CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS

2004

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 Research Projects 2004

Introduction

More than 565 scientific research projects and about 340 student theses and dissertations have been completed by Baruch Institute research associates since 1969. This work has resulted in the publication of more than 1,425 scientific articles, reports, and books that contribute new information in subject areas ranging from molecular biology to landscape ecology. The accumulating information provides a fundamental understanding of the structure, function, and condition of coastal ecosystems. Results of research projects are used by educators, coastal resource managers, health and environmental regulators, legislators, and many other individuals and organizations interested in maintaining or improving the health of estuaries in the face of increasing human activities in the coastal zone.

The following annotated list summarizes 85 of the projects currently being conducted at the Baruch Marine Field Laboratory (BMFL) by staff, graduate students, and faculty associated with the University of South Carolina and other institutions. The University of South Carolina is the home institution for 34 faculty, 18 technician, and 29 student investigators conducting research at the BMFL. In addition, 39 faculty, 8 technicians, 9 students and 10 volunteers representing 30 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 randomly grouped and each project summary includes title, investigator(s), affiliation, and project abstract. Projects that focus on long-term monitoring and research are grouped under the heading Long-term Studies. Education, Outreach, and Data Management Projects are described in another section.

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

Author and Title List

Long-term Studies

Characterization of intertidal zone creek networks

Investigators: Karyn I. Novakowski and Dr. Raymond Torres
Department of Geological Sciences, USC

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

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

The objectives of this proposed research are to 1) quantify estuarine channel network properties at North Inlet NERRS and 2) test terrestrial concepts for channel network evolution in estuarine systems. I propose to use Hack's law ($L = m \mathrel{⊦} A^n$, where L is total stream length, m is a parameter derived experimentally, A is drainage basin area, and n is a scaling exponent) to test for power law scaling in estuarine channel systems. I expect to reveal the utility of exponential scaling which may serve as an index needed to assess the large-scale health and stability of estuarine systems. It may also be the basis for channel system design in reconditioned coastal landscapes. This project is funded by the NERR-GRF program for the period June 2001-May 2004.

Intertidal marsh hydrology and geomorphology

Investigators: Drs. George Voulgaris[1] and Raymond Torres[2]
Department of Geological Sciences and Marine Science Program,USC[1],
Department of Geological Sciences, USC[2]

This project is designed to understand the development of tidal creek networks and to examine the applicability of terrestrial river network theories to intertidal environments. This will be accomplished by the development of a high resolution, high-density digital elevation model of an intertidal creek network using DGPS and bathymetric surveying. Measurements of flow and turbulence at various locations and for various tidal creek sizes will be examined. A 2-D numerical model will result.

This project is significant in providing the theoretical background for wetland restoration and is supported by the NSF from March 2003 until February 2004. Map location #16.

Along channel particle sorting in North Inlet, South Carolina

Investigators: Christopher Wargo[1] and Dr. Richard Styles[2]
Department of Geological Sciences, USC[1]
Department of Geological Sciences and Marine Science Program, USC[2]

Physical understanding of large-scale geomorphological entities, such as tidal inlets, is one of the main requirements for establishing a rigorous scientific basis for the management and sustainable development of coastal systems. The physics governing the dynamics of inlets are poorly understood because of their complex nature, scales of motion and geomorphic change. In this study we investigate the along channel distribution of the dominant grain size class in terms of mean flow speed and local current shear.

Field sampling was conducted in North Inlet, South Carolina during two complete tidal cycles in May of 2003. Sampling was along two transect lines that connect the inlet throat to the main creek systems that feed the marsh. The first ran from the intersection of Town Creek and Old Man Creek to a point approximately 0.5 km offshore of the inlet throat. The second survey was conducted from a point approximately 2 km up Jones Creek to approximately 1 km up Debidue Creek. Spatial sampling included an ADCP (Acoustic Doppler Current Profiler) to

measure full water column currents, a CTD to measure salinity, temperature and depth, a submersible pump to collect water samples, a surface grab sampler to collect bed sediments, and a LISST (Laser In Situ Scattering Transmissometer) to measure suspended sediment concentration and particle size distribution.

Preliminary results have identified differences in bed grain size distributions between flood and ebb, and the development of an ebb front at the convergence of Jones and Town Creek. Significant along channel salinity gradients also exist throughout both major creek systems. A small yet intense thunderstorm before the second day of sampling produced a thin fresh water lens in Jones Creek. An analysis of water column particulates indicate that the majority of the sediment transport likely occurs as bed load or by saltation within a very narrow region of the bottom.

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

Investigator: Dr. Brian Silliman
Department of Ecology, Brown University

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

Effects of global warming and marsh grass growth

Investigator: Dr. Brian Silliman
Department of Ecology, Brown University

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

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

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

Biogeographic theory predicts that consumer-prey interactions are more intense at lower latitudes, leading to increased defenses of prey. My students and I are testing this hypothesis in Atlantic Coast salt marshes. We are counting herbivores and measuring herbivore damage to salt marsh plants in ten sites in the South Atlantic Bight and ten sites in New England. At Baruch, we work about halfway along Goat Island and at the end of the 3rd Boundary Cutoff Road (map locations # 8 & 9). We will transplant standard marsh plants into a subset of our 20 sites for brief periods (ca. 1 month) to determine if standard salt marsh plants receive more herbivore damage in the south than in the north. This project will test a long-standing biogeographic theory that has received little experimental attention. This project is funded by the National Science Foundation through December 2005.

Plant-herbivore interactions: Latitudinal variation and impacts of climate change

Investigator: Chuan-Kai Ho
Department of Biology and Biochemistry, University of Houston

Latitudinal variation in plant-herbivore interactions in salt marshes has been studied for several years. Data have supported that salt marsh plants at higher latitudes (New England) are more palatable than those at lower latitudes (FL, GA, SC) (Pennings et al. 2001). My research will follow up and examine if there is a correlation between this herbivore preference pattern and herbivore performance. My approach is to use 13 NERR and 3 Long-Term Ecological Research (LTER) sites along the Atlantic Coast as a network to examine this plant-herbivore interaction.

Using a combination of greenhouse experiment and field sampling, my research will focus on four common marsh plant species (*Solidago sempervirens*, *Spartina alterniflora*, *Iva frutescens*, *Baccharis halimifolia*) and their most common six herbivore species (aphid, *Uroleucon pieloui*; planthopper, *Prokelisia marginata;* beetle, *Ophraella notulata*; beetle, *Paria aterrima*; aphid*, Uroleucon ambrosiae*; and beetle, *Trirhabda baccharidis*). This is a 3-year project, focused on one plant species each of the first two years and two in the third year. Each spring, I will conduct field sampling to nondestructively measure herbivore densities, damage to plants from herbivores, and herbivore weights. A small number of herbivore individuals (<25) will be collected from each NERR or LTER sites to conduct herbivore performance experiments in the greenhouse. In the fall, I will collect seeds from < 20 plants (except in the case of *Spartina*, for which I will collect five clonal ramets) for the next year's greenhouse experiments. This project is supported by a NERR Graduate Research Fellowship.

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

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

The historical controversy over the importance of natural enemies versus host plant resources in the population and community ecology of phytophagous insects has given way to a more unified view. The current perspective is that both so-called "top-down" and "bottom-up" forces contribute to herbivore suppression, and the present focus is on factors that alter the balance in favor of one force, either natural enemies or plant resources. For instance, habitat complexity, physical disturbance, and characteristics of the herbivores themselves can all influence the relative strengths of bottom-up and top-down control. Notably, interactions among species at higher trophic levels such as intraguild predation can drastically alter top-down impacts. Also, structural features of vegetation can moderate intraguild predation and increase the overall impact of the natural-enemy complex on insect herbivores. The integration of such information has led to a more sophisticated understanding of factors that influence top-down and bottom-up impacts on insect herbivores. Nonetheless, most information regarding the effects of host plants and natural enemies on insect herbivores has been generated in the context of closed-system dynamics.

What remains poorly understood, although potentially critical in determining local herbivore dynamics, is how spatial subsidies and allochthonous resources from neighboring systems (nutrients, detritus, competitors, and predators) might influence the relative strength of top-down and bottom control, alter food web dynamics, and influence the probability for trophic cascades. Surprisingly, dynamics arising from spatial subsidies are rarely incorporated into ecological studies, and their consideration in the context of the top-down and bottom-up control of insect herbivores is virtually non-existent. Some information is available regarding the consequences of basal resource subsidies such as nutrients and detritus on local consumers and ramifications for trophic dynamics. However, little is known about predator subsidies and their effects on local insect herbivores. Even less is understood about the spatial scale of the predator subsidy and the consequences of predator subsidies for herbivores and food-web dynamics at different distances from the source. Also, no information is available about how predator subsidies might interact with basal resources (vegetation complexity) and existing natural enemies (predators) to influence insect herbivores. If predator subsidies involve intraguild predators, their immigration into neighboring communities may dramatically alter food-web dynamics, increase reticulate interactions, promote the attenuation of enemy impacts, and buffer communities against trophic cascades.

Thus, the thrust of this proposal lies in extending our work on the top-down and bottom-up control of insect herbivores (planthoppers) inhabiting *Spartina alterniflora* marshes to include 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, our initial objective is to examine latitudinal variation in the abundance of invertebrate predators in relation to spatial changes in vegetation structure (the cover of upland habitats, and the standing crop biomass and leaf litter in *Spartina* marshes), factors that are known to influence the abundance of predators. Preliminary data suggest that both upland cover and leaf litter associated with *Spartina alterniflora* decrease along the Atlantic coast from New England to Florida. Associated with this spatial change in marsh vegetation structure is a dramatic decrease in the abundance of the ground-foraging community of predators (mostly hunting spiders) that colonize the low marsh from upland habitats. Thus, our expectation is that predator control of insect herbivores in *Spartina* will diminish from north to south along the Atlantic Coast. We aim to verify this latitudinal expectation by sampling vegetation structure (upland cover and leaf litter) and the density of insect herbivores and their associated predators in salt marshes along the Atlantic. 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, mid-Atlantic marshes (e.g., Baruch, SC) represent critical study areas because they are transitional 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.

Genetic variation and cryptic speciation in harpacticoid copepod populations

Investigators: Dr. Bruce C. Coull[1,2,3] and Stacy M. Villanueva[3]
Belle W. Baruch Institute for Marine and Coastal Sciences, USC[1];
School of the Environment, USC[2]; Department of Biological Sciences, USC[3]

We are currently working on projects investigating genetic variation in two estuarine meiobenthic copepods, *Nannopus palustris* and *Microarthridion littorale*. We have previously revealed a genetic basis for morphological variation in female *N. palustris*, suggesting the presence of cryptic species rather than polymorphism within the species. Collections of *N. palustris* will continue in an attempt to find similar variation in the male of the species. Investigations involving *M. littorale* will focus on variation of mitochondrial haplotypes on small temporal and spatial scales. The same population will be sampled seasonally to determine if haplotype frequency changes over the course of the year. Samples will also be taken along a transect from the high intertidal marsh to the subtidal creek bed to determine if horizontal zonation of *M. littorale* haplotypes occurs. Both projects will employ DNA extraction and PCR-RFLP techniques to determine genetic variation. All collections have been performed around the Oyster Landing Pier (map location # 3).

