CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS

2012

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 2012

Introduction

Since 1969, Baruch Institute research associates have completed more than 690 scientific research projects at the BMFL, and students have completed hundreds of theses, dissertations, and special research projects. All of this work as well as projects conducted in other locations in SC, the USA, and globally has resulted in the publication of more than 1,670 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 85 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 34 of the investigators conducting research at the BMFL. In addition, 75 investigators representing 40 other institutions and agencies are carrying out projects at the BMFL. Dozens of graduate and undergraduate students assist scientists throughout the year to obtain hands-on training in field methods and to conduct research.

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 (NI–WB NERR).

A wide variety of basic and applied research is represented. The projects are listed randomly and each project summary includes the title, investigators, affiliations, and project abstract. Those projects that focus on long-term monitoring and research are grouped under the heading Long-term Studies. Likewise, projects focused on education and outreach and on data management are are grouped under those respective headings.

Funds for these research projects are provided by a variety of sources, including the National Science Foundation (NSF), Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA) National Estuarine Research Reserve System (NERRS) and SC Sea Grant Consortium, US Department of Energy (US DOE), US Dept. of Defense (DoD), 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. 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 (www.baruch.sc.edu).

Author and Title List

Characterization of wave and current energy levels in estuarine waters for particulate studies: Case study in Winyah Bay, SC

Investigators: Gwen Simmons and Dr. George Voulgaris
Marine Science Program, University of South Carolina

The overall objective of this study is to identify the total wave-induced energy present in an enclosed estuarine environment such as that of Winyah Bay. Evaluation of this energy and its correlation with sediment remobilization processes can be used to establish a baseline energy level for identifying the effect of human activities on the system, such as boating and associated wake-induced energy. Also this research can be used to define areas with higher energy levels that are not suitable for the disposal of dredged material, as it will pose risks of subsequent remobilization and dispersion in other areas of the system. Accurate definition of those energy levels requires identification of the circulation patterns and their variability in space, as well as the natural wave activity within the various parts of the estuary during period of wind forcing. In-situ data were collected for approximately forty days over the months of March and April 2011. Two different locations were occupied using two acoustic Doppler velocimeters (ADV). The deployment locations were in the lower reaches of the estuary (site S: 33° 15.002'N 79° 13.672'W, site N: 33° 15.690'N 79° 13.269'W) corresponding to different fetch lengths for the different predominant wind conditions. The in-situ data were used to validate the wave generation and propagation model Simulating WAves Nearshore (SWAN). The SWAN model was set up for the whole estuary using a finite differences grid that matched that of the FVCOM circulation model and will be used to determine the energy and sediment mobility of the estuary. This project is to be completed by summer of 2012 and is funded by the South Carolina Sea Grant Consortium.

HF radar surface current measurements in Long Bay

Investigators: Dr. George Voulgaris[1] and Dr. Dana Savidge[2]
[1]Marine Science Program, and Department of Earth and Ocean Sciences, University of South Carolina; [2]Skidaway Institute of Oceanography, Savannah

The objective of this study is to remotely monitor the ocean surface currents and waves in Long Bay using two new High Frequency radar (HF radar) stations. Scientists from the University of South Carolina, in collaboration with the Skidaway Institute of Oceanography and assistance from the University of North Carolina at Wilmington, have recently set-up these two stations. One station is located on the Hobcaw Barony in Georgetown, SC (33°21'19.60"N, 79° 9'12.56"W) and the other station is located at Caswell Beach, NC (33°53'25.18"N, 78° 1'40.64"W). Each station remotely measures the surface ocean currents up to 120 miles offshore and when combined create maps of temporal and spatial distribution of waves and currents over the entire Long Bay area. The data collected from this installation are critical in helping scientists understand the development of phytoplankton blooms along the outer shelf that are seen by scientists in satellite imagery. During the summer, development of phytoplankton is related to eddies generated by the Gulf Stream and could cause low oxygen conditions. However, the mechanisms for bloom development during the winter are not well known yet. Phytoplankton blooms in the winter actually prove to be beneficial, as they could provide a favorable feeding environment for larval fishes. Additionally, the data collected are in support of the National Radar Network funded by IOOS. The two stations are set-up and are scheduled to collect data until June 2012. This project is funded by NSF and IOOS through the Southeast Coastal Ocean Observations Research Association (SECOORA). Map location 1A

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

Investigators: Dr. Raymond Torres[1], Lew Lapine[2] and graduate students Joseph Bell[1], Jessica Chassereau[1], and Si Chen[3]
[1]Department of Earth and Ocean Sciences, University of South Carolina; [2]SC Geodetic Survey; [3]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 site 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 21). Island area is 0.4 km^2 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 installed nine SETs, and established 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[1], Dr. James Morris[2], and Ph.D. student Andrea Hougham Hughes[3]
[1]Department of Earth and Ocean Sciences, University of South Carolina; [2] Department of Biological Sciences and Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [3]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 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 were calibrated to monitoring data from 2006-2008 and are being used to reconstruct groundwater flow conditions at the time of the dieback in 2001/2002. A study of temporal and spatial variations in Ra activity in the porewater is in progress, using a combination of new field data and numerical models. Map location 2B. This project was funded through 2009 by the South Carolina Sea Grant Consortium; Ra work was funded by a NERR Fellowship (A. Hughes).

Sediment accretion in North Inlet salt marshes

Investigators: Dr. James Morris[1,2] and Karen Sundberg[2]
[1]Department of Biological Sciences and Marine Science Program, University of South Carolina;
[2]Belle W. Baruch Institute for Marine and 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[1,2] and Karen Sundberg[2]
[1]Department of Biological Sciences and Marine Science Program, University of South Carolina;
[2]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 locations 2A, 2B, 2C, 2D, and 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.

Interspecific competition among some salt marsh perennials in South Carolina

Investigators: Dr. Richard Stalter[1] and John Baden[2]
[1]St. John's University, NY; [2]US Army Corps of Engineers (Retired), 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[1], Chester B. DePratter[3], and John Baden[2]
[1]St. John's University, NY; [2]US Army Corps of Engineers (Retired), NC
[3]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 October, 2012. 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[1] and John Baden[2]
[1]St. John's University, NY; [2]US Army Corps of Engineers (Retired), 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 l.8 meters wide and consisted of eight lm x l.8m plots in a row roughly parallel to the water's edge. Within each of these plots, a central 0.5m x lm 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 l5-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^2) 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 l00% 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 and oyster reefs

Investigators: Drs. Dennis Allen[1] and Juliana M. Harding[2], Paul Kenny[1], and students[2]
` [1]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [2]Department of Marine Science, Coastal Carolina University, SC

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 many 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. A continuation of this work in tidal creek basins and a new effort to determine fidelity of demersal fishes associated with oyster reefs (e.g., gobies, blennies) will enable us to address patterns and mechanisms of biomass transfer within the tidal landscape.

Tide-dependent habitat utilization by predatory fishes in salt marsh creeks

Investigators: Matthew R. Helms[1], and Drs. Robert F. Young[1] and Dennis M. Allen[2]
[1]Coastal Carolina University, SC; [2]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

While large active predatory fishes such as drum, bluefish, rays, sea bass, mackerel, sharks, and flounder are known to populate tidal creeks and salt marshes, their distribution and foraging behavior relative to small intertidal and tributary creeks is poorly understood across the tidal cycle. We will examine assemblages of piscivores in main creek channels both adjacent to intertidal creeks and adjacent to straight banks throughout the tidal cycle. At various tidal stages, custom-built trotlines baited with live minnows will be deployed in the main channel at both habitat types. The resulting data will allow us to infer the times when predators are randomly dispersed throughout the ecosystem and when they are focusing on the intertidal habitats in which prey items may have taken refuge. Preliminary work in 2011 has given promising results, and nine pairs of tidal creeks and straight banks have been selected for full field testing, which will take place during the summer of 2012.

Funding support is provided by Coastal Carolina University.

An index for estimating abundance of juvenile gag, *Mycteroperca microlepis*

Investigators: Dr. Marcel Reichert and Paulette Mikell
Marine Resources Research Institute, SC Department of Natural Resources

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. 1987 *Fishery Bulletin* 85(3): 648-653) 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 postlarve with black grouper (*Mycterperca bonaci*).

***Anguillicoloides crassus*, an invasive parasite in the American eel: Survey and health effect on fish in selected estuaries in South Carolina**

Investigators: Dr. Steve Arnott[1,4], Dr. Isaure de Buron[1,3], Jennifer Hein[2], and Bill Roumillat[1,4]
[1]Marine Resources Research Institute, SC Department of Natural Resources; [2]Department of Environmental Studies, College of Charleston; [3]Department of Biology, College of Charleston; [4]Department of Marine Biology, College of Charleston

Reports of eel populations in South Carolina estuaries have shown a decline since at least 2001, when the SCDNR electrofishing survey began. The invasive parasite, *A. crassus*, infects the eel swimbladder and is considered one potential reason for the decline in American eel populations. This nematode is endemic to East Asia, where it infects the Japanese eel. It was first seen in the United States in 1995 in an aquaculture facility and one year later it was found for the first time in U.S. wild eel populations in Winyah Bay, SC. The parasite has since been reported in American eels along the Atlantic Coast but we have no information regarding the status of infection and impacts of this parasite on eel populations in South Carolina estuaries. The goal of this project is to survey the presence and health effects of the invasive parasite, *Anguillicoloides crassus*, on the American eel populations in the ACE NERR, North Inlet NERR, Winyah Bay, and the Cooper River. North Inlet NERR samples were collected from the Hobcaw Barony. Eels were collected from January 2011 through January 2012 to determine prevalence, intensities, and abundances of *A. crassus* at each sampling site. Preliminary data show that 49%, 67%, 60%, and 61% of eels were infected in the ACE NERR, North Inlet NERR, Winyah Bay, and the Cooper River respectively. Damage to the swimbladder, including thickness, opacity, and presence of blood and pigmentation were evaluated using a ranking system. The validity of using eel vent coloration as a noninvasive diagnostic tool as an indicator of *A. crassus* infection is currently being tested. Funded by a SeaGrant/NERR: 2011 Coastal Research Fellowship Program. Sampling locations at Hobcaw Barony include 1000 Acre Marsh, Marsh Road, Crabhaul Road.

