# CURRENT RESEARCH PROJECTS

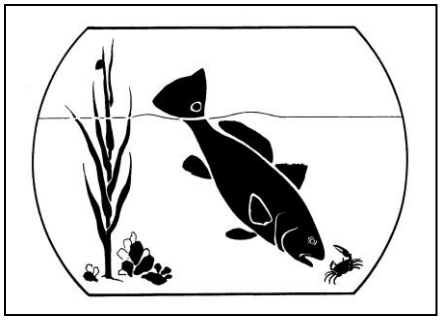
# 2002

## Baruch Marine Field Laboratory (BMFL)

## North Inlet – Winyah Bay
## National Estuarine Research Reserve
## (NERR)

## University of South Carolina

BARUCH INSTITUTE
UNIVERSITY OF SOUTH CAROLINA



**North Inlet – Winyah Bay**
**National Estuarine Research Reserve**

**Current Research Projects 2002**

**Introduction**

More than 530 scientific research projects and about 300 student theses and dissertations have been completed by Baruch Institute research associates since 1969. This work has resulted in the publication of more than 1265 scientific articles, reports, and books which 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 75 of the projects currently being conducted at the Baruch Marine Field Laboratory by staff, graduate students, and faculty associated with the University of South Carolina and other institutions. The University of South Carolina supports 33 faculty, 24 technicians and 17 students as investigators on these projects. In addition, 36 faculty, 6 technicians , 2 students and 6 volunteers representing 30 other institutions participate as investigators. Dozens of other graduate and undergraduate students assist these investigators throughout the year to obtain hands-on training in field research methods. A wide variety of basic and applied research is represented. The list includes only those projects which make regular use of the site. Most of the studies which involve field measurements and collections are being conducted within the North Inlet-Winyah Bay National Estuarine Research Reserve (see map).

The Projects are randomly grouped and each Research Summary includes title, investigator(s), affiliation, and project abstract. Projects which focus on long-term monitoring and research are located in the back section of the document

Funds for these research projects are provided by a variety of sources, including the National Science Foundation, Environmental Protection Agency, National Oceanic and Atmospheric Administration (National Estuarine Research Reserve System, and SC Sea Grant Consortium), U.S. Dept. of Energy, the Office of Naval Research, National Aeronautics and Space Administration, and the SC Dept. of Health and Environmental Control. The Friends of the Institute, an independent organization which 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, Dr. Dennis Allen, or Dr. David Bushek 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.

Research Summary Author and Title List

Tide Level: Long-term monitoring at Oyster Landing pier

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

Partners: Tom Mero, Chief (NOAA/NOS/OPSD) and Lewis Lapine, Director (SC Geodetic Survey)

Beginning in May 2001, a new tide gauge began measuring water level every six minutes and data are transmitting the data via NOAA's Geostationary Operational Environmental Satellites (GOES), making the data available on-line in near real-time. 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 #5

Characterization of Intertidal Zone Creek Networks

Investigators: Karyn I. Novakowski and Dr. Raymond Torres
Department of Geological Sciences, University of South Carolina

Tidal creeks and channels dissect the marsh landscape and produce discreet islands with well-defined drainage basin networks. Estuarine habitat structure results from the interactions between salt marshes, channel networks and landuse. 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 planform. 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. This project is funded by the NERR-GRF program for the period June 2001-May 2003.

Groundwater dynamics at the forest-marsh boundary

Investigators: Dr. L. Robert Gardner
Department of Geological Science, USC

The effects of fresh groundwater flow from upland forests on adjacent salt marshes, such as at North Inlet, are not yet well understood. We have installed bundles of piezometers at numerous stations along three forest-marsh transects across the Crabhaul Creek basin at the North Inlet National Estuarine Research Reserve site ( map location #12) in order to study the dynamics of groundwater flow and the effects of sea level rise on the salinization of this shallow water table aquifer. Between 1993 and 1996 bimonthly measurements of salinity were made in this network of 309 piezometers. Most of the piezometers were also instrumented with pressure transducers and data loggers for periods ranging from one month to about one year, yielding a spatially and temporally dense data set of 15 minute interval time series of water elevations (heads). These data reveal that fresh ground water seeps upward in the high marsh on the western side of the basin adjacent to the extensive mainland forest. This prevents salinization of the marsh soil water and colonization of the marsh by salt tolerant plants such as *Salicornia* and cedars. Conversely, along the eastern margin of the basin where only a narrow strip of forest is present, groundwater seepage has a strong downward component of flow which allows the infiltration and subsequent evapoconcentration of saline tidal water. As a result, a zone of hypersaline soil has formed and colonization by *Salicornia* has been successful. Efforts currently are directed towards developing a numerical flow model using the USGS code SUTRA to simulate the observed dynamics and salinity distribution across the system. We are also using the head time series along with measured soil parameters (hydraulic conductivity, porosity and specific yield) and meteorological data to develop water budgets for stations along the transects. The water budget components being estimated include losses due to evapotranspiration and seepage and gains due to recharge by tides and rain as well as seepage. These fluxes in turn control soil water salinity and thus botanical zonation and their estimation is therefore critical to understanding controls on the forest-marsh ecotone.

Papers related to this work are listed below:

Gardner, L.R., and D.E. Porter, Stratigraphy and geologic history of a southeastern salt marsh basin, North Inlet, South Carolina, USA, Wetlands Ecology and Management, V. 9, 371-385, 2001.

Gardner, L.R., H.W. Reeves, P.M. Thibodeau, Groundwater dynamics along forest-marsh transects in a southeastern salt marsh, USA: Description, interpretation and challenges for numerical modeling, Wetlands Ecology and Management, in press.

