

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

**2010-2011**

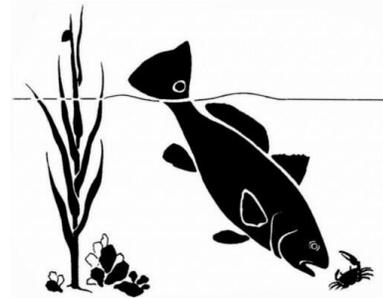
**Baruch Marine Field Laboratory (BMFL)**

**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 2010-2011

### 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 more than 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 71 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 46 of the investigators conducting research at the BMFL. In addition, 78 other investigators representing 34 other institutions and agencies 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, investigators, affiliations, 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 another section.

Funds for these research projects are provided by a variety of sources, including the National Science Foundation (NSF), US Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA) National Estuarine Research Reserve System (NERRS) and SC Sea Grant Consortium, US Department of Energy (US DOE), 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, maintaining 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 can also be obtained from the Institute's website <http://www.baruch.sc.edu>.

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

Investigators: Drs. Raymond Torres<sup>1</sup> and 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, University of South Carolina

<sup>2</sup>SC Geodetic Survey, <sup>3</sup>Marine Science Program, University of South Carolina

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 00.00N, 79 11 52.00W. 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.

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

Investigators: Dr. Alicia Wilson<sup>1</sup>, Dr. James Morris<sup>2</sup>; Ph.D. students Andrea Hougham Hughes<sup>1</sup> and Weihong Wang<sup>3</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, <sup>2</sup>Belle W. Baruch Institute for Marine & Coastal Sciences and Department of Biological Sciences, <sup>3</sup>Marine Science Program, University of South Carolina

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 was funded from 6/1/2006 until 8/31/2009 by the South Carolina Sea Grant Consortium; ongoing work focused on Ra is funded by a NERR Fellowship (A. Hughes).

### **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 '09, we documented 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. Sampling was repeated in August 2010. See map location 9A

### **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, University of South Carolina

<sup>2</sup>Belle W. Baruch Institute for Marine & Coastal Sciences, University of South Carolina

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, University of South Carolina

<sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

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.

## Testing snail – *Spartina* interactions in multiple South Carolina marsh systems

Investigators: Drs. Danny J. Gustafson<sup>1</sup> and Brian Silliman<sup>2</sup>

<sup>1</sup>The Citadel, Charleston, SC; <sup>2</sup>University of Florida, Gainesville, FL

There has been a long running debate among the salt marsh scientific community as to what is the most influential factor in determining salt marsh primary productivity. One group believes *Spartina alterniflora* growth is primarily driven by nutrient dynamics (bottom up) while more recent research has suggested that grazing activities of the ubiquitous *Littoraria irrorata* (southern marsh periwinkle) can have a significant top-down effect in addition to bottom-up nutrient dynamics (Mendelsohn and Seneca 1980; Morris and Dacey 1984; Howes et al. 1986; Silliman and Ziemann 2001; Silliman and Bertness 2002; Silliman et al. 2005; Kiehn and Morris 2009). In 2005, we conducted a field experiment testing the relative top-down effects of *Prokelisia marginata* (planthopper) and *Littoraria irrorata* on *Spartina alterniflora* productivity in Charleston County, South Carolina (Gustafson et al. 2006). Using snail densities seen in that marsh, we were able to show that snail grazing had significant negative effects on plant growth, much more of an effect than the planthoppers. One criticism of our work was that this research was conducted in only one SC marsh and may not reflect dynamics salt marshes more generally. We acknowledge this limitation of the study and would like to expand our experimental top-down control of *Spartina alterniflora* salt marshes by establishing cage exclusion experiments in multiple South Carolina marshes systems. We will therefore conduct this research at multiple marshes within the North Inlet–Winyah Bay and ACE Basin National Estuarine Research Reserve (NERR) sites. This research will contribute to our understanding on the dynamics in both of South Carolina’s National Estuarine Research Reserves. The results of this research will be combined with field research conducted in Virginia and Georgia salt marshes in order to more broadly address the generality of top down snail control of *Spartina alterniflora* productivity in southeastern marshes.

Within each NERR site, two marsh areas will have snail exclusion and cage controls established in the spring of 2010. The experimental methods follow that of Silliman and Ziemann (2001), with experimental treatments will consist of replicated (n = 6-8) 1-m<sup>2</sup> roofless cages constructed of 30” (76.20 cm) high wire screening (12.7-mm mesh galvanized hardware cloth). Galvanized hardware cloth was used as caging material because it provides both a physical and chemical barrier (i.e., the zinc coating deters contact) to snail migration (Bertness 1984). ‘Open’ cage controls (three sided with the forth open) will also be monitored to examine potential caging artifacts. All plots will be established at identical elevations and in area with snail populations between 50 and 200 snail m<sup>-2</sup>. Cages will be extended 5 cm into the substrate to prevent snail migration in and out of the cages and to exclude predators. Belowground connections between plants were severed to a 40 cm depth along the outside perimeter of each cage to prevent resource sharing between experimental and non-experimental plants.

We will estimate initial *Spartina alterniflora* productivity using percent cover and density within experimental units. To estimate aboveground biomass, we will randomly sample ten (0.25 x 0.25m<sup>2</sup>) quadrats in the same area of the marsh, determine *Spartina* density within the plot, collect the aboveground biomass, dry to constant weight, and use regression analysis to estimate initial biomass. Snail population structure (density, size class structure) will be determined at the beginning and end of the experiment. Plots will be surveyed monthly from April to October 2010. We will resample the *Spartina* and snail performance measures at the end of the experiment; we will estimate aboveground biomass within experimental units using the aforementioned methods.

## 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>, Chester B. DePratter<sup>3</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

<sup>3</sup>South Carolina Institute of Archaeology and Anthropology

The objective of this study is to investigate the vascular flora at four Indian clam shell middens in North Inlet and nearby marshes. 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 an 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. Cores will be taken from 20 large coastal red cedars, *Juniperus silisicola*, to determine the age of this taxon on the shell middens. Annual ring counts will be analyzed at Columbia University's Lamont Doherty Laboratory.

## **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. 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.

## **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, University of South Carolina

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 hydrogeomorphology 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

juvenile fishes (e.g. spot, silver perch, striped mullet) and grass shrimps, (*Palaemonetes spp.*) have high fidelity for individual 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 and some fishes move onto the flooded marsh during high tides, so we are interested to learn whether shrimps that enter one basin tend to remain within that watershed during very high tides or leave with the ebbing tide through another creek-basin. We have used stains, injected color plastic elastomers, and coded microwire tags to determine the movements, home ranges, and fidelity of juvenile fishes and grass shrimps. Animals are marked, released, and recaptured at several locations and at different stages of the tide. 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, SCDNR

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 (*Mycteroperca bonaci*).

### **Characterizing relationships between abiotic conditions and recruitment in a family of estuarine-dependent marine fishes (Serranidae) and testing the hypothesis that reproduction can be male-limited in these species**

Investigators: Katherine Allen<sup>1</sup>, Paulette Mikell<sup>2</sup>, Drs. Dennis Allen<sup>3</sup>, Marcel Reichert<sup>2</sup>, Robert Chapman<sup>2</sup>, and Joseph Quattro<sup>4</sup>

<sup>1</sup>Department of Biological Sciences, University of South Carolina; <sup>2</sup>Marine Resources Research Institute, SC DNR; <sup>3</sup>Baruch Marine Field Lab, University of South Carolina; <sup>4</sup>Marine Science Program and Department of Biological Sciences, University of South Carolina

Knowing the relative impacts of different abiotic factors on the distribution of larval fish assemblages is essential to the maintenance of estuarine biodiversity and productivity, as well as to the effective management of fisheries stocks with estuarine-dependent larvae. To expand our knowledge in this area, I plan to collect marine ichthyoplankton as they ingress into North Inlet, SC, and census the members of the Family Serranidae (which includes several commercially valuable species) within these samples. I will use this data in conjunction with NERRS system-wide environmental monitoring data to characterize the relationship between recruitment success and ambient abiotic conditions for these

species. In addition, given that several theoretical studies have suggested that spawning success in Serranids may be male-limited, and thus may cause fisheries managers to overestimate reproductive capacities, I plan to test this hypothesis using molecular data (mitochondrial DNA sequences and microsatellites) from a representative Serranid species (gag grouper, *Mycteroperca microlepis*) to be collected during sampling.