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

Investigators: Drs. George Y. Matsui[1] and Madilyn Fletcher[1,2]
[1]Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [2]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 romerianus*, 2) determine how these communities are distributed along the roots, and 3) determine what factors contribute to differences in microbial community and distribution. The roots of *S. alterniflora*, *J. romerianus* 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, Belle W. Baruch Institute for Marine and Coastal Sciences, 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_2 and CH_4 fluxes from the marsh suggest that net ecosystem production (NEP) is likely to decline as salt water moves into tidal freshwater regions, but that the driving factor in decreasing NEP is lower plant production rather than increased ecosystem respiration. This research will build upon and contribute to the growing expertise of the University of South Carolina in areas of climate change. The research was funded for 2007-2008 by a grant from the University of South Carolina, Office of Research and Health Sciences Research Funding Program and from 2010-2012 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[1], Scott Neubauer[2], and P.V. Sundareshwar[3]
[1]Duke University, NC, [2]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [3]South Dakota School of Mines and Technology, SD

The structure and function of ecosystems is governed by the patterns of nutrient limitation of the primary producers (e.g., plants) and heterotrophs (e.g., soil microbes). Often, these groups of organisms are limited by the same nutrient. However, an increasing body of evidence indicates that different nutrients can limit primary producers and heterotrophs in some ecosystems; this is known as differential nutrient limitation (DNL). This study examines why DNL occurs in some ecosystems (but not others), and what the consequences of DNL are with respect to the utilization vs. storage of carbon. These questions will be tested in four wetlands ranging from Rhode Island to Georgia and including both freshwater and saline systems. One of our study sites is in North Inlet, where DNL has previously been documented. At each site, a network of field-fertilized experimental plots will be utilized to influence the nature of nutrient limitation. A standardized sampling approach at all sites will emphasize measurements of plant and microbial productivity, phosphorus cycling, and ecosystem metabolism. It is expected that DNL will occur in ecosystems with higher rates of phosphorus mineralization and that DNL will result in less storage of carbon. This study has implications for ecosystem management and theories of ecosystem development. The research provides a conceptual framework to integrate ecological studies at multiple scales by understanding how ecological stoichiometry (i.e., nutrient ratios) affects the biogeochemical cycles that govern ecosystem energetics. This project includes a commitment to students from under-represented groups (including American Indians) through a field research-mentoring program that will advance the participation of these groups in ecosystem studies. The project will be supported by the National Science Foundation from 2008-2012.

Impact of salt water intrusion on C storage in temperate tidal freshwater wetlands: Assessing the amount, age, and fate of mobilized C

Investigators: Drs. Scott Neubauer[1] and S.L. McCallister[2]
[1]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [2]Virginia Commonwealth University, VA

Rising sea levels, reduced precipitation in watersheds, and global increases in water consumption may result in widespread saltwater intrusion into tidal freshwater wetlands (TFWs). The movement of saline water into these historically freshwater ecosystems is likely to impact organic carbon cycling, including plant productivity, the decomposition of roots and litter, and the metabolism of soil microbial communities. Because organic matter accumulation is important in driving vertical accretion in TFWs, changes in organic carbon storage have implications for the ability of these wetlands to track rising sea levels and will ultimately play a role in determining the long-term stability and persistence of these valuable coastal ecosystems. The overall goal of this project is to understand how saltwater intrusion will impact the fate of organic carbon in TFWs, with multiple wetlands selected in both South Carolina and Virginia. This goal will be addressed by collecting soils from a matrix of TFWs, to cover a range of soil types, plant communities, and potential responses to saltwater intrusion. The fate of exchangeable organic carbon will be studied using a series of concentration, kinetic, and characterization measurements. The

whole soil organic carbon pool will be studied in incubations designed to determine total effects of saltwater intrusion on soil decomposition and the underlying biogeochemical pathways. Mesocosm experiments, using a C_4 plant/C_3 soil design, will allow the integrated system-level effects to saltwater intrusion to be determined, while also partitioning autotrophic and heterotrophic responses. Field measurements of soil CO_2 will assess in situ effects on organic carbon sources and ages. The project will be supported by the National Science Foundation from 2012-2014.

Development of monitoring and assessment tools for nitrogen and phosphorus in South Carolina coastal wetlands

Investigators: Drs. Dianne Greenfield[1] and Robert Van Dolah[2]
[1]Hollings Marine Lab and Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [2]SC Department of Natural Resources

It is generally accepted that elevated levels of nitrogen (N) and phosphorus (P) are associated with eutrophication in a wide range of aquatic systems globally. Yet, surprisingly little is known about how variable nutrient levels affect phytoplankton community composition and the resultant primary productivity of coastal South Carolina estuaries. Elucidating the interactions between estuarine nutrient levels and phytoplankton communities in SC is not only central to understanding ecosystem function, it is of contemporary relevance because coastal SC is undergoing some of the most rapid urbanization in the country that contributes to the deposition and accumulation of nutrients and fertilizers, making SC estuaries potentially susceptible to eutrophication, particularly from N-loading. The goal of this project is to assess biological (phytoplankton) responses to various nutrient conditions across the SC coastal zone. Methods include interannual field monitoring and both field and laboratory experimentation. At TA, we are conducting seasonal, 48 hr nutrient addition bioassays over a 2-year time frame to assess phytoplankton community responses to a variety of nutrient conditions. This is accompanied by ISCO-based autosampling (24 hrs) and water quality data from deployable YSIs. Results will not only help us better understand the nutrient conditions of TA, but they will also be used to assist regulating agencies for establishing numeric criteria for nutrient inputs to the SC coastal zone. This project is ongoing and will finish February 29, 2014. That study site on Hobcaw Barony is located at Thousand Acres (TA): Latitude = 33^o 17’ 57”, Longitude 79^o 15’ 36”; map location 6A.

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 is 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.

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 shore-birds such as Willets and Clapper Rails. Using a blind, we will set up video cameras and record the feeding and pre-response movements of fiddler crabs during

low tide for a period of 1 week each summer, and then use the data back in our lab at WSSU to conduct computer motion analysis. This project will begin in the summer of 2009 and is supported by the Winston-Salem State University Summer Undergraduate Research (SURE) and Research Initiation (RIP) programs.

Hard clam (*Mercenaria mercenaria*) population dynamics in North Inlet tidal creeks

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

Hard clam (*Mercenaria mercenaria*) populations play an ecological and structural role within tidal creek habitats. The population biology and dynamics of hard clams will be quantitatively examined within a North Inlet tidal creek with oysters (live and shell) and a North Inlet tidal creek without oysters. Hard clam age structure, growth rates and sex ratios will be compared between these two creeks. These population descriptors will be combined with measurements of environmental variables (water temperature, salinity, dissolved oxygen, total suspended solids) to provide a baseline from which to begin to understand clam dynamics in tidal creeks and their effects on habitat structure within the creeks over multi-year time scales. Map location 5.

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

Investigator: Dr. Juliana M. Harding
Department of Marine Science, Coastal Carolina University, 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 2012. 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.

Evaluation of changes in the phenology of demersal fishes, oysters and their interactions

Investigators: Drs. Juliana M. Harding[1] and Dennis M. Allen[2]
[1]Department of Marine Science, Coastal Carolina University, SC; [2]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina;

The effects of long-term increases in South Carolina estuarine and tidal creek water temperatures on habitat quality are largely unknown. Resident species including the naked goby (*Gobiosoma bosc*) and Eastern oyster (*Crassostrea virginica*) are likely to respond to increasing temperatures by changing the timing and intensity of spawning, gonad conditioning, recruitment, and predator-prey relationships set by co-occurrence of life history stages with other resident species or transient species that seasonally use estuarine and tidal creek habitats for nursery and forage grounds. The relationship between recurring biological events and climatic or environmental factors that influence them is known as phenology. This study will address effects of changing temperature on the phenology of these resident organisms. We will describe the population biology of demersal fishes (e.g., *G. bosc*, *Chasmodes bosquianus*, *Hypsoblennius hentz*) and oysters within the Town Creek and Clambank Creek systems during 2012. Standard qualitative and quantitative methods will be used to describe adult densities, demographics, and biomass on a seasonal basis in concert with focused examination of fish nesting and larval biology in the creeks as well as in situ mesocosms. Regular collections of larval fishes and oysters from these creeks during 2012 will supplement existing historic and modern collections of mesozooplankton and enable us to place the observed 2012 trends in context with previous collections and evaluate changes in their phenology. Cultured fish larvae will be used to examine the intensity of the predator-prey interaction with respect to ambient plankton and oyster veligers with respect to water temperature and predator age. Data collected during 2012 will establish a baseline for comparison with data sets collected during 2013 using fishes and oysters at ambient temperatures as well as fishes and oysters held at temperatures 3-4°C above ambient temperatures from fall 2012 through early spring 2013. This project is funded by the SC Sea Grant Consortium 2012 – 2014. Map location 4.

