CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS

2008 - 2009

Baruch Marine Field Laboratory (BMFL)

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

University of South Carolina

Belle W. Baruch Institute for Marine & Coastal Sciences

North Inlet-Winyah Bay National Estuarine Research Reserve

Current Projects 2008-2009

Introduction

Since 1969, Baruch Institute research associates have completed more than 630 scientific research projects, and students have completed hundreds of theses, dissertations, and special research projects. All of this work has resulted in the publication of more than 1,475 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 74 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 68 of the investigators conducting research at the BMFL. In addition, 62 other investigators representing 20 other institutions are carrying out projects at the BMFL. Dozens of other graduate and undergraduate students assist these scientists throughout the year to obtain hands-on training in field research methods. A wide variety of basic and applied research is represented. This list includes only those projects that make regular use of the site. Most of the studies that involve field measurements and collections are being conducted within the North Inlet-Winyah Bay National Estuarine Research Reserve.

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

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

Author and Title List

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

Investigators: Dr. Raymond Torres[1], Dr. Lew Lapine[2] and graduate Joseph Bell[1] and Si Chen[3]
Department of Geological Sciences, University of South Carolina[1]
SC Geodetic Survey[2], Marine Science Program, University of South Carolina[3]

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 in the context of 3D island structure, 4) Characterize the temporal and spatial variability of processes controlling tidal creek network develop 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. Based on these benchmarks we created a high resolution RTK-GPS DEM of a salt marsh island, Maddieanna Island (map location 16). Island area is 0.3 km^2 and it is approximately 3 km SSW of the Marine Lab building. The DEM is made of 77000 GPS points with 0.5 m spacing around the creeks and 5 m spacing on the marsh platform. This DEM serves as a base for current and future research. In summer 2008, we will install nine SETs, and establish fixed positions for measuring sediment accretions with tiles at several more locations.

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

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

Investigators: Dr. George Voulgaris[1], Dr. Jay Pinckney[2], and Jeff Morin[1]
Department of Geological Sciences, University of South Carolina[1]
Department of Biological Sciences, University of South Carolina[2]

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

The overall objective of this study is to create a biogeochemical module that can be integrated with hydrodynamic models to simulate fluxes of benthic microalgae (BMA), non-living particulate organic matter (POM), and the particle size distribution of suspended sediments (SS) under turbulence conditions of tidal and wind-induced flows. The short-term objectives to be achieved within the 2-year length of the proposed project are:

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

Experiments will utilize high frequency (>2Hz) flow and BMA (Chlorophyll a) measurements in the benthic boundary layer. These will be accompanied by collection of water column samples for particle characteristic

analysis in the laboratory that will be used to verify/calibrate the automated measurements. Experiments will be carried out over full tidal cycles (spring and neap) at North Inlet for two different seasons (winter - summer) with different productivity characteristics. North Inlet is part of the Winyah Bay estuarine system and is composed of many shallow creeks traversing a large salt marsh encompassed by Debidue Island, North Island and the Mainland. The marsh is flooded twice over a 24 hour period and the sediments are generally a mixture of sand and silty clay.

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

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

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

Investigators: Abby Springer[1], and Drs. Douglas F. Williams[1], Scott White[1], Camelia Knapp[1], Robert Gardner[1], and Paul Gayes[2]
Department of Geological Sciences, University of South Carolina[1]
Director, Center for Marine and Wetland Research, Coastal Carolina University[2]

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

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

Salt marsh hydrology and acute marsh dieback

Investigators: Dr. Alicia Wilson[1], Dr. Jim Morris[2], Andrea Hougham[1], and Weihong Wang[3]
Department of Geological Sciences[1], Department of Biological Sciences and Belle W. Baruch Institute for Marine and Coastal Sciences[2], Marine Science Program[3], University of South Carolina

The goal of this work is to quantify groundwater flow in a salt marsh island to understand the role of submarine groundwater discharge (SGD) in nutrient cycling and to understand links between salt marsh hydrology and ecological productivity, particularly the cause of salt marsh dieback. An important hypothesis for this work is that acute marsh dieback at the site was caused by rapid changes within the normal range of marsh conditions during drought conditions. We have installed 7 piezometer nests (3 piezometers in each nest) to monitor temperature and fluctuations in hydraulic head. Monthly monitoring is in progress. Vibracores taken adjacent to each piezometer nest indicate that marsh stratigraphy changes near the dieback area. Surface temperature observations also suggest that the dieback area is poorly flushed. Hydraulic observations from the wells confirm that groundwater flushing in the

dieback area is very limited compared to groundwater flow near the creek banks, and the deep sand layer is an important pathway for fluid flow. Numerical models that can simulate coupled groundwater flow, heat transport, and solute transport are under construction. The models will be developed based on the stratigraphy and a detailed RTK GPS elevation survey, and they will be calibrated to monitoring data. Once the models are tested, we will use the models to estimate the hydrologic conditions (and the rate of change in those conditions) during the drought that peaked in 2002. Map location 2B. This project is funded from 6/1/2006 until 1/31/2009 by the South Carolina Sea Grant Consortium

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

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

Biogeographic theory predicts that consumer-prey interactions are more intense at lower latitudes, leading to increased defenses of prey. My students and I are testing this hypothesis in Atlantic Coast salt marshes, and are examining how latitudinal variation in both bottom-up (plant quality) and top-down (predators) factors affects latitudinal variation in herbivore populations. We are counting predators and herbivores, measuring herbivore damage to salt marsh plants and traits of the plants, and evaluating plant palatability in multiple sites from Florida to Maine. At Baruch, we work about halfway along Goat Island and at the end of the 3rd Boundary Cutoff Road (map locations 9 & 9A). This project will test a long-standing biogeographic theory that has received little experimental attention. This project has been funded by two grants from the National Science Foundation and is affiliated with the Georgia Coastal Ecosystems Long-Term Ecological Research program.

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

Investigators: Rachel Goeriz and Jessica Hines
Department of Entomology, University of Maryland

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

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

Predicting the persistence of coastal wetlands to global change effects

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

Our research at BMFL is part of a larger study which incorporates a series of controlled mesocosm and field experiments, landscape scale studies, an existing network of 15 coastal wetland monitoring sites, and a suite of predictive models to address critical questions regarding vulnerability of coastal wetland systems to global change. Specifically, we will evaluate the interaction of sea-level rise and elevated atmospheric CO_2 concentrations with salinity, flooding, nutrient enrichment, and disturbance effects. Our studies will be organized in a hierarchical structure that links mesocosm, field, landscape, and biogeographic levels so as to provide important information that recognizes that coastal wetland systems respond to multiple interacting drivers and feedback effects controlling wetland surface elevation, habitat stability, and ecosystem function. We will focus on the brackish wetland community because of its vulnerability to multiple disturbances.

At the mesocosm level, experiments will examine the relative response of mixed species communities to the interactive effects of elevated CO_2, salinity, nutrients, waterlogging, and disturbance in a controlled manner. Field plot experiments will examine the mechanisms of ecosystem response to these same drivers. Landscape scale studies will examine coastal wetland responses to nutrients and disturbance along elevation gradients. Coastal wetland surface elevation trends from an extensive long-term monitoring network will be used to examine both salt marsh and brackish wetland response to varying relative rates of sea-level rise. Explicit linkages across all scales will be achieved by measuring key ecosystem processes, wetland structural features, and carbon and nutrient pools at each level of the hierarchy. Finally, we will synthesize and integrate these measures in a predictive modeling framework that will forecast ecosystem change and provide important feedback to managers that will enable adaptive shifts in strategies for the sustainable management of coastal wetlands. This project is supported by the US Geological Survey Global Change Program (2003-2008).

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

Investigators: Pamela E. Marsh and Dr. Arthur D. Cohen
Department of Geological Sciences, University of South Carolina

In the southeastern United Stated, *Juncus roemerianus* is the plant that grows at the most inland extent of salt water influence in many salt marshes. As such, it is an excellent proxy for highest high water and sea level. Marsh and Cohen (2008) identified a palynomorphic fingerprint that distinguishes sediments found in *Juncus roemerianus* zones from sediments found in all other salt marsh zones. The components of this fingerprint include: high palynomorph diversity, an unidentified fungal spore type, and the fungal spore of *Atrotorquata lineata*. Our current research consists of several parts. First, we wish to show that this palynomorphic fingerprint occurs at all locations within *Juncus roemerianus* stands regardless of distance from the ocean or upland areas. To accomplish this, we have collected samples at 50-foot intervals along a 600 foot transect of a *Juncus roemerianus* stand located on the road to Clambank at the end of Crab Haul Creek at the Baruch. These samples showed that the palynomorphic fingerprint is present in all locations. Second, we hope to show that the palynomorphic fingerprint is present throughout the range of *Juncus roemerianus* (roughly Delaware to Texas). In addition to the previously mentioned samples from the Baruch Institute, we obtained sediment samples from throughout South Carolina as well as North Carolina, Florida and Alabama, with commitments of samples from Texas, Louisiana, Mississippi, and Georgia. All samples analyzed to date have contained the fingerprint. Third, we hope to show that our palynomorphic fingerprint is preserved beneath the surface and can be used to track minor changes in sea level. To date, we have found the *Juncus* fingerprint beneath the surface in South Florida and in cores from James Island, SC, and we have collected cores in a *Juncus* marsh near the intersection of Floating Bridge Road and Old Clubhouse Corner Road that we hope will allow us to trace sea level movement.