Goni, M.A., C.C. Jones, L.R. Gardner, E. Tappa and W. Johnson, Dissolved organic carbon dynamics in a shallow coastal aquifer: A study of a subterranean estuary, Limnology and Oceanography, submitted.

Gardner, L.R. and H.W. Reeves, Seasonal patterns in the soil water balance of a *Spartina* marsh site at North Inlet, South Carolina, USA, Wetlands, submitted.

Gardner, L.R. and H.W. Reeves, Spatial patterns in soil water fluxes along a forest-marsh transect in the southeastern United States, Aquatic Sciences, submitted.

Bathymetry Changes, Hydrodynamics and Sediment Dynamics in Debidue Creek

Investigators: Dr. George Voulgaris[1] and Lew Lapine[2]
Department of Geological Sciences and Marine Science Program, USC[1]
and The South Carolina Geodetic Survey[2]

Current theories of tidal wave propagation in shallow embayments indicate that the asymmetry of the tidal wave (i.e., higher ebb than flood flows or vice versa) depends on the ratio of the intertidal area (i.e., tidal flats, marshes) versus the area of the main channel. Recently, residents of the DeBordieu Colony obtained permit to carry out maintenance dredging of the main channel of DeBordieu creek that runs along Luvan Blvd. The dredging operations will increase the depth of the channel and thus change the area ratio of intertidal vs main channel. The goal of this study is to collect sea surface (tidal) and current strength data prior and after the dredging operations and compare the data to current hydrodynamic theories.
Source of Support: Dept. Geological Sciences, SC Geodetic Survey (in kind), Baruch Institute (in kind). See map location #13

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[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 habitat in cooperation with NERRS research coordinators and participating scientists across the country. The data base 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 data base 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 data base and protocol will establish NERRS as a leader in providing restoration assessment guidelines with respect to habitat elevation measures, criteria, analysis and interpretation. The NERRS 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)

Non-point sources of dissolved organic matter to the ocean: Groundwaters from coastal soils and sediments

Investigator: Dr. Miguel Goñi
Department of Geological Sciences and Marine Science Program, USC

The principal question fueling this work is: What is the role of groundwater on the cycling of dissolved organic matter (DOM) in coastal ecosystems? This project is designed to determine (1) the sources and characteristics of groundwater DOM; (2) the seasonal dynamics of groundwater DOM production and transport; and (3) the impacts of groundwater DOM on the coastal ocean. Several analytical techniques, including tangential ultrafiltration, 13C NMR, and the novel combination of compound specific isotope analyses with CuO oxidation and pyrolysis, are used to quantitatively characterize DOM. Groundwater samples are collected from wells across Crabhaul Creek while surface samples are collected at various locations in North Inlet and offshore regions of the South Carolina coast. Our data suggest that groundwaters are important non-point sources of DOM to the coastal ocean. These observations also suggest that groundwater DOM is quantitatively and compositionally different than DOM from rivers (point-sources). Given the unavoidable impact of human development on our coasts, it is imperative to understand how the diffused flow of groundwater constituents affects the dynamics of carbon, nitrogen and other nutrients in coastal environments.

Sediment accretion in North Inlet salt marshes

Investigator: Dr. James Morris
Department of Biological Sciences and Marine Science Program, USC

The objective of this study is to understand (1) the factors that cause the volume of sediment to change and (2) how changes in the volume of sediment relate to sedimentation. 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.

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. We are testing this hypothesis in Atlantic coast salt marshes. We are counting herbivores and measuring herbivore damage to plants in ten sites in the south Atlantic Bight and ten sites in New England. We will transplant standard marsh plants into a subset of these sites to determine if standard plants receive more herbivore damage in the south. The research will be done May through September of 2002, 2003 and 2004 and is funded through the NSF.

Sediment transport and trapping in estuaries, Southeastern United States

Investigator: Dr. Gail C. Kineke
Department of Geology and Geophysics, Boston College

This project has both a research and education component. The goal of the research is to examine sediment transport processes in three estuaries: Winyah Bay (SC), ACE Basin (SC), and the Satilla River (GA). Each study focuses on the physical processes responsible for trapping sediments within the estuary. The three estuaries are chosen to address specific sediment transport processes necessary for understanding resuspension, trapping, and turbidity maximum related questions. In contrast to the other two, more pristine sites, Winyah Bay is highly impacted by human activity and the channel is regularly dredged. The focus of study will be the trapping of sediments as a result of frontal dynamics in the lower part of the estuary, downstream of where a traditional turbidity maximum usually occurs. The study in Winyah Bay also serves as the foundation for the education component of this project which introduces undergraduate students to research in estuarine processes through individualized and team projects. The study is being carried out through a combination of hydrographic surveys using an instrumented profiling tripod, CTDs, and optical sensors for both spatial and time-series observations, bottom sediment characterization using dual frequency echosounders, and bottom sediment sampling. Understanding transport and trapping of fine sediments in estuaries is critical for dredging-related issues and transport of many contaminants (heavy metals, PCBs, pesticides) which are frequently adsorbed on fine-grained particles. This project is funded by the National Science Foundation. See map location #14

Temporal patterns of Dermo disease in North Inlet

Investigators: Drs. David Bushek[1] and Dwayne Porter[2], Jennifer Cardinal[1]
Baruch Marine Field Laboratory[1], Baruch Institute [2], USC

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 don't 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 through early 2002 has revealed a long-term trend of increasing infection intensity that correlates significantly with a long-term increase in salinity resulting from current drought conditions. The effect is not significant across shorter time intervals. This observation supports hypotheses from other directed research on transmission dynamics and the role of flushing.

Experimental studies of oyster, mussel, and barnacle recruitment in intertidal oyster reef habitats.