Response of the eastern oyster, *Crassostrea virginica,* to changes in temperature and oyster drill, *Urosalpinx cinera*, concentration with latitude

Investigator: Joshua Lord
University of Connecticut, Department of Marine Sciences, CT

This project is focused on assessing the thermal acclimation ability of oysters, as well as their physiological and morphological response to the presence of oyster drills. I have found oysters to produce thicker shells in the presence of the oyster drill *Urosalpinx cinerea* in laboratory experiments but have yet to measure this in the field. I will be sampling at up to 20 sites along the east coast of the US, including Oyster Landing in North Inlet, in March 2012. I will spend one to two days at each site and will measure oyster morphology and physiology at each site. Brief transect surveys will be conducted at each site to determine the population density of oyster drills. Sixty oysters will then be collected from along the transects and photographed (to determine shell area) and weighed. Oxygen consumption will be measured by keeping these oysters in closed containers for two hours exposed to one of four different treatments (n=15): ambient water temperature, five degrees above ambient temperature, 25 degrees Celsius, and ambient temperature in the presence of an oyster drill. After oxygen consumption is measured, 45 of the oysters will be put back in the habitat, while the other 15 will be dissected to assess gonad weights. This project would allow for many conclusions to be drawn about the different responses of the eastern oyster *Crassostrea virginica* to changes in temperature and predator density. If results from these experiments could be extrapolated to infer long-term responses to temperature increases and predation, then this could help predict the impact of environmental changes on this commercially important species. It may also help areas of the US west coast and Europe predict the impact of oyster drills, which are an invasive species in those locations.

Invasive species biology and foraging effects on mud crabs by infestation with *Loxothylacus panopaei*

Investigators: Katie O'Shaughnessy and Dr. Erin Burge
Coastal Marine and Wetland Studies, Coastal Carolina University, SC

Question: Does foraging success differ between unparasitized mud crabs and mud crabs parasitized by *Loxothylacus panopaei*?
Hypothesis: Parasitized crabs consume less oyster spat biomass than unparasitized crabs.
Objective: Calculate foraging rates of parasitized and unparasitized crabs within flow-through seawater tanks at the Baruch Marine Field Laboratory wet lab

Mud crabs of the species *Eurypanopeus depressus* will be collected from Clambank Creek. One flow-through seawater tank will contain ten small (15 cm x 15 cm x 4 cm) Tupperware containers with holes (<5 mm diameter) for water flow, and each holding one parasitized *E. depressus* individual; and one flow-through seawater tank will contain ten small (15 cm x 15 cm x 4 cm) Tupperware containers with holes (<5 mm diameter) for water flow, and each holding one unparasitized *E. depressus* individual. Live oyster spat adhered to tiles will be placed in each of the 20 containers in the seawater tanks, and counted before and after experiment. Spat will be collected by suspending tiles by string from Clambank Creek dock beginning mid-April, 2012. The experiment will be implemented the week of May 7, 2012, with duration of 5 days. Experiment will be repeated at least two times (May 21 – 28 and June 4 –11, 2012), or more if needed. Target date for completion of experiments is June 30, 2012.

Source of support: Coastal Carolina University, Coastal Marine and Wetland Studies Graduate Program.

Incorporation of a non-native seaweed into the food-web of southeastern estuaries

Investigators: Linsey Haram and Dr. James E. Byers
University of Georgia, Odum School of Ecology, GA

My dissertation research focuses on the impacts of an invasive species on the food-web structure and ecosystem function of southeastern salt marsh estuaries. This summer, I hope to address the most fundamental question of my research – How is this introduced species utilized by native consumers within the mudflats? The objectives of the project are to: 1) Determine what omnivorous organisms consume both live and decaying *Gracilaria vermiculophylla*, an exotic seaweed; and 2) Determine the role of secondary metabolites in controlling herbivory. I will achieve my goals by conducting controlled laboratory feeding trials using three different omnivorous consumers: the mud snail (*Ilyanassa obsoleta)*, a hermit crab species (to be determined), and amphipods. I will

compare consumption of *G. vermiculophylla* to that of *Spartina alterniflora* and *Ulva lactuca*, two native primary producers. Texture and shape of these three basal resources will be standardized by grinding the material and creating agars. Agars will be poured onto window screens to create an easily quantified grid.

To satisfy objective 1, feeding assays will be divided into 3 blocks: no-choice, choice, and control treatments. No-choice treatments will consist of offering consumers one of the three primary producer species. In the choice treatments, each consumer will be presented with equal amounts of all three primary producers. Finally, the control treatments will consist of primary producers without consumers. The consumers will be allowed to feed for 4 days or until 50% of the basal resource has been consumed. A total of 10 replicates will be executed per treatment per consumer species, resulting in 50 replicates per invertebrate species. I will run each replicate in an individual container (750mL) within the saltwater flow through system. This procedure will be applied for both live and decayed (sun-dried) primary producers.

For objective 2, I will extract the chemical compounds of *G. vermiculophylla* using standard techniques. Extracted chemical compounds in solution will then be coated on the surface of a known, benign food source (*Ulva lactuca*). I will also employ a control, in which *U. lactuca* will be coated with the same solution without the chemical compounds. These two food sources will be presented to consumers in the same design as presented for objective 1 (choice, no-choice, and control treatments).

Ideally, for each consumer species, I will run the three blocks simultaneously per objective, requiring nine different 4-day trial runs. However, if space is limited these runs could be broken down, which would require in a longer overall experimental duration.

This project will allow me to better understand the role that *G. vermiculophylla* plays within the estuarine food-web. Furthermore, by comparing consumption of *G. vermiculophylla* to that of *S. alterniflora*, my work will inform a longstanding debate about the importance of *S. alterniflora* as a food source within these systems. June 18, 2012 - August 3, 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. This work is funded by the National Science Foundation.

Individual personality and community interactions

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

Indirect interactions are common in ecological communities and are often propagated through communities via changes in individual behavior. However, many species exhibit large amounts of variation in individual behavior, with animals displaying different personality types. Further, individual animals often select habitat based on these personalities. Our work examines how individual personality influences the propagation of indirect interactions within food web interactions in oyster reef communities, and specifically, how personality alters the way that trophic interactions occur in different parts of the reef. This work is being conducted in tidal creeks within North Inlet and using wetlab facilities at Baruch. Results of this work will clarify community interactions and will improve our ability to predict the outcome of trophic dynamics.

Carry-over effects in physiological condition and reproduction

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

Many animals display annual cycles in activity that are tied to population growth. For example, many animals reproduce at specific times of the year. Yet often, this reproductive output is a result of physiological condition that is integrated over time scales much longer than the time period immediately surrounding reproductive events. A prime example of such a system is fiddler crabs that forage and store energy in their hepatopancreas that is used to finance reproductive efforts at a later time. I am examining how the timing and magnitude of reproduction is influenced by foraging during the previous year and by the duration and severity of winter periods of torpor. Results of this work could clarify likely responses of fiddler crab populations to climate change, and will also help us understand annual variation in reproduction.

Size-structured predator-prey interactions in intertidal oyster reefs

Investigators: Benjamin J. Toscano[1] and Dr. Blaine D. Griffen [1,2]
[1]Department of Biological Sciences, University of South Carolina; [2]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 currently supported by an NSF Graduate Research Fellowship under Grant No.DGE-0929297.

Effect of autotomy on *Panopeus herbstii* body temperature and mortality

Investigators: Cristián J. Monaco and Benjamin J. Toscano
Department of Biological Sciences, University of South Carolina

Our project's objective is to evaluate the combined effects of temperature fluctuations and autotomy on *P. herbstii* populations that inhabit intertidal oyster reefs in North Inlet estuary. 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 the Oyster Landing 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 to determine how autotomy might interact with environmental temperature to determine crab mortality. Cages will be set on pure-mud flats adjacent to Oyster Landing. 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 organism's thermal tolerance levels.

The effect of predation risk on the vertical distribution of personalities and TMII variation throughout the intertidal

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

Trait mediated indirect interactions (TMMI) are a form of indirect biotic interactions in which an organism influences the behavior, morphology, or physiology of a second species via its interactions with a third. Within the intertidal oyster reefs of South Carolina, the toadfish *Opsanus tau* influences the behavior of the mud crab *Panopeus herbstii* and has an indirect positive influence on bivalve survivorship. TMII, moreover, is influenced by individual

trait variation and their responses to predator cues. We plan to further explore the concept that individuals with bold personalities place themselves lower in the intertidal than those which tend to be shyer. This, in turn, will influence the TMII of the different regions, with a larger TMII response located higher in the intertidal. Within the oyster reefs of Oyster Landing, field cages will be distributed throughout different levels of the intertidal. Individual personalities will be assessed before transplanting individuals from the intertidal region to the subtidal region and vice versa. TMII will then be measured based on mussel survivorship. It is predicted that the spatial behavioral structure will result in a similar variation in TMII. The behavioral types demonstrated in this experiment will be used to improve our ability to predict the strength of TMII and how organisms organize themselves within an ecosystem. This work will begin in May 2012 and end in August 2012 and is supported by NSF grant number OCE-1129166.

Evaluating the impact of claw removal on diet, physiological condition and reproductive abilities of the female stone crab *(Menippe* spp.*)*

Investigators: Jessica Hogan, Erin Adams, and Dr. Blaine Griffen
Marine Science Program and Department of Biological Sciences, University of South Carolina

Though stone crabs (*Menippe* spp.) are well studied, little research has been conducted to determine the impact of claw removal on diet choice, physiological condition and reproductive ability.