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

This project began in 2006 and is expected to be completed in the fall of 2008. Funding for this project has been provided by the Baruch Institute Hodge Summer Fellowship, the Geological Society of America Graduate Research Grant, the Society of Wetland Scientists South Atlantic Chapter Student Research Grant, and the South Carolina Sea Grant Consortium.

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

Sediment accretion in North Inlet salt marshes

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

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

Experimental varying of the marsh platform and macrophyte response

Investigators: Dr. James Morris and Karen Sundberg
Department of Biological Sciences and Marine Science Program, 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 0.013 m separation between pipes with six replicates per treatment. One experiment examines effect of marsh platform on *Spartina alterniflora*, one focuses on the effect of marsh platform on *Juncus roemerianus*, and the third examines competitive interactions between the two macrophyte species. Monthly stem height measurements are obtained each year from April to October. Plants are harvested at the end of the growing seasons from Oyster Landing, North Inlet, South Carolina (map location 3).

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

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

Investigators**:** Weihong Wang[1] and Dr. James T. Morris[2]
Marine Science Program, University of South Carolina[1]; Department of Biological Sciences and Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina[2]

The preservation and accumulation of organic carbon is thought to be an important mechanism by which coastal wetlands keep pace with rising sea level. The survival of coastal salt marshes is especially challenged nowadays by continuous sea level rise caused by global warming. A fundamental understanding of sediment carbon

cycling mechanisms within the salt marsh system will provide a basis for evaluating the capacity of salt marsh to sequester carbon in sediments and the role of this process in maintaining relative elevation. This proposed research addresses (1) the seasonal and annual soil respiration in North Inlet salt marshes; (2) measurement and separation of root respiration from sedimentary organic matter (SOM) decomposition using carbon stable isotopes; (3) measurement of stem CO_2 fluxes and its fate by stable carbon isotope analysis; (4) and measuring the temperature dependence of soil respiration. In this research, three hypotheses will be tested: (1) root respiration and SOM decomposition have different temperature sensitivities; (2) stem CO_2 comes from two sources: CO_2 respired from roots and CO_2 derived from SOM decomposition and is a major pathway for carbon export; and (3) the carbon isotope composition of soil CO_2 is a function of two different carbon sources: root and SOM respiration. Stable carbon isotope analyses, soil respiration and stem CO_2 fluxes measurements, and sediment core incubation experiments will be used in this study to achieve the objectives and test our hypotheses. The results of this proposed research will provide information to policy makers and managers relative to the effects of sea level rise on a vital natural resource, namely our salt marshes. This project will start in Summer 2007 and end in Summer 2009. Support is provided by NOAA NERRS fellowship, the USC Marine Science Program, and the Baruch Marine Field Laboratory.

Interspecific competition among some salt marsh perennials in South Carolina

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

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 6A.

Effect of wrack accumulation on salt marsh vegetation

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

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 purchased from Forestry Suppliers, Jackson, MS. Wire staples were used to anchor the rope and netting to the ground. In April 2004, one plot in each array was uncovered and sampled. Subsequently, one plot in each array was uncovered in May, August and October, 2004. During mid October, 2004, vegetation within each experimental plot and the control were sampled with three randomly located 20 x 20cm quadrats located within the larger plots. Stems were counted by species. Vegetation of all species within the quadrats was cut at ground level and standing crop (gms of vegetation/m^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.

Nekton as processors and transporters of nutrients in intertidal creek basins: short-term contributions of dissolved nitrogen and phosphorus - Links Study I

Investigators: Dr. Dennis Allen[1], Dr. Robert Young [2], Dr. Stacy Luthy[3], Jason Garwood[2], and Dr. Richard Dame[2]
Baruch Marine Field Laboratory, University of South Carolina[1]; Marine Science Department, Coastal Carolina University[2]; University of the Pacific[3]

Nekton participate in the cycling of nutrients in salt marsh ecosystems. We believe that their role is significant and underappreciated. More than 50 species of fishes, shrimps, and crabs (nekton) move in and out intertidal creeks with the tides; summer densities are often 50-100 g/m^3. They forage in the creek bed, mud flats, and oyster reefs when flooded, and some species move onto the marsh during the highest part of the tide. Foraging in the sediments (bioturbation), handling (crushing) prey, and excreting wastes are primary means by which these animals contribute to the pool of dissolved nutrients. In this study, we are quantifying the amount of ammonium and orthophosphate contributed by the nekton while occupying intertidal creek basins. Nekton occupying residual pools of water in creek beds for several hours around low tide can substantially raise nutrient concentrations. A series of mesocosm experiments with multiple treatments has been conducted to quantify nutrient production by nekton, microbial components of the water column, and the biotic components of the sediments during low tide. Other field experiments measure the flux of dissolved nutrients into and out of intertidal creeks over tidal cycles. Nekton and other processes within the creeks result in the enrichment water in pools and near the creek mouth around low tide. The retention and pulsing of nutrient enriched water back into the creek-basin with the flooding tide constitutes a positive feedback mechanism (self-fertilization) that likely contributed to high primary and secondary productivity within basins. The Links project is supported by the National Science Foundation, through the Ecosystems Studies Program (January 2005-September 2008).

Spatial variations in growth, condition, and site fidelity of nekton among intertidal creek basins – Links Study II

Investigators: Dr. Dennis Allen[1], Jason Garwood[2], Dr. Robert Young[2], and Dr. Stacy Luthy[3]
Baruch Marine Field Laboratory, University of South Carolina[1]; Marine Science Department, Coastal Carolina University[2]; University of the Pacific[3]

Previous studies that we conducted in North Inlet revealed that use of intertidal creeks by fishes, shrimps, and crabs (nekton) varied among sites and that consistent differences in the magnitude of use were related to unique physical features of those intertidal creeks. In the first two years of the present study, we found significant differences in the growth rates of certain transient species among intertidal creek basins. The pattern of growth was similar both years. Initial mark-recapture studies indicated that some individuals return to the same creek tide after tide. This suggests a mechanism by which groups from the same year class can remain segregated for weeks to months and potentially grow at different rates. We are continuing mark-recapture studies this year using implanted microwire tag technology to determine the extent of site fidelity for multiple common species. In addition to addressing relationships between nekton use and nursery habitat quality, our research will contribute to a broader understanding of the export of living biomass from intertidal salt marsh basins to the lower estuary and ocean. The Links project is supported by the National Science Foundation, through the Ecosystems Studies Program (January 2005–September 2008).

Site fidelity and movements of grass shrimps, *Palaemonetes* spp., in North Inlet intertidal creek-basins

Investigators: Krystle Ludwig[1], Dr. Dennis Allen[2], and Dr. Robert Young[1]
Marine Science Department, Coastal Carolina University[1]; Baruch Marine Field Laboratory, University of South Carolina[2]

Grass shrimps, *Palaemonetes spp*., are important residents of and play major roles in salt marsh estuarine ecosystems; they decompose detritus, consume small invertebrates, contribute dissolved inorganic nutrients (primarily ammonium) through digestion, and provide a source of food for many large predators. Grass shrimp abundances usually surpass those of other crustaceans and fishes in intertidal creek basins, but very little is known about their movements within and among creeks. We are interested in their tendency to remain or return to certain locales (high site fidelity). The objective of this study is to determine patterns of movement using color stain mark-recapture techniques, and to determine what factors affect their distributions from tide to tide. For instance, do grass shrimps exit and re-enter the same creek tide after tide? Do they re-occupy the same intertidal creek pools over multiple tidal cycles and days? With mark-recapture, we have shown that fidelity for individual creeks is high, even though many or most grass shrimps occupying the creek at high tide retreat to the adjacent subtidal channel at low tide. Additional tests have shown that although some shrimps can be recaptured in the same intertidal pool in which they were stained the day before, many can be found in other pools both uptide and downtide; this suggests only moderate fidelity for individual low tide pool refuges. Combined with information from other ongoing studies, this study will help us to better understand (1) relationships between these keystone salt marsh crustaceans and inter-creek variations in habitat quality and (2) the patterns and mechanisms of biomass transfer within the tidal landscape. The project is supported by the National Science Foundation, through the Ecosystems Studies Program (January 2005–September 2008).

