot (*Leiostomus xanthurus*), Atlantic menhaden (*Brevoortia tyrannus*), flounders (*Paralichthys* spp.).

## **Long-term changes in zooplankton in the North Inlet Estuary and relationships with climate change and variability**

Investigators: Dr. Dennis M. Allen, Ginger Ogburn-Matthews, Tracy Buck, Paul Kenny and Dr. Erik Smith  
Baruch Marine Field Laboratory and North Inlet-Winyah Bay  
National Estuarine Research Reserve, USC

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 tows capture larval fishes, shrimps, and crabs and other large zooplankton species. Seasonal and interannual changes in abundance, diversity, and species composition of the assemblages in Town Creek are documented and correlated to fluctuations in the physical characteristics of the estuary. Information is collected for more than 50 taxonomic groups and species. These datasets are among the most complete and longest running in the world. They reveal rates and directions of change in an undisturbed estuarine ecosystem, and provide an opportunity to assess impacts of climate change. Recent analyses of the large zooplankton component have shown that although the composition and overall densities have not changed significantly, several constituent groups have shown large and consistent responses to climatic events including ENSO (El Nino) and drought. Of particular note has been the steady decrease in total small zooplankton, especially copepods, over the past 28 years. Long-term increases in water temperatures, especially for the winter, have been documented. Since many zooplankton species are developmental stages of larger animals, the study provides indications of the timing of larval production and recruitment success of several commercially and/or recreationally important species. The value of these datasets continues to increase as we formulate and test new hypotheses and extend the time series. See map location #10.



## **Long-term monitoring of grass shrimp as a bioindicator of non-point source runoff in South Carolina watersheds**

Investigators: Dr. Pete Key, Dr. Michael Fulton, and Blaine West  
NOAA, Center for Coastal Environmental Health and Biomolecular Research

Long-term ecological monitoring is important to developing fundamental understandings of both biogenic and anthropogenic effects on ecosystem health. Long term monitoring may provide great insight into natural factors such as disease, pests and weather (e.g., global climate change, drought, floods and increased intensity of tropical storms and hurricanes), which may affect populations throughout a geographical region. In addition to population perturbations caused by natural stressors, is the complexity of differentiating "anthropogenic effects" of chemical and biological contaminants in aquatic ecosystems from "natural background effects". There is a clear need to develop accurate "Ecological Forecasts" using long-term ecological data sets. Long-term ecological monitoring data thus can be used not only to ascertain effects of natural and anthropogenic stressors, but also when properly used in conjunction with GIS and advanced modeling techniques may enhance predictive capabilities. The grass shrimp, *Palaemonetes pugio*, is the dominant macrobenthic invertebrate in tidal creek systems of the southeastern United States and is an important prey item for higher trophic levels. The North Inlet Oyster Landing (map location #10) site is maintained as a long-term reference site for comparison to estuarine sites with other land uses.

Grass shrimp populations are sampled monthly using a push-netting approach (Leight, A.K., G.I. Scott, M.H. Fulton, and J.W. Daugomah. 2005. Long-term monitoring of grass shrimp, *Palaemonetes* sp., metrics at sites with agricultural runoff influences. *Integrative and Comparative Biology* 45:143-150).

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

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

This long-term project, begun in September 1997, has investigated various questions related to the ecological role of bottlenose dolphins in the North Inlet and Winyah Bay systems. As surface-associated apex predators, dolphins are a highly visible indicator species for movements in the prey community and potential system-wide changes. Using photo-ID and focal follow and transect surveys, we have identified long-term resident dolphins in both North Inlet and Winyah Bay. 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. 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. Dolphin distribution in North Inlet has been correlated with changing patterns of salinity and prey distribution, and in Winyah Bay it has been correlated with salinity and bottom type. Mothers with young calves apparently favor low current areas, and salt marsh residents swim slower and expend less energy while traveling than coastal dolphins. Continuing studies will address the distributional response of dolphins and other trophic levels to short-term but tidally predictable chlorophyll maxima.

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>, Nicole Saladin<sup>2</sup>, Lindsay Thomas<sup>2</sup> and other volunteers  
<sup>1</sup>DeBordieu Colony; <sup>2</sup>North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, USC

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 each 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 (which includes the Hobcaw) plus the middle and north sections to Pawley's Inlet typically account 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.