Effects of variation in egg size on embryonic development and larval nutrition in the poecilogonous annelid *Streblospio benedicti*

Investigator: Dr. Bruno Pernet
Friday Harbor Laboratories, University of Washington

Larvae of some marine invertebrates develop from small eggs and must feed to fuel their development, while larvae of other species develop from large eggs and do not feed until after metamorphosis. I am using a comparative approach to test hypotheses on the developmental events underlying this correlation between egg size and larval nutritional mode, focusing primarily on differences in the timing of gut morphogenesis associated with variation in egg size. At BMFL, I am studying the "poecilogonous" annelid *Streblospio benedicti*, a species in which some individuals produce small eggs that develop into feeding larvae, but others produce large eggs that develop into

nonfeeding larvae. Techniques used include confocal and scanning electron microscopy, and functional studies of feeding. Results of this project will provide an important link between the fields of development, larval ecology, and life history evolution. In a related project, I am trying to find genetic markers that differentiate the two reproductive forms of *S. benedicti*; these will be useful in a) testing the hypothesis of poecilogony, and b) exploring patterns of mate choice in sympatric populations of the two reproductive forms. This work has been supported by a Visiting Scientist Award from the BMFL, and by the Friday Harbor Laboratories (University of Washingon). The collection site is the high marsh near Oyster Landing (map location # 3).

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

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

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

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

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

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

Expression of phase II enzymes in estuarine fish species: Phylogeny, diet, and environmental pollutants

Investigators: Dr. Peter van den Hurk and Kristen Gaworecki
Environmental Toxicology Program, Clemson University

This research project focuses on Phase II, conjugating enzymes in fish species. These enzymes are important in the breakdown and excretion of endogenous compounds like hormones and bilirubin. But they are also instrumental in the breakdown of unwanted compounds that enter the system through food and respiratory organs. In the medical realm these enzymes are of importance because they mediate the disposition of therapeutic drugs, hence the name "drug metabolizing enzymes". But the same enzymes are also active in detoxification pathways when animals are exposed to natural toxins and environmental pollutants.

We have been studying these enzymes, and specifically the sulfotransferases and UDP-glucuronosyltransferases, for a couple of years. We have generated antibodies for these enzymes, and we have studied the catalytic activity and expression in channel catfish (*Ictalurus punctatus*), and in mummichog (*Fundulus heteroclitus*). All these experiments point at unexpected, yet considerable differences between mammalian and lower vertebrate forms of these enzymes. And recent results showed even larger differences between catfish and

mummichog, the last one not expressing the phenol-type sulfotransferase at all. This has large consequences for this species: if one enzyme is not expressed, its physiological role has to be taken over by the other enzyme. We want to investigate why these species differences exist, and therefore we will investigate a suite of different fish species to find out if the differential expression of these enzymes is linked to phylogenetic differences, or ecological differences (fresh water species, marine, estuarine, herbivores, omnivores, predators).

A variety of fish species will be collected from the vicinity of the Baruch Marine Field Lab, using different collecting techniques (beach seine, cast net, otter trawl). Collected fish are transported to the Field lab on ice, where livers and gills are dissected and stored in liquid nitrogen. At our Pendleton facility the tissues will be homogenized, separated into subcellular fractions, and analyzed for enzyme expression and activity by electrophoresis, Western blotting, and standardized enzyme activity assays. In addition, feeding experiments will be conducted with selected species to investigate if diet has an effect on the expression of these enzymes. Finally, effects of pollution on the expression of these enzymes will be studied in fish collected from the heavily contaminated Sampit River, close to the BMFL. The project is supported by Clemson University E&G funding and by a BMFL Visiting Scientist Award.

Sediment elevation dynamics in tidal marshes: Functional assessment of accretionary biofilters

Investigators: Drs. Robert Costanza[1], Roelof Boumans[1], Christopher Swarth[2], David M. Burdick[3], and Donald Cahoon[4]
Institute for Ecological Economics, University of Maryland[1]; Jug Bay Wetlands Sanctuary, MD[2]; Jackson Estuarine Laboratory, University of New Hampshire[3]; Wetlands National Research Center, Lafayette, LA[4]

We are developing a data depository on sediment elevation changes in estuarine habitats in cooperation with NERRS research coordinators and participating scientists across the country. The database built during this project will serve national estuarine research goals of establishing baseline data of sediment elevation changes from a variety of estuaries, a standardized protocol for use and analysis of data collected by means of the SET (Sediment Erosion Table), and criteria that will be used to assess success in created and restored critical habitats. The database will contain data from SET stations and marker horizons along with bibliographic references. We will use the database also to establish restoration assessment guidelines (success criteria) with respect to measures of elevation change in critical estuarine habitats. Our project creates an enormous potential for regional and nation-wide comparisons and predictions of estuarine habitat sustainability. The database and protocol will establish NERRS as a leader in providing restoration assessment guidelines with respect to habitat elevation measures, criteria, analysis and interpretation. The NERR sites involved in the project are Jug Bay, MD, Great Bay Estuary, NH; Webhanet River Estuary, Wells, ME; Waquoit Bay, MA; Prudence Island, RI; Tijuana River, CA; Rookery Bay, FL; and North Inlet-Winyah Bay, SC. The project is funded by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

Sediment accretion in North Inlet salt marshes

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

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

Experimental varying of the marsh platform and macrophyte response

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

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

Our goal was to ascertain aboveground and belowground allocation patterns and quantify where the bulk of belowground biomass was located in relation to marsh elevation and sea level. There are six treatments ranging from supra optimal elevation (i.e., floods only on spring tides) to completely inundated (i.e., waterlogged) with 0.013 m separation between pipes with six replicates per treatment. Monthly stem height measurements were obtained from April to November 2002 and again from April to October 2003. Plants were harvested at the end of both growing seasons from Oyster Landing, North Inlet, South Carolina (map location #3).

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

DMSP production and phytoplankton community structure in a salt marsh tidal creek

Investigators: Dr. Duane C. Yoch[1], Nitin R. Kulkarni[1], Dr. Alan Lewitus[2], and Dr. David White[3]
Department of Biological Sciences, USC[1]; SC Department of Natural Resources[2];
Belle W. Baruch Institute for Marine and Coastal Sciences, USC[3]

We are studying the factors in the salt marsh that affect the level of dimethylsulfide (DMS) emitted into the atmosphere. DMS emission is a key step in the global sulfur cycle. This organosulfur compound is released by bacterial decomposition of dimethylsulfoniopropionate (DMSP), a tertiary sulfonium compound which is produced in high concentrations by certain species of marine algae and plant halophytes for regulation of their internal osmotic environment. It is released into seawater as dissolved DMSP by grazing activity of zooplankton or by senescence of algae. We are studying the $DMSP_p$ (particulate) levels and Chl *a* levels as an indicator of phytoplankton biomass in the tidal creek and oceanic waters. $DMSP_p$ concentrations may be influenced by various factors like salinity, light, tidal phase, time of the day, phytoplankton community, nutrient concentration in the waters, and zooplankton grazing. We have observed consistent correlation between the $DMSP_p$:Chl *a* ratios, which is an indicator of phytoplankton DMSP levels, and the tidal stage which is not observed in the oceanic (near shore) waters. At this point, we are evaluating the factors that are responsible for the changing $DMSP_p$:Chl *a* ratios. We have shown that the tidal trend of DMSP in the Clambank creeks are a function of changing phytoplankton community, with more DMSP producing phytoplankton advecting from nearshore waters at high tide and low DMSP producing benthic phytoplankton getting resuspended into the creek water during the low tide. We are also looking at how different salinity levels affect the levels of $DMSP_p$ in a given estuarine system.

Currently, we are looking at the change in phytoplankton populations that can produce DMSP along a salinity and nutrient gradient. DMSP production is known to increase with increase in salinity and we have observed a similar trend here. DMSP, also known to increase with increased nutrient stress, is also being investigated at the same time. This will also give a good indication, how nutrient loading and salinity affect the DMSP production in phytoplankton population and their community structure as a whole in an estuarine system.

We are also monitoring the annual changes in $DMSP_p$, Chl *a*, total bacterial counts by AODC, total viable counts, and counts of microbes producing DMS. We are also preserving samples to estimate qualitative changes in phytoplankton populations by monitoring changes in the pigment profile every month.

Our study sites include Clambank, Oyster Landing, Thousand Acre rice field, Pawleys Island, Goat Island, and the Black and Pee Dee rivers at the marina in Georgetown (map locations # 15A, 6B, 15B, 2A, 6A). This project is currently supported by the Department of Biological Sciences, University of South Carolina, Columbia.

A high accuracy micro-topographic determination of marsh topography

Investigators: Juana M. Montané and Dr. Raymond Torres
Department of Geological Sciences, USC

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

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

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

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

Funding for this project is pending. The field study was initiated in January 2002 and is ongoing. See map location #16

Paleotempestology in the Carolinas; a calibration of the sedimentary historical record

Investigators: Abby Springer[1], Dr. Doug F. Williams[1], Eugene Karabanov[1], and Dr. Cary Mock[2]
Department of Geological Sciences, USC[1]; Department of Geography, USC[2]

Paleotempestology is a branch of science that attempts to identify the frequency and intensity of historical hurricane landfall through the use of sedimentological and geochemical proxies in coastal sediments. Previous paleotempestological studies are based upon the occurrence of macro-scale sand layers, preserved overwash events, in sediments of coastal lakes to provide a proxy record for hurricane landfall. The sedimentary record of these storm events is then calibrated against local historical and meteorological data. This investigation will strive to enhance the field of paleotempestology by introducing a new technique to resolve micro-scale evidence for storm events of varying intensities both within macro-scale sand layers and within cores that do not exhibit macro-scale structures. This strategy will rely on the methods developed by Francus (1997). Special software made available by Pierre Francus will be used to perform computer assisted examinations of the composition and sedimentary microstructures of the cores. The combination of the data at micro and macro- scales will be compared to the local historical and meteorological record (Mock, 2003b) and used to 1) evaluate whether the micro-structural approach can be used to determine the frequency and intensity of storm events of the last 300 years from coastal sediments, and 2) determine if a micro-structural analyses of carefully selected coastal sediments can be used to establish confidence limits on the ability to reconstruct the intensity of storm events.

Vibra-cores will be taken in parallel transects in several coastal ponds including two cat-eye ponds on Goat Island (map location 12) , Middleton Pond on the Prince George Tract and Moccasin Pond on Bulls Island, Cape Romain. In consultation with paleoclimatologist Cary Mock, Department of Geography, USC, these sites were selected based on a comprehensive analysis of historical meteorological records of storm events impacting the South Carolina coast since 1700? (Mock, submitted, *Science* January 2004). Double cores will be taken at each of site: one core to be extruded for Pb-210/Cs-137 to establish sedimentation rates and a geochronology for the cores; the other core will be opened and split into archive and working halves. Prior to sampling, the working half will be described and digitally photographed. Additional image analysis will be obtained by back-scattered electron (BSE) images, as suggested by Francus and Karabanov (2000). Magnetic susceptibility will be measured at 0.5 centimeter intervals for stratigraphic correlation. For the micro-structural analyses of the sedimentary fabric, thin-walled aluminum boxes (dimensions 15x3x0.5 cm) will be used to take undisturbed samples from selected intervals of the core face. These flat sub-cores will be thin-sectioned after freeze-drying using the methodology developed by von

Merkt (1971) and Francus (1997). Special software made available to us by Pierre Francus will be used to perform computer assisted examinations of the composition and sedimentary micro-structures of the sub-cores. The back-scattered electron (BSE) images will provide quantitative data of size, shape, orientation and packing of the grains forming the sedimentary structures (Francus and Karabanov, 2000). In addition, samples will be taken from the working half of the core for bulk density, water content, grain size, TOC and C/N ratios. The combination of these data at the micro- and macro-scales will be compared to the historical record (Mock, unpublished) and used to 1) evaluate whether the micro-structural approach can be used to determine the frequency and intensity of storm events of the last 300 years from coastal sediments, and 2) determine if a micro-structural analysis of carefully selected coastal sediments can be used to establish confidence limits on the ability to reconstruct the intensity of storm events.