The data collected during the course of this study will directly contribute to the long-term estuarine fauna monitoring program at the North Inlet–Winyah Bay reserve, as well as provide information about biodiversity and resource sustainability within estuarine ecosystems, both of which are priority management issues for the NERRS program. These results will help to identify the abiotic conditions that are most favorable for recruitment of Serranid ichthyoplankton. Additionally, the molecular analysis results will provide an empirical measure of reproductive success exhibited in a cohort that can be used to determine whether Serranid reproduction is likely to be male-limited. The information gained through this study can help predict how changes to environmental conditions and limitations to the reproductive capacity of a managed population could impact community composition in ocean-dominated estuaries.

This project is funded from March 2011 to June 2013 by the National Estuarine Research Reserve System (NERRS) Graduate Research Fellowship and SC DNR

### **The comparison of large nekton communities in two National Estuarine Research Reserve Systems (NERRS) and between pristine and impacted estuaries in South Carolina**

Investigators: Christopher A. Smith<sup>1</sup> and Dr. Robert F. Young<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

Large nekton communities (defined here as including any fish or invertebrate that can be captured by a 3 cm square mesh net) will be compared between two pristine South Carolina National Estuarine Research Reserve System (NERRS) sites, North Inlet–Winyah Bay, and ACE Basin, and an impacted, urbanized salt marsh, Murrells Inlet, SC. It is hypothesized that CPUE, species richness, Shannon diversity and evenness in North Inlet (pristine) will be significantly different from Murrells Inlet (urbanized) but will not be significantly different from the ACE Basin (pristine). Sampling of each estuary will occur monthly from March to November of 2011. Nekton will be collected using a 400 ft. trammel net set repeatedly from high to low tide. This is a collaborative project with the South Carolina Department of Natural Resources (SCDNR), in which, using identical methods, SCDNR will sample ACE Basin and I will sample North Inlet and Murrells Inlet. A non parametric Kruskal-Wallis test will be used to determine significant differences in CPUE, species richness, Shannon diversity and evenness among the locations. This project will provide baseline data on these estuaries, and I expect to see differences between systems related to the amount of urbanization, likely stimulating further research on the potential natural and anthropogenic causes and their management implications.

### **Comparative impact of the invasive parasitic species *Anguillicoloides crassus* on the American eel populations between the ACE Basin and North Inlet–Winyah Bay NERRS and the Cooper River**

Investigators: Jennifer Hein<sup>1,2</sup>, Dr. Steve Arnott<sup>1,4</sup>, Bill Roumillat<sup>1,4</sup>, and Dr. Isaure de Buron<sup>1,3</sup>

<sup>1</sup>Marine Resources Research Institute, SC DNR; <sup>2</sup>Department of Environmental Studies, College of Charleston; <sup>3</sup>Department of Biology, College of Charleston; <sup>4</sup>Department of Marine Biology, College of Charleston

The goal of this project is to study and compare the presence, intensity, and health effects of the invasive parasite *Anguillicoloides (Anguillicola) crassus* on the American eel populations in the ACE NERR, the North Inlet–Winyah Bay NERR, and the Cooper River. In 2003, concerns were raised regarding the health of eel stocks worldwide and in 2004, a petition was filed with the United States Fish and Wildlife Service and National Marine Fisheries Service to list the American eel, *Anguilla rostrata*, as an endangered species. Reports of eel populations in South Carolina (SC) estuaries show a decline since at least 2001, when the SCDNR electrofishing survey began. The invasive parasite *Anguillicoloides (Anguillicola) crassus* is considered one potential reason for the decline. This invasive nematode (roundworm) infects the swim bladder of eels. It is endemic to East Asia and is believed to have been introduced to the United States via aquaculture in 1995. *A. crassus* was found for the first time in a United States wild eel population in Winyah Bay, SC. The parasite has since been reported in Chesapeake Bay, Maryland, Florida, New England, and eastern Canada. Currently, we have no knowledge of the status of infection and impacts of this parasite on eel populations in the SC NERRs (ACE Basin and North Inlet–Winyah Bay), or of the seasonal fluctuations in infection. During this study, we will determine the prevalence, intensities, and abundances of *A. crassus* in American eels

collected from the ACE and North Inlet–Winyah Bay NERRs and compare them with a separate population collected from a heavily polluted habitat (Cooper River), since contaminants may affect the ability of eels to resist infection. By sampling different locations over an entire year, the study will determine whether levels of *A. crassus* infection vary spatially and temporally. The eels that are captured will also be examined to determine whether infection by *A. crassus* is associated with any discernable effects on host health.

### **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 and Coastal Sciences, University of South Carolina

<sup>2</sup>Department of Biological Sciences and Marine Science Program, University of South Carolina

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* and *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, University of South Carolina

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 CO<sub>2</sub> and CH<sub>4</sub> 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 and for 2010-2011 by the Department of Energy, National Institutes for Climatic Change Research.

## **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, University of South Carolina;  
<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 is supported by the National Science Foundation for 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, University of South Carolina

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, University of South Carolina

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.
- Marinelli, R.L., C.R. Lovell, S.G. Wakeham, D. Ringelberg, D.C. White. 2002. An experimental investigation of the control of bacterial community composition in macrofaunal burrows. *Marine Ecology Progress Series* 235:1-13.
- 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.

## **Spectral fluorometric characterization of CDOM and phytoplankton photosynthetic efficiency using the Algae Online Analyzer**

Investigators: Emily Goldman<sup>1</sup> and Dr. Tammi Richardson<sup>1,2</sup>  
<sup>1</sup>Marine Science Program, University of South Carolina; <sup>2</sup>Department of Biological Sciences, University of South Carolina

Phytoplankton are important contributors to estuarine primary production and their community composition in estuaries can be highly variable in space and time. There is a general lack of information on how phytoplankton community composition varies on shorter time scales (hours to days) which stems, in part, from the fact that continuous monitoring of phytoplankton community composition usually involves microscopy, which is laborious and time-consuming. Our study examines the performance of a commercially available, fixed wavelength spectral fluorometer, the Algae Online Analyzer (AOA) in characterizing the seasonal and tidal variability in phytoplankton community composition in North Inlet, South Carolina. The AOA has light-emitting diodes (LEDs) centered at 450, 525, 570, 590, and 610 nm with emission measured at 680 nm (red) which allows specification of a library of spectral fluorescence signatures to which acquired spectra are compared for characterization of the phytoplankton community. This instrument is designed for long-term, platform-based continuous monitoring and uses a small peristaltic pump to move water from a chosen depth into the sample cuvette. The shape of the spectral fluorescence signature is used to distinguish between taxa, while the fluorescence intensity and the group-specific fluorescence/chl *a* ratios are used to estimate total phytoplankton biomass (as chl *a*). The AOA also estimates concentrations of chromophoric dissolved organic matter (CDOM) by UV excitation at 370nm. This is a measurement that is fundamental to the study of water-related optics, remote sensing, and aquatic ecology in general (as CDOM absorbs the blue light favored by marine phytoplankton), yet relatively little is known of its dynamics in salt-marsh estuaries. Oyster Landing provides a natural

laboratory for examining the response of the AOA under varying conditions of light, nutrients, and phytoplankton community composition on a variety of timescales.

Funding is provided by the Slocum-Lunz Foundation and the National Science Foundation.