The objective of the proposed research at Baruch is to determine:

The impact of injury on diet choice of *Menippe* spp.

The impact of changing diet on *Menippe* spp.'s ability to reproduce

To determine the impact of claw removal on diet choice of female crabs, crabs with both claws and crabs with an autotomized claw will be presented a diet of both algae and mussel.

To determine the natural impacts of claw loss on diet, twenty female stone crabs will be caught from the North Inlet estuary to observe gut content. Of the twenty crabs examined, ten will have lost a claw prior to being caught.

To determine the impact of varying diet on physiological condition and reproductive output, female crabs will be obtained, half will be forced to autotomize one claw, presented a diet of varying mussel and algae content, and will be allowed to reproduce.

The energy required for the crabs to regenerate limbs is expected to decrease the amount of energy allocated to reproduction, thus lowering yearly fecundity of female crabs. Gaining an accurate understanding of how limb regeneration impacts yearly fecundity of females is necessary to fully understand the dynamics of the stone crab population. The results of this study could lead to an improved management strategy for the stone crab fishery in South Carolina.

Diet Choice: A total of twenty mature female stone crabs of various sizes will be obtained from North Inlet estuary. The crabs will be individually contained in aquaria with filtered flow-through seawater in an outdoor laboratory, thus allowing temperature and salinity to fluctuate with the ambient conditions in the estuary. The crabs will be fed three times a week with a diet consisting of equal amounts of algae and mussel. One crab will be forced to autotomize one of its claws. After approximately one month of feeding, the crabs will be sacrificed and dissected to analyze gut content and size.

Diet Choice, Physiology & Reproduction: Forty reproductively mature female crabs will be obtained from the North Inlet estuary. The crabs will also be individually contained in aquaria with filtered flow-through seawater in an outdoor laboratory. The individual containers will be designed to capture all excess food and generated feces. The provided diet will contain mussels and algae, and will vary in composition from 0% algae – 100% mussel, to 100% algae – 0 % mussel at 25% increments. A total of twenty treatments varying in the amount of food and composition of the food will be used. The crabs will be fed three times per week with all remaining food and generated feces collected after 24 hours. The crabs will be paired by carapace width, and one crab from each pairing will be caused to autotomize one of its claws. To determine the crabs' reproductive output, the crabs will be allowed to produce as many egg masses as possible over the course of five months. The sponge produced from each crab will be collected and eggs will be counted to approximate yearly reproduction. After approximately four months of feeding and reproducing (representing the peak reproductive season between May and August), the crabs will be sacrificed and dissected. From this, the gut content, hepatopancreas size, ovary size will be determined. Further analyses will be conducted to determine carbon, nitrogen, and lipid content and energetics of the hepatopancreas and ovaries. This project will begin in May and conclude in August, 2012. Crabs will be collected from various sites in North Inlet

Impacts of climate warming on the reproductive biology of *Uca pugnax*

Investigators: Dr. Renae Brodie and students
Mount Holyoke College, MA

Renae Brodie's lab at Mount Holyoke College is investigating the impacts of climate warming on the reproductive biology of *Uca pugnax*, a species of fiddler crab whose northern range edge is located just south of Cape Cod (their southern range edge is in Florida). Renae and collaborators from three other labs have deployed dataloggers in fiddler crab habitats from Massachusetts to Georgia to record temperatures experienced by the crabs each hour, year-round. They will test hypotheses about how temperature impacts the ability to survive and invest in reproduction, both of which will have an impact on the geographic range of this species as the climate continues to change.

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

Investigators: Drs. James E. Byers[1], David Kimbro[2], Jonathan Grabowski[3], Michael Piehler[3], and Randall Hughes[2]
[1]University of Georgia, GA; [2] Florida State University, FL; [3] UNC, Institute of Marine Science, NC

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[1], Erik Alberts[1], Stephen Taylor[1], and Paul Kenny[2]
[1]Department of Chemistry, Purdue University, IN; [2]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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

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 were determined. Swashes typically are estuarine systems maintained by tidal rivers draining localized watersheds over mainland beaches during high tide. In December 2009 bivalves collected from a common field location were placed in mesh cages within 3 swashes and 3 ocean-dominated inlets along the Grand Strand, SC. The caged bivalves were monitored and then recollected in December 2010 and growth and survival of individuals were assessed. Differences were noticed in the survival of oysters and mussels over the one year period based on location. In May 2010 settlement samplers were placed at the same swash and inlet locations and the contribution of larval settlement and survival to oyster population dynamics assessed. It was found that there is a significant difference in oyster spat settlement between inlets and swashes. Food available in the water column for bivalves was determined by water samples which were collected 7 times throughout summer/fall 2010 and used to assess salinity and the amount of chlorophyll/pheophytin. Results of this study provide critical information necessary to predict whether bivalve populations within swashes can be increased through oyster reef restoration in an attempt to address declining water quality in the area.

Sublethal effects of crude oil on the community structure of estuarine phytoplankton

Investigators: Kailen Gilde and Dr. James L. Pinckney
Marine Science Program and Department of Biological Sciences, University of South Carolina

While the ecological impacts of crude oil exposure have been widely studied, its sublethal effects on phytoplankton community structure in salt marsh estuaries has not been well-documented. The purpose of this study was to simulate oil spill conditions using a microcosm design to examine short-term (2 day) changes in phytoplankton community composition and total biomass following exposure to crude oil obtained from the Deepwater Horizon oil spill and a mixture of Texas crude oils. Microcosm experiments were performed in situ in North Inlet Estuary near Georgetown, SC. A control and six replicated experimental treatments of crude oil additions at final concentrations of 10, 50, or 100 $\mu l\ l^{-1}$ of either Deepwater Horizon spill oil or the Texas crude mixture were incubated under in situ conditions. Photopigments were analyzed using HPLC and community composition was determined using ChemTax. Total phytoplankton biomass (as chl *a*) declined with increasing crude oil concentrations. Prasinophytes, the most abundant microalga in both experiments, showed no response to oil exposure in one experiment and a significant negative response in the other. Diatoms euglenophytes, and chlorophytes appeared relatively resistant to oil contamination at the exposure levels used in this study, maintaining or increasing their relative abundance with increasing oil concentrations. Chlorophytes and cyanobacteria increased in relative abundance while cryptophyte abundance decreased with increasing oil concentrations. The results of these experiments suggest that low levels of crude oil exposure may reduce total biomass and alter phytoplankton community composition with possible cascade effects at higher trophic levels in salt marsh estuaries.

Funding for this project was obtained through an award to K. Gilde from the Magellan Scholar Undergraduate Research Program, Office of Undergraduate Research, University of South Carolina

Anthropogenic antibiotics and their unintended consequences upon the marine benthos

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

The last two decades have seen an increasing interest in the ecological effects of pharmaceuticals and personal care products, tons of which are released into the environment every year. Antibiotics have received a great deal of scrutiny over that time as worries about drug-resistant microorganisms and unintended effects upon non-target

species have grown. A global effort is currently underway to identify compounds of concern and document their toxicological and ecological effects. The vast majority of these studies have ignored marine systems, focusing instead on the effects of single compounds upon freshwater systems and freshwater species. While herbicide mixture effects have been investigated, very few studies have investigated the effects of pharmaceutical combinations upon non-target organisms.

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 diatoms. Diatoms are important as carbon fixers, food items and regulators of bigeochemical fluxes across the sediment/water interface. Stressors that negatively impact BMA communities therefore have the potential to cause a cascade of environmental and ecological effects across multiple scales.

The overall objective of this study is to investigate the impacts of antibiotics in marsh ecosystems. Our completed objectives include the quantification of negative impacts of three common antibiotics and their combinations upon two common benthic diatom species. The objectives for 2012 are:

1. Show whether three antibiotic compounds and their combinations directly affect benthic diatoms and BMA communities in situ at environmental concentrations.

2. Apply these findings to a food web model to estimate ecological impact.

The antibiotics to be used are tylosin (veterinary), lincomycin (veterinary) and ciprofloxacin (human). Each targets a different component of prokaryotic biochemistry and are commonly found in the environment. They will be used both singularly and in combination to assess their effect upon benthic community primary productivity and whether combinations behave synergistically, antagonistically or additively. Effect will be determined using core samples taken from Oyster Landing and incubated in mesocosms at USC, Columbia. Project duration: Spring 2010-Fall 2012. This project is funded by the USC Estuarine Ecology Lab.

Trophic responses to chronic exposure to polycyclic aromatic hydrocarbons and copper in tidal mudflats of North Inlet, South Carolina

Investigators: Leslie Muggelberg and Dr. James L. Pinckney
Department of Biological Sciences, University of South Carolina

This project will investigate the potential effects of two common pollutants, polycyclic aromatic hydrocarbons (PAHs) and copper (Cu), on estuarine communities in the North Inlet – Winyah Bay National Estuarine Research Reserve (NI-WB NERR). The effects of PAHs and Cu on benthic microalgae (BMA) as well as the consequential effects on the food web will be determined by examining the effects on feeding rates of fiddler crabs.

Sediment cores and crabs will be collected from Oyster Landing. The cores will be transferred to microcosms and exposed to one of three treatments: 1) +PAH, -Cu, 2) -PAH, +Cu, 3) +PAH, +Cu. Controls will include (-PAH, -Cu) or (+ toluene). After 10 days of incubation, BMA biomass and primary productivity will be measured. Three experiments will be performed to assess the direct, indirect and combined effects of the contaminants singly and in combination on crab feeding rates by exposing crabs only, BMA only and both crabs and BMA to the contaminants (with the same treatments as above). Feeding rate will be assessed by measuring the difference between initial and final BMA biomass after crabs have been introduced to the sediment cores and allowed to feed for 4 days. This will start in May 2012 and conclude in October 2012 and is supported by the Estuarine Ecology Lab, USC

Aqueous- and sediment geochemical-phase toxicity of the divalent metal nickel to estuarine invertebrates under high and low organic carbon conditions.