Investigators: Drew Lohrer[1], Sarah Foose[2]
NIWA Laboratory, New Zealand [1], and Baruch Marine Field Laboratory, USC[2]

Two experiments were deployed in summer 2001 to examine the recruitment of oysters, scorched mussels, and barnacles on uniform (artificial) settling surfaces while we experimentally controlled (1) the height of these surfaces above sediment-water interface, and (2) amount of interstitial space in between these surfaces. In general, recruitment was greatest when the interstitial spaces were small and on panels nearest to the reef surface. However, levels of recruitment were extremely low in all cases (relative to recruitment on similar panels that were suspended above the reef). Thus, continued experimentation will examine factors responsible for low recruitment to the reefs during times when recruitment potential is extremely high.

Role of an exotic species as a novel prey item in an oyster reef ecosystem

Investigators: Mary Jo Hartman, Dr. Andrew Lohrer and Dr. Stephen Stancyk
Marine Science Program, USC

Invasive organisms can have significant effects on ecosystems due to competition for resources, disruption of habitats and changes to trophic systems. Many studies have examined the role of a new predator to a system, but less is known of the effect of a novel prey item. *Petrolisthes armatus*, the green porcelain crab, has recently invaded South Carolina and we are monitoring its distribution by monthly collections at three sites in North Inlet (see # 14A,B, C on map). Sampling of *P. armatus* is being conducted by placing trays filled with oyster shell at each of two zones (subtidal and intertidal). Trays are left in the field until the next sampling period when all *P. armatus* are collected as well as other components of the oyster reef community which are being quantified to determine whether *P. armatus* densities affect biodiversity. *P. armatus* was abundant (50-200 crabs/$m^2$) during summer and early fall of 2000. Coincident with an unusually cold winter, *P. armatus* densities declined dramatically and it was not detected in monthly samples from January through July 2001. It has reappeared in low numbers in the fall and winter of 2001. This study continues to provide baseline information on the invasion, and is being used in the design of experiments to examine the influence of *P. armatus* on South Carolina oyster reefs. To quantify the response of native predators to a novel prey type, we are simulating pre- and post-invasion scenarios in laboratory mesocosms. Specifically, we use toadfish (*Opsanus tau*), blue crab (*Callinectes sapidus*) and pinfish (*Lagodon rhomboides*) as the native predators and the invasive crab (*P. armatus*), and the native xanthid crab (*Panopeus herbstii*), as prey items. We estimate the functional responses of each predator feeding on xanthid crabs in the presence and absence of *P. armatus* (and at varying densities). Because xanthid crabs are important predators of oyster spat, the invasions by *P. armatus* may have indirect (negative) consequences on the recruitment of oysters to reefs. This project started in May 2000 with a tentative end date of Spring 2003, and has been funded by NERR-GRF, USC Marine Science Program and the Baruch Marine Field Laboratory.

Use of Diamondback terrapins (*Malaclemys terrapin*) as indicators of estuarine health

Investigators: Dr. Travis Glenn[1,2] and Susanne Hauswaldt[1], Steven Christopher[3], John Kucklick[3], Craig Downs[4], and Mark Melancon[5]
[1]USC Department of Biology; [2]Savannah River Ecology Laboratory; [3]National Institute of Standards and Technology, Charleston; [4]EnVirtue Biotechnology, CA , [5]USGS Patuxent Wildlife Research Center, MD

Diamondback terrapins are strictly estuarine turtles. They have life history traits that should make them better indicators of chemical pollution in estuaries than many other organisms. They mainly feed on snails and crabs, animals that are known to accumulate toxicants, and can live up to 40 years, providing sufficient time for bioaccumulation of toxicants. In addition, whereas many other vertebrates inhabit

estuaries for certain stages of their life and/or on a seasonal basis only, terrapins are thought to stay in the same tidal creeks over many years. We will be examining multigenerational site-philopatry with microsatellite DNA markers and mitochondrial DNA D-loop sequences in terrapin populations within river systems, within estuaries, and from different estuaries in South Carolina (ACE Basin, Charleston Harbor, Cape Romain, Winyah Bay, and North Inlet [NI]). In NI 20 terrapins will be caught with a trammel net or seine net from Town Creek, Bread and Butter Creek and/or Old Man Creek during March-May 2002 for genetic analysis. We are also comparing body burden of trace element and organic contaminants as well as biomarker responses in terrapins from 2 contaminated (Shipyard Creek; Winyah Bay) and 2 pristine sites (ACE Basin and NI). Correlating body burden and biomarker data allows assessment of terrapin health in respect to contamination status of an estuary. Funding comes from an NERRS National Estuarine Research Reserve Graduate Research Fellowship.

Status and Distribution of Hummingbirds in the Coastal Plain of SC

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 birds 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.

Patterns of Nekton Behavior in Salt Marsh Intertidal Creeks

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

Within salt marshes, nekton 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, distributions, movements, foraging behavior, or interactions while occupying flooded creeks. Sampling mobile organisms in this dynamic environment is difficult and often requires the application of unique methods. To determine the timing and structure of nekton migrations into flooding intertidal creeks, nekton were collected in Summer 2001 during three consecutive daytime flood tides inside the mouths of three intertidal creeks in North Inlet. See map locations #'s 14B, 15A, B for study sites. Samples were collected at 10 cm intervals from 10 to 100 cm water depth using a sweep flume, a new sampling method which allows investigators to sample nekton within an intertidal creek channel regardless of the stage of the tide (depth). The timing of peak movements into the creeks varied among species, and the sequence was similar among the three creeks. The orderly entry of nekton into intertidal creek habitat suggests that species may minimize competition for foraging opportunities by staggering their entries. 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 2003. Support is provided by the USC Marine Science Program, the NI-WB NERR, and the Baruch Marine Field Laboratory.