### **Pseudo-nitzschia distribution along the Southeastern US coast**

Investigator: Dr. Steve Morton and Andrew Shuler  
NOAA Phytoplankton Monitoring Network, Charleston, SC

Blooms of toxin producing diatoms known as *Pseudo-nitzschia* are common on the West Coast of the United States and actively researched. However, little research has been done to look at the distribution and impacts these species may be making on the East Coast. Domoic Acid (DA) is the excitatory neurotoxin produced by *Pseudo-nitzschia*, which causes Amnesic Shellfish Poisoning (ASP) in humans and Domoic Acid Poisoning (DAP) in marine mammals. Over the last 3 years samples taken during the investigations of the stranding of pygmy sperm whales on the southeastern US coast have tested positive for high concentrations of DA. Since high levels of DA is a common cause for the stranding of marine mammals on the West Coast this suggest that more attention should be put on the impacts *Pseudo-nitzschia* and its associated toxin may be having on the East Coast.

Routine offshore phytoplankton samples collected from collaborative agencies including the SC Department of Natural Resources and the South Carolina Maritime Foundation will be combined with inshore sampling efforts conducted by NOAA phytoplankton monitoring staff and network volunteers to assess the distribution of *Pseudo-nitzschia* along the southeastern US coast. Sampling on Hobcaw Barony will be done at Clambank Bridge, Clambank Landing, Oyster Landing, and Thousand Acre bridge. This research will provide the first steps towards developing the necessary tools for further investigations of health impacts on marine mammal populations and potential transfer of domoic acid into seafood.

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

Investigators: Drs. Evelyn Lawrenz and Tammi Richardson  
Department of Biological Sciences and Marine Science Program, University of South Carolina

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. The research is funded through the National Estuarine Research Reserve Graduate Research Fellowship Program.

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

Investigators: Dr. Steven Viscido and students  
Department of Life Sciences, Winston-Salem State University, 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 shorebirds 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 each summer, and then use the data 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) and Research Initiation (RIP) programs.

### **Quantitative descriptions of oyster (*Crassostrea virginica*) population biology in North Inlet Estuary**

Investigator: Dr. Juliana M. Harding  
Department of Marine Science, Coastal Carolina University, Conway, SC

Oyster (*Crassostrea virginica*) population biology sets the foundation for maintenance and persistence of the biogenic habitat as well as the associated trophic communities and ecological services. These dynamics respond to a variety of factors functioning at time scales ranging from days to decades. This research will describe basic oyster population parameters including recruitment intensity and periodicity as well as density, demographics, and condition index at Oyster Landing and Clambank beginning in spring 2011. Environmental data will be collected concurrently and integrated with the biological data. The integrated data sets will be examined in the context of available historic data and documented environmental changes across decadal time scales. The resulting quantitative population descriptions will support focused examinations of the reproductive biology of these populations beginning in 2012.

### **Fitness implications of individual diet choice in marsh crabs**

Investigators: Dr. Blaine D. Griffen  
Marine Science Program and Department of Biological Sciences, University of South Carolina

Trophic interactions are a foundation of ecological connections because the food an organism eats provides the nutrients and energy needed for growth and reproduction, and thus ultimately drives population dynamics. However, understanding the link between food consumption and growth and reproduction (i.e., individual fitness) is often complicated by the fact that diets frequently vary across individuals in the same population as individuals specialize on certain food items. The goal of this research is to forge an explicit link between food consumption and individual fitness or fecundity. This work combines field diet assessment and experimental manipulations (using geometric diet analysis) of several intertidal crab species in estuarine/marsh habitats along the U.S. east coast, but principally at Baruch and on the New Hampshire coast. Several crab species are being used that range from primarily herbivorous species to primarily carnivorous species. Empirical results will be used to develop a species-independent and nutrient-specific dynamic energy/nutrient budget model for brachyuran crabs. This project was initiated in 2010 and I anticipate that it will continue for several years. Financial support of the project has thus far come from the University of South Carolina.

### **The link between metabolism and behavior in fiddler crabs**

Investigators: Dr. Blaine D. Griffen and Rachel Decker  
Marine Science Program and Department of Biological Sciences, University of South Carolina

This study examines the role of metabolic state in the behavioral decisions of fiddler crabs. For example, does the level of stored energy and nutrients influence the decision of male fiddler crabs to perform mating displays (waving) as opposed to engaging in foraging? Also, does energetic state influence the boldness of foraging fiddler crabs? Does energetic state or nitrogen influence the frequency of intraguild predation among fiddler crabs. This project is part of a larger goal to understand the role of individual variation in population dynamics. Work on this project at Baruch has focused on both *Uca pugilator* and *Uca minax*. The project was initiated in 2009 and will likely continue for several years. Financial support of the project has thus far come from the University of South Carolina.

### **Size-structured predator-prey interactions in intertidal oyster reefs**

Investigators: Benjamin J. Toscano<sup>1</sup>, and Dr. Blaine D. Griffen<sup>1,2</sup>  
<sup>1</sup>Department of Biological Sciences, University of South Carolina; <sup>2</sup>Marine Science Program, University of South Carolina

The mud crab, *Panopeus herbstii*, is an important predator of bivalves in North Inlet's intertidal oyster reefs. Individuals within *Panopeus* populations span a range of body sizes that co-occur in high densities, and their population size structure varies seasonally due to recruitment pulses and size-selective winter mortality. Using a combination of field and laboratory experiments, our research explores how such ontogenetic functional variation in *Panopeus* determines their interactions with the oyster reef community. This research will provide a better understanding of how size-structure in populations can scale up to influence population and community dynamics. Field experiments are conducted in intertidal oyster reefs in the vicinity of Oyster Landing and lab experiments are conducted in the wet laboratory. This project started in May 2010 and is ongoing and supported by the Belle W. Baruch institute.

### **Effect of autotomy on *Panopeus herbstii* body temperature and survival rates**

Investigators: Cristián Monaco, Ben Toscano, and Corey Scott  
Marine Science Program and Dept. of Biological Sciences, University of South Carolina

The effects of temperature shifts on natural systems are pervasive. Ecologists have long known that temperature fluctuations can influence every level of biological organization. The scenario becomes even more complex if we consider the existence of other physical and/or biotic forces, which are likely to vary along with temperature. If we are to predict the fate of such complex systems, efforts should go towards mechanistically describing the impacts of interacting factors. As climate change research continues revealing evidence for dramatic shifts of multiple species distribution ranges and phenologies, ongoing studies are further providing information on the potential outcomes when considering ecological interactions as well. For example, we now have some understanding of how predator-prey interaction intensities are regulated by organism's body temperatures. However, in some occasions, the outcome of a predator-prey interaction will determine body temperatures. This appears to be the case for organisms that autotomize body parts as a mean of escaping from predators. The mud crab, *Panopeus herbstii*, an important ecological component of the intertidal zone of salt marshes from the east coast of the USA, frequently autotomizes appendages in response to predators such as blue crabs and fish. This species is also constrained by strong seasonal temperature fluctuations, which requires them to behaviorally respond by burrowing in the mud or crawling up to oyster-shell matrices depending on the microhabitat temperatures. Given that mud crabs use their claws for burrowing, autotomizing them for assuring survival could also prevent it from burrowing. Our project's objective is to evaluate the combined effects of temperature fluctuations and autotomy on a *P. herbstii* population that inhabits the salt-marsh area around Oyster Landing (Baruch Marine Laboratory, USC). Research will involve both field and laboratory experiments and observations. Temperature measurements are being continuously recorded using I-buttons deployed at different heights and depths to estimate microhabitat thermal variability. Every ~2 mo we are doing population surveys on a reef located ~200 m away from Oyster Landing's weather station. Through those surveys we are estimating density, proportion of autotomized individuals, microhabitat use, number of burrows, and sex ratio. Field experiments include caging 20 individuals in independent minnow traps during periods of 3-4 weeks. Cages will be set on pure-mud flats. These experiments will be conducted twice a year, during winter and summer seasons. Laboratory experiments, which will be conducted in Columbia, SC, are being designed for assessing organisms' thermal tolerance levels.