The contribution of various nekton species to nutrient cycling through excretion and bioturbation in an intertidal creek

Investigators: Carrie Jones and Dr. Robert Young
Coastal Marine and Wetland Graduate Program, Coastal Carolina University
Marine Science Department, Coastal Carolina University

Nekton (fish, shrimp and crabs) thrive in marsh-estuarine systems and could be important in the cycling of inorganic nutrients by excretion and bioturbation (the mixing of sediments by living organisms). The role of the Atlantic blue crab (*Callinectes sapidus),* common marsh fish species (spot, mullet, pinfish), and shrimp (grass shrimp and white shrimp) in bioturbation is unknown. The objectives of this study are to quantify the nutrient contribution to the water column via bioturbation by blue crabs and to compare their contribution to that of other nekton (fish and shrimp). This study will be separating blue crabs from specific fish species as independent measurements. If there are significant differences, we would like to find the mechanisms which differentiate between them. We hypothesize that blue crabs are a sink of dissolved inorganic nutrients while other nekton are a source, because blue crabs disturb the sediment to a greater depth. Field and laboratory studies will be conducted in a closed system, mimicking the pools of the intertidal creek environment. Experiments will follow a factorial design of nekton presence and vexar (3mm plastic mesh screen) presence. The screen will be placed above the sediment in the mesocosms in order to prevent access of nekton to the sediment and hence preventing bioturbation. The mechanisms will be described and the depth of disturbance will be examined. This study is important in that it will characterize the role of these organisms in processing and transporting materials within the marsh-estuarine system. This project is supported by Coastal Carolina University and the Links project, and will be conducted May 2008-September 2008.

Investigation of grade C8 barium ferrite ($BaFe_2O_4$) permanent magnets as a possible elasmobranch bycatch reduction system

Investigators: Craig O'Connell and Dr. Daniel Abel
Coastal Marine and Wetland Studies Graduate Program, Coastal Carolina University

Bycatch of elasmobranchs on commercial fishing gear, especially longlines, is an urgent problem (Myers and Worm, 2003), leading to large-scale reductions in populations of large predatory fishes like sharks. In Winyah Bay/North Inlet, S.C., site of a five-year longline study (Abel et al., 2007), C8BF permanent magnets will be deployed on baited longlines throughout the summer sampling season, and elasmobranch catch on magnetic hooks will be compared to control hooks. Pilot studies were conducted on the nurse shark (*Ginglymostoma cirratum*) and the southern stingray (*Dasyatis americana*), which demonstrated that the feeding behavior of *G. cirratum* and *D. americana was* affected by the presence of Barium Ferrite permanent magnets (O'Connell et al., unpublished). If C8BF permanent magnets are effective in repelling elasmobranchs, elasmobranch bycatch on commercial longlines may be reduced, which may allow these slow maturing and reproducing fishes to recover from the harsh fishing pressures.

Predator identity effects on the survival of the eastern oyster, *Crassostrea virginica*

Investigator: Dr. Antony M. Knights
Department of Marine Science, Coastal Carolina University

The removal of predator species by human-induced extinction and the rate of species loss are increasing globally. Eastern oyster (*Crassostrea virginica*) populations in South Carolina are preyed upon by two common predators, namely blue crab (*Callinectes sapidus*) and mud crab (*Panopeus herbstii*). Using a factorial experiment, manipulating the presence and abundance of the two crab species, we examined the effects of predator extinctions, the effect of species richness and the identity of those predators on the survival of juvenile oysters. Undertaken in North Inlet using a series of cages and control treatments, different combinations of both crab species, as well as treatments with complete exclusion of crabs, each replicated three times. The design allows us to test the functional compensation of one species when the other is excluded, simulating extinction, as well as quantify the consumption rates of each species, separately. The study will help us to understand the role of biodiversity in ecosystem functioning, as well as addressing practical concerns relating to over-harvesting or loss of predators from a system. It also provides a detailed knowledge of the mechanisms that are operating at the ecosystem level, based on sound experimental evidence rather than observations or generalized models. *Population Biology MSCI 472 Laboratory Project*

Density-dependent recruitment and top-down control of eastern oyster (*Crassostrea virginica*) populations

Investigators: Drs. Antony M. Knights[1], Keith Walters[1], and Loren Coen[2]
Department of Marine Science, Coastal Carolina University[1],
Sanibel-Captiva Conservation Foundation, Sanibel, FL[2]

Activities that reduce or remove species abundance, such as fishing, can lead to ecological extinctions and have a dramatic cascading effect within the system. Oysters, such as the Eastern oyster (*Crassostrea virginica*), have been commercially exploited such that native beds are being depleted both regionally and locally. Degradation of oyster reef habitats has resulted in not only the loss of a commercially-harvested resource, but also the many ecosystem services that they provide e.g., habitat stabilization, water quality and erosion control. We conducted a field experiment to assess how oyster populations develop, in the event of newly available habitat, and the effect of water flow rate, conspecific cues, and habitat complexity on population growth. Recruitment of oysters was estimated over 14 wk between May and August 2008 using artificial collectors at 3 locations: North Inlet, Cape Romain and Murrells Inlet. Recruitment was estimated at 2 wk intervals from biweekly counts, and compared to cumulative counts (changes in accumulated population growth) to test for the effects of density-dependence and assess the effect of spawning peaks on population growth. Caged, uncaged and procedural control treatments were used in conjunction to assess the effect of predator exclusion. In combination with replication of recruitment estimators within differing habitat complexities, flow rate zones and position within existing bed structures, the

study will help us better understand how: (1) recruitment effects population maintenance, (2) the effect of habitat characteristics on settlement success, (3) the role of several key predators in population control, and (3) provide insights for improved management and preservation of a highly exploited resource. The project is supported by the National Fish and Wildlife Foundation (January 2007–March 2008).

Development and application of a real-time voltammetric microelectrode system for tidal creek sampling

Investigators: Dr. Brent L. Lewis and Christopher B. Manley
Marine Science Department, Coastal Carolina University

For this study, a voltammetric Hg/Au microelectrode in conjunction with a minimal-volume flow cell will be used to follow changes in redox-sensitive dissolved chemical species in Crab Haul Creek, North Inlet, SC, over the course of a 12-hour tidal cycle. The microelectrode, originally developed by Luther and colleagues at the University of Delaware, is comprised of a Hg-plated 100 µm diameter gold wire encased in a PEEK tubing body. Similar electrodes have been used for *in situ* measurements of dissolved oxygen, manganese, iron, sulfide, and other redox-sensitive species in sediments, suboxic water columns and at hydrothermal vents.

For this study, the microelectrode/flow cell system has been incorporated into a trace-metal-clean sampling train which will allow for real-time vertical profiling of the species above, as well as the simultaneous collection of unfiltered and filtered samples for metals, nutrients and other chemical constituents. The first test of this system will take place in late April, 2008, sampling from a skiff moored at the floating dock at the end of the Oyster Landing Pier (map location 3). Should the initial test prove successful, results of the sampling at Crab Haul Creek, a relatively pristine site, will be compared to data collected in a similar manner from one or more of the tidal "swashes" (drainage systems) located along the Grand Strand. An analogous system will be integrated with an upcoming Sea Grant funded well-sampling program to study shallow submarine ground water discharge. The latter could be a contributor to episodic near-shore hypoxic conditions observed in Long Bay (NE South Carolina coast) during the summer.

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]
Belle W. Baruch Institute for Marine & Coastal Sciences, University of South Carolina[1]
Department of Biological Sciences and Marine Science Program, University of South Carolina[2]

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, 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). I will use a two-phase approach to 1) develop and refine methods for in situ salinity manipulations, and 2) measure greenhouse gas emissions from a tidal freshwater marsh exposed to elevated salinity, as a proxy for how these systems will respond to sea level rise and salt water intrusion. This research will build upon and contribute to the growing expertise of University of South Carolina in areas of climate change. The research is funded for 2007-2008 by a grant from the University of South Carolina, Office of Research and Health Sciences Research Funding Program.

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

Investigator: Dr. Scott Neubauer
Baruch Marine Field Laboratory, University of South Carolina

This study will describe some of the spatial and temporal patterns in inorganic carbon fluxes in the North Inlet salt marshes. This project will build upon previous work that has shown that a wide variety of factors including the presence/absence of plants, soil composition, and temperature affect rates of heterotrophic metabolism (i.e., CO_2 production) in tidal marsh soils. A fraction of carbon dioxide produced in marsh soils is exported to tidal waters in the form of dissolved inorganic carbon (DIC), but there have been few studies that have robustly documented how and why DIC concentrations vary over the course of the year. Rates of soil metabolism will be measured on soil cores that have been removed from intertidal marsh zones and processed in the lab under anaerobic conditions. Soil subsamples will be incubated anaerobically in sealed bottles at ambient temperatures. Soil respiration and decomposition rates (i.e. the increase in carbon dioxide within the bottle headspace) will be measured over short (hours to days) and longer (~months) time scales. Specific locations for this part of the research have not yet been determined. I will measure the DIC concentrations of water samples collected from the Oyster Landing Pier over tidal and diurnal cycles by acidifying water samples and measuring the total amount of evolved carbon dioxide. Furthermore, the partial pressure of carbon dioxide will be measured using a gas equilibrator connected to an infrared gas analyzer. The timing of these analyses will be coordinated with the NERRS System-Wide Monitoring Program to take advantage of other data that are regularly collected at Oyster Landing (e.g. nutrients, dissolved organic carbon, chlorophyll).