### **Clapper rail, *Rallus longirostris*, distribution in the marshes of the North Inlet Estuary**

Investigators: Drs. Jennifer Plunket and Erik Smith  
North Inlet-Winyah Bay National Estuarine Research Reserve and  
Baruch Marine Field Laboratory, USC

The populations of many species of birds that depend on emergent marsh habitat appear to be declining, but basic information on the population status and habitat requirements of many of these species is lacking. This information is necessary to evaluate the impacts of management actions or activities on marsh bird populations. The distribution of clapper rails in the North Inlet marsh will also be examined in the context of habitat type. Clapper rails will be surveyed for a second year by boat using a standardized call broadcast method. Survey stations will be grouped into 4 survey areas: Clambank Landing (representing mid-marsh habitat), Oyster Landing (representing upland border habitat), Jones Creek (representing barrier island back habitat), and Debidue (representing developed upland habitat). Observers will record the timing, direction, estimated distance, and call type of clapper rails and least bitterns throughout the total 7 minute sampling time at each station. Surveys will be completed at all survey stations between sunrise and 10:00 AM. Sampling periods will occur from March through June 2009. The results of this analysis will further our understanding of the habitat requirements of this species and be used to examine to potential effects of land use change and sea level rise on the population status of clapper rails and least bitterns.

### **The Painted Bunting Monitoring Project**

Investigators: Dr. Jamie Rotenberg<sup>1</sup>, John Gerwin<sup>2</sup>, and volunteer Kathy Shaw<sup>3</sup>  
<sup>1</sup>Department of Environmental Studies, University of North Carolina Wilmington; <sup>2</sup>North Carolina Museum of Natural Sciences; <sup>3</sup>Nashville, TN

We initiated the Painted Bunting Monitoring Project to study the eastern population of Painted Bunting (*Passerina ciris*) in North and South Carolina. Breeding Bird Survey data shows that eastern Painted Buntings have declined at least 3.2% annually over a 30 year period, possibly due to increased coastal development and agricultural practices, both of which reduce the shrub-scrub brush vital to breeding Painted Buntings. We are conducting a mark-recapture-release study by banding Painted Buntings in public and private sites across coastal and inland areas of the Carolinas. The sampling location on Hobcaw is beside the Baruch Marine Lab's boatshed. Our project also includes about 200 citizen scientists who report behavioral observations to us on Painted Buntings through our website, [www.paintedbuntings.org](http://www.paintedbuntings.org). Each banded bird is uniquely color marked so that citizen observations contribute both to our distributional information and to our mark-recapture work in the form of re-sightings. The research and monitoring will allow us to quantify demographic parameters such as population distribution, density

and abundance; productivity and adult survival; and, behavioral patterns of site-fidelity and habitat use. The project is in its third year and will run for five more years. Our partnership includes the University of North Carolina Wilmington (UNCW), the North Carolina Museum of Natural Sciences, South Carolina DNR, USFWS, and USGS. Funding is provided by USFWS, NC Wildlife Commission, and SCDNR.

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

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

The South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) have been conducting a comprehensive collaborative coastal monitoring program since 1999. 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, more than 500 sites have been sampled state wide, with 6 located in the North Inlet estuary and an additional 24 stations located in the adjacent Winyah Bay. 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**

Investigator: Beth Thomas and Lindsay Thomas  
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field  
Laboratory, USC

Education and outreach targeted to local schools in Georgetown, Horry, and surrounding counties informs students and others about the importance of healthy water quality and the value of watersheds and estuaries. These programs feature curriculum components of the K-12 Estuarine Education Program (KEEP) developed by the National Estuarine Research Reserve System (NERRS). An extensive curriculum focusing on estuaries includes classroom and field activities and offers hands-on activities for investigating water quality and watersheds. A new website created by the NERRS education sector- [www.estuaries.gov](http://www.estuaries.gov) -also provides a multitude of educational resources. Teachers and students work with Reserve staff to study water chemistry and quality, sample bodies of water near their schools, and access local and national estuarine data collected from the NERR 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 and testing equipment are also offered.