To date most paleotempestological studies of coastal pond, small lake and marsh sediments are based on the occurrence, thickness and lateral extent of overwash sand layers. Other supporting evidence used in these studies typically involves analyses of diatom abundance, C/N ratios, total organic carbon (TOC) and carbon isotopes of the TOC. The sedimentary record of storm events is then calibrated against local historical and meteorological records.

This proposed research is important scientifically because its primary objective is to determine if computer assisted thin-section analyses of the sedimentary fabric of coastal sediments of North and South Carolina can be used to better calibrate the macro-scale relationship between overwash sand layers and storm intensity. The Carolinas coastlines have encountered numerous hurricanes in recent times resulting in huge economic losses. In September 2003, Hurricane Isabel made landfall on the North Carolina coast causing an estimated $4 billion dollars in damage (NOAA, 2004). By establishing confidence limits on resolution of past storm events, this investigation may be able to provide an estimate of both future hurricane landfalls in the area and estimates of future economic losses due to winds, hurricane intensity and storm surges.

Currently, this project is being supported by the Department of Geological Sciences (stipend for Springer) and from overhead funds provided by the South Carolina Honors College through May 2005. Plans are underway to submit proposals for external funding.

Inter-estuarine comparison of water quality using Dataflow

Investigators: Drs. Eric Koepfler[1], Alan Lewitus[2], and D. Gandy[1]
Marine Science Department, Coastal Carolina University[1]; Baruch Marine Field Laboratory, USC, and SC Department of Natural Resources[2],

Measurements of water quality in three neighboring estuaries of different hydrologic and landscape development nature, are being performed in this study. Winyah Bay (river dominated - moderate impact), North Inlet (marine dominated - pristine), and Murrells Inlet (marine dominated - heavily impacted) are being measured monthly using Dataflow, a high resolution spatial sampling platform. Dataflow measurements (taken every two seconds) measure surface water temperature, salinity, pH, dissolved oxygen, dissolved organic matter (DOM), and chlorophyll *a*. Of interest in this study is how water quality characteristics between these systems vary in terms of spatial and temporal scales, and the degree to which this is explained by hydrologic and landscape characteristics.

Time series measurements of import-export water quality characteristics in North Inlet watersheds

Investigators: Drs. Eric Koepfler[1], Alan Lewitus[2], and Sam Lake[1]
Marine Science Department, Coastal Carolina University[1]; Baruch Marine Field Laboratory, USC, and SCDNR[2]

Measurements of water quality in three North Inlet sub-watersheds including Debidue Creek, Town Creek, and Jones Creek are being collected during monthly samplings. Over 24-hour (diel) sampling cycles, tidal inflow and outflow water quality characteristics are being measured using Dataflow, a high resolution spatial sampling platform. Dataflow measurements (taken every two seconds) measure surface water temperature, salinity, pH, dissolved oxygen, dissolved organic matter (DOM), and chlorophyll *a*. Of interest in this study is how water quality characteristics within these differing watersheds within North Inlet vary in terms temporal scales, and more specifically how import-export characteristics vary between day and night.

Status and distribution of hummingbirds in the coastal plain of South Carolina

Investigator: Gary Phillips
Hummer/Bird Study Group, Clay, Alabama

Although commonly seen in area gardens and woodlots during the breeding season and apparently becoming more common winter residents, little is known of hummingbird specifics in North or South Carolina. Little is known about migration routes, population biology, and effects of habitat change of Ruby-throated hummingbirds. As neo-tropical migrants, their future is as uncertain as that of a number of other bird species so classified. This project will document the status and distribution of hummingbirds in the coastal plain of South Carolina. Specific topics of investigation include migration route fidelity, breeding site fidelity, territory size for male ruby-throated hummingbirds during breeding season, assessment of territory quality and requirements, and comparison of morphometric data collected from individuals at various study sites in the region. Goals are also to increase the number of banded birds in the Atlantic flyway to aid in the determination of migration pathways, stop over sites and winter destinations, to increase knowledge of post-breeding dispersal movements, and through subsequent recaptures gather data with regard to hummingbird longevity/survivorship. Long-term data collection will add to the existing body of hummingbird knowledge and be useful in assessing conservation needs. Data collected from hummingbirds at Hobcaw Barony will also be used as part of a larger scale study.

Nekton behavior in salt marsh intertidal creeks: Patterns and mechanisms of tidal movement

Investigators: Kurt Bretsch[1] and Dr. Dennis Allen[2]
Marine Science Program, USC[1]
Baruch Marine Field Laboratory, USC[2]

Within salt marshes, nekton (motile fishes, shrimps, and crabs) are thought to play a vital role in the transfer of intertidal production to the estuary. Many investigators have shown that nekton make regular migrations into salt marsh intertidal creeks with the flood tide, yet little is known about the timing of their migrations, or about interactions while nekton occupy flooded creeks. During summers 2001-2002, a new sampling method, the sweep flume, was used to determine the timing (water depth) and sequence of migration of taxa into flooding intertidal creeks. The depth of peak movements into the creeks varied among species, and the sequence of occupation was similar among creeks, suggesting that partitioning use of the intertidal creek habitat is a broadly based phenomenon. During Summer 2003-Fall 2004, biotic causal mechanisms of migration will be investigated by testing the hypothesis that depth preferences of individual nekton taxa (grass shrimp, spot, pinfish, mummichog, mullet) change in the presence of other species. Additional experiments will be conducted in which the effect of predator presence on the depth distribution of grass shrimp will be investigated. All experiments will be conducted on the lab grounds in large tanks designed to represent conditions in flooding intertidal creeks. The results of this research will contribute to the scientific understanding required to measure, model, maintain, and/or restore the integrity and sustainability of salt marsh ecosystems. This project started in Spring 2001 and has a tentative end date of Fall 2004. Support is provided by NOAA's Nancy Foster Scholarship Program, the USC Marine Science Program, the NI-WB NERR, and the Baruch Marine Field Laboratory.

Nekton use of intertidal creek pools; a spatial analysis of relationships between geomorphology and nekton occupation during low tide

Investigators: Dr. Henrietta Hampel[1] and Dr. Dennis M. Allen[2]
Royal Belgian Institute of Natural Sciences, Brussels[1]
Baruch Marine Field Laboratory, USC[2]

Recent studies in North Inlet demonstrated strong relationships between geomorphological features of intertidal creeks and the densities of nekton that occupied them at high tide. Although most of the tidal migratory fishes, shrimps, and crabs leave the creeks with the ebbing tides, large numbers remain in isolated pools of water along the axis of the creeks. Previous studies revealed large differences in the composition and abundance of nekton among pools. Measurements will be made of pool morphology, positions, water quality, and nekton within and

among intertidal creeks of different configurations in an effort to determine primary factors controlling the pools' uses. Existing information on the physiological tolerances, swimming behavior, and trophic relationships among pool inhabitants will be used along with field data to interpret the observed patterns. Mark-recapture techniques will be used to examine site fidelity and home ranges for grass shrimps and other dominant species. This project is supported by the BMFL Visiting Scientist Award.

Evaluation of North Inlet, South Carolina, as essential fish habitat and examination of the effects of tide and creek size on sub-adult shark distributions

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

Few shark nursery ground studies exist for South Carolina and no prior systematic studies of elasmobranch fauna in North Inlet have been done. This study will identify the elasmobranch species using the estuary from April through October of 2004 and will determine how tide and creek size affect sub-adult shark distribution in the system. We hypothesize that North Inlet Estuary provides nursery ground habitat for coastal sharks and can be considered an Essential Fish Habitat area as defined by the Magnuson-Stevens Fishery Conservation Act of 1996. In addition, we expect to see sub-adult sharks concentrating in the larger creeks during low tide and expanding their range into smaller creeks at high tide. To test these hypotheses we will set 500 ft longlines with 25 12/0 hooks to target sub-adult sharks in three distinct sampling areas. Each sampling area will include one main channel creek site and one smaller adjacent tidal creek site. Our three sampling areas include the following creeks: Town and Bread and Butter, Old Man and Bass Hole Bay, and Jones and Duck (map locations # 2D, 5, 7, 13). Each site will be sampled for three consecutive days in one week, with every day consisting of a high and low tide set. Catch-per-unit-effort (CPUE, number of sharks caught per 100 hooks per hour) values will be calculated to standardize the data. The near-pristine quality of North Inlet Estuary makes this study an ideal benchmark to which future studies and anthropogenic effects can be compared.

Source of support: Coastal Atlantic States Shark Pupping and Nursery (COASTSPAN) program, Georgetown Environmental Protection Society.

Habitat utilization of North Inlet, SC, by bottlenose dolphins and red drum: An examination of potential predator-prey interactions

Investigators: Dr. Rob Young[1], Elizabeth Moses[1], and Dr. Dennis Allen[2]
Marine Science Department, Coastal Carolina University[1]
Baruch Marine Field Laboratory, USC[2]

We are concurrently studying the size and habitat utilization patterns of the dolphin population and their potential prey fish populations in North Inlet. We hypothesize that dolphins in winter and early spring will focus on creeks with overwintering red drum aggregations. Our goal is to estimate the proportion of the total fish in winter drum aggregations that are removed by dolphin predation. Since 1997, we have conducted an ongoing study of North Inlet dolphins using photo-identification and focal follows. Fish population estimates and movements will be determined by tag and recapture trammel net surveys. A 400 foot trammel net is used to sample 12 sites per month from among 30 randomized sites throughout the North Inlet system. Dolphin dietary patterns are determined by matching the fatty acid signatures of potential dolphin prey species with the fatty acids signatures stored in dolphin blubber. Blubber biopsies are taken from resident dolphins using rifle-mounted biopsy darts. This study has a direct impact on the management of the red drum fishery, and is in cooperation with SCDNR and Dr. Charlie Wenner who oversees the red drum management research in South Carolina.

Source of support: Subcontract to the grant, "Contributions to the Biology of the red drum, *Sciaenops ocellatus*, in South Carolina," an Unaligned Management Project funded by the National Marine Fisheries Service (PI - Charlie Wenner, SCDNR). The study period is October 2001-December 2004.

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

Investigators: Jennifer Beseres[1] and Dr. Robert Feller[2]
Marine Science Program and Baruch Marine Field Laboratory, USC[1]
Department of Biological Sciences and Marine Science Program, USC[2]

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

This field study uses manipulative caging experiments to test our hypothesis in both NI-WB, SC (Crabhaul Creek, map location #3), and Sapelo Island, GA (Factory Creek). Normal and elevated white shrimp densities were held in inclusion cages and allowed to feed on macrobenthos on and in the creek bottom for 7 days. Preliminary results suggest that macrobenthos abundance significantly decreased over a 7-day period in our shrimp treatment cages. Thus, white shrimp may be one of the primary predators on macrobenthos in the subtidal creek bottoms during the summer months, and may be responsible for changes in macrobenthos abundance and community composition. Further experiments are being designed to test the mechanism of macrobenthos decline observed in our experiments. This project is funded by a NOAA/NERR Graduate Research Fellowship through 2006.