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]
Duke University, Durham, NC[1]; Baruch Marine Field Laboratory, University of South Carolina[2]; South Dakota School of Mines and Technology, Rapid City, SD[3]

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, with funding expected to begin in late summer/early fall 2008.

Stable isotopes: A tool for detecting sediment nitrogen mineralization

Investigators: Melissa Engle[1] and Dr. Marjorie Aelion[2]
Marine Science Program, University of South Carolina[1]
Department of Environmental Health Science and Marine Science Program, USC[2]

Sediment microcosms have been used to investigate denitrification and dissimilatory nitrate reduction to ammonia (DNRA) rates in salt marsh sediments. In these studies the generated NH_4^+ is most often attributed to DNRA, though sediment organic nitrogen mineralization may play a role in NH_4^+ production. The objectives of this study were to determine how increasing the amount of added NO_3^- during microcosm experiments affects NH_4^+ production and to identify the source(s) of produced NH_4^+ by using the natural abundance of nitrogen stable isotopes as an indicator. Sediment samples will be collected from three salt marsh locations along the South Carolina coast including Kiawah Island, North Inlet, and Murrells Inlet. The acetylene block technique will be used to determine denitrification rates during slurry microcosm experiments and nitrogen isotopes will be measured at the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University using isotope-ratio mass spectrometry. This study is important as a means of testing the usefulness of the natural abundance of nitrogen stable isotopes as a tool in laboratory nitrogen cycle experiments. Work on this study began in May, 2007, and will continue through August, 2008. Funding is provided through NOAA and by the University of South Carolina Environmental Research Initiative Committee.

Colonization of man-made surfaces in the marine environment

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

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

Recent publications associated with the work:

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

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

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

Infaunal burrows and their impacts on sediment microbiota

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

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

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

Sampling initially aimed towards identifying routes of bacterial transport within the North Inlet-Winyah Bay estuary introduced the finding that infaunal burrows are sites of *Vibrionaceae* enrichment. For the transport study, *Vibrionaceae* were originally chosen as a model assemblage due to their prevalence in marine systems, their ability to grow quickly and distinctively on a well-established indicator medium, thiosulfate citrate bile salts sucrose (TCBS) agar, as well as their capacity to employ numerous metabolic pathways and growth strategies that could promote their survival and propagation. *Vibrio parahaemolyticus* is of substantial interest to management of local

shellfisheries and was used in this study as an individual species indicator. *V. parahaemolyticus* occurs naturally in temperate coastal waters and is an opportunistic human pathogen, capable of causing illness or death as a result of consuming raw or undercooked shellfish. Seasonal variation in water temperature is known to affect *Vibrio* population dynamics, with highest numbers and greatest potential for epidemic outbreaks occurring in the warmer months, though data from NI-WB indicate that local *Vibrionaceae* assemblages are maintained year-round, primarily in infaunal burrows.

Identification of infaunal burrows are enrichment zones has led to further questioning as to why burrows maintain these enrichments. For the upcoming 2008 sampling, I plan to determine if burrows are "hot spots" for *Vibrionaceae* or all marine heterotrophic bacteria by using duel probe fluorescent in situ hybridizations (FISH). It is also hypothesized that the enrichments could be a result of physical dynamics related to burrow structure and tidal flushing or introduction by macrofauna. Lastly, burrow water will be monitored for its chemical constituents to determine if particular conditions provide an improved habitat for *Vibrionaceae* or other marine heterotrophic bacteria. Identification of an enrichment zone has significant implications for transport studies as well as total bacterial community profiles.

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

A survey of water quality using a coastal monitoring program

Investigators: Kenneth Hayes[1] and Andrew Shuler[2]
Baruch Marine Field Laboratory, University of South Carolina[1]; Marine Resources Research Institute, SC Department of Natural Resources[2]

Water quality and eutrophication issues are important concerns for coastal South Carolina. With more than 60% of the nation's estuaries experiencing nutrient related water quality problems, South Carolina has a need for more targeted seasonal and spatial monitoring program. This study will 1) determine the temporal water quality index of 20 coastal sites in South Carolina; 2) determine environmental factors that favor phytoplankton blooms (including harmful algae) in SC estuaries and 3); determine if water bodies that receive a poor EPA water quality index rating are more prone to occurrence of HAB species. The sampling occurs at low tide on a monthly basis to determine existing physical (temperature, salinity, dissolved oxygen, pH, water clarity and TSS), chemical (ammonium, nitrate/nitrate, orthophosphate, silicate, dissolved organic nitrogen and dissolved organic phosphorus) and biological parameters (chlorophyll *a*, phytoplankton community composition and HPLC) throughout the state. Sampling sites are evenly distributed along the coast with Clambank Dock being one of the sites. We will be able to use the data and compare the indicator variables of different U.S. and European assessment methods: EPA-NCA; NOAA-NEEA/ASSETS and OSPAR-COMPP. Another objective of this pilot study is to see if such a sampling program can be developed to include trained volunteers similar to The Alliance Citizen Monitoring program in the Chesapeake Bay area. NOAA NOS. 1 May 2007 to 30 October 2008.

The South Carolina Harmful Algal Bloom Program

Investigators: Krista DeMattio[2], Kenneth Hayes[1], Chuck Keppler[2], Jiqing Liu[1], Sarah Williams[2], and collaborators from NOS-Charleston, SC Sea Grant Consortium, SC Department of Health and Environmental Control, SC Department of Natural Resources, Clemson University, Medical University of South Carolina, US Geological Survey
Baruch Marine Field Laboratory, University of South Carolina and Hollings Marine Laboratory[1], Marine Resources Research Institute, SC Department of Natural Resources[2]

The South Carolina Harmful Algal Bloom Program (SCHABP) was created in October 2000 to document the statewide distribution of HABs and determine their prevalence, the factors that trigger and sustain them, how and to what extent they impact fish and shellfish, their potential effects on human health, and educate the public on these issues. This study will 1) determine the present distribution of harmful algae in SC estuaries; 2) determine environmental factors that favor HAB formation in SC estuaries so future effects can be predicted; and 3) establish a statewide HAB surveillance system. The monitoring effort consists of an intensive statewide spatial monitoring (on a monthly to annual basis) to determine existing physical, chemical and biological parameters (including algal

distribution) throughout the state. Sites that are routinely monitored from the Baruch Field Laboratory will include North Inlet (Clambank Bridge). Additional water samples are collected for the purposes of algal experiments, identification, isolation, and culturing of the bloom species. These cultured algal species will be used for bioassays to determine the role of nutrient quantity and quality in HAB stimulation as well as the role that microzooplankton plays in the food web. NOAA NOS. 1 October 2007 to 30 September 2008.

Phytoplankton monitoring at the NERRS sites (North Inlet-Winyah Bay)

Investigators: Kenneth C. Hayes[1], Sarah Williams[2] and Dr. Erik Smith[1]
Baruch Marine Field Laboratory, University of South Carolina[1], Marine Resources Research Institute, SC Department of Natural Resources[2]

We will coordinate our sampling dates within North Inlet-Winyah Bay with the on-going long-term monitoring at the NERRS sites. We collect phytoplankton samples and screen for species composition and utilize HPLC to determine biomass within algal classes. Any algal blooms will be quantified and potentially toxic blooms will be analyzed for toxin production. This additional monitoring will add to the extensive existing data on the North Inlet-Winyah Bay system.

Utilization of dissolved nucleic acids as a phosphorus source by marine bacteria

Investigators: Rhiannon L. Rognstad and Dr. Richard A. Long
Department of Biological Sciences, University of South Carolina

The focus of this research is to understand factors controlling use of dissolved nucleic acids (d-NAs) by bacterial communities, as well as to quantify and identify bacteria capable of hydrolyzing and utilizing d-NAs in the natural environment and gain additional information on the mechanism of this utilization. I will conduct experiments under the umbrella of the global hypothesis: Dissolved nucleic acids are a significant component of the phosphorus pool utilized by a genetically diverse community of marine bacteria. Early experiments will focus on identification of phylogenetic groups capable of uptake of d-DNA hydrolysis products, followed by experiments to examine the effects of increased inorganic phosphorus (P_i) on uptake. Further experiments will examine the role of enzymes in the d-DNA hydrolysis and uptake mechanism.