## **The influence of predators on community structure and resultant ecosystem functioning at a biogeographic scale**

Investigators: Drs. James E. Byers<sup>1</sup>, David Kimbro<sup>2</sup>, Jonathan Grabowski<sup>3</sup>, Michael Piehler<sup>3</sup>, and Randall Hughes<sup>2</sup>  
<sup>1</sup>University of Georgia; <sup>2</sup>Florida State University; <sup>3</sup>UNC Institute of Marine Science

Predators structure ecological communities by both consuming (consumptive effect, CE) and altering the traits of prey (non-consumptive effect, NCE), yet these effects have only recently been linked to local variation in ecosystem functions such as primary production and nutrient cycling. Furthermore, such linkages may operate differently across biogeographic scales because factors (e.g., predator diversity, resource supplies, and physical conditions) known to affect local predator mechanisms also vary with latitude. The deficiencies in our knowledge of both how predators locally affect ecosystem functions and how predator-prey interactions vary over a biogeographic range inhibit our understanding of linkages between ecological communities and ecosystems, and thus our ability to manage valuable ecosystem services. Intertidal oyster reefs (*Crassostrea virginica*) are a model system to address these knowledge gaps for several reasons: they occur throughout the mid-Atlantic and Gulf coasts (1,750 km); they contain a similar food-web assemblage across latitudinal gradients in predation, resource supplies, and environmental conditions; they are strongly influenced by predator effects; and they influence sediment and nutrient cycles by enhancing benthic-pelagic coupling. We are examining whether CEs and NCEs of predators differentially influence oyster reef benthic-pelagic coupling, and whether and why these predator-ecosystem linkages differ throughout the oyster's biogeographic range. Specifically, this proposed research involves a series of standardized sampling and experimental studies to: (1) investigate biogeographic patterns in oyster food web structure, resource supplies, environmental conditions, and sediment properties associated with reef function (2) determine how the vital rates of oysters (i.e., growth and survivorship), which can influence benthic-pelagic coupling, vary geographically; and (3) examine experimentally the relative importance of consumptive and non-consumptive predator effects on oyster reef communities and the ecosystem processes they provide, and how these effects vary latitudinally. This project will provide a mechanistic understanding of the basis for biogeographical shifts in valuable ecosystem services performed by an important marine foundation species, and it will also advance our understanding of the interactions between predator effects in food webs and the ecosystem processes that depend on them. This project began in July 2010 and is supported by NSF Biological Oceanography until August 2013

## **Characterization of oyster cement**

Investigators: Dr. Jonathan Wilker<sup>1</sup>, Erik Alberts<sup>1</sup>, Stephen Taylor<sup>1</sup>, and Paul Kenny<sup>2</sup>  
<sup>1</sup>Department of Chemistry, Purdue University, IN; <sup>2</sup>Baruch Marine Field Laboratory, University of South Carolina

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 (November 2009-October 2012).

## **Settlement, survival and growth of bivalves within Myrtle Beach swash estuaries**

Investigators: Caitlin Wessel and Dr. Keith Walters  
Department of Marine Science, Coastal Carolina University, SC

The relative importance of larval settlement, survival, and growth to maintenance of oyster, *Crassostrea virginica*, and mussel populations, *Geukensia demissa*, inhabiting 'swashes' along the coastline of Myrtle Beach, SC will be determined. Swashes typically are estuarine systems maintained by tidal rivers draining localized watersheds over mainland beaches. In December 2009 bivalves collected from a common field location were numbered, sized, and

placed in 7.0 mm mesh cages within 3 swashes and 3 ocean-dominated inlets along the Grand Strand. Survival and growth of the caged bivalves will be monitored throughout 2010 to test whether differences in mortality and/or growth exist for swash and inlet populations. Beginning in April settlement samplers will be placed at the same swash and inlet locations and the contribution of larval settlement and survival to oyster population dynamics assessed. Results will provide critical information necessary to predict whether bivalve populations within swashes can be increased either through the addition of shell to construct new oyster reefs and/or actual transplantation of bivalves into new swash locations. Increasing bivalve populations within swashes is one possible solution to addressing historical declines in water quality and more frequent beach advisories directly attributable to swash runoff.

### **Effects of variation in egg size on embryonic development in the poecilogonous annelid *Streblospio benedicti***

Investigator: Dr. Bruno Pernet  
Department of Biological Sciences, California State University, CA

Larvae of some marine invertebrates develop from small eggs and must feed to fuel their development, while larvae of other species develop from large eggs and do not feed until after metamorphosis. I am using a comparative approach to test hypotheses on the developmental events underlying this correlation between egg size and larval nutritional mode, focusing primarily on differences in the timing of gut morphogenesis associated with variation in egg size. At BMFL, I am studying the "poecilogonous" annelid *Streblospio benedicti*, a species in which some individuals produce small eggs that develop into obligately feeding larvae, but others produce large eggs that develop into facultatively feeding larvae. Techniques used include confocal and light microscopy, and functional studies of feeding. Results of this project will provide an important link between the fields of development, larval ecology, and life history evolution in marine invertebrates. This work is supported in part by internal awards from California State University, Long Beach, and an equipment grant from the National Science Foundation. The collection site is the high marsh near Oyster Landing (map location # 3).

### **Anthropogenic pharmaceutical impacts on the structure, function, and antibiotic resistance of estuarine benthic microbial communities**

Investigators: Drs. James L. Pinckney, Charles R. Lovell, and Richard A. Long  
Department of Biological Sciences and Marine Science Program, University of South Carolina

The primary objectives of the proposed research are to (1) quantify structural and functional responses of benthic microbial communities to sub-chronic exposures to the individual effects of the antibiotic sulfamethoxazole in estuarine ecosystems and (2) determine if the presence of this compound selects for potentially virulent, antibiotic resistant bacterial strains. We will use a combined bioassay and microcosm approach to quantify the microbial responses of natural communities to the singular effects of sulfamethoxazole. Microcosm tanks, which simulate tidal flooding, *in situ* irradiances, and temperatures, will be employed to assess the effects in a fully-crossed experimental design. At the termination of the bioassay, 8 different rate measurements will be used as indicators of microbial community function since all are essential processes for microbial growth and biogeochemical cycling in sediments. Antibiotic resistance will be assayed and microbial community composition will be quantified as an indicator of community structure. Our results will provide the necessary quantitative evidence for adopting new policies for regulating the permissible concentrations of pharmaceutical products in wastewater effluent and estuarine habitats. Furthermore, the project results will be useful for the creation of voluntary environmental stewardship programs that emphasize the responsible use and disposal of pharmaceuticals as well as reducing inputs into the environment. Where voluntary efforts are not effective, our results can be used for the development of formal rules, decisions, and guidance for state and federal agencies. This research is funded through July 2011 by the South Carolina Sea Grant.

### **The potential impact of antibiotics and their unintended consequences upon benthic diatoms and benthic microalgal communities**

Investigators: Isaac M. Hagenbuch and Dr. James L. Pinckney  
Department of Biological Sciences, University of South Carolina

As human populations have grown and healthcare has become more accessible, overall pharmaceutical use has increased, with a concomitant increase in antibiotic use. The use of antibiotic compounds hasn't increased solely in

human medicine but in veterinary medicine as well and applications aren't confined to terrestrial organisms. Antibiotics are commonly used as feed additives for livestock (terrestrial and aquatic) as a way to enhance animal growth and reduce disease. The potential impacts of individual antimicrobial and antibiotic compounds upon natural bacterial communities are widely recognized. Multiple studies have documented their presence in drinking water and aquatic sediments and it is generally thought that the activities of antibiotics are very tightly-focused upon their respective targets. However, multiple studies have shown that common prokaryotic antibiotics exhibit significant cross-reactivity to non-target organisms, specifically eukaryotic microbes. This suggests that presence of these drugs has a wide array of implications for the benthic microbial populations that are foundational in estuarine and coastal food webs. Given that antibiotics are likely to be present in the environment not as single compounds but as mixtures, it is stunning how few studies have investigated how mixtures of antibiotics behave either in laboratory cultures or in the environment.