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

Investigators: Dr. Alan J. Lewitus[1,2], Jason Kempton[2], Dr. Amy Ringwood[2], Raphael Tymowski[1], and Megan Heidenreich[1]
Baruch Marine Field Laboratory, USC[1]; Marine Resources Research Institute, SCDNR[2]

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

This project is supported by ECOHAB (NOAA, NSF, EPA, NASA, ONR) and is funded for the period September 2, 2002 to August 31, 2005.

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

Investigators: Dr. Alan J. Lewitus[1,2], Raphael G. Tymowski[1], Dr. David White[1], and Sabrina Hymel[1]
Baruch Marine Field Laboratory, USC[1]; Marine Resources Research Institute, SCDNR[2]

CHEMTAX is a modeling program used to derive the abundance and class composition of phytoplankton from HPLC pigment data. Although it has been applied successfully to open-ocean algae, it produced inaccurate results in an estuarine system. Further study indicated that CHEMTAX output is accurate only if the pigment ratios used to calibrate the model are near those of the phytoplankton in the community being examined. Thus, a model calibrated

using open-ocean phytoplankton is not applicable to an estuary containing similar taxa. The main goal of the current study was to produce a set of calibration pigment ratios that would allow the model to be used in several SC estuaries. Phytoplankton composition derived using the newly calibrated CHEMTAX model was compared to that determined through microscopic enumeration. The results of the two methods agree closely, although additional research is required to achieve greater resolution between algal classes.

Salt marsh mesocosm

Investigators: Drs. James Morris[1] and L. R. Gardner[2]
Department of Biological Sciences, USC[1]; Department of Geological Sciences, USC[2]

A set of eight replicate salt marsh mesocosms is being used to investigate the effects of hydrology and nutrient loading on the productivity and sediment biogeochemistry of salt marshes. Each marsh mesocosm (1 m x 10 m) is filled with inorganic sediment and planted with *Spartina alterniflora*. The sediment surface has a slope of approximately 20 cm/10 m. A computer-controlled pump will simulate the spring and neap diurnal tides. Flood water will be loaded with combinations of N and P fertilizer in a factorial design to determine how primary production and the accumulation of organic matter in sediments vary as a function of the N and P supply. The experiment will allow researchers to better understand the dynamics of organic matter production and accumulation in salt marshes. This study is funded through the NSF.

Chemically mediated interactions in a sedimentary assemblage

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

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

Colonization of man-made surfaces in the marine environment

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

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

Recent publications associated with the work:

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

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

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

Infaunal burrows and their impacts on sediment microbiota

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

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

Publications associated with the work:

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.

Plant defense by volatile emissions

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

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

Bioluminescence in North Inlet brittlestars

Investigators: Dr. Stephen Stancyk [1,2] and Cassandra Lovato[2]
Department of Biological Sciences, USC[1]; Marine Science Program, USC[2]

Many brittlestars are capable of giving off light when they are disturbed or attacked. In other parts of the world, congenors of ophiuroids found in North Inlet are bioluminescent, and recent research has shown that the degree of bioluminescence declines with exposure to some pollutants. Whether any of the seven or so ophiuroid species in North Inlet bioluminesce is unknown. The purpose of this research is 1) to collect as many ophiuroid species as possible from North Inlet and test their ability to bioluminesce when exposed to KOH; 2) to test whether exposure to heavy metals in the water or sediment will affect the degree of luminescence. See map location #17

Zooplanktivory by the burrowing brittlestar, *Hemophilic elongate*: Tests on natural plankton assemblages

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

Most burrowing brittlestars are in the family Amphiuridae, and obtain nutrition from surface and subsurface deposit-feeding on detritus. *Hemophilic elongate*, however, is in a different family (Ophiactidae) and has been shown to readily feed on brine shrimp and copepods. Because most zooplanktivorous brittlestars are found in the deep sea or Antarctica, the presence of *H. elongate* in North Inlet provides an opportunity to learn more about feeding responses and prey selection in ophiuroids. To develop feeding response curves and prey preference information, individual brittlestars are placed in cores and allowed to feed on known densities and mixtures of unnatural (brine shrimp, *Artemia*) and natural (field-collected copepods, larvae, etc) prey assemblages. *H. elongate* is uncommon in North Inlet and lives around tube-caps of the polychaete, *Diopatra cuprea,* only in muddy sands. See map location #17.

Structure, dynamics, and functional relationships between phytoplankton, epiphytic microalgae, and foodwebs in a salt marsh estuarine system

Investigators: Dr. Richard Zingmark[1], Dr. Alan J. Lewitus[1,2], M. Gabriella Jackson[1], and Raphael Tymowski[1]
Baruch Marine Field Laboratory, USC[1]
Marine Resources Research Institute, SC Department of Natural Resources[2]

This project examines and quantifies the fate of phytoplanktonic carbon from the ocean as it passes into a tidal creek. Past studies have shown that the Bly Creek Basin is a highly productive system, with fairly high inputs of particulate organic carbon (POC). However, the functional mechanisms for processing this POC influx are not well understood. To this end, the planktonic and epiphytic communities of *Spartina* are to be identified and quantified, both by pigment analysis and microscopy, along transects of the marsh, during spring and neap tides for one year. We will compare seasonal patterns of phytoplankton and epiphyte taxonomic structure, biomass, and dynamics on live vs. dead *Spartina* plants, tall vs. short *Spartina*, leaves vs. stems, and at high tide vs. low tide. Grazing experiments will determine the impact of direct grazing by zooplankton, periwinkles, benthic suspension feeders (clams, oysters, mussels), and insects. Artificial *Spartina* substrate experiments will determine the rate of epiphyte community development, the impact of epiphytic mucus production on the passive filtration of phytoplankton, and the subsequent availability of the resulting epiphyte/phytoplankton aggregates to herbivores. This is an on-going project, with funding from New Jersey Sea Grant and South Carolina Sea Grant Consortium.

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 and Coastal Sciences, USC[1]
Department of Biological Sciences and Marine Sciences, USC[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* and *J. romerianus* and the sediment associated with those plants will be collected and microbial DNA will be extracted from the samples. Microbial communities will be examined by 16S polymerase chain reaction-denaturing gradient gel electrophoresis (PCR-DGGE) for differences in the communities of the roots and the associated soils. The distribution of microbial communities associated with the roots of the plants will be determined by fluorescence *in situ* hybridization (FISH) of 16S used in conjunction with confocal laser scanning microscopy (CLSM). PCR-DGGE or FISH of either specific phylogenetic groups or functional genes will be used to examine functional differences within the communities. Pore water will be collected 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 locations # 10 & 8. Support provided by NSF award MCB-0237854 and the Belle W. Baruch Institute.

Estuarine eutrophication and microbial community composition

Investigators: Wes Johnson[1] and Drs. James Morris[2] and Madilyn Fletcher[3]
Marine Science Program, USC[1]; Department of Biological Sciences, USC[2];
Belle W. Baruch Institute for Marine and Coastal Sciences, USC[3]

Microbial communities play critical roles in the processing of matter and energy in estuarine ecosystems. The composition, structure, and function of these complex assemblages are thought to be controlled by either top-down mechanisms (grazing), or by bottom-up effects (nutrient availability, temperature, and salinity). This project examines the bottom-up effects of water chemistry and primary productivity on planktonic microbial community composition. Compositions of planktonic bacterial communities are determined by amplifying 16S rDNA using polymerase chain reaction (PCR) and subsequent separation of the amplified products using denaturing gel electrophoresis (DGGE). The study is being conducted at the Baruch Marine Field Laboratory and University of South Carolina (Columbia). Comparisons of the five sampling sites indicate compositional changes along salinity gradients, as well as seasonal changes relating to phosphorus availability. The relationship of primary production to microbial community structure and identification of the members of the community are currently being investigated. The study is supported by EPA/NOAA/NASA, CISNET: Molecular to Landscape-Scale Monitoring of Estuarine Eutrophication.

Microbial community responses to eutrophication in a southeastern US salt marsh estuary

Investigator: Wes Johnson
Marine Science Program, USC

This study examines the effects of nutrient loading on microbial communities in salt marsh sediments. Chemical fertilizers are applied to selected plots of salt marsh within the North Inlet system from which sediment and pore water samples are collected monthly. The microbial community compositions are determined using polymerase chain reaction/denaturing gradient gel electrophoresis of 16S rDNA. Analysis of the resulting profiles

has indicated that there is no measurable change in the composition of the bulk bacterial communities attributable to the addition of inorganic nitrogen (N) and/or inorganic phosphorus (P). The number of bacteria is not significantly different between controls, P additions, or N additions, however cell counts increase significantly with simultaneous addition of both P and N. This finding suggests that N and P dynamics are coupled in the sediment system. Currently, experiments involving the addition of labile carbon (C) substrates to sediments are being conducted to determine the effects C availability may have on bacterial growth and community composition. This study is supported by the NOAA/NERRS Graduate Research Fellowship Program.

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 is being monitored to measure the relative importance of interspecific competition and abiotic factors as determinants of zonation patterns between the salt marsh cord grass, *Spartina alterniflora,* and the black needle rush, *Juncus roemerianus*. See map location # 6A.

Recruitment, habitat utilization, and growth of estuarine dependent fishes, with emphasis on the ecology and life history of the fringed flounder (*Etropus crossotus*), hogchoker (*Trinectes maculates*), and summer flounder (*Paralichthys dentauts*)

Investigator: Dr. Marcel Reichert
Department of Biological Sciences and Marine Science, USC

This ongoing project was initiated in 1992 and one of the findings of field data and various laboratory experiments was that the life cycle of the fringed flounder, one of the most abundant flatfishes in North Inlet, is foremost characterized by the short life span of 15 months. This makes the fringed flounder one of the very few known annual flatfish species. Within this period fringed flounder grow up to an adult size and reproduce during one extended spawning season. Adult fringed flounder inhabit the shallow coastal waters. Although newly settled juveniles and reproductively active females can be found in almost all months of the year, the peak in spawning activity takes place from March through August. Larvae and metamorphosing juveniles migrate into the estuarine nursery areas. Newly settled juveniles start their demersal life in the marsh creeks at a length of about 9 mm. Following settlement, they find favorable temperatures and an abundance of food in the form of copepods, small epibenthic crustaceans, and polychaetes. This diet shifts little during development to adulthood. Juveniles generally migrate out of the estuary at 6cm in length.

Distribution and abundance of various other flatfish species are currently analyzed to provide information on the habitat utilization and recruitment of these species. It is anticipated that monthly sampling of flatfish populations in the area will resume in the spring of 2004. Collections will be made using the 1 meter beamtrawl in various location in the inlet and Winyah Bay.

Besides this field sampling, the next phase of this project will focus on
1) bioenergetic aspects of feeding, and 2) the early life history, in particular the transport and migration of eggs, larvae and early juveniles from the spawning grounds to the nursery areas in the marsh creeks.

The feeding ecology of the three focus species will be investigated in a number of experiments using the flume (anticipated to be operational later this year). Transport of larvae and juveniles into North Inlet will be studied using light traps and physical data collected in collaboration with other faculty.

Urbanization and Southeastern Estuarine Systems (USES)

Investigators: Drs. Dwayne E. Porter[1,2], Alan Lewitus[1,2], Tom Chandler[1,2], Marj Aelion[1,2], Alan Decho[1,2], Dan Tufford[2], Geoff Scott[2,3], John Ferry[1], Mike Fulton[2,3], and Tom Siewicki[2,3]
Belle W. Baruch Institute Baruch for Marine and Coastal Sciences, USC[1]
Norman J. Arnold School of Public Health, USC[2]
NOAA's Center for Coastal Environmental Health and Biomolecular Research[3]

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 08/01/01 though 07/31/04 (www.urbanestuary.org).