Investigators: Dr. G. Thomas Chandler and Kate Washburn
Arnold School of Public Health, Department of Environmental Health Sciences, University of South Carolina

Sediment-associated metals are often the most abundant and persistent contaminants in estuarine and marine ecosystems (Chapman *et al.* 1982, 1983, 1984). In addition, >95% of sediment infauna reside in oxygenated microenvironments, but unfortunately few ecotoxicological methods are currently available for marine fauna to address these dynamics at the population levels and above.

This is the first phase of an anticipated three year project in which, we will examine: (1) chronic aqueous and spiked sediment toxicity of the model divalent metal nickel to two representative estuarine organisms -- the meiobenthic copepod *Amphiascus tenuiremis*, and the infaunal amphipod *Leptocheirus plumulosus*. For the

copepod, aqueous Ni exposures will be conducted using a 96-well microplate format to produce a detailed Leslie-matrix population dynamics model of predicted population growth and structure over time for each exposure concentration.

For the copepod and amphipod, fresh field-collected sediments from a "high and low % organic carbon" mudflat in the North Inlet estuary will be used in the "*Leptocheirus plumulosus* 28-d growth and reproduction test" to assay nickel effects and biogeochemical controls on amphipod toxic response. The meiobenthic copepod sediment toxicity test will be extended through 28 days. Stage and sex-specific survival rates coupled with fecundity measures will be used to produce estimates of intrinsic population growth (r), as a function of nickel exposure and extrinsic factors such as TOC, DOC, sediment sulfides, etc. A robust comparative risk assessment for nickel in estuarine systems is the desired outcome of the project. Funding Source: Nickel Producers Environmental Research Association (NiPERA)

Detection of medically important gram negative bacteria in surrounding water bodies of Hobcaw Barony

Investigators: Veronica Obregon, Kala Downey, and Dr. H. Neval Erturk
Converse College, SC

The original purpose of this study was to investigate the phytoplankton diversity in water bodies surrounding Hobcaw Barony using Environmental PCR. However, we encountered some difficulty in both collecting phytoplankton and isolating DNA to perform PCR. As a result, we decided to use differential tests and PCR to identify medically important gram negative bacteria. Bacteria of the Enterobacteriaceae family typically exist in the human gut and are part of the normal intestinal flora. However, this family also consists of pathogenic and opportunistic bacteria, such as *Salmonella* spp. and *Escherichia coli.*

Water was collected from five different locations varying in salinity and dissolved oxygen. The Remel RapID ONE^{TM} system, a biochemical diagnostic test, was used to identify bacteria of the Enterobacteriaceae family. PCR was also performed to detect the presence of *Escherichia coli.* The identification tests revealed a presence of different opportunistic pathogens, including *Acinetobacter calcoaceticus.* Upon gel analysis from PCR products, *E. coli* was found to be present in two different sites with both sites having little to no salinity.

These results indicate that there is a presence of gram negative bacteria in these bodies of water. The *E. coli* could be of human or wildlife origin. Further investigation would be needed to confirm the source of the bacteria. Extensions of this project could include a repeat of the study next year and subsequent years in order to evaluate if the impact is increasing or decreasing. Also, the study could be performed at different times of the year to investigate if there are any possible fluctuations in the Eneterobacteriaceae bacteria content throughout the seasons. Funding support came from the Belle Baruch Foundation.

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, Ashley Riggs, and Amy Willman
Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina, 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 South Carolina Sea Grant Consortium for the period February 2010 to July 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: Dr. Erik Smith[1], Angie Defore[1], Dr. Richard Peterson[2], Dr. Susan Libes[2], Dr. Richard Viso[2], Dr. Denise Sanger[3], Dr. Jennifer Plunket[1], and M. Richard DeVoe[3]
[1]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina and the North Inlet–Winyah Bay National Estuarine Research Reserve, [2]Coastal Carolina University, SC; [3]South Carolina Sea Grant Consortium

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 the period September 2010 to August 2013.

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

Investigators: Dr. Erik Smith[1], Tracy Buck[1], Amy Willman[1], and Dr. Eric Koepfler[2]
[1]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina and the North Inlet–Winyah Bay National Estuarine Research Reserve; [2]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.

Development and pilot study of a vulnerability assessment tool for coastal and estuarine environments

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

Vulnerability assessments are useful to help resource managers better understand and plan for the potential impacts of climate change on species and habitats. Existing climate change vulnerability assessment tools were developed based on terrestrial habitats or species, or migratory species such as shorebirds, and there currently is no tool that focuses on the unique sensitivities, stressors, exposure and adaptive capacities of estuarine and coastal environments. The National Estuarine Research Reserve System and other coastal partners are initiating the use of vulnerability assessments to aid in planning and targeted management actions, and therefore need a tool that can effectively and efficiently assess vulnerability of the habitats within coastal habitats. A workgroup from the Reserve system has begun to examine the questions, approaches, information management infrastructure and decision making process of existing models in order to develop a tool that can be applied to reserves. This tool will be piloted at four reserves, including the North Inlet-Winyah Bay NERR. Results from the pilot vulnerability assessment will be shared with local coastal partners, and also used to refine the model for use throughout the Reserve System.

Relating marsh characteristics to relative abundances of three species of wintering *Ammodramus* marsh sparrows in South Carolina

Investigators: Kim Trinkle[1] and Dr. Chris Hill[2]
[1]Coastal, Marine, and Wetland Studies, Coastal Carolina University, SC; [2] Biology Department, Coastal Carolina University, SC

Saltmarsh sparrows (*Ammodramus caudacutus*), seaside sparrows (*A. maritimus*), and Nelson's sparrows (*A. nelsoni*) winter in salt marshes along the Atlantic coast. Previous research has found differences in relative abundances of the three species at several sites in South Carolina. The objective of this study is to determine if the differences in relative abundances between sites is due to differences in the marsh landscape at each site. We will band sparrows approximately once every two months at each site from 0700hr-1100hr. Our five sites include two high marsh islets near Goat Island (33.340533°N, 79.183587°W; 33.338810°N, 79.187924°W), a small island on Town Creek (33.335519°N, 79.173519°W), a small island on Debidue Creek (33.343164°N, 79.166773°W), and a site on the southern edge of the property along Reserve Bank Road (33.304426°N, 79.243745°W). Habitat at each site will be analyzed by estimating percent cover at 45 1-m^2 vegetation plots as well as using GIS.

Knowledge of these species' breeding biologies is increasing, yet little is known about their winter habits. Identification of habitat variables associated with the relative abundance of each species can be combined with models of habitat change caused by sea level rise to predict how this phenomenon will affect wintering populations of sparrows.

This study began October 2011 and will continue until April 2012. This study is supported by funds from the Coastal, Marine, and Wetlands Studies Program at CCU, a graduate research incentive grant to Kim Trinkle, and the Franklin and Virginia Spivey Ornithology Endowment.

Choices and consequences of habitat selection in tidal marsh sparrows

Investigators: Alyssa Borowske[1] and Chris Elphick[1], in collaboration with Kim Trinkle[2] and Chris Hill[3]
[1]Ecology and Evolutionary Biology Department, University of Connecticut, CT; [2]Coastal Marine and Wetland Studies Program, Coastal Carolina University, SC; [3]Biology Department, Coastal Carolina University, SC

Saltmarsh (*Ammodramus caudacutus*), seaside (*A. maritimus*) and Nelson's (*A. nelsoni*) sparrows are short-distance migrants whose threatened global populations winter exclusively in tidal marshes in the south-eastern United States. While closely related and with similar habitat requirements, the three species have different strategies regarding territoriality, monogamy, and parental care, which lead to distinct predictions regarding choices and consequences of habitat selection throughout the annual cycle. Little is known about within-species migration patterns or survival and condition of tidal marsh sparrows, but the information will be important for determining in which season, and in which part of the annual range, conservation efforts should be concentrated.

Through extensive mist-netting during the non-breeding period in South Carolina and the breeding period in Connecticut (saltmarsh and seaside only), we will use key comparisons between species, within species (separated by sex), and across seasons to investigate differential migration patterns and within-season body condition and survival. We will mist-net sparrows at high tide roosts at five locations in North Inlet: two near Goat Island (33°20'19.72"N, 79°11'16.53"W; 33°20'25.92"N, 79°11'0.91"W), two east of Town Creek (33°20'7.87"N, 79°10'24.67"W; 33°20'35.39"N, 79°10'0.38"W) and one by Reserve Bank Road (33°18'15.92"N, 79°14'39.17"W). We will visit each site one to three times between December and March, for three years. We will band, weigh, and measure the sparrows, assess fat and muscle condition, and collect feather samples as a source of DNA for genetic sexing. Non-breeding season data will also be collected at Huntington Beach State Park and Waties Island.

The non-breeding component of this study began in December 2011, and will continue through March 2014. This study is supported by an NSF Graduate Research Fellowship to ACB and, for the breeding season work, by a U.S Fish and Wildlife Service State Wildlife Grant to CSE et al. (Saltmarsh Habitat and Avian Research Program).