Benthic microalgal (BMA) communities can be found in virtually any aquatic system where sunlight penetrates to the benthos. In temperate zones like coastal South Carolina, BMA communities are dominated by motile benthic diatoms. Diatoms are widely recognized to be important as carbon fixers, consumable food and regulators of biogeochemical fluxes across the sediment/water interface within inter and subtidal habitats. Stressors that negatively impact BMA communities therefore have the potential to cause a cascade of environmental and ecological effects across trophic levels.

The overall objective of this study is to determine the possible ecosystem impacts of antibiotic presence in the marsh intertidal. The short term objectives, to be completed within the 1 year length of the project, are:

1. Show whether common antibiotic compounds directly affect benthic diatoms and BMA communities *in situ*.
2. Determine how multiple antibiotic compounds interact to impact these organisms.
3. Apply these findings to a food web model to quantify ecosystem response.

Experiments will utilize primary productivity and Chlorophyll *a* measurements from the benthic surface as well as sealed chamber incubations of intact cores of intertidal sediment and microscopic cell counts. Initial experiments will be performed on algal cultures at USC Columbia with field experiments to be performed at the Baruch Marine Field Lab at North Inlet during the spring of 2011. The antibiotics to be used are sulfamethoxazole, neomycin, and tylosin. All of these compounds are commonly used in human or veterinary medicine and each targets a different component of prokaryotic biochemistry. They will be used both singularly and in combination to assess their effect upon benthic diatoms and whether they behave synergistically, antagonistically or additively.

This project is funded by the USC Estuarine Ecology Lab.

### **Linking residential development and organic matter loading to the coastal zone: The role of stormwater ponds as sources of bioreactive organic carbon and nitrogen**

Investigators: Dr. Erik Smith, Dr. Jennifer Plunket, Amy Willman, and Amber Stojak  
Baruch Marine Field Laboratory and the North Inlet–Winyah Bay National Estuarine Research Reserve

Stormwater ponds, especially wet 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 these ponds function as ecosystems, or quantifying basic biogeochemical processes in ponds, is almost entirely lacking. This has greatly hampered an understanding of how the proliferation of stormwater detention ponds affects key biogeochemical linkages along the terrestrial-aquatic interface. In particular, quantifying the magnitude and fate of organic carbon and nitrogen produced within these ponds is critical to determining the influence of stormwater ponds on water quality impairment of adjacent coastal waters, many of which are on the EPA 303(d) list for dissolved oxygen impairment. A key issue in this regard is the effects that various development practices and current design criteria for stormwater ponds have on pond Net Ecosystem Production (NEP) and bioavailability of pond-derived organic carbon and nitrogen.

The specific objectives of this study are to (1) quantify rates of NEP across 30 individual stormwater ponds and determine relationships between nutrient conditions and NEP in these ponds, (2) quantify degradation kinetics and bioavailability of pond-derived dissolved organic carbon (DOC) and dissolved organic nitrogen (DON), the extent to which these vary as a function of pond NEP, and the effects that pond-derived DON has on primary productivity and phytoplankton species composition of coastal marine ecosystems, (3) determine the role that stormwater pond size and design attributes have on nutrient – NEP relationships and DOC/DON production and bioavailability, and (4) compare and contrast temporal dynamics of pond productivity, internal nitrogen transformations, and DOC/DON production and

bioavailability in response to storm events among a subset of ponds of varying development density, pond morphometry and design criteria.

This project is funded by the SC Sea Grant Consortium for the period February 2010 to January 2012.

### **Determining the role of estuarine ‘swashes’ on water quality impairment along the Grand Strand of South Carolina: Impacts of land use and stormwater runoff**

Investigators: Drs. Erik Smith<sup>1</sup> and Jennifer Plunket<sup>1</sup>, and M. Richard DeVoe<sup>2</sup>, Drs. Denise Sanger<sup>2</sup>, Susan Libes<sup>3</sup>, Richard Viso<sup>3</sup>, and Richard Peterson<sup>3</sup>

<sup>1</sup>Baruch Marine Field Laboratory and the North Inlet–Winyah Bay National Estuarine Research Reserve, <sup>2</sup>South Carolina Sea Grant Consortium, <sup>3</sup>Coastal Carolina University, SC

Recently, the occurrence of episodic hypoxia has been documented in the nearshore waters of Long Bay, South Carolina. These events have occurred directly off the Grand Strand, an urbanized beach-front resort community encompassing the greater Myrtle Beach metropolitan area, located along the central portion of Long Bay. Evidence suggests discharges from a series of estuarine tidal creeks (locally known as swashes) play a prominent role as sources for inputs of organic matter and nutrients fueling oxygen demand leading to hypoxia in these waters.

Effective management and mitigation of hypoxia formation in Long Bay requires understanding the extent and means by which swashes serve as sources of enhanced organic matter loading to the coastal ocean. This, in turn, requires a mechanistic understanding of the extent to which current land use and stormwater practices impact terrestrial nutrient and organic loading to swashes and the impacts these have on internal swash dynamics and subsequent material export.

The state and local intended users that we are working with recognize the potential impacts hypoxia could have on the region’s tourism-based economy and have acknowledged that there is a lack of data available for the swashes, such that they are forced to make management decisions without complete scientific information. The proposed research will address this knowledge gap by: quantifying terrestrial inputs of nutrients and organic matter associated with surface stormwater runoff and groundwater inputs to selected swashes of the Grand Strand under both dry weather and stormflow conditions; establishing the link between terrestrial nutrient loading under contrasting flow conditions and the net organic matter production occurring within swashes; and determining the subsequent net tidal export of material (magnitude and forms) from these swashes. Through a collaborative effort between scientists and managers, the results of this project will provide the scientific justifications necessary for enabling the development of effective management strategies that improve and protect coastal water quality, particularly with respect to hypoxia, in Long Bay.

This project is funded by the NOAA/NERRS Science Collaborative for September 2010 to August 2013.

### **Water quality dynamics and plankton metabolic responses in nearshore water of Long Bay, South Carolina**

Investigators: Dr. Erik Smith<sup>1</sup>, Tracy Buck<sup>1</sup>, Amy Willman<sup>1</sup>, and Dr. Eric Koepfler<sup>2</sup>

<sup>1</sup>Baruch Marine Field Laboratory and the North Inlet–Winyah Bay National Estuarine Research Reserve, <sup>2</sup>Coastal Carolina University, SC

Our previous work on hypoxia formation in nearshore waters of Long Bay, South Carolina, has demonstrated significant relationships between water column oxygen demand and concentrations of particulate organic matter and nutrients. This suggests that particulate resources are more important than dissolved resources in fueling bacterial heterotrophy in these waters. The role of in situ phytoplankton production of dissolved organic carbon has yet to be assessed, however. Concentrations of dissolved organic carbon in these waters are substantial, and if only a small, but highly labile portion of this pool is turning over to support heterotrophic respiration, this would not be apparent in relationships with the bulk pool. Further, previous experiments in Long Bay have shown that additions of dissolved inorganic nutrients (nitrogen and especially phosphorus) can significantly stimulate bacterial metabolism and consumption of organic carbon. While these results are similar to those observed in other coastal environments, how this relates to importance of particulate versus dissolved organic substrates in fueling bacterial heterotrophy in Long Bay has not been resolved. Addressing this is critical to predicting the effects that continued nutrient runoff from the Grand Strand, via current stormwater management practices, will have on oxygen consumption rates and the potential for hypoxia formation in nearshore waters.

Objectives of the present study are to: 1) Characterize temporal variability in water quality conditions in surface and bottom waters at Apache Pier, Myrtle Beach; 2) Quantify relationships between nutrient conditions and phytoplankton primary production rates; 3) quantify the relative roles of particulate and dissolved organic matter in supporting bacterial metabolism in surface and bottom waters during times of contrasting hydrodynamic and bottom

water oxygen conditions; and 4) Quantify response of bacterial metabolism to inorganic nutrient (N & P) enrichment during times of contrasting hydrodynamic and presumed organic matter conditions.