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], Jeff Allen[4], Marj Aelion[1,2], and Heath Kelsey[2] and Sam Walker[2]
Belle W. Baruch Institute for Marine and Coastal Sciences, USC[1]
The Norman J. Arnold School of Public Health, USC[2]
NOAA's Center for Coastal Environmental Health and Biomolecular Research[3]
The Strom Thurmond Institute, Clemson University[4]

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

The advent of database management programs, the Internet and the World Wide Web (WWW), and Geographic Information Systems (GIS), particularly when coupled to statistical modeling, allow new approaches to managing development of our coastal ecosystems. The South Atlantic Bight Land Use - Coastal Ecosystems Study (LU-CES) will combine existing and newly gathered data into a single (virtual) archive for use in forecasting impacts to coastal and estuarine ecology in the SC&GA region. The project will then be able to devise alternative development strategies to minimize these impacts. This project also seeks to predict human source fecal coliform

contamination and nutrient levels in the surface and groundwaters of golf course associated developments, based on land use characteristics in the vicinity of monitoring points. The project is testing the hypothesis that fecal coliform levels from human sources are significantly higher in areas close to certain land use characteristics, and determining whether the source of the bacterial contamination is from human or non-human sources.

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

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

Geographic Information Systems (GIS) are used to characterize various land uses within the study areas. Data from the fecal coliform classification are incorporated into the GIS to examine the spatial distribution of human and animal source fecal coliforms. Using the land use characterizations and the fecal coliform distribution, GIS and statistical procedures will be used to attempt to predict the fecal coliform levels from human and animal sources based on the land use characteristics. Specific land use characteristics characterized include septic tank density, population density, housing density, vegetation, impervious surfaces, sewage treatment outfalls, and stream locations and volumes. Additional variables include rainfall, salinity, temperature, and tidal fluctuation. Statistical procedures include kriging, multiple regression and logistic regression. This project is funded for the period from 08/01/00 to 07/31/04 by SC Sea Grant Consortium.

Use of integrated remote sensing and field techniques for assessing and managing the distribution of invasive plant species in southeastern estuaries

Investigators: Samuel P. Walker and Dr. Dwayne E. Porter
The Norman J. Arnold of the School of Public Health, USC[1]
The Belle W. Baruch Institute for Marine and Coastal Sciences, USC[1,2]

The goal of this research is to evaluate an integrated approach combining in situ and remote sensing data collection techniques with digital image processing and geostatistical and statistical modeling to assess the distribution of invasive species in the North Inlet and ACE Basin estuaries. The project is funded through NOAA and the National Estuarine Research System Graduate Research Fellowship Program. This project is funded through May 2005 by NOAA, and National Estuarine Research Reserve System Graduate Research Fellowship.

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

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

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

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

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

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

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

This project is funded from 1/1/2004 through 12/31/2005 and is funded by The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

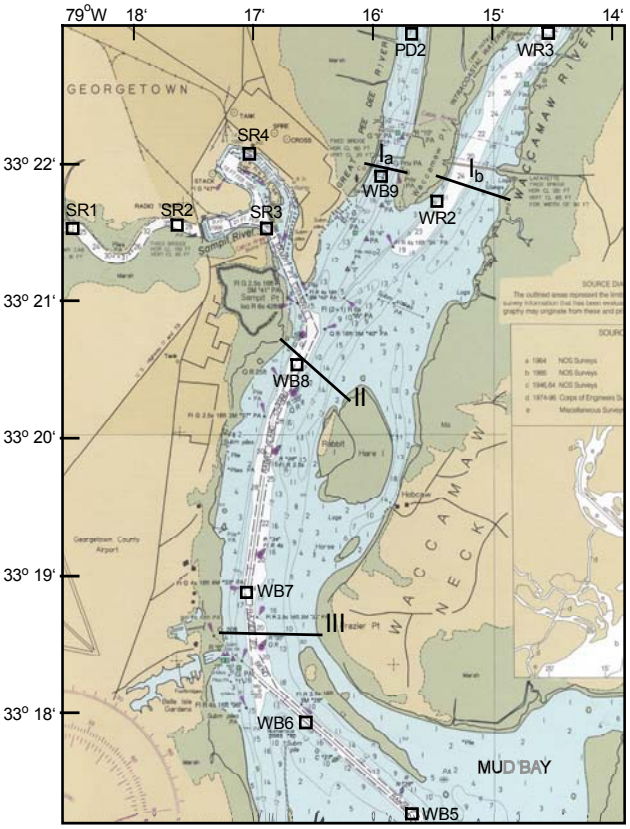
A multidisciplinary approach to quantify and model the transport and deposition of organic pollutants in coastal environments

Investigators: Drs. Miguel A. Goñi[1], George Voulgaris[1], Richard Styles[1], and John Ferry[2]
Department of Geological Sciences, USC[1]
Department of Chemistry and Biochemistry, USC[2]

Two key issues directly affect the ability of environmental managers to assess the effects and mitigate the impacts of enhanced pollutant loadings in estuaries. One is the determination of the sources and mode of contaminant introduction in coastal areas. The second is the estimation of pollutant residence times in estuaries. Our research objectives are aimed to specifically address these two critical issues by conducting intensive sampling, analyses and modeling of the fluxes and compositions of PAHs in coordination with a suite of physical and chemical measurements of fluid flow and sediment dynamics.

In order to accomplish this goal, we will first measure water flow, fractional suspended sediment concentrations, dissolved, colloid- and particle-bound PAHs concentrations along three transects in the upper mid-section of an impacted estuary (Winyah Bay, SC). We will measure the stable isotopic compositions of PAHs to infer their sources. Based on these data, we will calculate a contaminant budget for the study area, including fluxes across the boundaries and short-term pollutant deposition in bay sediments, in order to estimate the residence time of PAHs in this system. Finally, we will integrate these measurements into a 3-D model that will be applied to other environmental conditions and other estuaries within the state.

The research will provide diagnostic as well as predictive information on the transport, deposition and dispersion of contaminants in estuaries. We expect to improve our current risk assessment and risk management capabilities by incorporating the measured chemical and physical variables into a 3-dimensional water quality model similar to the Environmental Fluid Dynamics Code developed and implemented by EPA. The source of support is EPA/EPSCOR. The project period is 7/1/01-6/31/04



The mid and upper reaches of Winyah Bay. Station locations of previous work are identified as well as the location of the proposed transects.

Identification of toxicant-responsive genes in the mummichog (*Fundulus heteroclitus*)

Investigators: Janis S.K. Peterson, Horacio Gonzalez, and Dr. Lisa J. Bain
Department of Biological Sciences, University of Texas at El Paso

Increasing pressure on the coastal environment is resulting in adverse impacts on many estuarine organisms. Thus, more information is needed on the chronic and subtle effects of pollutants on estuarine organisms, and how to adequately detect these adverse sublethal effects before these populations decline further. The area surrounding Charleston Harbor has several impacted estuarine sites that empty into the harbor proper which are heavily contaminated with polycyclic aromatic hydrocarbons (PAHs) and heavy metals. We are using mummichogs (*Fundulus heteroclitus*) as an indicator species to study the chronic effects of contamination by examining altered gene expression in fish from these impacted sites compared to those collected from Town Creek at the North Inlet

NERR. We hope to use DNA markers to correlate gene expression with alterations in reproduction, growth, and development, which are parameters that are difficult and time-consuming to assess in the field. Project period: July 2003-October 2004.

Impact of boat wakes on intertidal reefs of the oyster *Crassostrea virginica*: A comparison of reefs in South Carolina tidal channels versus a Florida estuary

Investigators: Drs. Linda Walters[1], Loren Coen[2], and Paul Sacks[3]
Department of Biology, University of Central Florida[1]; SCDNR, Marine Resources Research Institute[2]; Deltona High School, Deltona, FL[3]

Research Site Location: Oyster reefs along Town Creek

Resource Managers are increasingly concerned that huge increases in recreational boating activities may be negatively impacting intertidal reefs of the economically and ecologically important eastern oyster *Crassostrea virginica*. Using a variety of hull designs, engine profiles (trim angles) and velocities, we are experimentally evaluating the impact of recreational boating on *C. virginica* in two of the dominant habitat types in the southeastern United States: 1) narrow tidal channels in SC with 1-2 m tidal range, 2) shallow estuaries in F Florida with minimal tidal amplitudes. In replicated trials in Town Creek waters adjacent to the Baruch Marine Field Laboratory in July 2003, we measured shell retention (required for recruitment of oyster spat), turbidity, wind speed, and flow rates generated after each boat pass. Wind alone never moved shells. However, significant shell movement and turbidity spikes were associated with boat generated wakes. In the summer of 2004, we plan to continue this line of inquiry and ask if boat-wake induced shell dispersal can injure/destroy juvenile oysters that have recently recruited to shells on intertidal reefs. Mimics juvenile oysters, the dimensions of 1-week old spat and created from plasticene, will be attached to oyster shells and damage accessed after each boat pass.

Dr. Coen's laboratory is also conducting erosion measurements in creeks across SC as part of the SCORE community oyster restoration program. Nine sites are being monitored as part of this former program and four sites as part of our Charleston long-term assessment. Mean monthly marsh erosion rates ranged from SCORE ranged from 1 cm to 6.5 cm as of March 2004. Overall shoreline losses for SCORE sites ranged from ranged from 18 to 330 cm monitored from 15 to 34 months. At the longer term Charleston sites (40-53 months), overall marsh losses ranged from 100 to 160 cm. Project period: July 2003-July 2004. Support: Florida Sea Grant, University of Central Florida, and SC DNR

Testing an alternative oyster reef restoration strategy

Investigators: Dr. David Bushek[2] , Paul Kenny[1], and Laura Schmidt[1]
Baruch Marine Field Laboratory, USC[1]
Haskin Shellfish Research Laboratory, Rutgers University[2]

During a recent dredging project, oyster reef habitat was inadvertently destroyed when dredge pipes drifted over oyster reefs during high tide and settled on them during low tide. In a collaborative effort between residents from the local residential community and staff from the Baruch Marine Field Laboratory, oyster recruitment stakes were planted to attract settling oyster larvae to the site. Half of the stakes were coated with a thin layer or concrete, which has been anecdotally reported to increase recruitment. Stakes were planted in June 2003 (see map location # 11). Summer and Fall recruitment was apparently low, but the peak recruitment generally occurs in spring. Stakes will be monitored and examined to assess success of the effort. Support is being provided by the Debordieu Colony Community Association, the North Inlet-Winyah Bay NERR, and the Baruch Marine Field Laboratory.

Temporal patterns of Dermo disease in North Inlet

Investigators: Dr. David Bushek[1], Megan Heidenreich[2], and Dr. Dwayne Porter[3]
Haskin Shellfish Research Laboratory, Rutgers University[1], Baruch Marine Field Laboratory, USC[2], Belle W. Baruch Institute for Marine and Coastal Sciences, USC[3]

The protozoan parasite *Perkinsus marinus* causes Dermo disease in oysters. The disease is not harmful to humans, but can be deadly to oysters. Seasonal patterns of intensification and remission in North Inlet correspond to the well-known seasonal effects of temperature observed in other areas. In North Inlet and throughout the southeast, however, oysters do not appear to succumb to the disease as readily as they do in the larger bays of the mid-Atlantic or Gulf coasts. This observation has lead to a series of directed investigations on resistance, transmission and thermal tolerances of the parasite relative to the oyster. Analysis of monthly data from 1995 to date has revealed a long-term correlation of infection intensities with long-term changes in salinity. The effect is not significant or apparent across shorter time intervals. This observation supports the hypothesis that system flushing and water residence time, which are often correlated with salinity, may be more important in controlling infection intensities than salinity. This research is supported by the USES project described elsewhere.