Geographic variation in salt marsh endemic marsh wrens

Investigators: Sarah Manor[1], Drs. Russell Greenberg[2] and Bernard Lohr[1]
[1]University of Maryland, MD; [2]Smithsonian, National Zoological Park

This project will quantify the geographic variation of populations of marsh wrens in the eastern United States, with particular emphasis on populations native to tidal salt marshes. I will measure variation by using metrics with different levels of sensitivity to divergence (color, morphology, behavior, and genetics) so that I can use marsh wrens as a model for studying early-stage speciation.

Methods: Capture individual marsh wrens using targeted mist netting (fine nylon mesh nets for catching song birds). Photograph, measure, and take blood samples from each bird. Birds will also be banded with a USGS aluminum leg band. Netting and handling of birds is all in keeping with guidelines set forth by the North American Ornithological Council and is always practiced to reduce stress to the bird. In addition to catching birds, recordings will be made of the vocalizations of free-ranging birds. Vocal recordings will not impact the birds in any way.

Discussion: Geographic variation in the marsh wren is widespread, with 16 described subspecies in the United States and Mexico. Some subspecies inhabit fresh water marshes, while others inhabit tidal salt marshes. These two widely different environments likely result in local adaptations necessary for the survival of local populations. Geographically separate populations with local adaptations are a classic model used to explain early stages of divergence and eventual speciation. By studying populations in this early stage of divergence, and measuring their variation using metrics of different sensitivity (physical appearance, behavior, and genetics), I will better understand the processes of early-stage divergence. Additionally, quantifying the variation of populations of marsh wrens along the Atlantic Coast will assist in determining the necessity of conservation for populations in threatened habitat, such as northern Florida, where marshlands are under considerable pressure from human development. This project will begin in April 2012 and completion is expected in July 2015.

Kleptoplasty in the North Inlet and Winyah Bay estuaries(Hobcaw Barony) SC

Investigators: Dr. Megan Cevasco and students
Department of Biology, Coastal Carolina University, SC

Kleptoplasty is a term used to describe the ability of a heterotrophic host organism to "steal" the photosynthetic organelles (plastids) of its prey. Stolen plastids (kleptoplasts) remain functional within the host for extended periods of time and enable the host organism to photosynthesize and obtain energy through autotrophic CO2 fixation, as well as, from heterotrophic feeding: a condition known as "mixotrophy". Mixotrophy due to the kleptoplastic condition has been shown to have important stabilizing effects on the trophic structuring in ecosystems by increasing the total primary and secondary production in planktonic food webs. In the last decade, multiple foraminifera genera have been found to harbor kleptoplasts; *Elphidium* and *Haynesina* are two of the most common inhabitants of the Western Atlantic estuarine and tidal marsh habitats.

The primary aim of this study is to identify and examine the potential ecological contribution of the kleptoplastic condition in the foraminiferal taxa inhabiting North Inlet and Winyah Bay, by determining the presence and abundances of kleptoplastic foraminifera. The PI with students found both *Elphidium* and *Haynesina* to be present and in high abundance at Waties Island, SC. As part of this study, molecular and microscopic techniques will be used to determine the taxonomic identification of the foraminiferal hosts as well as the plastid donors. Exploratory feeding and photo-inhibitions experiments will be conducted on subsamples of kleptoplastic foraminifera to assess the prevalence and robustness of the kleptoplstic condition as it contributes to primary production and the tropic ecology of Winyah Bay. Surveys of micro-algal and foraminiferal biodiversity in estuarine habitats will also be untaken.

Methods: The top 1 cm of sediment will be sampled monthly at low tide from multiple estuarine and tidal marsh locations with North Inlet and Winyah Bay beginning the in the summer of 2012. Sediments will be sieved to remove particles >500µm and examined for live foraminifera (~100-250µm) under a dissecting scope. A subsample of the foraminifera will be imaged by epifluorescent and light microscopy, the rest will be starved in dark conditions, so that only the kleptoplasts will remain the host's cytoplasm. These starved foraminifera will be processed before standard DNA extraction using the *Qiagen All Prep DNA/RNA Mini Kit*. This research will use a combination of algal 18S ribosomal primers and 16 S plastid primers in PCR amplification. All samples selected for nucleotide sequencing will be cleaned using ExoSAP-IT® (Affymetrics) and sent to *Gensript* Sequencing Services. For Mixotrophy experiments, kelptoplastic foraminifera will be starved for a week and then provided with alternate algal prey. Using the DNA and PCR techniques described above, kleptoplast identity will be determined to test the ability of the foraminifera to establish kleptoplastic relationships with alternate prey.

This project is supported by the 2012 Harry M. Lightsey, Jr Visiting Scholar Award by the Belle W. Baruch Foundation's Board of Trustees.

The effects of salinity, pH, and dissolved oxygen on the sensitivity of PCR identification of the T4 bacteriophage in estuarine water

Investigators: Dr. Paul Richardson and students
Department of Chemistry, Coastal Carolina University, SC

Bacteriophages, also referred to as phages, are a class of viruses that only infect bacteria. Phages are a very simplistic entity because they are not a living organism. They can only replicate when they have infected a host, and therefore, are parasitic. They take over cellular operations and multiply in the host until the bacteria cell busts open, and then they begin searching for a new bacterial host to infect. The bacteriophage T4 (a coliphage) infects *Escherichia* coli (*E. coli*), which is a common bacterium that is found in water contaminated with fecal matter. Although all fresh or salt water have large number of bacteria in them, many bacteria are not pathogenic. Bacteriophages are critical to the control of bacterial populations and maintaining colony diversity.

Bacteriophages have been used as indicators to predict the presence of pathogenic bacteria in drinking, waste, and recreational waters; and coliphages are as adequate an indicator of fecal pollution as are actual coliform counts. But little is known about the survival and persistence of bacteriophages in saline environments; however, recent research has shown that phages are sensitive to temperature, chemical treatments, and salinity. The lower number of bacteriophages present in salt water requires a sensitive detection method to be an effective indicator. A PCR protocol which has been developed for ideal laboratory conditions will be used to evaluate whether seawater properties affect the sensitivity of this PCR method. This study's focus is to determine the effect of the different water characteristics on the sensitivity of the PCR identification of virus particles; this will allow a detection

threshold to be determined on environmental samples and further test the sensitivity of the protocols developed. This study will further elucidate the effect seawater (salinity, pH, and dissolved oxygen content) has on bacteriophage levels in an estuary.

Methods: Water and soil samples will be collected semi-monthly at 4 Hobcaw estuarine sites. Water quality (salinity, pH, and dissolved oxygen content) values will be recorded. Samples will be filtered using a 0.45µm filter, and half the filtered sample will be added to an *E. coli* culture to be amplified. The other half will be used to count the number of viral particles present. PCR and gel analyses will be run on the amplified samples. Counts of bacteriophages per milliliter of viral sample will be determined by counting the number of lytic plaques on triplicate LB agar plates multiplied by the dilution factor multiplied by 30.

This project is supported by the 2012 Harry M. Lightsey, Jr Visiting Scholar Award by the Belle W. Baruch Foundation's Board of Trustees.

Nesting ecology of the diamondback terrapin (*Malaclemys terrapin centrata*) in the North Inlet and Winyah Bay estuaries, South Carolina

Investigators: Dr. Scott L. Parker and Dr. Kevin S. Godwin
Department of Biology, Coastal Carolina University, SC

Understanding nesting ecology of diamondback terrapins is essential for conservation efforts because female terrapins require nest sites with suitable thermal and moisture conditions to support successful egg incubation. The aim of this study is quantify biophysical characteristics of diamondback terrapin nesting sites in the North Inlet and use these data to generate a model to predict environmental microhabitat features of likely nesting sites. Ten terrapin nests were located on a small sandy island located in high marsh habitat (33° 21' 45'' N; 79° 10, 09'' W) during spring and summer 2011. Substrate nest temperature, moisture, salinity, percent vegetation ground cover, and plant species composition were measured for each nest as well as for 10 randomly selected simulated nests. Nest predation by raccoons was extremely high and occurred within 24-48 hours of nest construction. The study will continue in the spring and summer 2012 and expanded to include surveys of probable nesting areas in sand dune habitat adjacent to Debidue Creek.

Funding for this project was provided by the Belle W. Baruch Foundation, Harry M. Lightsey Visiting Scholars Grant and Coastal Carolina University.

Spatial ecology and nest substrate biophysics of diamondback terrapin (*Malaclemys terrapin)* in a South Carolina marsh

Investigators: William B. Hills, and Drs. Scott L. Parker and Eric Koepfler
Department of Biology, Coastal Carolina University, SC

This research project will radio-track Diamondback terrapins *Malaclemys terrapin* and survey nests during the nesting season in North Inlet. The primary objectives of data collection will address three aspects of terrapin ecology; spatial distribution in the salt marsh, thermal environment of terrapin during active season, and biophysical characteristics of the nesting substrate with regards to the hydric environment.

Terrapin will be captured using a variety of techniques: primarily seines and trammel nets, supplemented by dip nets and cast nets, as well as trapping using crab pots modified to provide air access to trapped turtles and modified pit-fall traps. Terrapin will be marked along marginal scutes continuing a pattern already in use in North Inlet by Dr. Peter King of Francis Marion University uniquely identifying individuals. Measurements will be taken and sex determined according to Tucker et al. (2001). A subset of approximately 20 terrapin will have radio-transmitters and temperature loggers attached to the rear portion of their carapace using marine epoxy, avoiding the need to drill into a carapace. Terrapin will then be assigned to a tracking schedule to monitor daily movement and activity during different tidal heights, monitoring each individual multiple times weekly throughout the nesting season.