Field work for this project will be conducted at Apache Pier, Myrtle Beach, and is supported by funding from SC OCRM for the period of September 2010 to December 2011.

### **An investigation into natural selection and population genetic structure across the North American range of the blue crab, *Callinectes sapidus*, using single nucleotide polymorphism (SNP) markers**

Investigator: Bree K. Yednock  
University of Louisiana at Lafayette, LA

The blue crab, *Callinectes sapidus*, is a euryhaline decapod crustacean with an expansive native range extending from Nova Scotia to Argentina in the western Atlantic Ocean. Its meroplanktonic life cycle suggests this species has the potential for widespread dispersal and genetic mixing throughout its range. However, previous studies have uncovered striking patterns of spatial and temporal genetic differentiation in *C. sapidus* on regional scales. Investigations into genetic differentiation in other marine species that encompass similarly broad environmental ranges, and have equally high dispersal potential, have identified significant genetic partitioning based on selective mechanisms. These findings suggest selection may also be important in structuring *C. sapidus* populations. This study will investigate spatial and temporal genetic variation in *C. sapidus* along the Atlantic and Gulf of Mexico coasts using protein-coding single nucleotide polymorphism (SNP) markers that are being developed in a concurrent project. Spatial distributions of SNP alleles will be compared as a preliminary test of selection. In addition, both synonymous and non-synonymous SNP loci will be analyzed to test the extent to which SNPs that result in amino acid substitutions are under selection. *C. sapidus* is an ecologically important species that supports economically valuable commercial and recreational fisheries in the United States. This project will contribute to our understanding of population connectivity within the North American range of *C. sapidus* and allow us to better predict the extent to which local extinctions can be replenished by larval input from nearby locations.

### **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.

### **Distribution and sediment preference of elasmobranchs inhabiting Winyah Bay and North Inlet, South Carolina**

Investigator: Moriah Moore  
Coastal Marine and Wetland Studies Program, Coastal Carolina University, SC

Many factors are thought to contribute to habitat preference of elasmobranchs (sharks, rays, and skates) and bony fish including predator avoidance, prey abundance, depth, and tidal currents. Previous studies of habitat preference in elasmobranchs have focused on pelagic more so than benthic or benthopelagic species, and thus did not focus on sediment preference. The distribution of benthic and benthopelagic elasmobranchs will be studied with regard to mud, sand, and shell gravel habitats. Sediment samples for each sampling site will be collected by surface grabs, sieved, and classified on a traditional phi scale. Animals will be captured with a nylon tangle net, processed (species, sex, and dimensions), and tagged for recapture. Sediment preference of benthic and benthopelagic elasmobranchs will be determined in a lab experiment utilizing a choice tank divided into thirds, and each section containing one of the sediments in question. Only one animal will be in the tank at a time and the animal will be observed to see which

sediment type it rests on. Distribution of elasmobranchs based on sediment will then be compared to sediment preferences found in the lab study. The following questions will be answered in this study: 1.) Do benthic and benthopelagic elasmobranchs exhibit a sediment preference? 2.) Is the sediment preference species specific? 3.) Given the limited visibility in these two estuaries, is there a correlation between substrate color and dorsal surface color of the animal? I expect few benthic elasmobranchs to be found over shell gravel since it is a hard substrate and difficult to bury in, and I expect both benthic and benthopelagic elasmobranchs to be found over either mud or sand based on their dorsal surface coloration for camouflage. Results of this study will add to the elasmobranch database for Winyah Bay and North Inlet and will further the understanding of elasmobranch habitat utilization.

### **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 Institute's marine field laboratory (BMFL). 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>.

### **Linking trophic structure and intertidal geomorphology: The application of ecological network analysis to explore relationships between creek structure and habitat use by tidal migratory nekton**

Investigators: Drs. Robert R. Christian<sup>1</sup> and Dennis M. Allen<sup>2</sup>

<sup>1</sup>Department of Biology, East Carolina University, NC<sup>2</sup> Baruch Marine Field Laboratory, University of South Carolina

The relationship between geomorphology and ecosystem function is an issue of significance for both scientific understanding and environmental management. This research project addresses the issue by extending recent findings that large and persistent spatial differences exist in the extent of nekton use of adjacent intertidal creek basins in North Inlet. Allen and Christian will apply a modeling approach called ecological network analysis based on a robust set of physical, chemical, and biological data collected synoptically at eight creeks. The project will unite the considerable expertise of these systems available at BMFL with Christian's of ecological network analysis. Specifically, we will address the following question: How does the geomorphology of creeks affect trophic structure and dynamics? The initial products of this research will be a series of network models of tidal creek food webs. These will be used to provide a unique assessment of the relationship between habitat structure and an important aspect of ecosystem function.

### **Spatial trends in vegetation and microbial diversity along environmental gradients**

Investigators: Dr. Daehyun Kim<sup>1</sup> and Soo Hyun Jung<sup>2</sup>

<sup>1</sup>University of Kentucky, <sup>2</sup>Ewha Woman's University, Korea

Species diversity is of primary focus in ecology. The so-called environmental stress models (ESM) have been developed to explain diversity patterns along physical gradients. These models almost unanimously postulate that disturbance is a key factor that influences patterns of diversity. Consequently, a question arises concerning the general applicability of the current ESMs to communities that exhibit stressful conditions but limited, infrequent effect of disturbance, that is, communities where a degree of equilibrium conditions may be attained. In this proposed research, we investigate spatial patterns of vegetation and microbial diversity along both lethal and non-lethal stress gradients in a salt marsh. We aim to examine if spatial trends in diversity vary between these two different gradients and how well the ESMs predict the diversity patterns along the gradients.

Upon arrival at North Inlet, we will select an appropriate tidal creek system in one of the islands near Georgetown, and establish 10 transects, 5 for points bar sides and 5 for cutbank sides, respectively. This design is based on the assumption that the point bar part represents (near-) equilibrium conditions with little effect of disturbing forces, while the cutbank edge side is under non-equilibrium due to erosion processes that cause vegetation and soil collapse. Each

transect is about 25 m-long, perpendicular to and extending away from different tidal creeks. Along each transect, we will put 10 1 m × 1 m square quadrats to examine percent cover of each plant species present. We will also collect soil samples in the middle of each quadrat. A DNA sequencer will be used to analyze diversity of microorganisms in soil samples collected. For both vegetation and microorganism data, we will calculate diversity indices such as Shannon-Wiener index, richness, and evenness.

We expect that this proposed study will provide insights into the role of stress in shaping ecological diversity in salt marshes. Specifically, we take into account stress at a variety of levels from minor to lethal. Our ultimate goal is to develop appropriate conceptual framework of stress-diversity relations for communities with different levels of stress levels.

### **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  
Virginia Commonwealth University, VA

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 James 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, University of South Carolina

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>, 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; <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.

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. Santee Cooper's contribution is an instrumented 50m met tower on Goat Island, Hobcaw Barony, near Clambank Landing. Savannah River National Laboratory and Clemson University will monitor and analyze the data. Santee Cooper and SRNL will continue to interact with the Belle W. Baruch Foundation and USC's Baruch Marine Field Laboratory to assess the potential for offshore facilities. Interest in the potential for commercial scale wind power and the prospects of wind farms (turbines) off of the SC coast continues to increase.

## **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 (<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, SC

This mark-recapture study of diamondback terrapins began in 2006 in North Inlet. As of August 2010, 382 terrapins have been marked, mainly from tidal creeks off Town, Old Man, Debidue and Jones Creeks. 104 recapture events have been recorded. Recaptures to date indicate high site fidelity to feeding areas in the marsh. Remote sensing of acoustic tags attached to 6 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. Abundance of terrapins in an area of marsh bordered by Old Man, Town and Debidue Creeks was calculated as 466 in 0,645km<sup>2</sup> based on 3 years of mark-recapture in that area. This would give an upper estimate of 16,794 terrapins in the low marsh area of North Inlet. The study will continue to investigate status of the terrapin population and aspects of terrapin ecology.