Patterns of thermal stress and disease in oysters, *Crassostrea virginica*

Investigators: Drs. Sarah E. Gilman and Brian Helmuth
Department of Biological Sciences, USC

Temperature can alter the outcome of species interactions such as predation, competition, and disease. Temperature stress may increase an organism's susceptibility to pathogens, if the organism must divert resources from pathogen defense to repairing thermal damage. Alternately, temperature may provide a refuge from pathogens if the host organism is more resistant to thermal stress than the pathogen. The eastern oyster, *Crassostrea virginica*, is commonly infected by the pathogen *Perkinsus marinus* (aka "Dermo") throughout its distribution in the Western Atlantic. Mortality rates from dermo are much lower in South Carolina than in New England, and warmer temperatures have been implicated as an explantion. If temperature influences susceptibility to disease in South Carolina oysters, then infections rates in natural populations of *C. virginica* should vary with local thermal conditions. We are testing this hypothesis by monitoring oyster temperatures and dermo infections on within and among natural reefs in North Inlet. If temperature affects the susceptibility of oysters to dermo infection, we expect to see lower infection rates during the hottest times of the year and in microsites (locations within an oyster reef) with warmer overall temperatures. This project will start in Spring 2004 and continue through 2005.

An evaluation of remote sensing and traditional surveying approaches for rapidly assessing the status and trends of oysters and adjacent marsh habitats

Investigators: Drs. Loren Coen[1], David Bushek[4], Dwayne Porter[2], and Steve Schill[3], and Ray Haggerty[1]
SC Department of Natural Resources, MRRI[1]; Baruch Marine Field Laboratory, USC[2]; GeoMetrics Inc.[3]; Haskin Shellfish Research Laboratory, Rutgers University[4]

The primary objective of this effort is a collaborative effort to evaluate a variety of remote sensing (ADAR, GeoVantage, Lidar, NAPP, Hyperspectral) and on-the-ground surveying approaches to rapidly assess status and eventually trends of oysters and adjacent marsh habitats using shellfish beds in Jones Creek and adjacent areas. Sites in Jones creek include the previously unsurveyed recreational-only State Shellfish Ground (S342) and a larger adjacent area that is part of the Baruch Grant area (G-344) originally surveyed in the 1990s fringing one side of Jones Creek (see map location #13). Secondary objectives include a cost-benefit analysis comparing the original survey methods developed by OFM in the1980s to those using a new surveying GPS unit. Also we will be comparing a portion of the Jones Creek's original survey data within the Baruch Grant area (G344) with our updated and resurveyed data.

With the recent acquisition of the Trimble GPS survey unit mentioned above, intertidal oyster reefs can be walked and simultaneously surveyed generating polygon areas with very accurate GPS. Attribute data (e.g., oyster

spatial density codes–or "strata", matrix composition and depth, etc.) are then keyed into the touch pad in the field for rapid post-processing. This survey regimen will be repeated also at a subset of sites each year for current status and eventual trends and compared to remote sensing information. We will use these collected datasets for ground-truthing purposes in the evaluation of remote sensing technologies and their aerial imagery products for this area.

Previously, we conducted visual qualitative assessments of the recreational only State Shellfish Ground in January of 2002, using a modified protocol based on that used for the annual assessment of SC's commercial State Shellfish Grounds (S-342). An additional assessment category (reef density) was added to the original three (quantity, quality, and size) used to assess commercial grounds. In this assessment methodology, density refers to the spatial proximity of oyster clusters within oyster reefs, while quantity refers to the overall number and footprint of all reefs within the ground's boundaries (see attached S-342 boundary map). As with commercial assessments, the category of quality includes presence or absence of recent growth (white feathered edges), color or shade and relative thickness of live oysters' shell (dark gray-green vs. "sickly" paler gray), and the relative amount of recent mortality (visible, clean white interior shell surfaces on gaping and unhinged oyster shells). Size is the length in inches of the predominantly visible portion of oysters on the reefs (a visual "mode"). Each of these assessment categories are assigned a rating from1 to 5 ("poor" to "excellent"), and their scores averaged to yield an overall assessment score.

Increasing human activity in this area nearby development will inevitably impact oyster populations and adjacent tidal creek habitats. Development and utilization of more rapid, extensive and accurate population census methodologies will aid resource managers and policy makers in the more proactive management of marine resources in this and other portions of the state. They will also be more cost effective with a subset reevaluated in a more timely manner as remote sensing points to problem areas.

This project is supported by SCDNR, Saltwater Recreational Fisheries License Program, and NOAA-CICEET through September 2004.

Impacts of selected contaminants on *Perkinsus marinus*

Investigators: Dr. David Bushek[1], Megan Heidenreich[2], and Dr. Dwayne Porter[3]
Haskin Shellfish Research Laboratory, Rutgers University[1], Baruch Marine Field Laboratory, USC[1], Belle W. Baruch Institute for Marine and Coastal Sciences, USC[3]

The protozoan parasite *Perkinsus marinus*, which causes Dermo disease in oysters, is transmitted through the water as a free-living stage. During this period it is exposed directly to any contaminants that are present in the water. Studies of host-parasite interactions often assume that pollutants negatively impact the host, making it more susceptible to parasites and disease. The results of such work are often equivocal because the impacts of pollutants on the parasite are often not examined. As part of NOAA's USES project, this study is examining the effects of pollutants that are commonly found in South Carolina estuaries on *P. marinus*.

LIDAR-based watershed modeling of North Inlet

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

The goal of this project is to model sediment and surface water movement in the North Inlet watershed. We will delineate the North Inlet watershed and develop parameters suitable for input in the AGNPS model. Using the AGNPS model, we will predict problem areas for non-point source pollution (sediment). This project requires several sources of ancillary data, including a LIDAR-derived elevation model, and a current land cover map. The LIDAR data were collected in early 2003 and were used to create a digital elevation model with a vertical accuracy of "15 cm. The land cover map will be developed from various sources of digital imagery, including IKONOS satellite imagery and digital orthophoto quads. This work will give the North Inlet-Winyah Bay NERR staff a better understanding of the development pressures influencing North Inlet.

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

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

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

Settlement distribution of pre-adult fiddler crabs (*Uca* spp.)

Investigators: Matthew Behum and Dr. Renae Brodie,
Marine Science Program and Department of Biological Sciences, USC

The fiddler crab (*Uca* spp.) is an important benthic organism to both temperate and tropical intertidal habitats. Their burrowing and feeding behaviors foster energy flow within the trophic structure they are a part of, and they are the preferred diet of many organisms. *Uca pugnax* and *Uca pugilator* are common in saline, temperate marsh habitats, where *U. pugnax* adults frequent muddier substrate surrounded by the marsh grass, *Spartina alterniflora,* and *U. pugilator* occupies sandier sediment without vegetation. It is unclear, however, where juvenile *U. pugnax* and *U. pugilator* reside. Previous work dealing with settlement along an intertidal gradient has suggested that postlarvae of both species settle directly into their respective adult habitats after migrating from the coastal ocean where larval development occurs. However, these results are based on an unreplicated study with low sample size due to the difficulty of identifying postlarval crabs in the laboratory. This research focused on the reinvasion of adult habitats by postlarval *U. pugnax* and *U. pugilator* across habitat types (without tidal height variation) in the North Inlet Estuary, South Carolina to gain a better understanding of the recruitment dynamics of these species. Juvenile crabs were collected along transects at three different sites that spanned both *Spartina*-covered and open sand habitats with adult populations of *U. pugnax* and *U. pugilator*. Juvenile crabs were identified via restriction fragment length polymorphism (RFLP) using amplification of the internal transcribed spacer region (ITS-1) gene and a digest with the *Hpa*-II enzyme. RFLP allows larvae and juveniles to be identified directly, eliminating the need to rear young crabs in the laboratory to a more advanced stage for identification. Greater than 75% of the 821 crabs collected were *U. pugnax*, showing a heavier recruitment by this species compared to *U. pugilator*. Juveniles of all sizes of *U. pugnax* preferred adult, muddy habitat, but habitat preferences of juvenile *U. pugilator* varied by site. Generally, *U. pugilator* displayed a shift in distribution from *Spartina* cover to sandier habitat, during early juvenile stages. Sediment temperature and water content did not significantly influence juvenile distribution for either species. Preference for *Spartina*-covered, muddier habitat during younger juvenile stages could be a predator avoidance strategy or organic matter may be more easily consumed by juveniles in these areas. *U. pugilator* juveniles develop specialized mouthparts to scrape organic matter from larger sand grains, but these are not present in early *U. pugilator* juveniles or *U. pugnax* juveniles at any stage. Though young juvenile *U. pugnax* strongly favored *Spartina*-cover, older juveniles were occasionally observed in sandier habitat with *U. pugilator,* probably because they were able to dig burrows for protection at later developmental stages. The results of this study increase our understanding of *Uca* settlement and post-settlement migration by analyzing horizontal distributions and introducing a novel technique for identifying juveniles that make studies with greater sample sizes possible.

Salinity and its effects on *Uca minax, U. pugilator* and *U. pugnax* survivorship during larval, megalopal and juvenile stages

Investigators: Jenice Godley and Dr. Renae Brodie
Department of Biological Sciences and Marine Science Program, USC

The 2004 field season will encompass a continuation of last year's project (salinity fluxes and *Uca* juvenile survivorship) and a few new lab-based projects addressing questions that arose from the aforementioned study. Salinity measurements, and *Uca* juvenile collection, will be taken from July 1 to August 31 at two sites on the Baruch property: Hell Site and Clambank Bridge (see attached map). The long-term collection of data will help us to see trends that occur from year to year with salinity and the *Uca* populations at these two sites. Collection of the *Uca* juveniles will occur twice a week and the salinity data will be collected biweekly. We also plan to map out the adult *Uca* distributions along salinity gradients, in the creeks and rivers, throughout the summer in the North Inlet Estuary.

As for the lab-based projects, we plan on investigating the affects of salinity on survivorship of the larvae, megalopae and juveniles of the three *Uca* species to see if there is any differential survivorship among the species at various salinities. The larval project will begin May 15 with a collection of brooding females in the Georgetown area. The megalopal and juvenile experiments will be done throughout the summer, dates depending on when we start an experiment. The megalopae and juveniles for these experiments will be reared at the Baruch Marine Field Lab. With the continuation of field work and these experiments more light will be shed on how much of a role salinity plays in the *Uca* spp. distribution and what it takes for them to successfully reach settlement. Project period: May 15- August 31, 2004

Impact of microenvironment conditions on the internal body temperature of *Ilyanassa obsoleta*, the common mud snail

Investigator: Maxine Henry
Marine Science Program, USC

A primary goal of recording microclimate mud temperature data from a mudflat close to the head of Bly Creek began in June 2003. These data are currently being combined with environmental data gathered by the NIWB-NERR weather station on the pier at Oyster Landing to continue testing a mathematical model of *Ilyanassa obsoleta* body temperature prediction. A secondary goal (to be addressed in the summer of 2004) is to compare microclimate mud temperatures at Bly Creek and at Oyster Landing (map location # 3 & 4) to determine spatial heterogeneity in mudflat microenvironments at the scale of tidal creeks.