Use of flooded marshes by migratory fishes and crustaceans

Investigator: Dr. Dennis Allen, Ginger Ogburn-Matthews, and Paul Kenny
Baruch Marine Field Laboratory, 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 monthly high tide collections in Oyster Landing Basin are coupled with the long-term low tide seine collections in an adjacent creek. Together, these studies are revealing patterns of temporal and spatial partitioning in the use of creek and vegetated intertidal marsh. Changes in the use of the habitats occur as a function of season, weather conditions, flooding depth, and time of day. 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 watersheds proximal to nursery habitat. See map location #2

Nitrogen regeneration by nekton (fish, shrimps and crabs) in intertidal saltmarsh creeks

Investigators: Drs. Susanne Haertel and Dennis Allen
Baruch Marine Laboratory, USC

Nekton (fish, crabs and shrimps) have the potential to impact the trophic structure directly through predation and indirectly by nutrient regeneration through habitat modification and excretion. While the predation component is relatively well known,

recent studies indicate that nekton might significantly contribute to the pool of dissolved nutrients, particularly ammonium, in the system. Thus nekton might indirectly affect primary production. We are investigating the nitrogen release by nekton assemblages in intertidal salt marsh creeks through a combination of field sampling, field and mesocosm experiments: Species-specific excretion rates are determined in bag experiments for nekton captured after feeding in tidal creeks. Nitrogen excretion is distinguished from nitrogen release via bioturbation by a series of tank experiments where nekton assemblages are permitted or denied access to simulated creek sediments. By combining these results and nekton density data from field collections, the overall amount of nitrogen released by nekton assemblages can be estimated. Nitrogen dynamics in summer, when creek use by nekton is high, is compared to a winter scenario, when only a few species are present. The study will provide the first estimate of the role of nekton in nutrient processing in marsh-estuarine systems, and thus give insights in the role of nekton in controlling the structure and function of these systems. This project is funded by NOAA for the study period August 2001 – December 2002

Feeding dynamics of juvenile white shrimp, *Litopenaeus setiferus* and brown shrimp, *Farfantepenaeus aztecus*

Investigators: Jennifer Beseres and Dr. Robert Feller
Department of Biological Sciences and Marine Science Program, USC

Overfeeding represents the main cause of water pollution in shrimp aquaculture. The goal of this study is to examine the major shrimp feed components (lipids, fiber, and protein) to determine optimal feed formulations for increased shrimp growth and improved pond water quality. Thirteen shrimp feeds with varying levels of lipids, fibers, and carbohydrates were tested in a caging study with juvenile white and brown shrimp in Oyster Landing Creek. Feed location in the shrimp digestive tract was documented over time to assess the effect of varying feed components on gut passage times and to test the hypothesis of reduced gut passage times with increasing protein or fiber levels, and no change in gut passage times with varying lipid levels. Results will be used in aquaculture to provide cleaner feeds, therefore improving water quality of the effluent from shrimp ponds. See map location #2

The influence of sediment chemistry on dinoflagellate benthic stages in a North Inlet tidal creek

Investigators: Kenneth C. Hayes and Alan J. Lewitus
Baruch Marine Laboratory, USC and SC DNR / Marine Resources Research Institute

This project examines the influence of sediment and water column properties on the distribution of the planktonic community at the Clambank Bridge site in North Inlet (see map location #16). This is a site where the dinoflagellates *Pfiesteria piscicida* and *P.*

*shumwayae* have been confirmed, as well as the red tide forming *Kryptoperidinium sp.* All three of these dinoflagellates can form benthic resting and active cyst stages, and therefore can settle to the sediment surface until conditions are optimal for growth. This site is highly affected by episodic rain events, and rapid salinity and nutrient (e.g. DOM, NH4, NO3) changes can occur over the course of a tidal cycle. Sampling occurs twice a month from late March to early October, and monthly for all other months. Surface and pore water samples are collected for plankton analysis (microscopy), pigment analysis (Chlorophyll a and HPLC), and nutrient analysis (NH4, Si, NO3, OP, DON, DOP, TDN, TDP, TN, TP, DOC, DIC). Sediment samples are also brought back to the lab for isolation and culturing of dinoflagellates and other plankton.

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

Investigators: Dr. Alan J. Lewitus, Jennifer Wolny, Jason Kempton, and Dr. Amy Ringwood
Baruch Marine Laboratory, USC, and MRRI, SCDNR

*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 may 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.

Pigment responses of phytoplankton to UV-induced fluoranthene toxicity: A USES project substudy

Investigators: Dr. Alan Lewitus[1,2], Jennifer Cardinal[1], Jennifer Wolny[1,2], Andrew Shuler[1], and Jennifer Keesee[1]
Baruch Marine Laboratory, USC[1], and MRRI, SCDNR[2]

Results from the USES program have yielded recognition of several byproducts of urbanization that affect ecosystem functioning in Murrells Inlet estuary. Of these, demonstrable effects of PAH loading on fauna have been documented in several USES

publications. To further explore the potential effects of PAHs on ecosystem degradation, we are examining the physiological response of phytoplankton to UV-activated fluoranthene toxicity, a topic rarely studied. We hypothesize that the relatively low photosynthetic efficiency of phytoplankton communities in Murrells Inlet (Kleppel and Lewitus in prep) is related, in part, to compensatory responses to physiological stress caused by fluoranthene toxicity. Specifically, Murrells Inlet phytoplankton may require a greater expenditure of metabolic energy and material on the synthesis of protective carotenoids (e.g. ß-carotene) at the expense of biosynthesis of photosynthetic machinery (e.g. light-harvesting pigments). The study combines monitoring of North Inlet and Murrells Inlet microbial food web structure and PAHs, bioassays testing the effects of UV-induced fluoranthene inhibition on natural communities, and physiological response experiments using axenic cultures of estuarine phytoplankton isolates. Results from this study will improve our understanding of the potential adverse effect of PAH loading on phytoplankton community composition, production, and photosynthetic efficiency and capacity. This study is funded from 1999-present.