5-bromo-2'-deoxyuradine (BrdU) is a thymidine analogue that has been used to measure growth rates of individual bacteria cells in marine environments by immunochemical detection. I propose "feeding" natural bacterial communities with the BrdU-labeled DNA and using fluorescence microscopy to determine the percentage of the total community incorporating the hydrolyzed products of d-DNA. The phylogenetic identity of members of the total community and the community incorporating the d-DNA hydrolysis products will be determined using bacterial community fingerprint analysis (ARISA) and generation of a clone library. Natural bacterial communities will be sampled from approximately one mile outside of North Inlet. This project will continue through 2009.

Potential impacts of upstream land use change on phytoplankton community dynamics in Winyah Bay, SC

Investigators: Evelyn Lawrenz and Dr. Tammi Richardson
Marine Science Program, University of South Carolina

Winyah Bay is characterized by high concentrations of colored dissolved organic matter (CDOM) which gives the estuary a tea-colored appearance and alters availability and spectral composition of the underwater light field. Due to high CDOM, orange-red wavelengths dominate the light environment with blue light only being available at the surface. With increasing distance from the rivers CDOM concentrations decline so that the spectral quality of the underwater light field changes to predominantly green downstream. Phytoplankton differ in their pigment composition and thus also in their ability to use varying wavelengths of light along the salinity gradient of the estuary. Upstream land use change may cause alterations in the amount of CDOM leaching from wetlands in the watershed altering light availability and spectral quality of the underwater light field. Our research focuses on (1) quantifying seasonal changes in the underwater light field and phytoplankton community composition and (2) on

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.

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Urbanization and Southeastern Estuarine Systems (USES)

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

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

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

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

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

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

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

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

Investigators: Drs. Dwayne E. Porter[1,2], Tom Siewicki[2,3], Marj Aelion[1,2], Heath Kelsey[2], and Sam Walker[2]
Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina[1]
The Norman J. Arnold School of Public Health, University of South Carolina[2]
NOAA's Center for Coastal Environmental Health and Biomolecular Research[3]

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

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

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

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

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

This project is funded for the period 07/01/04 to 06/30/08 by SC Sea Grant Consortium. (www.lu-ces.org).

Habitat mapping of North Inlet

Investigator: Jennifer Spicer
North Inlet-Winyah Bay National Estuarine Research Reserve

A habitat map will be developed for the area within the North Inlet Winyah Bay NERR and a land use map will be created for the North Inlet watershed using the NERRS Habitat and Land Use Classification System. Digital aerial photos, ADAR and LiDAR data will be used to map the area to a 1 m resolution. The classification scheme developed by the NERRS Habitat Mapping and Change Committee has a five-level, nested hierarchical structure based on the Cowardin and Anderson classification systems, and will facilitate the exchange of habitat data among reserves. These maps will serve as a baseline for temporal studies that examine trends in land use and land cover change. The North Inlet habitat map will also be used to examine habitat distribution and availability for key species in the Reserve.

Larval transport of the freshwater fiddler crab, *Uca minax*

Investigator: Dr. Renae Brodie
Student assistants: Megan Flenniken, Christine Raczka, Augusta Ankoh, Asinath Rusibamayila
Mount Holyoke College

Dense populations of the fiddler crab *Uca minax* (Le Conte 1855) are common along tidally influenced freshwater rivers and streams > 50 km from the sea. Adults do not migrate from inland sites to release larvae, but instead release them directly into an environment where they cannot survive. During 2003-2005, laboratory salinity tolerance experiments were used to determine that larvae were only able to survive for 2-5 days. Estimated travel times to reach permissive salinities from the inland-most population based on current profiles were 3-5 d for larvae using night-time only ebb-tide transport and1.5-2.5 d for those using ebb-tide transport both day and night. Pump sampling data from the Pee Dee River indicate that *U. minax* zoeae travel during both day and night-time ebb tides, however, more larvae are present in the water column at night. We plan to repeat the pump sampling at Clam Bank bridge during August 2008 to see if we get a similar pattern. Surface water from the tidal creek will be pumped continuously through a plankton net and samples of *Uca* larvae will be collected every 20 minutes for 24 hours. Larval specimens will be preserved in ethanol at BMFL and identified using PCR-RFLP at Mount Holyoke College in Massachusetts.

This project investigates the evolution of freshwater tolerance in the larva of a freshwater crab with marine planktonic development This project is supported by the NSF CAREER Grant for August 2008

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

Investigators: Simmone Williams and Dr. Renae Brodie
Department of Biological Sciences, University of South Carolina

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

Habitat parameters such as land cover type will be derived from ADAR imagery. Nine sample sites will be selected within North Inlet and in situ data, such as salinity, will be collected fortnightly along transects between February 15, 2006 and August 31, 2008. Population density will be determined from quadrat counts at sample sites. Both derived and in situ data will be used to build a habitat suitability model that estimates likely variations in habitat and population distribution of adult *U. minax* and *U. pugilator*. We will also evaluate the usefulness of the applied integrated remote sensing, statistics and field approach in large scale assessments of adult *U. minax* and *U. pugilator* habitat and population distribution. Map location 10

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.

Nitrogen cycling in salt marsh ecosystems

Investigators: Drs. Behazd Mortazavi[1] and James T. Morris[2]
Department of Biological Sciences, University of Alabama[1]; Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina[2]

Although nitrogen biogeochemistry has been studied in salt marsh ecosystems for decades, nitrogen budgets at the ecosystem level remain controversial and unresolved. The proposed research will quantify rates of nitrogen loss in salt marsh sediments using state-of-the-art measurements. During a two week period starting in July 28, 2008 we will conduct two sets of experiments. We will examine nitrogen loss through denitrification at an unamended plot and at a nutrient treated plot. The methodology consists of injecting ^{15}N-labeled NH_4^+ into undisturbed vegetated salt marsh sediments and following ^{15}N retention over a week long period in a series of destructively sampled sediment cores and their associated aboveground biomass. If our working hypothesis is correct, then higher rates of nitrification-denitrification will be measured in the fertilized plot, indicating that the extra nitrogen in the sediments relieves the competition between the macrophytes and the microbial community for nitrogen.

Long-term productivity in salt marsh productivity is driven by a complex interaction between sea level change and nutrient cycling. Nitrogen is most often implicated as the macronutrient limiting primary productivity in coastal marine ecosystems and nitrogen flow in salt marshes is mediated by a combination of plant uptake and microbial transformations. Nutrient cycles are mediated by macrophyte-microorganism interactions and these interactions are modulated by marsh elevation responding to changes in mean sea level (Morris et al. 2000). A small rise in sea level will reduce salinity in pore water of salt marsh sediments and result in an increase in primary productivity. Increases in primary production will have a series of impacts on nitrogen transformations in the sediments: (i) It will provide organic matter to the sediments which will fuel nitrogen fixation and (ii) affect the redox potential of the sediments which increases the sulfidization effects on nitrification/denitrification. Salt marsh primary productivity and sedimentary biogeochemical cycles interact through a complex feedback loops that are modulated by relative marsh elevation. Our long-term goal is to provide through a collaborative effort (Dr. Morris at USC, Dr. Kostka at FSU) a mechanistic understanding of the linkages between relative marsh elevation, plant growth, and sedimentary nutrient cycles in marsh ecosystems.

References:

Morris, J.T., P.V. Sundareshwar, C.T. Nietch, B. Kjerfve, and D.R. Cahoon. 2000. Responses of coastal wetlands to rising sea level. Ecology 83:2869-2877.

Organic geochemical characterization of DOM in North Inlet

Investigators: Drs. Ralph Mead[1] and Erik Smith[2]
Department of Chemistry, University of North Carolina, Wilmington[1]; Baruch Marine Field Laboratory, University of South Carolina[2]

The goal of this research is to characterize the chemical nature of the DOM pool exported from the marsh, its diagenetic state and the relative contributions of *Spartina*, algal (microphytobenthos and phytoplankton) and sediment/soil sources to heterotrophic bacterial metabolism. Water will be sampled during falling tide to chemically characterize the dissolved organic matter present and to relate back to microbial metabolism rates. The methods I

will be using involve initial water filtration at Baruch with subsequent organic characterization (fluorescence, NMR and mass spectrometry) in my laboratory at UNCW.

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

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

Investigators: Dr. Leigh McCallister and Lindsey Koren
Virginia Commonwealth University

This project seeks to address a fundamental gap in our understanding of C cycling in terrestrial aquatic systems by applying a multidisciplinary approach to characterize the age of soil/terrestrial OC transferred to the aquatic environment and its respiratory fate. This project will be coordinated with current ongoing research with Dr. Scott Neubauer. The primary research objectives are

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

2) To determine the total lability of the desorbed OC and the natural stable and radiocarbon isotopic signatures of the respired C.