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>

<sup>1</sup>Department of Biological Sciences and <sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

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, University of South Carolina; <sup>2</sup> Department of Earth and Ocean Sciences, University of South Carolina

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. 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, University of South Carolina and North Inlet-Winyah Bay National Estuarine Research Reserve

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.

### **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, University of South Carolina and North Inlet–Winyah Bay  
National Estuarine Research Reserve

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, Tracy Buck, and Amy Willman  
Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay  
National Estuarine Research Reserve

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: Tracy Buck and Dr. Erik Smith  
Baruch Marine Field Laboratory, University of South Carolina and the North Inlet–Winyah Bay NERR

As part of a NERRS system-wide initiative in biological monitoring, the North Inlet–Winyah Bay NERR is conducting biological monitoring of salt-marsh emergent vegetation. The long-term goal is to assess the effects of 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 re-sampled 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 re-sampled 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, and Amy Willman  
Baruch Marine Field Laboratory, University of South Carolina and the North Inlet–Winyah Bay NERR

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 (<sup>3</sup>H leucine incorporation rate) and respiration (in vitro O<sub>2</sub> 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.

### **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, University of South Carolina  
<sup>2</sup>Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

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.
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- 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.
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- 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.
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- 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: Drs. 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, University of South Carolina

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 NERR, University of South Carolina

In this study, the timing and the magnitude of nekton migrations onto the vegetated marsh surface are measured by enclosing several acres 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 (monthly Nov-March) 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 (lunar tides, sea level), freshwater runoff, and other environmental conditions. Started in 1996, this 15 year high tide enclosure time series represents an extension and refinement of a time series (1984-2003) based low tide seine collections at the same site. The low tide seine collections showed long-term stability in the composition and production of dominant transient fishes and shrimps that occupied the intertidal habitat. However, over the 20-year period, overall abundance increased, evenness decreased, and water temperatures increased (especially in winter). For spot, the most abundant fish every year, 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. From 1996 to 2003, high tide collections were compared to same-day low tide seine collections from an adjacent intertidal pool in Oyster Landing Creek. This comparison revealed that the composition and abundance of nekton remaining in the low tide pool was representative of the nekton using the flooded marsh at high tide. 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.

### **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 NERR, University of South Carolina

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 Niño) and drought. Analysis of the 153 micron size fraction has indicated a steady decrease in total small zooplankton, especially copepods, over the past 29 years. Long-term increases in water temperatures, especially for the winter, have been documented. The developmental stages of most invertebrates and fishes, including many commercially and/or recreationally important species, are planktonic. Changes in the abundance and timing of larval production for some but not all species have been observed. These results provide insights into the dynamics and changing conditions of local benthic assemblages and migratory populations of crustaceans and fishes. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change. See map location #10.

### **Geographic variations in larval spot (*Leiostomus xanthurus*) ingress to estuaries; long-term patterns of arrival times, abundance, and size distribution from South Carolina to Massachusetts and relations to climate change**

Investigators: Drs. Dennis M. Allen<sup>1</sup>, Ken Able<sup>2</sup>, Tim Targett<sup>3</sup>, Eric Hilton<sup>4</sup>, Joey Love<sup>5</sup>,  
Gretchen Martin<sup>6</sup> and Chris Taylor<sup>6</sup>, and Jon Hare<sup>7</sup>

<sup>1</sup>Baruch Field Lab and North Inlet–Winyah Bay NERR, <sup>2</sup>Rutgers University Marine Field Station, Tuckerton, NJ; <sup>3</sup>University of Delaware, Lewes, DE, <sup>4</sup>Virginia Institute of Marine Science, Gloucester Point, VA, <sup>5</sup>Maryland Dept. of Natural Resources, Annapolis, MD; <sup>6</sup>NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, NC; <sup>7</sup>NOAA National Marine Fisheries Service, Narragansett, RI

In most estuaries along the US Atlantic and Gulf of Mexico coasts, the spot, *Leiostomus xanthurus*, is one of the most abundant epibenthic fishes. Adults spawn in the ocean during late fall and winter, producing larvae that arrive at inlets through the cold season. Once in shallow tidal waters, larvae transform to bottom feeding juveniles and grow within salt marsh and other shallow estuarine habitats until falling temperatures force their migration to the coastal ocean in the fall. Although much work has been done on the early life stages of this keystone species, studies have been site specific and of short duration. A recently developed collaborative effort among investigators from various locations in the Southeast and Middle Atlantic Regions will compare and interpret patterns of abundance, timing, and size structure during ingress over multiple years. Our time series of spot larvae from the large mesozooplankton program at North Inlet, appears to be the longest continuous dataset, with the 31<sup>th</sup> year of biweekly collections beginning in January 2011. Information about spot ingress in North Inlet will be provided by numerous other studies conducted here over the past 40 years. Time series collections in Beaufort, NC (since 1985), Great Bay, NJ (since 1989), DE (since 2006), and VA (since 2007) will contribute to the analyses. Additional data from MD and ocean areas (sporadically since 1971) will add to our interpretation of patterns and mechanisms of change on a large spatial scale. Changing climate is expected to alter patterns of reproduction, movement, and growth for many coastal fishes, and preliminary analyses suggest that spot phenology and growth are responding to increasing temperatures.

### **Assessment of seasonal sunscreen concentrations in coastal ecosystems based on different coastal development patterns**

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

Organic UV sunscreens are widely used in an array of personal care products and cosmetics, as well as in plastic surface coatings used for food preservation. The compounds have been noted to bioaccumulate in wildlife and humans, act as endocrine disruptors and cause bleaching effects in corals. This project is intended to assess seasonal sunscreen concentrations in coastal ecosystems based on different coastal development patterns; to study fate of selected compounds in both fresh water and seawater; and to assess the concentrations of sunscreen compounds in nationally protected marine areas. The assessment of sunscreens in the near-shore environment will give an insight into how the use of land and beaches relates to the occurrence and fate of these compounds. Information on occurrence, fate and transport of these chemicals may be used to support coastal management decisions in order to effectively conserve and protect natural resources and marine environments. The relationships between land use and concentrations of sunscreen compounds in coastal South Carolina will be assessed including the National Estuarine Research Reserve site at North Inlet, South Carolina.

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

Investigators: Dr. Peter Key, Dr. Michael Fulton, James Daugomah, 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 site (33.350498, -79.190612) 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, J.W. Daugomah. 2005. Long-term monitoring of grass shrimp, *Palaemonetes* sp., metrics at sites with agricultural runoff influences.)

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

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

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. We hope to address the genetics and parentage of North Inlet and Winyah Bay dolphins during the summer of 2011.

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>, Lindsay Thomas<sup>2</sup>, and other volunteers

<sup>1</sup>DeBordieu Colony; <sup>2</sup>North Inlet–Winyah Bay NERR, Baruch Marine Field Laboratory, University of South Carolina

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 North Inlet-Winyah Bay NERR at the Baruch Marine Field 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 NERR, Baruch Marine Field Laboratory, University of South Carolina

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 DeBordieu (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.

### **Wintering site fidelity in salt marsh sparrows**

Investigators: Susan Shaw<sup>1</sup> and Dr. Chris Hill<sup>2</sup>

<sup>1</sup>Coastal Marine and Wetland Studies Program, <sup>2</sup>Biology Department, Coastal Carolina University, Conway, SC

Saltmarsh sparrows *Ammodramus caudacutus*, Seaside sparrows *A. maritima* and Nelson's sparrows *A. nelsoni* all winter in tidal marshes of the mid-Atlantic Coast. Populations of all three may be affected by changes in marsh

composition and availability due to human impacts and sea-level rise. Little is known about survival, habitat use, or habits of these species on their wintering grounds. We are investigating site fidelity and movement within winters and across winters. We will monitor sparrows at three high-tide roost sites, mist-netting and banding sparrows once a month at each site from October to April. Our sites include two shrubby islets near Goat Island (33.34056N, 79.1837 W; 33.3389N, 79.1879 W) and another small islet east of Town Creek (33.3356 N, 79.1879 W). Data from these three banding sites will be compared to three other banding sites at Waites Island, SC.