The nutritional physiology of the toxic dinoflagellate, *Pfiesteria piscicida*

Investigators: Dr. Alan Lewitus[1,2], Kenneth Hayes[1,2], Aaron Shurtleff[1], and Jennifer Wolny[1]
Baruch Marine Laboratory, USC[1], and MRRI, SCDNR[2]

The nutritional versatility of dinoflagellates is a complicating factor in identifying potential links between nutrient enrichment and the proliferation of harmful algal blooms. For example, although dinoflagellates associated with harmful algal blooms (e.g. red tides) generally are considered to be phototrophic and use inorganic nutrients such as nitrate or phosphate, many of these species also have pronounced heterotrophic capabilities either as osmotrophs or phagotrophs. Recently, the widespread occurrence of the heterotrophic toxic dinoflagellate, *Pfiesteria piscicida* has been documented in turbid nutrient-rich estuarine waters, and thought to be the causative factor in several NC fish kills and a Chesapeake Bay fish kill in the summer of 1997. *P. piscicida* has a relatively proficient grazing ability, but also has an ability to function as a phototroph by acquiring chloroplasts from algal prey, a process termed kleptoplastidy. The potential impact of P. piscicida on fish communities may be related to the abundance of nontoxic zoospores which serve as seed populations that fuel toxic outbreaks. Laboratory and field evidence suggests that nontoxic zoospore abundance can be stimulated by nutrient enrichment, either indirectly (by enhancing phytoplankton prey abundance) or directly (through saprotrophic nutrient uptake). We are testing a working hypothesis that depicts a seasonal transition in the mechanism of nutrient stimulation of the growth of nontoxic *P. piscicida* zoospores that serve as precursors of summer toxic populations. This research has implications toward the potential link between nutrient loading and *P. piscicida*-related toxic outbreaks. This study is funded for the period 1995-present.

The distribution and physiological ecology of *Pfiesteria piscicida* and other harmful algal blooms (e.g. red tides) in South Carolina: an ECOHAB study

Investigators: Dr. Alan Lewitus[1], Kenneth Hayes[1], Jennifer Wolny, Aaron Shurtleff, Raphael Tymowski, Dr. JoAnn Burkholder[2], Dr. Howard Glasgow[2], and Dr. Patricia Glibert[3]
Baruch Marine Laboratory, USC[1], North Carolina State University[2], and Horn Point Laboratory, University of Maryland[3].

ECOHAB: This is a regional comparison (Delaware, Maryland, North Carolina, South Carolina) of the physical, nutritional, and trophodynamic mechanisms that contribute to blooms of *Pfiesteria* and other dinoflagellates that cause harmful blooms. We hypothesize that certain attributes of *Pfiesteria* and related dinoflagellates contribute to their ability to form and maintain blooms under certain conditions. These attributes include the ability to use diverse nutrient and energy sources for growth and survival. For instance, many of these dinoflagellates are capable of alternating between phototrophic (plant-like) and heterotrophic (animal-like) nutrition, which allows them great flexibility in adapting to changing or extreme environments. One of the key issues addressed in the ECOHAB study is whether nutrient loading is linked to *Pfiesteria* toxic outbreaks, and, if so, what types of nutrients are stimulatory to *Pfiesteria* activity, and in what ways. Through a combination of field efforts relating the distributional relationships between *Pfiesteria* and nutrient regimes, and laboratory experiments on the physiological response of *Pfiesteria* to nutrient enrichment, the ECOHAB study seeks to determine whether or to what extent and how, nutrients produced by man's activities are contributing to the proliferation of *Pfiesteria* and other harmful dinoflagellate blooms.

Fish kill/lesion event response: The South Carolina Task Group on Toxic Algae

Investigators: Dr. Alan Lewitus, Kenneth Hayes and several others
Baruch Marine Field Laboratory, USC, and MRRI, SCDNR

Given the growing recognition that *Pfiesteria piscicida* was a problem in NC and MD with respect to ecosystem and human health, its discovery in North Inlet in 1997, and its potential link to the fish lesion problems in Bushy Park and elsewhere, 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 was organized by Rick DeVoe (SC Sea Grant Consortium) and includes representatives from USC, SC DHEC, SC DNR, NOAA/NOS, Clemson University, MUSC, USGS, and Charleston VA Medical Center. One of the first accomplishments of the group was to implement a program to monitor for *P. piscicida* (ECOHAB-funded) and respond to fish kills or lesion events in the summer of 1998 (CDC grant to SC DHEC), with particularly emphasis on the Bushy Park region, the site of recurrent menhaden lesion occurrence. From July-October, 1998, we analyzed water samples from several fish kill or lesion events throughout SC (in collaboration with SC

DHEC and SC DNR). Presumptive *Pfiesteria* abundances were consistently low compared to NC areas impacted by the dinoflagellate, with 62 and 34 cell/ml in two Hilton Head samples, but < 15 cell/ml in all other samples. Thus, evidence linking *Pfiesteria* to SC fish events was lacking. This proactive program is ongoing, with plans to continually expand research efforts in environmental and human health surveillance. This project is funded for the period 1998-present.

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

Investigators: Alan J. Lewitus, Raphael G. Tymowski, David White, and Sabrina Hymel
Baruch Marine Field Laboratory, USC, and MRRI, SCDNR

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 which 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 Bob Gardner[2]
Department of Biological Sciences[1] and Department of Geological Sciences[2], USC

A series of salt marsh mesocosms are being constructed 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) will be filled with inorganic sediment and planted with cuttings of Spartina alterniflora. The sediment surface will have a slope of approximately 20 cm/10 m. A computer-controlled pump will simulate the spring and neap diurnal tides. Experiments will begin in 2002 and continue indefinitely. 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 National Science Foundation

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.