Understanding how the environment affects the body temperature of this intertidal snail will help elucidate elements controlling snail distributions, not only in the local area of Bly Creek, but also throughout the range of this snail (across the Atlantic seaboard from Canada to Florida). Having a valid model can also be used to examine the possible effects of climate change on this snail and other intertidal organisms.

Support for this project comes from an NSF grant to Brian Helmuth, Biology Department, USC. Project dates: June 2003-July 2005

The effects of body size and microhabitat on the body temperature of *Geukensia demissa*

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

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

The goal of this research is to examine the effects of body size and microhabitat, in terms of marsh location and position within the sediment, on the body temperature of *Geukensia demissa*. Using thermally matched temperature loggers (empty mussel shells filled with silicone and equipped with an iButton temperature logger) with an accuracy of ±1°C, we will estimate body temperatures at three body sizes, three marsh locations (in the marsh area adjacent to the road leading to Oyster Landing behind the boat shed), and three sediment depths, starting April 2004 and continuing for a period of one year. Mussel loggers of three sizes (small = 4-6 cm shell length, medium = 6-8 cm, large = 8-10 cm) will be buried in the salt marsh until the uppermost portion of the shell is flush with the sediment surface (0 cm sediment depth). To determine the effects of sediment depth, mussel loggers of one size (6-8 cm) will be attached to wooden dowels using Z-Spar (a marine epoxy), fixing the mussel loggers at one of three sediment depths (0, 3 or 6 cm). Again, sediment depth will be measured by the position of the uppermost portion of the mussel shell above the sediment surface. Also, in order to determine the effects of these microhabitats on mussel survival and growth in the field, living mussels will be attached to wooden dowels (again using Z-Spar) and placed in the field at depths of 0, 3 and 6 cm. Over time, we will monitor survival and growth rates of the mussels. Replicates of this portion of the study will include living mussels within the three size classes of interest. Funding for this research is provided by NSF OCE 0323364 to BSTH.

Macrozooplankton dynamics and the role of the estuarine plume in the recruitment of crustacean larvae at Winyah Bay, SC

Investigators: Dr. Dennis M. Allen[1], Dr. Martin Posey[2], Dr. Tom Lankford[2], Paul D. Kenny[1], and Tracy Buck[1]
Baruch Marine Field Laboratory, USC[1]; Center for Marine Science, University of North Carolina at Wilmington[2]

Macrozooplankton collections along a transect from inside the Winyah Bay jetties to the sea buoy several kilometers offshore will provide information about the timing and magnitude of larval migrations. The focus is on the blue crab, which spawns near the mouth of the estuary. Its young larvae move to deep water tens of kilometers offshore, and late developmental stages (megalopae) return to the estuary in late summer and fall. Simultaneous collections at the Cape Fear, NC, and Winyah Bay estuaries are being compared in an effort to determine regional differences in recruitment patterns of the blue crab and related species. Remotely sensed and shipboard measurements of physical conditions, especially ocean currents, will be used to interpret the patterns. Samples are collected at multiple levels in the water column on either side of the line that separates the relatively clear coastal ocean water and the turbid estuarine water mass (plume). Collections made during the ebbing tide will help characterize the role of this moving edge in aggregating and attracting larvae. The project seeks to understand the mechanisms of recruitment for multiple species of blue crabs, penaeid shrimps, and fishes that use the estuary as a nursery area.

Long-Term Studies

The summaries listed below document the long-term studies that are ongoing in North Inlet. One of the valuable resources provided by the BMFL are 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 and appropriately attribute trends in the data from their shorter, more focused research. 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) or the National Science Foundation's Long-Term Ecological Research (LTER) site.

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

Investigators: Virginia Ogburn-Matthews[1] and Dr. L. Robert Gardner[2]
Baruch Marine Field Laboratory, USC[1]; Department of Geological Sciences, USC[2]

Partners: Tom Mero, NOAA/NOS/OPSD, and Lewis Lapine, SC Geodetic Survey

Support: National Science Foundation, NOAA/NOS/OPSD, and SC Geodetic Survey

Begin and End Date of database: May 2001 to present (ongoing) (missing data during July 2002-February 2003)

The tide gauge measures water level in reference to MLLW at 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 (three hour delay). Visit the NOAA tides online site at http://tidesonline.nos.noaa.gov/geographic.html for North Inlet's data. The gauge is part of the NOS's National Water Level Observation Network (NWLON); NOS oversees all data management. The tide gauge's base datum is referenced to the North American Vertical Datum of 1988 (NAVD88). This state-of-the art tide gauge is accurate to "3 mm with a resolution of "1 mm, and the data it provides, aids in predicting tides, observing sea level rise, and modeling local phenomenon in North Inlet Estuary. See map location #3.

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

Investigators: Amy Cook, Jennifer Keesee, and Tracy Buck
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

A fully functional meteorological station (National Weather Service installation) is positioned on a pier that extends over the tidal marsh in North Inlet Estuary. Wind speed, wind direction, air temperature, barometric pressure, solar radiation, and precipitation are measured with sensors mounted on a tower at the pier. A computerized data acquisition system provides regular uploads of data to the laboratory via a short haul modem. The public can obtain up-to-date readings and monitor our weather data in real time from the main laboratory or over the Internet. Records have been gathered for more than 13 years for most parameters. See map location # 3

National Atmospheric Deposition Program (NADP)

Investigator: Jennifer Keesee
North Inlet-Winyah Bay NERR, Baruch Marine Filed Laboratory, USC

The North Inlet-Winyah Bay NERR established a precipitation chemistry monitoring site in North Inlet Estuary in January 2002; atmospheric deposition data are collected according to NADP/National Trends Network (NTN) protocols. The work is made possible by the US EPA National Estuary Program and the SC Department of Health and Environmental Control. This partnership was formed to better represent coastal areas in our nation's

deposition monitoring networks and also to gain a better understanding of the atmospheric deposition of nutrients and pollutants into the North Inlet system. The collection instruments consist of a recording rain gauge and event recorder, an analytical balance, a pH meter, and a conductance meter and cell. Samples are collected and analyzed in accordance with the analytical chemistry contract with the Program. See map location #3. NADP data can be viewed at the following web address: http://nadp.sws.uiuc.edu/.

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

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

Using YSI data loggers deployed to four tidal creeks within the NI-WB Reserve boundaries, we collect information about the physical parameters of our estuarine waters every half-hour, every day, all year long. The YSI instruments are calibrated and deployed according to strict protocols. Those protocols were agreed upon by the NERR System and are adhered to nation wide. Furthermore, detailed metadata records are kept and data are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control. The parameters measured include temperature, salinity, depth, pH, dissolved oxygen, and turbidity. See map location #'s 6A, 6B, 3, 2C for datalogger deployment locations. Data can be accessed via the CDMO website: http://cdmo.baruch.sc.edu/.

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

Investigators: William Johnson[1], Amy Cook[1], Tracy Buck[1], Dr. L. R. Gardner[3], and Dr. James Morris[2]
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC[1];
Department of Biological Sciences, USC[2]; Department of Geological Sciences, USC[3]

Chemical analyses of North Inlet estuarine water samples began in the late 1970s. Since 1993, ISCO automated water sampling devices have been used to collect water samples at regular intervals over two complete tidal cycles within the North Inlet-Winyah Bay NERR. Once every 20 days, ISCO samplers are deployed at four stations. They are programmed to take a sample at predicted low tide and then sample every 2 hours and 4 minutes for a period of 24:48 (hr:min). The chemical analyses performed produce data on suspended solids, dissolved organic carbon, total nitrogen, ammonium, nitrate-nitrite, total phosphorus, orthophosphate, and chlorophyll *a*. The water chemistry data are collected from the same four locations where YSI dataloggers record complementary environmental data (see above). See map location #'s 6A, 6B, 3, 2C.

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, USC[1]
Belle W. Baruch Institute for Marine and Coastal Sciences, USC[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). See map locations 8 and 10.

Some of the most recent publications associated with the work:

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

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

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

Brown, M.M., M.J. Friez, and C.R. Lovell. 2003. Expression of *nifH g*enes 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.

A harmful algal bloom initiative for South Carolina: Assessing the potential environmental impacts of red tides, *Pfiesteria*, and toxic algae/ South Carolina Task Group on Harmful Algae

Investigators: Dr. Alan Lewitus[1,2], Krista DeMattio[2], Sarah Habrun[1], Kenneth Hayes[1,3], Megan Heidenreich[1], Sabrina Hymel[1], Chad Johnson[2], Jason Kempton[2], Jiqing Liu[1], Lara Mason[2], Andrew Shuler[1], Raphael Tymowski[1], and Dr. Susan Wilde[1],
and collaborators from NOS-Charleston, SC Sea Grant, SCDHEC, SCDNR, Clemson University, MUSC, USGS
Baruch Marine Field Laboratory, USC[1]; Marine Resources Research Institute, SCDNR[2]; SCDHEC[3]

The SC Task Group on Toxic Algae was formed in late 1997, with the goal to develop a coordinated state strategy to cope with the possible consequences of a *Pfiesteria* toxic outbreak. The Task Group has since expanded to include assessments of harmful algal blooms in general. One of the first accomplishments of the group was to implement a program to respond to fish kills or lesion events in SC estuaries, and determine the potential association with harmful algal blooms. Efforts of the Task Group led to NOAA funding in support of the South Carolina Harmful Algal Bloom Program (SCHABP), the first statewide effort to assess the distribution and potential adverse effects of HABs in South Carolina estuaries. This study will 1) determine the present distribution of harmful algae in SC estuaries; 2) determine environmental factors that favor HAB formation in SC estuaries so future effects can be predicted; and 3) establish a statewide HAB surveillance system. The monitoring effort consists of an intensive statewide spatial monitoring (on a monthly to annual basis) to determine existing physical, chemical and biological parameters (including algal distribution) throughout the state. In addition, known "hot spots", which are areas with previous algal blooms and/or lesioned fish, are monitored on a more frequent basis (biweekly), in order to document the physical, chemical, and biological factors which exist previous to a bloom event, should one occur. In the event of a potentially harmful algal bloom, an event response method was formulated to standardize the measurement of environmental parameters that exist at the time of the bloom. Additional water samples are collected for the purposes of identification, isolation, and culturing of the bloom species. These cultured algal species will be used for bioassays to determine the role of nutrient quantity and quality in HAB stimulation. NOAA NOS. 1 October 2002 to 30 September 2004.

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

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

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

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

Investigators: Drs. Bruce Coull[1] and Robert Feller[2]
School of the Environment, USC[1]; Marine Science Program, USC[2]

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

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[1], Dr. Steve Stancyk[2], Paul Kenny[1], Tracy Buck[1], and Ginger Ogburn-Matthews[1]
Baruch Marine Field Laboratory and NI-WB NERR, USC[1];
Department of Biological Sciences and Marine Science Program, USC[2]

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

Settlement patterns of the eastern oyster in the North Inlet Estuary

Investigator: Paul Kenny
Baruch Marine Field Laboratory, USC

Oyster reefs are important structural and functional components of the estuarine ecosystem. They provide food, shelter, and biological filtration. Patterns of oyster larvae settlement and their relationships to biotic and abiotic characteristics of the estuary have been studied since 1982. This long-term investigation involves collecting and counting recently metamorphosed oysters on settlement plates. The plates are suspended in vertical arrays next to intertidal oyster reefs. Biweekly processing has provided information about seasonal and interannual variation in settlement success. Although the timing and duration of the settlement season are stable among years, large fluctuations in abundance are typical. Such information allows us to monitor the condition of the oyster resource and determine natural factors that influence the population. See map location # 13

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

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

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

Long-line survey of sharks of Winyah Bay and nearby waters

Investigators: Dr. Daniel C. Abel, Bree Yednock, Jason Garwood, and Mario Travaline
Marine Science and Biology departments, Coastal Carolina University

Recent surveys of sharks along the southeast coast have shown declines in several species, e.g., sandbar and dusky sharks. These and other sharks inhabit coastal waters and/or estuaries, and use the latter as nurseries. We are undertaking a long-term long-line study to survey the sharks of Winyah Bay and nearby waters; to determine which sharks use the Bay as a nursery; and to understand habitat selection in selected species in the Bay We will thus understand more about the life history, diversity, abundance, and seasonality of sharks in Winyah Bay. Detailed information arising from this study will contribute to a greater understanding of the health of this group along the southeast coast.