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

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

Dissolved organic carbon (DOC) lability, bacterial respiration and production - DOC lability will be determined from long-term parallel (14 day) duplicate re-growth incubations of filtered water as per McCallister et al., (2006). DOC samples will be taken at multiple time points and analyzed in my lab at VCU. Bacterial respiration will determined from O_2 consumption via the Winkler method. Rates of bacterial production will be estimated from the incorporation of ^{3}H-Leucine following the centrifugation method of Smith and Azam (1992).

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

Investigators: Drs. Cathy Wigand[1], Earl Davey[1], Erik Smith[2], and Jim Morris[2], and Karen Sundberg[2] and Paul Kenny[2]
US Environmental Protection Agency NHEERL Atlantic Ecology Division, RI[1]
Baruch Marine Field Laboratory, University of South Carolina[2]

We propose that the combination of computer-aided tomography (CT) and soil respiration measures may be a practical and useful approach to monitor condition and assess impairment in coastal salt marshes. CT imaging will be used to examine macro-organic matter and belowground structure in cores collected from long-term fertilized plots, control plots, and salt marsh areas with varying nutrient status. The CT imaging will allow for an estimate of the plant tissue-gas and peat-water volumetric fractions of the salt marsh cores. Coupled with these measures of belowground structure in the salt marsh plots, *in situ* measures of CO_2 efflux, as an indicator of soil respiration, will be determined. We expect an increase in the soil respiration rates in the fertilized plots compared to the control ones, and a decrease in the below-ground macro-organic matter, in particular, the peat-water fraction. We will also report on the belowground structure and soil respiration in natural plots with varying nutrient status in the North Inlet-Winyah Bay NERR. Partial funding for summer sampling (2007, 2008) was provided to visiting scientist C. Wigand from the Baruch Marine Field Laboratory, USC and additional funding by the US EPA, Atlantic Ecology Division.

Carbon sequestration rates in impounded vs. non-impounded tidal wetlands

Investigator: Dr. Benjamin Tanner
Department of Geosciences and Natural Resources, Western Carolina University

The most recent report of the Intergovernmental Panel on Climate Change (2007) suggests that anthropogenic contributions of greenhouse gasses to the atmosphere are "very likely" increasing mean global surface temperatures. Consequently, there is increasing interest from scientists and policy makers in finding sinks for atmospheric carbon and determining their importance in the global carbon cycle. Salt marshes are highly productive ecosystems that represent a significant component of the global carbon cycle. I am studying rates of carbon sequestration in different types of tidal wetlands at and around BMFL, including a formerly-impounded wetland (1000 Acre Rice Field) and a currently impounded wetland (Estherville Plantation), in order to determine which types of wetlands have the greatest sequestration potential. I have collected soil cores from multiple sites and have sub-sampled the cores to determine soil organic carbon % (CNS analyzer), soil bulk density, and soil age (^{210}Pb). While organic carbon analysis is ongoing, preliminary ^{210}Pb modeling shows an average sediment accumulation rate of 0.11 cm yr^{-1} at the 1000 Acre Rice Field core location and an average sediment accumulation rate of 0.18 cm yr^{-1} at the Estherville Plantation location. Soil carbon accumulation rates will be calculated as a product of the average soil accretion rate and the average carbon density for each core. Results of this study will be relevant to other scientists and policy makers who are interested in an improved understanding of the role of tidal wetland biospheric feedbacks in the global carbon cycle. This project has been funded by a Visiting Scientist Award from BMFL. This project will begin in August '08

Effects of inter-tributary dissolved organic carbon on heterotrophic microbial communities in upper Winyah Bay

Investigators: Emma Wear[1], Drs. Eric Koepfler[2], Erik Smith[3], Joe Bennett[2], and Mike Ferguson[3]
Coastal Marine and Wetland Studies Graduate Program[1], Marine Science Department, Coastal Carolina University[2]; Baruch Marine Field Laboratory, University of South Carolina and North Inlet-Winyah Bay National Estuarine Research Reserve[3]; Biology Department, Coastal Carolina University[3]

Dissolved organic carbon (DOC) has been shown to affect the metabolic activity and phylogenetic composition of free-living heterotrophic bacteria in rivers and estuaries. This study will compare bacterial activity and community composition across the four main rivers leading into Winyah Bay and in the estuary proper. We hypothesize that anthropogenic land use in the rivers' watersheds will alter their DOC loading, leading to differing responses of the bacterial communities in each site. Metabolic activity will be measured by respiration and BIOLOG substrate trays, and DOC will be assessed by bioassays and UV-VIS absorption spectra. Phylogenetic richness and community similarity will be examined using denaturing gradient gel electrophoresis of 16S rDNA, which is indicative of evolutionary lineages. Dissolved nutrients, chlorophyll, and in situ water quality parameters will also be measured. This research is supported by a National Estuarine Research Reserve System Graduate Research Fellowship.

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.

Ecology of diamondback terrapins (*Malaclemys terrapin*)

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

A mark-recapture study of diamondback terrapins is in progress in North Inlet. As at August 2007, 86 terrapins have been marked, mainly from tidal creeks off Town Creek and Old Mann Creek. Four recaptures were made from 2 creeks during summer 2007. Nesting areas have been identified on the east and western banks of Debidue Creek. To date no juveniles have been found. The study will continue to investigate habitat use, movement within the Inlet, and diet of terrapins. In 2008, several individuals will be fitted with acoustic tags and their movements will be tracked to determine site fidelity and home ranges.

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

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

Investigators: Dr. James Morris[1,2] and Karen Sundberg[2]
Department of Biological Sciences[1] and Belle W. Baruch Institute for Marine and Coastal Sciences[2], University of South Carolina

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

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

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

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

The tide gauge measures water level in reference to MLLW in Crabhaul Creek (Oyster Landing Pier) every six minutes. The data are transmitted to NOAA via NOAA's Geostationary Operational Environmental Satellites (GOES), making the data available on-line in near real-time (one hour delay). Data are available to the public, and

are useful in showing tidal anomalies, observing sea level rise, and modeling local phenomenon in North Inlet Estuary.

This state-of-the art tide gauge is accurate to ±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. The National Tidal Datum Epoch has been updated to the 1983-01 epoch on April 21, 2003. The updated bench mark sheets are available on the CO-OPS website: http://co-ops.nos.noaa.gov/datum_update.shtml.

For viewing the on-line near real-time data for North Inlet, visit NOAA's website at http://tidesonline.nos.noaa.gov/geographic.html [Select SC on the map and then Oyster Landing, SC (North Inlet Estuary)]. 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

Baruch's web link indicates the availability of the data: http://links.baruch.sc.edu/Data/NIWaterLevel/data/DataAvailabilityTable.Jun2001-Feb08.pdf

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

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

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

As part of the North Inlet-Winyah Bay National Estuarine Research Reserve (NERR), a fully functional meteorological station (National Weather Service installation) is located on the Oyster Landing Pier at North Inlet. Wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation are recorded at 15 minute intervals. Data are telemetered via the NOAA GOES satellite system to the NERR Central Data Management Office, and made available in near real time at http://cdmo.baruch.sc.edu. For most parameters, records have been collected for more than 13 years. Long-term, continuous weather records provide data for determining the effects of climatology on the various biological and physical processes being studied in the North Inlet estuary. Map location 3.

National Atmospheric Deposition Program (NADP)

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

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

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

Investigators: Dr. Erik Smith and Tracy Buck
Baruch Marine Field Laboratory, 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 and Benjamin Lakish
Baruch Marine Field Laboratory, University of South Carolina and North Inlet-Winyah Bay National Estuarine Research Reserve

As part of the NERRS System-Wide Monitoring Program, water chemistry sampling was initiated in June of 1993 to monitor concentrations of suspended solids, dissolved organic carbon, total nitrogen, ammonium, nitrate, nitrite, total phosphorus, orthophosphate, and chlorophyll a at four locations within the North Inlet-Winyah Bay NERR. Water samples are collected every 20 days with ISCO automated water sampling devices at intervals of 2 hours and 4 minutes over two complete tidal cycles. Sampling and chemical analyses adhere to strict national protocols developed as part of the NERRS System-Wide Monitoring Program. The consistent, long-term collection of water chemistry variables allows for the characterization of short-term variability and detection of long-term change in key water quality parameters. These data also provide critical information for various studies of biological and physical processes in the North Inlet estuary. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control, and then made available via the CDMO website: http://cdmo.baruch.sc.edu. Map locations 6A, 6B, 3, 2C. Water chemistry data collected in North Inlet prior to the initiation of the NERRS SWMP sampling (some dating back to 1978) are available via the BMFL Data Archives web site: http://links.baruch.sc.edu/Data/index.html.