Sediment cores will be taken at known nesting areas and will be analyzed according to grain size, sorting roundness, and organic content. The project looks to employ emerging sensor technology that is small and accurate enough to quantify hydric environment characteristics throughout the incubation cycle, measuring water content and water potential by inserting them immediately adjacent to the nesting chamber. Temperature data will also be collected. This data will be coordinated with tidal, precipitation, and temperature data to give a comprehensive look at how water potential varies seasonally in correlation with incubation length and hatchling survival.

Baruch wind assessment: Project summary

Investigators: Ralph Nichols[1], Eric Bosseneck[2], Dennis M. Allen[3], and George Chastain[4]
[1]Savannah River National Laboratory; SC; [2]Renewable Energy Department, Santee Cooper;
[3]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences,
University of South Carolina; [4]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 are in these same areas in Horry, Georgetown, and Charleston counties. 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 understanding coastal and offshore wind potential. This project proposes to assess wind conditions in the North Inlet area (map location 8). 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.

Baruch Visiting Scientist Awards

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

Evaluating connectivity and resource use patterns by resident fishes of intertidal and subtidal marsh creeks

Investigators: Drs. Kevin Boswell[1], Matt Kimball[2], and Dennis M. Allen[3]
[1]Department of Biological Sciences, Florida International University, FL; [2]GTM NERR and
University of North Florida, FL; [3]Baruch Marine Laboratory, Belle W. Baruch Institute for Marine
and Coastal Sciences, University of South Carolina; and North Inlet–Winyah Bay NERR

Goals: I propose to expand the general theme of fidelity, habitat utilization and movement of numerically dominant fish and invertebrate species (e.g., killifishes, pinfish, mullet, croaker, spot, crabs) to the intertidal creeks of North Inlet–Winyah Bay (NI-WB) estuary. Specifically, I propose to describe the fine-scale behavioral patterns and habitat affinity at the individual scale through the integration of PIT tags and intensive field sampling. By relying on tidal cues to elicit movement in estuarine fishes, we will be able to effectively partition movement and habitat use as a function of water level, thereby providing insight into the connectivity of various adjacent estuarine habitats (marsh surface, intertidal channel, subtidal channel, etc.) on a taxon-specific scale.

Methods: The proposed work will entail intensively sampling a connected intertidal-subtidal marsh complex, focusing on the interface between intertidal and subtidal habitats over a 2-week time period in late July/ early August. Sampling effort will consist of repeated trap, seine, and cast-net collections among the available interconnected habitats, with collected fishes being measured, rapidly tagged with Oregon RFID PIT tags (8 mm) and then released. Approximately 250 individuals will be tagged during the first collection periods. Following tagging, repeated sampling will commence 24 hours later as organisms will have had time to recover from the brief tagging stress. We anticipate tagging efforts (~250 tagged fish) to require a two-day period with a one-day recovery

period. Thus on the fourth day, sampling will commence and continue for approximately 4 days during daylight hours. Intensive sampling will be conducted starting at slack high-tide and continue through the following slack high-tide, with captured organisms being 'scanned' with a hand-held reader. Additionally, we will sample at least two tidal periods during the night hours for comparison. Previously tagged individuals will be automatically identified and digitally recorded with the hand-held reader. Fishes will be quickly released and sampling will resume. A spatially-explicit database will be developed where fish location, habitat type and water level (tidal height and water depth) will be input as covariates within statistical analysis. Coupled with this sampling effort will be the integration of a brand new imaging sonar technology (Adaptive Resolution Imaging Sonar; ARIS) to examine the fine-scale (on the order of centimeters) movement of organisms (both fish and invertebrates) at and along the marsh edge. I have developed methods of collecting and processing this high-resolution data, and have recently acquired the only available ARIS sonar, operating at 3MHz, offering sub-centimeter resolution capable of imaging juvenile fish and small invertebrates. Thus we will take this opportunity to evaluate the efficacy of observing fine-scale behavioral patterns of organisms associated with the marsh edge, and as a function of tidal phase.

Effects of *Phragmites* invasion on ecosystem carbon balance

Investigators: Drs. Thomas J. Mozdzer[1] and Scott Neubauer[2]
[1]Smithsonian Environmental Research Center, [2]Baruch Marine Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

Goals: To measure net ecosystem exchange (NEE) and trace gas emissions to better understand how *Phragmites* invasion may change the ecosystem carbon balance.

Methods: I will conduct a field campaign to measure net ecosystem exchange and trace gas emissions along a salinity gradient in invaded and non-invaded wetlands using Dr. Scott Neubauer's ecosystem metabolism chambers. These will be deployed in two *Phragmites* stands and adjacent non-*Phragmites* tidal marsh on Hobcaw Barony, with specific locations to be selected following an initial visit in May.

Given the potential for increased methane emissions (from my unpublished work at the Smithsonian Environmental Research Center), it is possible that with *Phragmites* invasion, tidal wetlands that are generally considered to be net C-sinks, may change to C-sources. Therefore, it is critical to understand how species invasion may alter critical ecosystem services so we can potentially develop land management strategies. This project will take place between May 13 and July 31, 2012

Long-term Studies

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

The conservation status of the canebrake rattlesnake at Hobcaw Barony, with identification of key areas for conservation of its herpetofauna

Investigator: Dr. Allan L. Markezich
Department of Natural Sciences, Black Hawk College, IL

As a continuation of an ongoing project began five years ago, this effort is assessing the abundance and microgeographic and ecological correlations of the canebrake rattlesnake (*Crotalus horridus atricaudatus*) in the approximate 8000 acres of terrestrial communities of Hobcaw Barony. Observational efforts in this project involve

timed road and walking surveys and usage of drift fences and cover boards along with various marking techniques of specimens to assess abundance. Data taken on snake occurrences involve coordinates of specific geographic localities, topography, general and specific ecological characteristics of communities, and variables involving specific microhabitat and seasonal associations. Observations and associated data taken by others and information on historical land usage at Hobcaw Barony are also utilized. A conclusion from this project currently indicates that a relatively small metapopulation of the species exists on the property, with highest densities in specific and relatively small areas. Hardwood forests and palmetto swamplands bordering upland areas are key components of its environment. While severe droughts in 3 of the 5 years of the project may have reduced observed occurrences and movement, current information indicates that the current conservation status of the canebrake rattlesnake in Hobcaw Barony is poor.

Similar data on other reptilian and amphibian species are also taken in this project in order to understand geographic and habitat correlates of herpetofaunal diversity (i.e. species richness) on the property. Results of these observations suggest that hardwood forests, freshwater wetlands, and associated ecotones between these and pine forests are critical for herpetofaunal diversity. The area of greatest species richness has been found to be in the northern portion of the property; managed pine forests have had the lowest. Further sampling will improve knowledge of the canebrake rattlesnake at Hobcaw Barony as well as provide specific recommendations for the conservation of its herpetofauna.

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^2 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[1,2] and Karen Sundberg[2]
[1]Department of Biological Sciences and [2]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: Ginger Ogburn-Matthews[1], Tom Mero[2], and Lewis Lapine[3]
[1]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [2]NOAA/NOS/OPSD; and [3]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 ±3 mm with a resolution of ±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 . 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.

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, Belle W. Baruch Institute for Marine and Coastal Sciences, 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, Belle W. Baruch Institute for Marine and Coastal Sciences, 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, Belle W. Baruch Institute for Marine and Coastal Sciences,
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, Belle W. Baruch Institute for Marine and Coastal Sciences,
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 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 vegetation and tidal dynamics. Sampling within each permanent plot includes: percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by non-destructive sampling techniques; water table height at low tide; porewater salinity, and nutrient and sulfide concentrations. Soil organic content and bulk density adjacent to each plot were determined in 2008 and will be resampled at 3 year intervals. Elevation data (mm scale vertical resolution) for each plot was established in summer of 2008, allowing for the determination of duration and frequency of tidal inundation at each plot along the elevation gradients of each region. Plot elevations will be resampled at 3 year intervals. The project is being conducted in partnership with NOAA's National Geodetic Survey (NGS) and Center for Operational Products and Services (COOPS) to link the ecological monitoring (vegetation community metrics, sediment chemistry and accretion rates) to local and national geospatial infrastructure. Map location 10

Microbial heterotrophy in salt marsh tidal creeks

Investigators: Dr. Erik Smith, Tracy Buck, and Amy Willman
Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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 (map location 3) in conjunction with the NERR 20-day water quality and water chemistry monitoring program. Microbial metabolic responses are determined by quantifying rates of microbial production (^{3}H leucine incorporation rate) and respiration (in vitro O_2 consumption rates) in both whole water and size-fractionated samples. Independent variables include particulate organic carbon and nitrogen, dissolved organic carbon, nitrogen and phosphorus, inorganic nitrogen and phosphorus, total nitrogen and phosphorus, inorganic and organic suspended sediments, and chlorophyll *a*. Sampling began in 2005 and is on-going.