Some basic wintering biology of these birds has not been documented, and establishing site persistence within a winter, rates of return across years, and the timing of arrival and departure will allow more informed management decisions in response to anticipated changes in marsh composition and availability.

This study began in February 2010 and fieldwork is scheduled to run through April 2011. The study has support from the Coastal, Marine and Wetlands Studies program at CCU, a Graduate Research Incentive Grant to SMS, and the Franklin and Virginia Spivey Ornithology Endowment.

### **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, <sup>2</sup>University of North Carolina Wilmington, NC, 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 fifth year and will run for at least 3 more years. Our partnership includes the University of North Carolina Wilmington (UNCW), the North Carolina Museum of Natural Sciences, SCDNR, USFWS, and USGS. Funding is provided by USFWS, NC Wildlife Commission, and SC DNR.

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

Investigators: Drs. D. Bergquist, R.F. Van Dolah, and G. Riekerk, M.V. Levisen, and 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, University of South Carolina

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, University of South Carolina

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.

### **‘Plantation Path’ – Establishing and monitoring usage and impacts of an experiential environmental education foot trail**

Investigators: Beth Thomas<sup>1</sup>, Richard Camlin<sup>2</sup>, and Dr. Jennifer Plunket<sup>1</sup>  
<sup>1</sup>North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, University of South Carolina, <sup>2</sup>Belle W. Baruch Foundation

The goal is to establish an experiential education area away from long-term research sites to take visitors (K12 and adults) for estuary field trips and other guided environmental education programming that can be accessed by foot and allow participants to experience a variety of coastal habitats via a looped walking trail. An area near 3<sup>rd</sup> Boundary and Crabhall Roads has been identified as a potential site and includes easy access for bus parking and is in close proximity to the BMFL (for safety concerns and restroom access). This trail will supplement the marsh boardwalk to allow users to experience habitats outside the confines of the boardwalk and to accommodate larger group sizes (~65-70 participants). With the help of BMFL’s Research Resource Specialist and the NERRS Stewardship Coordinator, a trail will be determined and marked, then cut by hand using staff and volunteers. Stations will be established to mimic research and monitoring plots and will be used to conduct student research. With assistance and guidance from the NERR Stewardship Coordinator, a monitoring design and protocol will be established to measure the impacts of visitor use over time.

### **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, University of South Carolina

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>, Dr. Dennis Allen<sup>2</sup>, and Karen Fuss<sup>3</sup>  
<sup>1</sup>North Inlet–Winyah Bay National Estuarine Research Reserve, <sup>2</sup>Baruch Marine Field Laboratory, University of South Carolina; <sup>3</sup>Center for Marine and Wetland Studies, Coastal Carolina University

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. 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.

A new community enhancement project component for 2011 is the South Carolina ‘Green Steps’ Schools Initiative with Georgetown High School. This program helps schools take steps towards becoming more environmentally responsible and identify community mentors to assist with grant-funded projects that emphasize waste reduction and recycling, energy and water conservation, pollution prevention, and habitat restoration. Beth Thomas and Karen Fuss are serving as Green Steps mentors to Georgetown High School’s Environmental Studies classes instructed by Dr. David Wylie. The school plans to adopt Morgan Park and use grant funds from Sunoco and SC Department of Health and Environmental Control to monitor water quality as well as clean and beautify the park and its surroundings.

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

Investigator: Leigh Wood  
North Inlet–Winyah Bay National Estuarine Research Reserve and Baruch Marine  
Field Laboratory, University of South Carolina

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: Dwayne E. Porter<sup>1,2</sup>, Tammy Small<sup>1</sup>, Melissa Ide<sup>1</sup>, Jennifer Kessie<sup>1</sup>, and Brooks Folk<sup>1</sup>  
<sup>1</sup>Belle W. Baruch Institute for Marine and Coastal Sciences and the Baruch Marine Field Lab,  
University of South Carolina; <sup>2</sup>Arnold School of Public Health, University of South Carolina

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/Dept. of Commerce. The CDMO website is [cdmo.baruch.sc.edu](http://cdmo.baruch.sc.edu).

### **University of South Carolina and Georgetown County School District Partnership Project "Creating an Early Childhood Nature-Based Inquiry (NBI) Model"**

Investigators: Dr. Bert Ely<sup>1</sup>, Amy Weinmeister<sup>2</sup>, Dr. Celeste Pringle<sup>3</sup>, Carolyn Greene<sup>3</sup>, Patti Hammel<sup>3</sup>, Chanda Cooper<sup>4</sup>, and Dr. Steve Thompson<sup>5</sup>

<sup>1</sup>Center for Science Education, University of South Carolina; <sup>2</sup>Longleaf Project, School of Environment, University of South Carolina; <sup>3</sup>Georgetown County School District; <sup>4</sup>Naturalist and Collections Manager, University of South Carolina Herbarium, <sup>5</sup>University of South Carolina College of Education

Current research shows to effectively teach science through inquiry, a teacher must have a strong understanding of the inquiry process and have had opportunities to conduct projects through an inquiry-based approach. Two significant components of effective science instruction at all education levels are 1) a teacher's strong science content background, including a solid understanding of the scientific or inquiry process, and 2) teacher self-efficacy in teaching science. In general, early childhood (PreKindergarten-3<sup>rd</sup> Grade) teachers do not possess either of these and therefore face significant obstacles to effectively teach science to their students. In addition, children naturally enjoy observing and thinking about nature, an educational setting that few teachers perceive as necessary for the teaching and learning of science. This translates into a need to plan and design more content-rich, inquiry-based professional development opportunities, including courses for in-service teachers, in natural or outdoor settings, in order to change teacher practices. Additionally, help is needed to support the design and construction of more areas in elementary schools where nature-based science learning experiences in the early childhood years can occur. Changing beliefs is the first step in changing classroom practices and allows teachers to become content and process competent.

The project targeting Pre-K – 3<sup>rd</sup> grade teachers in the Georgetown County School District's nine elementary schools provides professional development and science mentorship opportunities to strengthen teacher-participants' skills in teaching science to children, and will collect data on the effectiveness of such outreach services on student outcomes.

Our goal is to help teachers look at an alternative method to the teaching of science that builds on current research supporting the role of nature in students' cognitive and emotional development.

#### Measurable Objectives

- Increase teacher self-efficacy in science
- Increase teacher content knowledge in science

- Increase teacher application of inquiry processes and skills
- Increase student performance in science

Product Objectives

- Modification of outdoor spaces (school yards) to serve as outdoor inquiry areas.
- A Pre-K to 2nd grade nature-based inquiry guide and training manual aligned to state and national standards.
- Support of publications in peer-reviewed journals by participants, local and national teacher led presentations and USC/NBI mentors.

Now in year 3, the *Improving Teacher Quality (ITQ)* grant funds up to 15 teachers/administrators/media specialists per year to participate in a summer ecology institute at Hobcaw Barony and USC's new Longleaf Environmental Learning Center site at Prince George, with follow-up sessions during the school year with science and education specialists from the university. Additionally, Weinmeister works as science mentor with teachers, school personnel, and students at each school to plan and establish an onsite outdoor classroom/nature trail to be used in teaching children inquiry-focused science lessons.

Participating Schools:

Year 1, Andrews Elementary and Pleasant Hill Elementary

Year 2, Maryville Elementary, McDonald Elementary, and Plantersville Elementary

Year 3 (current), Brown's Ferry Elementary, Waccamaw Elementary, and LowCountry Preparatory\*

Year 4 (pending federal renewal), Kensington Elementary and Sampit Elementary

\* *Received permission by the CHE to expand its work into private schools in the community.*

Start and End Dates: Summer 2008- Summer 2012

Funding Sources: SC Commission on Higher Education and U.S. Department of Education

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