Shallow coastal waters in the southeast U.S. may represent vital habitat and nursery grounds for viviparous sharks, many of whose populations are in decline. From May to November in 2002 (a drier than average year) and 2003 (a wet year) we set 227 bottom longlines (16/0 and 12/0 hooks) in Winyah Bay, a 65 km^2 estuary in northeast South Carolina. We also made 119 trammel net sets from June-October in both years in North Inlet, a 32 km^2 high-salinity estuary connected to both Winyah Bay and the Atlantic Ocean. In 2002, 196 sharks (38 adults, 158 juveniles/young-of-year [YOY]/neonates) representing 10 species were captured in Winyah Bay, whereas 73 sharks (17 and 56, respectively) representing 4 species were caught in 2003. CPUEs for all sharks were not significantly different between 2002 and 2003. CPUEs for *Carcharhinus limbatus and C. isodon* declined significantly on 16/0 longlines. For 12-0 longlines, CPUEs of three species (*C. plumbeus*, *R. terraenovae*, and *C. isodon*) out of five declined significantly. Within Winyah Bay, CPUEs for sharks on both longline configurations were not significantly different between lower and middle bay sites for 2002 but were for 2003. CPUE correlated with bottom salinity for both years. In North Inlet, in 2002 30 sharks (20 adults, 10 juveniles/YOY/neonates) comprising five species were caught, whereas 57 sharks (26 and 31, respectively) representing three species were caught in 2003. CPUE for 2002 was significantly less than 2003. The two most numerous species (*R. terraenovae* and *Sphyrna tiburo)* exhibited statistically significant increases in CPUEs. In 2002 and 2003, respectively, immature sharks of seven and four species were caught in Winyah, and four and one species in North Inlet. These results support the conclusion that salinity structure strongly influences the use of estuaries by sharks as habitat and nursery grounds. In addition, Winyah Bay and North Inlet should be further evaluated as *Essential Fish Habitat* for sharks (as defined in the Magnuson-Stevens Fishery Conservation and Management Act) because of the large number of juveniles, YOY, and/or neonates found in both systems.

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

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

Long-term monitoring project: began September 1997

This project seeks to identify resident populations of bottlenose dolphins in the North Inlet and Winyah Bay systems and to identify their patterns of habitat utilization. This information is used to model the trophic role of dolphins within the system and to model the potential impact of dolphins upon prey populations. Photo-identification is used to identify and catalog individual dolphins based on the shape of the dorsal fin, and focal follows are used to establish habitat utilization patterns. Our initial studies have determined that the small number of resident dolphins regularly using the North Inlet system (on average, less than 10 in any given season) consume a significant proportion of the prey fish populations (9.1 to 14.2 metric tons per year) and utilize between 3 and 7% of the annual primary production in North Inlet. Due to their changing seasonal patterns in North Inlet, dolphins may serve as a highly visible indicator species for changes and movements in the prey community. This research also contributes to the NMFS Mid-Atlantic Bottlenose Dolphin Catalog whose aim is to determine the stock structure of coastal migratory dolphins between New Jersey and Florida.

Support: Subcontract to the grant, "Contributions to the Biology of the red drum, *Sciaenops ocellatus*, in South Carolina," an Unaligned Management Project funded by the National Marine Fisheries Service (PI - Charlie Wenner, SCDNR), and the Georgetown Environmental Protection Society

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

Wading bird nesting on Pumpkinseed Island: 1979-2004

Investigators: Dr. Dennis M. Allen[1], Dr. Keith Bildstein[2], and Wendy Allen[1]
Baruch Marine Field Laboratory, USC[1], Hawk Mountain Sanctuary Association[2]

Numbers of nesting wading birds are counted or estimated each spring and early summer to determine numbers of birds returning to the historically large colony. An average of 7,000 pairs occupied the island each year through the 1980's, but not a single pair nested in the spring following Hurricane Hugo (September 1989). About 2,000 pairs nested in 1992 and numbers reached a high of 2,700 in 1993. Numbers decreased each year to a low of about 200 in 1999. In 2001, more than 500 pairs of white ibis used the island and scattered clusters of nests on the south and west quadrants of the island marked the first time since 1989 that these areas were used. More white ibis returned in 2002 and almost all nesting was in the southwest portion of the rookery. Tri-colored herons, great egrets, and snowy egrets also use the island and have produced about 2,000 nests in recent decades. Until Spring 2003, the numbers of glossy ibis and tri-colored herons nests on Pumpkinseed were some of the highest in the state. Map location # 14

Sea turtle nest monitoring on Debidue Beach/Hobcaw Barony

Investigators: Betsy Brabson[1] and Robin Baughn[1] (Debidue Beach Coordinators),
Wendy Allen[2], Tracy Buck[2], Jennifer Keesee[2], and other volunteers
DeBordieu Colony[1], Baruch Marine Field Laboratory, USC[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 and the Baruch Institute of Clemson, residents of DeBordieu Colony, and members from surrounding communities participate in the monitoring program. Volunteers walk the beach early in the morning during the nesting and hatching season, record information on false crawls and nests, and protect nests from predators with screening. Nests laid in areas subject to flooding by tides are carefully relocated to higher areas. Volunteers also monitor the hatching success of the nests. Nest inventories are conducted 72 hours after the major hatch, indicated by dozens of baby turtle tracks in the beach

sand. Volunteers excavate the nest chamber and record the number of empty shells, number and stages of development of unhatched eggs, and number of live hatchlings in the nest, if any. Nest inventories are conducted near dark and usually draw a crowd of interested visitors, providing an excellent opportunity to share information about the natural history and conservation of sea turtles. The volunteers are members of a larger volunteer group, the South Carolina United Turtle Enthusiasts (SCUTE), which covers the northern beaches of the state from the southern, undeveloped end of Debidue Beach known as Hobcaw, to North Myrtle Beach. Debidue Beach, including Hobcaw, plus the middle and north sections, typically accounts for 30-50% of all nests in the region which includes 13 different beach areas. A final report summarizing nesting activity and success for the SCUTE region is prepared and submitted to the South Carolina Department of Natural Resources that oversees the volunteer sea turtle program for the state. See map location #1

South Carolina Estuarine and Coastal Assessment Program

Investigators: Drs. R.F. Van Dolah and D.E. Chestnut
SC Department of Natural Resources

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, will provide 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 will be 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 2003. 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.

Education, Outreach, and Data Management

Estuary-Net Project - National Estuarine Research Reserve

Investigator: Beth Thomas
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

Estuary-Net is a volunteer water quality monitoring project developed by the National Estuarine Research Reserve System to educate high school students and others about the importance of healthy water quality and the value of watersheds and estuaries. It includes a complete curriculum with both classroom and field activities that provide a hands-on approach for investigating non-point source pollution and its impacts on estuaries. Teams of

students from local school districts work with Reserve staff to design a sample plan, survey waterways near their schools, and share their collected data through the Estuary-Net web site: http://inlet.geol.sc.edu/estnet.html. Participating schools work closely with the Reserve's Education Coordinator and receive an introductory classroom visit highlighting the Reserve System, the Estuary-Net project, and instruction on monitoring equipment and sampling protocols for a variety of sampling variables. The schools then begin their site monitoring and data collection and report their findings via the data directory on the website. Follow-up visits and seasonal sampling summaries are also provided.

Education activities - National Estuarine Research Reserve

Investigator: Beth Thomas
North Inlet-Winyah Bay NERR, Baruch Marine Field Laboratory, USC

Educational activities that integrate findings from research are offered throughout the year. Baruch lecture series provide an informal means for people to learn about ongoing research programs at the coast. Other regular offerings include open houses and the Fishes of North Inlet Estuary program whereby participants help Reserve scientists sample and process collections of fishes, shrimps and crabs made on a bi-weekly basis. Contact the Reserve for a schedule of events at (843) 546-6219 or visit the Reserve's web site at: www.northinlet.sc.edu.

Coastal Training Program for local decision-makers

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

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

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 DHEC - Office of Ocean and Coastal Resource Management (OCRM), South Carolina Sea Grant Consortium, and the NOAA Coastal Services Center (NOAA CSC). These agencies constitute the South Carolina CTP Coordinating Committee that provides oversight, guidance, and statewide coordination for the Coastal Training Programs that are administered by the two South Carolina NERRs.

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

Investigator: Ginger Ogburn-Matthews
Baruch Marine Field Laboratory, USC

Support: NOAA/Coastal Services Center, Charleston

Begin and End Date of Project: August 1, 2002 to present (ongoing)

Baruch Institute has many valuable ecological and environmental coastal long-term databases that date from the late 1970s through the 1990s that are not readily accessible to the public and researchers. Technology and information management has changed dramatically just in the last 5 years with the growth and availability of the Internet. The goal of this project is to verify, rescue, organize, archive, and disseminate each database and its documentation (metadata) in a variety of forms (paper, Compact Disk (CD), and web).

First the data and the documentation for each database is assessed. All data are graphed, verified, and documented for missing data and outliers. All previous documentation, programs, summary data, and processed files are organized and documented. After the data are verified error-free, final graphics are created, and exported in a .jpg format. All documentation is verified with the data, and summarized in a standardized form, using the Federal Geospatial Data Committee (FGDC)/National Biological Information Infrastructure (NBII) format. All raw datasheets are scanned and saved as .jpg formatted images. Raw data images, processed data (including programs and earlier documentation), and final data are archived to a CD. All final data, metadata, and graphics are printed out; these hardcopy versions along with the CDs are placed in a three-ring binder notebook that is kept in the computer lab at the Baruch Marine Field Laboratory. The final data, graphics, and metadata are also posted to Baruch's Website (http://links.baruch.sc.edu/data/) and the metadata is posted to Baruch's Isite Node that is registered with the NOAA CSC (http://www.csc.noaa.gov/CID/), NBII (http://mercury.ornl.gov/nbii/), and FGDC (http://clearinghouse2.fgdc.gov/) clearinghouses.

The National Estuarine Research Reserve System Centralized Data Management Office

Investigators: Dr. Dwayne E. Porter[1,2], Tammy Small[1], Ashly Norman[1], Danna Dowdy[1], and Nick Stines[1]
Belle W. Baruch Institute for Marine and Coastal Sciences and the Baruch Marine Field Lab, USC[1]; The Norman J. Arnold School of Public Health, USC[2]

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, biodiversity monitoring, and land-use and habitat change analysis.

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. This project is funded from 09/01/01 to 02/28/04 by NERRS/NOAA/Dept. of Commerce. The CDMO website is *cdmo.baruch.sc.edu*

Research Locations in North Inlet

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