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

Investigators: Beth Thomas and Lindsay Thomas  
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field  
Laboratory, USC

Educational activities that highlight coastal ecology and integrate findings from research are offered throughout the year. A seasonal schedule of activities is produced 3-4 times per year, and programs are promoted through printed fliers, Reserve newsletters, newspapers, and the Reserve's website, [www.northinlet.edu](http://www.northinlet.edu). Program offerings include estuarine and beach ecology programs for all ages, biking and kayaking programs that feature coastal ecology, open houses and research lectures, and research-based programs in which participants assist scientists with long-term monitoring programs and volunteer monitoring efforts. Field trips for K-12 students, homeschool students, and special groups such as Elderhostel, Boy and Girl Scouts, 4H clubs, and church groups are also available, as well as job shadowing and research experiences for high school students.

Off-site outreach includes events such as the annual Winyah Bay Heritage Festival and Huntington Beach State Park's Wildlife and History Day, summer reading programs at Georgetown County library branches, afterschool programs for local elementary and middle schools, science and environmental fairs, and career days.

Partnerships with other local environmental education providers including the ACE Basin National Estuarine Research Reserve, South Carolina Department of Natural Resources, Centers for Ocean Science Education Excellence-Southeast (COSEE-SE), SEWEE Association, and the Waccamaw National Wildlife Refuge provide opportunities for teacher training and professional development, and shared staff and resources for enhanced programming and outreach.

### **Coastal Waccamaw Stormwater Education Consortium (CWSEC) Core Education Provider – National Estuarine Research Reserve**

Investigators: Beth Thomas, Nicole Saladin, and Lindsay Thomas  
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field  
Laboratory, USC

Reserve public education and Coastal Training Program (CTP) staff participate as core education providers of the Coastal Waccamaw Stormwater Education Consortium (CWSEC). Created in 2004 as a partnership between Clemson University's Carolina Clear Program, North Inlet-Winyah Bay NERR Coastal Training and NERR Public Education Programs, Coastal Carolina University's Waccamaw Watershed Academy, Winyah Rivers Foundation's Waccamaw Riverkeeper Program, and Murrells Inlet 2007 & Beyond (now Murrells Inlet 2020), the Consortium was formed to provide a clearinghouse for stormwater education resources for local MS4 communities in Horry and Georgetown Counties. The Consortium education providers offer a variety of outreach activities and resources designed to maximize efficiency of stormwater education efforts in the northeastern coastal region of South Carolina by using a regional/watershed approach and to help local MS4s to meet NPDES Phase II Permit requirements for public stormwater education and outreach. Additional information on the Consortium is available at <http://www.cwsec-sc.org/>.

## **Community enhancement activities - National Estuarine Research Reserve and Baruch Marine Field Laboratory, University of South Carolina**

Investigators: Beth Thomas<sup>1</sup> and Dr. Dennis Allen<sup>2</sup>  
<sup>1</sup>North Inlet-Winyah Bay National Estuarine Research Reserve  
<sup>2</sup>Baruch Marine Field Laboratory, USC

The Reserve currently participates in several community enhancement and stewardship activities in partnership with Keep Georgetown Beautiful (KGB), the local chapter of Keep America Beautiful. Reserve and BMFL staff assist in river and marsh cleanups, lead recycling programs for elementary students and afterschool programs, and assist with a county-wide monofilament recycling program in partnership with the SC Department of Natural Resources. Beth Thomas is serving a second two-year term on the Board of Directors (June '09-'10) of KGB and she participates in school, beautification, and litter prevention subcommittees within the organization. Dr. Dennis Allen is serving on the Morgan Park Task Force, which is spearheading the revitalization of a historical site and community park located where the Sampit River intersects Winyah Bay.

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

Investigator: Nicole Saladin  
North Inlet-Winyah Bay National Estuarine Research Reserve and 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 Department of Health and Environmental Control - Office of Ocean and Coastal Resource Management South Carolina Sea Grant Consortium, and the NOAA Coastal Services Center.

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

Investigators: Dr. Dwayne E. Porter<sup>1,2</sup>, Tammy Small<sup>1</sup>, Melissa Ide<sup>1</sup>, Jennifer Kessee<sup>1</sup>,  
Brooks Folk<sup>1</sup> and Jay Poucher<sup>1</sup>  
<sup>1</sup>Belle W. Baruch Institute for Marine & Coastal Sciences and the Baruch Marine Field Lab, USC;  
<sup>2</sup>Arnold School of Public Health, USC

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.
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 winter of 2010.
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 09/01/08 to 02/28/10 by NERRS/NOAA/Department of Commerce. The CDMO website is [cdmo.baruch.sc.edu](http://cdmo.baruch.sc.edu).



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