Long-term monitoring of emergent salt-marsh vegetation in the North Inlet estuary

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

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

biomass by non-destructive sampling techniques; and porewater salinity. Map location 10.

Plankton community respiration in the North Inlet estuary

Investigators: Dr. Erik Smith, Amy Willman, and Tracy Buck
Baruch Marine Field Laboratory, University of South Carolina and North Inlet-Winyah Bay National Estuarine Research Reserve

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

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

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

Investigators: Drs. Charles R. Lovell[1] and Madilyn Fletcher[1,2], and students
Department of Biological Sciences, University of South Carolina[1]
Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina[2]

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 ten years and is supported by the National Science Foundation (1994-2008, so far). Map locations 8 and 10.

Some of the most recent publications associated with the work:

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

LaRocque, J., P.W. Bergholz, C.E. Bagwell, and C.R. Lovell. In press. Influence of host plant-derived and abiotic environmental parameters on the composition of the diazotroph assemblage associated with roots of *Juncus roemerianus*. Antonie van Leeuwenhoek.

Lovell, C.R. In press. Belowground interactions among salt marsh plants and microorganisms. In: E. Kristensen, J.E. Kostka, and R.H. Hease (eds.) *Interactions Between Macro- and Microorganisms in Marine Sediments*, Coastal and Estuarine Studies Series. American Geophysical Union, Washington, D.C.

Brown, M.M., M.J. Friez, and C.R. Lovell. 2003. Expression of nifH genes by diazotrophic bacteria in the rhizosphere of short form *Spartina alterniflora*. *FEMS Microbiology Ecology* 43:411-417.

Leaphart, A.B., M.J. Friez, and C.R. Lovell. 2003. Formyltetrahydrofolate synthetase sequences from salt marsh plant roots reveal a diversity of acetogenic bacteria and other bacterial functional groups. *Applied and Environmental Microbiology* 69:693-696.

Beeson, K., D.L. Erdner, C.E. Bagwell, C.R. Lovell, and P.A. Sobecky. 2002. Differentiation of plasmids in marine diazotroph assemblages determined by randomly amplified polymorphic DNA analysis. *Microbiology* 148:179-189.

Lovell, C.R. In press. Plant-microbe interactions in the marine environment. In: G. Bitton (ed.) *Encyclopedia of Environmental Microbiology*. Wiley, New York, NY.

Bergholz, P.W., C.E. Bagwell, and C.R. Lovell. 2001. Physiological diversity of rhizoplane diazotrophs of the saltmeadow cordgrass, *Spartina patens*. Implications for host specific ecotypes. *Microbial Ecology* 42:466-473.

Bagwell, C.E., M. Dantzler, P.W. Bergholz, and C.R. Lovell. 2001. Host specific ecotypic diversity of rhizoplane diazotrophs of the perennial glasswort, *Salicornia virginica* and selected salt marsh grasses. *Aquatic Microbial Ecology* 23:293-300.

Leaphart, A.B., and C.R. Lovell. 2001. Recovery and analysis of formyltetrahydrofolate synthetase gene sequences from natural populations of acetogenic bacteria. *Applied and Environmental Microbiology* 67:1392-1395.

Lovell, C.R., M.J. Friez, J.W. Longshore, and C.E. Bagwell. 2001. Recovery and phylogenetic analysis of nifH sequences from diazotrophic bacteria associated with dead aboveground biomass of *Spartina alterniflora*. *Applied and Environmental Microbiology* 67:5308-5314.

Lovell, C.R., C.E. Bagwell, M. Czako, L. Marton, Y.M. Piceno, and D.B. Ringelberg. 2001. Stability of a rhizosphere microbial community exposed to natural and manipulated environmental variability. *FEMS Microbiology Ecology* 38:69-76.

Phytoplankton monitoring at the NERRS sites (North Inlet-Winyah Bay)

Investigators: Drs. Susan B. Wilde[1,2] and Erik Smith[1]
Baruch Marine Field Laboratory, University of South Carolina[1], Marine Resources Research Institute, SC Department of Natural Resources[2]

We will coordinate our sampling dates within North Inlet/Winyah Bay with the on-going long-term water quality monitoring program at the NERRS sites. We collect phytoplankton samples and screen for species composition and utilize HPLC to determine biomass within algal classes. Any algal blooms will be quantified and potentially toxic blooms will be analyzed for toxin production. This additional monitoring will add to the extensive existing data on the North Inlet/Winyah Bay system.

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

Investigators: Drs. Robert Feller and Bruce Coull (Distinguished Emeritus)
Marine Science Program, University of South Carolina

Regular (biweekly or monthly) collections of two size fractions of animals that live in the sand or mud have been made at the same locations in the North Inlet Estuary since 1972 (meiofauna) and 1981 (macrofauna). For logistical reasons, we switched to quarterly sampling in 2002, however. Small invertebrates, less than 0.5 mm in size, comprise the meiofauna. The meiofauna collection is the longest estuarine meiofauna time-series in the world. Although collections of both meiofauna and macrofauna continue to be collected, sample processing, predictably, lags behind, with only 4 of 8 replicate samples counted since 1992. Although these benthic communities contain hundreds of different species, only dominant taxa are identified regularly. The meiofauna are dominated by nematodes and harpacticoid copepods, while the macrofauna consists mostly of polychaete and oligochaete worms, bivalves, and small crustaceans. Both size groups of organisms demonstrate annual cycles of abundance, peaking in late winter/early spring, with lows in late summer/early fall. Simultaneous measurements of physical conditions in the water, sediment, and air help investigators determine causes of these variations in abundance over time. We also have noticed that the macrobenthos appears to increase and decrease on a cycle of between 9 and 11 years, but the time-series must become longer before this cycle can be confirmed. Data from undisturbed North Inlet habitats provide a baseline to which other areas, including contaminated areas, can be compared. These studies also provide an opportunity to examine the recruitment dynamics of soft-bottom benthic organisms. Map location 7.

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

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

In this study, the timing and the magnitude of nekton migrations onto the vegetated marsh surface are measured by enclosing a one acre area of flooded marsh at high tide and determining the taxonomic and life stage composition of the fauna leaving the area with the ebbing tide. These biweekly high tide collections in Oyster Landing Basin relate short-term, seasonal, and interannual changes in the abundance and composition of resident and transient species to flooding depth (sea level), freshwater runoff, and other environmental conditions. Comparisons of high tide collections at this site with same-day seine collections from the adjacent creek from 1996 to 2003 revealed that the composition and abundance of nekton remaining in the low tide pool was representative of the nekton using the flooded marsh. Low tide collections (1984-2003) showed long-term stability in the composition and production of the nine dominant transient fishes and shrimps that occupied the intertidal habitat. However, during the 20-year period, overall abundance increased, evenness decreased, and water temperatures increased (especially in winter). Relationships between OL Basin nekton and larval fish catch data from the long-term zooplankton series indicate the importance of recruitment success in determining annual production of some taxa. This long-term time series is unique for the Southeast region and is becoming increasingly important as we interpret

impacts of global climate change on nekton populations and the shallow water habitats that are essential to their development. Results have implications for the management of salt marsh-estuaries, watersheds, and fisheries. Map location 3.

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

Investigators: Drs. Ken Able[1], Dennis M. Allen[2], Donald Hoss[3], Stanley Warlen[3], Gretchen Bath-Martin[3], and Perce Powles[4]
Rutgers University Marine Field Station[1]; Baruch Marine Field Laboratory, University of South Carolina[2]; NOOA NOS Beaufort, NC[3]; Biology Department, Trent University, Ontario, Canada[4]

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

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

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

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 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. Long-term increases in water temperatures have been documented especially for the winter. During the past 25 years, the timing of larval shrimp and fish arrivals from offshore spawning grounds and period of larval production by resident grass shrimp populations has expanded. Since many zooplankton species are developmental stages of larger animals, the study provides indications of the reproductive and recruitment success of several commercially and/or recreationally important species. The value of these datasets continues to increase as we formulate and test new hypotheses and extend the time series. Map location 10.

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

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

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

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

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

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

This long-term project, begun in September 1997, has investigated various questions related to the ecological role of bottlenose dolphins in the North Inlet and Winyah Bay systems. As surface-associated apex predators, dolphins are a highly visible indicator species for movements in the prey community and potential system-wide changes. Using photo-ID and focal follow and transect surveys, we have identified long term resident dolphins in both North Inlet and Winyah Bay. This information is used to model the trophic role of dolphins within the system, to model the potential impact of dolphins upon prey populations, and to examine resident dolphin bioenergetics, social structure, and behavior. Our initial studies have determined that the dozen or so resident dolphins in the North Inlet system consume a significant proportion of the prey fish populations (11-14 metric tons per year) and that 3 - 7% of the annual primary production in North Inlet is required to support them. Dolphin distribution in North Inlet has been correlated with changing patterns of salinity and prey distribution, and in Winyah Bay it has been correlated with salinity and bottom type. Mothers with young calves apparently favor low current areas, and salt marsh residents swim slower and expend less energy while traveling than coastal dolphins. Continuing studies will address the distributional response of dolphins and other trophic levels to short-term but tidally predictable chlorophyll maxima.