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), and the Georgetown Environmental Protection Society

Young, R.F. and H.D. Phillips. 2002 (In press). Primary production required to support bottlenose dolphins in a salt marsh creek system. Marine Mammal Science.

Habitat Utilization of North Inlet, SC, by Bottlenose Dolphins and Red Drum: An Examination of Potential Predator-Prey Interactions

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

October, 2001 – December, 2003

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 40 randomized sites throughout the North Inlet system. Bioenergetic models will be used to estimate prey removal rates. 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).

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.

Population dynamics of rhizosphere nitrogen fixing bacterial assemblages

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

This project examines nitrogen fixing bacterial (NFB) assemblages associated with several species of salt marsh plants, focusing on the environmental stresses and plant host characteristics affecting them. Stress factor gradients and interspecies interactions in salt marshes result in a number of well-defined vegetation zones. The smooth cordgrass *Spartina alterniflora* occurs in a tall form at the banks of tidal creeks to less productive short form plants at higher elevations. The black needlerush *Juncus roemerianus* occurs at high marsh elevations near the fringes of the terrestrial biome and in isolated patches within the short *Spartina* zone. The perennial glasswort *Salicornia virginica* occurs in sporadic monotypic meadows in the high marsh and can also grow in association with short *Spartina* and with *Juncus*. Differences in abundance and activity of rhizosphere

NFB, which contribute nitrogen to these plants, may also be explained by the stress gradients that contribute to formation of the vegetation zones, as well as by the host plant responses to them. Field *Spartina* and *Juncus* plots will be experimentally manipulated and the resulting effects on NFB assemblages determined using DNA denaturing gradient gel electrophoresis and quantitative DNA-DNA hybridization methods. Studies to date have defined the NFB assemblages of tall and short *Spartina* and explored some of their responses to changing environmental parameters. Current studies are focused on the NFB assemblages of *Juncus* and *Salicornia* and employ a variety of manipulations in order to explicitly define the interaction of NFB with their plant host and with the environmental parameters that control the abundance, productivity, and distribution of both the plants and their microflora. Parallel sampling at the Plum Island Sound and Sapelo Island LTER sites allows the generality of results from North Inlet to be assessed for most of the Atlantic coast range of *Spartina alterniflora.* See map locations 18 and 2. This project is supported by the National Science Foundation (1994-2002, so far).

Some of the most recent publications associated with the work:

Population dynamics of rhizosphere nitrogen fixing bacterial assemblages
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. 2002. Plant-microbe interactions in the marine environment. In: G. Bitton (ed.) *Encyclopedia of Environmental Microbiology*, pp. Wiley, New York, NY, (in press)

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.

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. 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.

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.* In press.

Infaunal burrows and their impacts on sediment microbiota

Investigators: Dr. 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*. See map location 19 for sampling sites.
Publications associated with the work:

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.

Biogenic bromophenols: community structuring agents?

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

Many polychaete and hemichordate worms produce brominated aromatic compounds. These compounds are similar to another group of compounds (chlorophenols) released by pulp mills and other industries. Sediments contaminated by these noxious organic compounds have been shown in previous studies to act as negative recruitment cues and as predator deterrents. Areas where the sediments are appreciably contaminated by these compounds may act as chemical refuges from predation. Many of the worms that produce these compounds are very small (< 5 cm in length). In a series of laboratory and field experiments, we are exploring how the predator deterrency of these compounds is affected by the community context in which they occur, including patch

density, size and composition. These studies will further explore how biogenic brominated aromatic compounds affect infaunal community structure. See map location #17

Geochemical solutes: negative recruitment cues?

Investigators: Dr. Sarah Woodin[1], Dr. Roberta Marinelli[2], and Erin Wolfe[1]
Department of Biological Sciences and Marine Science Program, USC[1];
Chesapeake Biological Laboratory, University of Maryland[2]

Many infaunal organisms alter the characteristics of the sediment surface during their feeding and defecation activities, as do physical erosion and deposition events and predatory digging. In many of these cases the chemical signature of the disturbed surficial sediments resembles that of a subsurface sediment, lowered oxygen concentration and elevated ammonium concentration. We previously demonstrated that new juveniles show rejection behaviors in response to such surfaces in still water experiments. We are running a series of field and laboratory flume experiments to determine whether our assumption that these rejection behaviors result in lowered retention rates of the juveniles is correct. We are also initiating a series of experiments to separate the effects of lowered oxygen and elevated ammonium on larvae in the field. See map location #17

Brittlestar population studies: Use of skeletal growth rings as markers

Investigators: Drs. Stephen Stancyk[1] and William Dobson[2]
Marine Science Program and Department of Biological Sciences, USC [1],
and Appalachian State University[2]

Large populations of brittlestars which live in sediments in the North Inlet Estuary have been the subject of many physiological studies over the past decade. In this study, animals from a natural population are sized, marked with calcein dye, and returned to the same area. Replaced animals are confined in plastic cores so that the same individuals can be relocated and brought into the lab for inspection. The goal is to determine the efficacy of using growth rings in arm vertebral ossicles as markers for aging individuals and for correlating growth bands to temporal events which may alter rates of brittlestar development and regeneration. Additional studies are also being undertaken to determine how variability in environmental parameters, e.g. physical stress, nutrient load, and temperature affects the rate of growth ring production. The objective is to establish an explicit analysis regarding the mechanism of deposition of coarse-pored or fine-pored stereom in vertebral ossicles. This information will help elucidate environmental effects on brittlestar growth. See map location #17