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

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[1] and Madilyn Fletcher[1,2], and students
[1]Department of Biological Sciences, University of South Carolina; [2]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_2 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_2 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_2 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 10 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:

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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 benthic macrofauna

Investigators: Ginger Ogburn-Matthews, Paul Kenny, and Dr. Dennis M. Allen
Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

A long-term time series for benthic macrofauna that started in 1981 is being continued. Until 2002, collections of animals that live in the shallow subtidal mud bottom of Bread and Butter Creek, North Inlet Estuary were made every two weeks. Without direct grant support to continue the time series, the effort has been reduced such that collections have made at quarterly intervals for the past decade. Sample processing lags behind, with only 4 of 8 biweekly replicate samples counted through June 1997 and quarterly through 2008. Although these benthic communities contain at least 100 different species, only dominant taxa are identified in the sample processing. The macrofauna consists mostly of polychaete and oligochaete worms, bivalves, and small crustaceans which demonstrate annual cycles of abundance, peaking in late winter/early spring and reaching much lower levels in late summer/early fall. A companion series of collections of the meiofauna, a much smaller and more numerous group of bottom dwelling organisms, was made until 2008; see the Baruch Institute Data Archives on the web site for more information. Measurements of physical conditions in the water, sediment, and air at the time of macrofauna collection help investigators determine causes of these variations in abundance over time. Total macrobenthos appears to increase and decrease on a cycle of between 9 and 11 years and is negatively associated to salinity, water temperature, and chlorophyll values. Long-term trends show that the macrobenthos is increasing over the ~30years of spring seasons, while fall numbers are decreasing. In addition to providing an indication of how this critical community is responding to changing climate condition, 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, and Paul Kenny
Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

Time series collections of nekton (fishes, shrimps, and crabs) have been made in the Oyster Landing salt marsh basin since 1984. The objective has been to track the composition, abundance, and biomass and length distributions of nekton and determine patterns, trends, and factors influencing changes over seasons, years, and decades. From 1984- 2003, this effort was based on biweekly seine hauls from an isolated pool in the intertidal creek. In 1996, we started a new time series based on collections made from the flooded marsh surface (high tide) adjacent to the creek. From 1996-2003, both the low tide seine and high tide enclosure collections were made on the same day and tide. 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 similar to the nekton using the flooded marsh at high tide, but differences indicated that not all species or size classes moved into the upper intertidal when flooded and not all species and size classes using the flooded marsh remained in intertidal pools (refuges) during low tide. High tide collections continued through Fall 2011. Analyses of the high tide series showed a steady reduction in overall numbers of nekton since 2003 when the last major period of high rainfall and low salinities occurred. These long-term time series are unique for the Southeast region and are 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. In 2012, a continuation of the time series has begun with a directed effort to document the timing and size of ingressing juvenile transient species and their growth rates during the seasons of nursery occupation. These rare long-term studies can be used to inform the management of salt marsh-estuaries, watersheds, and fisheries in the region. 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, and Paul Kenny,
Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences,
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 Nino) 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, but cannot explain the major decrease in the 153 micron assemblage. Reductions in river inflow, nutrient discharges , and related densities of phytoplankton best explain the major reductions in copepods and larvae of resident estuarine invertebrates. 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 of local benthic assemblages and migratory populations of crustaceans and fishes in relation to environmental conditions. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change. Map location 11.

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[1], Ken Able[2], Tim Targett[3], Eric Hilton[4], Joey Love[5],
Gretchen Martin[6], and Chris Taylor[6], Jon Govoni[6], and Jon Hare[7]
[1] Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina and North Inlet–Winyah Bay NERR; [2]Rutgers University Marine Field Station, NJ; [3]University of Delaware, DE; [4]Virginia Institute of Marine Science, VA, [5]Maryland Department of Natural Resources, MD; [6]NOAA Center for Coastal Fisheries and Habitat Research, NC; [7] NOAA National Marine Fisheries Service, 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 32th year of biweekly collections beginning in January 2012. 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.

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., population metrics at sites with agricultural runoff influences. *Integrative & Comparative Biology* 45(1): 143-150)

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

Investigator: Dr. Rob Young and students
Department of Marine Science, Coastal Carolina University, 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 and Hobcaw Barony

Investigators: Betsy Brabson[1] and Robin Baughn[1] (Debidue Beach Coordinators), Wendy Allen[2], Lindsay Thomas[2], and other volunteers
[1]DeBordieu Colony; [2] North Inlet–Winyah Bay NERR, Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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 and Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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 is being examined in the context of habitat type. Clapper rails are surveyed by boat using a standardized call broadcast method. Survey stations are 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 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 are completed at all survey stations between sunrise and 10:00 AM. Sampling occurs on four days between March and May. The results of this analysis will further our understanding of the habitat requirements of this species and be used to examine to potential effects of land use change and sea-level rise on the population status of clapper rails and least bitterns.

The Painted Bunting Monitoring Project

Investigators: Dr. Jamie Rotenberg[1], John Gerwin[2], and volunteer Kathy Shaw[3]
[1]Department of Environmental Studies, University of North Carolina Wilmington, NC; [2]North Carolina Museum of Natural Sciences, NC; [3]Murrells Inlet, SC

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 show 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. 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, South Carolina DNR, USFWS, and USGS. Funding is provided by USFWS, NC Wildlife Commission, and SCDNR.

South Carolina Estuarine and Coastal Assessment Program

Investigators: Drs. D. Bergquist and 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

Investigators: 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 value of watersheds and estuaries and importance of healthy water quality. These programs feature curriculum components of the K-12 Estuarine Education Program (KEEP) developed by the National Estuarine Research Reserve System (NERRS). Extensive curricula for middle and high school students focusing on estuaries includes both classroom and field activities and offers hands-on activities. A website created by the NERRS education sector (www.estuaries.noaa.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 Reserve Education staff and receive classroom visits highlighting the Reserve System and the North Inlet–Winyah Bay NERR, estuarine ecology, water quality monitoring information, and instruction on monitoring equipment and sampling protocols for a variety of sampling variables. Reserve site visits, 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 event calendars on both NIWB NERR's website, www.northinlet.sc.edu, and Hobcaw Barony's website www.hobcawbarony.org, as well as on their respective Facebook pages and other local community event online calendars. 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 middle and 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, the Waccamaw National Wildlife Refuge, and the Coastal Waccamaw Stormwater Education Consortium (see separate entry following) 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[1], Richard Camlin[2], and Dr. Jennifer Plunket[1]
[1]North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina, [2]Belle W. Baruch Foundation

An experiential education area that can be accessed by foot was established away from long-term research sites to take visitors (K12 and adults) for estuary field trips and other guided environmental education programming and allow participants to experience a variety of coastal habitats via a looped walking trail. An area near 3rd Boundary and Crabhaul roads was selected for the site and includes easy access for bus parking and is in close proximity to the BMFL (for safety concerns and restroom access). The trail supplements 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 was creating in early 2011 using staff and volunteers. Stations have been established to mimic research and monitoring plots and are used to conduct student research. With assistance and guidance from the NERR Stewardship Coordinator, education staff will monitor the impacts of visitor use over time and continue maintenance of the trail throughout the year.

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

Investigators: Beth Thomas, Leigh Wood, and Lindsay Thomas
North Inlet–Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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 to help local MS4s meet NPDES Phase II Permit requirements for public stormwater education and outreach. Additional information on the Consortium is available at http://cwsec-sc.org.

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

Investigators: Beth Thomas[1], Dr. Dennis Allen[2], and Karen Fuss[3]
[1]North Inlet–Winyah Bay National Estuarine Research Reserve, [2]Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; [3]Center for Marine and Wetland Studies, Coastal Carolina University, SC

The Reserve currently participates in several community enhancement and stewardship activities and assist in river and marsh cleanups, lead recycling programs for elementary students and afterschool programs, and assist with a local 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 2011-2012 is the South Carolina "Green Steps" Schools Initiative with Georgetown High School and McDonald Elementary School in Georgetown, SC. Beth Thomas and Karen Fuss serve as Green Steps mentors for Georgetown and Horry County schools. 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.

Coastal Training Program for local decision-makers

Investigator: Leigh Wood
North Inlet–Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, Belle W. Baruch Institute for Marine and Coastal Sciences, 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) 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[1,2], Melissa Ide[1], Jennifer Kessee[1], Amber Knowles[1], Brooks Folk[1], and Vembu Subramanian[3]

[1]Belle W. Baruch Institute for Marine and Coastal Sciences,Baruch Marine Field Lab, University of South Carolina ; [2]Arnold School of Public Health, University of South Carolina ; Southeast Coastal Ocean Observing Regional Assocation[3]

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 29 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 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.

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 workshop will be held in the winter of 2012.

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 federal IOOS 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 09/01/11 to 02/28/13 by NERRS/NOAA/Dept. of Commerce. The CDMO website is http://cdmo.baruch.sc.edu or www.nerrsdata.org.

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

Investigators: Dr. Bert Ely[1], Dr. Celeste Pringle[3], Patti Hammel[3], Chanda Cooper[4], Dr. Steve Thompson[5], and Trista Hindman[6]
[1]Center for Science Education, University of South Carolina; [3]Georgetown County School District; [4]Naturalist and Collections Manager, University of South Carolina Herbarium, [5]University of South Carolina College of Education, [6]Hobcaw Barony: Belle W. Baruch Foundation

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-3rd 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 – 3rd 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 participates, local and national teacher led presentations and USC/NBI mentors.

Now in year 4, Belle W. Baruch Foundation staff member, Trista Hindman, is acting as science mentor to the only school participating, Kensington Elementary School. The *Improving Teacher Quality (ITQ)* grant is funding 7 teachers from the school to participate in two summer ecology institutes at Hobcaw Barony, with follow-up sessions during the school year with science and education specialists from the University of South Carolina. Hindman works as science mentor with teachers, school personnel, and students at Kensington Elementary 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, Browns Ferry Elementary, Waccamaw Elementary, and LowCountry Preparatory*
Year 4 (current), Kensington Elementary
* *Received permission by the CHE to expand its work into private schools in the community.*

Start and End Dates: Summer 2008- Summer 2012

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Research Locations in North Inlet

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