Young, R.F. and H.D. Phillips. 2002. Primary production required to support bottlenose dolphins in a salt marsh creek system. *Marine Mammal Science* 18(2):358-373.

Sea turtle nest monitoring on Debidue Beach/Hobcaw Barony

Investigators: Betsy Brabson[1] and Robin Baughn[1] (Debidue Beach coordinators), Wendy Allen[2], Lindsay Thomas[2] and other volunteers
DeBordieu Colony[1]; North Inlet-Winyah Bay National Estuarine Research Reserve, Baruch Marine Field Laboratory, University of South Carolina[2]

Nesting activity of the threatened loggerhead sea turtle, *Caretta caretta*, on the Hobcaw Barony portion of Debidue Beach is monitored by trained volunteers, May-October. This beach, owned by the Belle W. Baruch Foundation, is undeveloped and is about 2.2 miles in length. Staff from the Baruch Marine Lab, residents of

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

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

Investigators: Jennifer Spicer and Dr. Erik Smith
North Inlet-Winyah Bay National Estuarine Research Reserve, and Baruch Marine Field Laboratory, University of South Carolina

Goals:

1) To determine the population size of Clapper rail, *Rallus longirostris*, in the marshes of North Inlet.
2) To examine relationships of clapper rail distribution to landscape patterns including distance from upland edge and upland development.
3) To contribute data on clapper rail population status to a National marsh bird monitoring database.
4) To detect the presence of least bitterns, *Ixobrychus exilis*, in North Inlet.

Clapper rails will be surveyed by boat using a standardized call broadcast method. Thirty-five survey stations will be marked with 1 m pvc poles at the marsh-creek edge. Survey stations will be grouped into 4 survey areas: 10 stations at Clambank Landing (representing mid-marsh habitat), 10 stations at Oyster Landing (representing upland border habitat), 10 stations along Jones Creek (representing barrier island back habitat), and 5 stations at Debordieu (representing developed upland habitat). Stations within each survey area will be spaced 400 m apart. At each survey station, observers will follow a standardized protocol that begins with a five minute listening period, followed by 30 seconds of broadcast clapper rail calls, a 30 second listening period, 30 seconds of least bittern, *Ixobrychus exilis*, calls, and a final 30 second listening period. Pre-recorded calls distributed by the USGS Arizona Cooperative Fish and Wildlife Research Unit will be broadcast facing a pre-determined compass direction at each station using an IPod and/or CD player and portable speakers, with a sound pressure of 80-90 db at 1 m in front of the speakers determined by a sound-level meter. Observers will record the timing, direction, estimated distance, and call type of clapper rails and least bitterns throughout the total 7 minute sampling time at each station. Surveys will be completed at all 35 survey stations between sunrise and 10:00 AM over a sampling period of two consecutive days. Sampling periods will occur in May and June during the weeks after the new and full moon, for a total of 4 replicate sampling periods.

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. To address the need for a nationwide, standardized monitoring program, the U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, has published a standardized survey methodology, conducts training courses, and maintains an online data base intended for use on National Wildlife Refuges and other protected areas across North America. Data from this study on clapper rail and least bittern populations in North Inlet will contribute to this national database and will help to determine the population status of these species in South Carolina. The distribution of clapper rails in the North Inlet marsh will also be examined in the context of habitat type. The effects of distance from the marsh/upland edge and the presence of developed upland area will be examined using GIS and spatial analysis techniques. 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.

South Carolina Estuarine and Coastal Assessment Program

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

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

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

To date, three sites have been sampled in the North Inlet estuary as part of the program and another is planned for sampling in 2008. Many more stations have also been sampled in the adjacent Winyah Bay system. The relatively small size of the North Inlet estuary limits the number of sites that would be identified through the random, probability-based sampling approach, but it does provide an opportunity to compare conditions within North Inlet to other locations in the state.

Education, Outreach, and Data Management

High School Water Quality Program – National Estuarine Research Reserve

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

Education and outreach focusing on water quality is targeted to local schools in Georgetown, Horry, and other counties, and informs students and others about the importance of healthy water quality and the value of watersheds and estuaries. This program (started as a pilot in 1996) is an offshoot of the former Estuary-Net volunteer water quality monitoring project (http://www.northinlet.sc.edu/estnetweb/estnet.html) developed by the National Estuarine Research Reserve System (NERRS). It includes a complete curriculum with both classroom and field activities that provide a hands-on approach for investigating water quality and watersheds. Teachers and students from local school districts work with Reserve staff to study water chemistry and quality, sample bodies of water near their schools, and access local and national estuarine data collected from the NERRS' System-Wide Monitoring Program (SWMP). Participating schools work closely with the Reserve's Education staff and receive introductory classroom visits highlighting the Reserve System and the North Inlet Winyah Bay NERR, the water quality project, and instruction on monitoring equipment and sampling protocols for a variety of sampling variables. Reserve site visits, estuarine ecology, follow-up school visits and sampling assistance (including testing equipment) are also offered.

Education activities – National Estuarine Research Reserve

Investigators: Beth Thomas 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. Long-term program offerings include estuarine and beach ecology, open houses, "Bike to the Boardwalk", "North Inlet Kayak Tours", and the monthly "Fishes of North Inlet Estuary" program in which participants help Reserve scientists sample and process collections of fishes, shrimps and crabs made on a biweekly basis. Field trips for high school students, homeschool students, and special groups such as Elderhostel, Boy and Girl Scouts, 4H clubs, and church groups are also available.

Off-site outreach includes events such as the annual Winyah Bay Heritage Festival and Wildlife and History Day at Huntington Beach State Park, summer reading programs at Georgetown County library branches, afterschool programs for local elementary and middle schools, science and environmental fairs, and career days. Contact the Reserve for a schedule of events at (843) 546-6219 or visit the Reserve's web site at: www.northinlet.sc.edu.

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

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

Investigators: Beth Thomas, Nicole Saladin, and Lindsay Thomas
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, 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, the Consortium was formed to provide a clearinghouse for stormwater education resources for local MS4 communities in Horry and Georgetown Counties. The Consortium education providers offer a variety of outreach activities and resources designed to maximize efficiency of stormwater education efforts in the northeastern coastal region of South Carolina by using a regional/watershed approach and to help local MS4s to meet NPDES Phase II Permit requirements for public stormwater education and outreach. To learn more about the CWSEC, please visit http://www.northinlet.sc.edu/training/stormwater_education/index.htm

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

Investigators: Beth Thomas[1] and Dr. Dennis Allen[2]
North Inlet-Winyah Bay National Estuarine Research Reserve[1]
Baruch Marine Field Laboratory, University of South Carolina[2]

The Reserve currently participates in several community enhancement and stewardship activities in partnership with Keep Georgetown Beautiful (KGB), the local chapter of Keep America Beautiful. Reserve and BMFL staff assist in river and marsh cleanups, lead recycling programs for elementary students and afterschool programs, and assist with a county-wide monofilament recycling program. Beth Thomas is serving on the Board of Directors (June '08-'09 term) of KGB and she participates in school, beautification, and recycling subcommittees within the organization. Dr. Dennis Allen is serving on the Morgan Park Task Force, which is spearheading the revitalization of a community park located on the Winyah Bay at the Sampit River.

Coastal Training Program for local decision-makers

Investigator: Nicole Saladin
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Field Laboratory, University of South Carolina

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

CTP training can be conducted in a variety of settings and formats, and training is always tailored to the specific needs of the audience. All training sessions include take-home reference materials and digital access (through the CTP website: www.northinlet.sc.edu/training) 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

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

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

The continuation and advancement of the System-wide Monitoring Program data and information management program. This priority area will support data management protocols for water quality and meteorological data and associated metadata, documentation, data archival, development of software-specific programs to assist with data QA/QC procedures, and data and information dissemination. The CDMO will continue efforts to (a.) improve the process for making SWMP monitoring data and associated metadata available via the SWMP/CDMO web presentation; and (b.) support applications and programs to assist with the processing, quality control, management and metadata of data collected using the water quality data loggers and meteorological stations. Once operational, the CDMO will also be responsible for the data assimilation, management, and documentation as related to expanded phase I data collection efforts.

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.

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.

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.

The continuation of the CDMO Technicians' Training Workshop series to provide training for NERRS research technicians working on SWMP initiatives. The CDMO will again conduct a multi-day workshop series to provide hand-on assistance to research technicians in support of SWMP equipment setup, operation and maintenance; data collection and management; and QA/QC activities. The workshops will be held in the winter of 2009.

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

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Research Locations in North Inlet

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