Brittlestar regeneration/calcification studies: The effects of arm and disc loss on reproductive effort of *Amphipholis gracillima*

Investigators: Stephen Stancyk and Traci Heincelman
Department of Biological Sciences and Marine Science Program, USC

Large populations of brittlestars which live in sediments in the North Inlet Estuary have been the subject of many physiological studies over the past decade. The primary objective of the present study is to determine the effects of arm and/or disc loss on reproduction by Amphipholis gracillima. Pieces of tissue are removed from brittlestars in February (beginning of gametogenesis) and May (middle of gametogenesis). Animals are replaced in the field in plastic cores to allow regeneration under natural conditions. In early July (time of first spawning), experimental and field control animals are collected. Gonads are excised, sectioned and stained for assessment of oocyte numbers and diameters. Comparison of experimental with control animals allows determination of how much reproduction is lost due to tissue loss in these burrowing brittlestars. This information will help elucidate environmental effects, particularly predation, on brittlestar reproduction. See map location #17

***In Memory of Traci Heincelman:***

*Traci died in a car accident on March 9, 2002. Traci was an outstanding student, a McNair Scholar who maintained a 4.0 grade point average while simultaneously completing her undergraduate degree in Marine Science and working on her Master's in Biological Sciences. She was nominated for Outstanding Woman at USC, and was voted the Outstanding Undergraduate in Marine Science. Traci was a loving, generous person who will be remembered fondly by all who knew her. This research is dedicated to her memory.*

Zooplanktivory by the burrowing brittlestar, *Hemipholis elongata*: Tests on natural plankton assemblages

Investigators: Dr. Stephen Stancyk and Frank Helies
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. *Hemipholis elongata*, 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. elongata* 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.*

*elongata* 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] and Alan J. Lewitus[1,2], M. Gabriella Jackson[1], Raphael Tymowski[1] and Aaron Shurtleff[1,2]
Baruch Marine Field Laboratory, USC[1] and SC DNR / Marine Resources Research Institute[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 coming from New Jersey Sea Grant and South Carolina Sea Grant Consortium.

A harmful algal bloom initiative for South Carolina: Assessing the potential environmental impacts of red tides, *Pfiesteria*, and toxic algae

Investigators: Dr. Alan J. Lewitus[1,2], Jennifer Wolny[2], Aaron Shurtleff[2], Raphael Tymowski[1], Sam Baughman[1], and Andrew Shuler[1]
Baruch Marine Field Laboratory, USC[1] and SC DNR / Marine Resources Research Institute[2]

Throughout the world, harmful algal blooms (HABs) have increased dramatically over the past few decades. It is thought that this recent proliferation of HABs may be due to nutrient pollution caused by coastal urbanization. Although historically South Carolina has had very few HABs, recent red tides have shown that our baseline knowledge of the environmental conditions that affect algal communities in these estuaries is lacking. This project is part of a state-wide study of the distribution and potential adverse effects of HABs in South Carolina estuaries, and includes representatives from USC, SCDNR, NOAA-NOS, DHEC, and SC Sea Grant. This study

will 1) determine the present distribution of harmful algae in SC estuaries; 2) determine environmental factors that favors 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 which 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. This is an on-going project, with funding coming from NOAA NOS.

Estuarine eutrophication and microbial community compositions

Investigators: Wes Johnson[1], and Drs. James Morris[2], Peter Noble[3] and Madilyn Fletcher[3]
Marine Science Program[1], Department of Biological Sciences[2], and Baruch Institute[3], USC

This project examines the effects of water chemistry and primary productivity on planktonic microbial community composition. Microbial compositions of planktonic communities are determined by amplifying 16S rRNA using polymerase chain reaction (PCR) and separating 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). Comparison of the five sampling sites will enable us to determine if there are differences in the microbial community structure as a function of nutrient concentration and primary productivity. The study is supported by EPA/NOAA/NASA, CISNET: Molecular to Landscape-Scale Monitoring of Estuarine Eutrophication. The project period for this study is from September 1999-August 2002

Microbial community responses to eutrophication in a southeastern U. S. salt marsh estuary

Investigator: Wes Johnson
Marine Science Program, USC

This study examines the effects of nutrient loading (nitrogen and phosphorus) 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 porewater samples are collected monthly. The microbial community compositions are

determined using ploymerase chain reaction/denaturing gradient gel electrophoresis of 16S rDNA. The activity of the communities will be measured using assays of enzyme activity on a range of enzyme substrates in sediment samples. This research will help determine what impact, if any, nutrient loading has upon salt marsh ecosystems in the southeast. This study is supported by the NOAA/NERRS Graduate Research Fellowship Program, and will be conducted from June 2001- June 2003.

Interspecific competition among some salt marsh perennials in South Carolina

Investigators: Drs. Richard Stalter[1] and John Baiden[2]
St. John's University, NY[1] and 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 no. 6B, C.

Habitat utilization and growth of juvenile flounder, with emphasis on the ecology and life history of the fringed flounder, *Etropus crossotus*

Investigator: Dr. Marcel Reichert
Belle W. Baruch Institute for Marine Biology and Coastal Research, USC

Field data and various laboratory experiments revealed that the life cycle of the fringed flounder in the South Atlantic Bight is foremost characterized by the short life span of 15 months, which makes the fringed flounder one of the very few know 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 the presence of 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. Multiple batches of pelagic eggs (9,000 - 47,000 eggs per batch) are spawned in the shallow coastal waters. There are no indications that spawning takes place in the estuaries. The eggs are about 0.5 mm in diameter. The total fecundity was estimated to be between 112,500 and 587,500 eggs, meaning that a female can produce her own weight in eggs over the spawning season. Larvae and metamorphosing juveniles migrate into the estuarine nursery areas. The newly settled juveniles start their demersal life in the marsh creeks at a standard length of

about 9 mm. Following settlement, juvenile fringed flounder find favorable temperatures and an abundance of food in the form of copepods, small epibenthic crustaceans, and polychaetes, a diet that shifts little during ontogenetic development. A bioenergetics growth model developed for juvenile fringed flounder indicated that growth rates are highest from May through August. With increasing size, they gradually move to deeper areas. Since few fringed flounder larger than 6cm standard length are found in the estuary, it is assumed that most juveniles reaching that size migrate out of the estuary. In the fall both the temperatures and the densities of the important food items decrease, and growth conditions depreciate. Juveniles large enough to migrate to the coastal waters grow there to an adult length and complete gonadal development. Females can potentially reach sexual maturity at a standard length of 7cm, but 50% maturity of the population occurs between 8 and 9 cm standard length. Although fringed flounder hatched early in the reproductive season can potentially reach sexual maturity after their first summer, there is virtually no spawning activity in the fall.

Distribution and abundance of various other flatfish species are currently analyzed to provide information on the habitat utilization of these species. This project was initiated in 1992 and is ongoing.

This project is funded, in part, by the Belle W. Baruch Institute.

Urbanization and Southeastern Estuarine Systems

Investigators: Drs. Dwayne E. Porter[1,2], John Vernberg[1], Winona Vernberg[1,2], David Bushek[1], Alan Lewitus[1,2], Tom Chandler[1,2], Hank McKellar[1,2], Marj Aelion[1,2], Al Decho[1,2], Dan Tufford[2], Geoff Scott[2,3], Mike Fulton[2,3], and Tom Siewicki[2,3]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health, and [3]NOAA's Center for Coastal Environmental Health and Biomolecular Research

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:

1. to delineate the impact of multiple stresses resulting from urbanization on high-salinity estuaries; and
2. 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 Coastal Oceans Program/NOAA/Dept. of Commerce from 08/01/01though 07/31/02

CISNet: Molecular to Landscape-scale Monitoring of Estuarine Eutrophication

Investigators: Drs. Dwayne E. Porter[1,2], J.R. Jensen[3], A. Lewitus[1], J. Morris[1], M. Fletcher[1] and D. White[1]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health, and the [3]Department of Geography

Chlorophyll-a is highly absorbent of radiation in the spectral range of 630-690 nm and reflective in the range of 760-900 nm. Previous attempts to estimate biomass from remote images have met with limited success in part because the concentration of chlorophyll in leaf tissues is not constant. Instead, chl-a concentration in tissue varies with phenology and with nutrition. However, since photosynthetic rate and chl-a concentration are directly related, chl-a concentration is actually a more sensitive indicator of the condition of higher plants than biomass and should be investigated as an index of stress. We have hypothesized therefore that at a landscape-scale, remote sensing of the concentration of chlorophyll in emergent wetland vegetation will provide a quantitative index of the wetland condition. During the first two years (1999, 2000) we will develop a model to assess the functional condition, as measured by chlorophyll content in emergent vegetation, of the *Spartina*-dominated coastal wetland. For the subsequent year, this model will be applied to the study site and we will monitor changes in the estuary.

This research, in conjunction with the USES project and the NASA/EPSCoR project, also examines North Inlet (NI), and Murrells Inlet (MI), SC, for spatial gradients in nutrients, phytoplankton biomass, and phytoplankton community composition in relation to land use and land cover. Both estuaries are high salinity, shallow, tidally dominated systems that are similar in structure and function. However, MI is affected by non-point source pollution, whereas NI is relatively unimpacted anthropogenically. The research objectives are to: (1) provide an analysis of eutrophication and its influence on biomass and phytoplankton composition; (2) examine the relationship between nutrient

ratios and community structure; and (3) utilize Geographic Information Systems (GIS) to correlate the spatial relationships among land use and land cover, eutrophication, phytoplankton community composition, and biomass. This research will address the effects of non-point source pollution on estuarine ecosystems and mechanisms for sustaining resources within estuarine ecosystems by examining the role of land use and land cover in non-point source pollution in its relation to phytoplankton biomass and community structure. This project is funded by the Environmental Protection Agency for the period 01/01/99 – 09/30/02

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]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health, and [3]NOAA's Center for Coastal Environmental Health and Biomolecular Research, and the [4]Strom Thurmond Institute, Clemson University

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 from 08/01/00-07/31/04 by the SC Sea Grant Consortium.

<u>Biocomplexity – Incubation Activity: Multidimensional Consequences Of Urban Encroachment To Natural Ecosystems</u>

Investigators: Drs. Dwayne E. Porter[1,2], Gary Kleppel[3], Jeff Allen[4], Bob Becker[4], and Peter Noble[5]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health; [3] State University of New York – Albany; [4]Strom Thurmond Institute, Clemson University; [5]University of Washington

The goal of this project is to develop mathematical tools that identify and characterize the relevant interdependencies between the human (demographic, socioeconomic) and natural environments by: (1) exploring relationships between the natural and human environments, (2) describing the mechanisms by which processes in one environment create instabilities in the other, (3) explaining interactions between spatial and temporal scales, and (4) identifying mechanisms by which stability can be maintained or re-established within and between the natural and human environments. This project is funded from 10/01/00-09/30/02 by the National Science Foundation.

Measuring Estuarine Habitat Quality: Ribbed Mussel (*Geukensia demissa*) Growth and Survival Across Tidal Creek Habitats

Investigators: Drs. Keith Walters[1] and Loren Coen[2]
Department of Marine Science, Coastal Carolina University[1], and SC Marine Resource Research Institute[2]

The functional similarity and overall quality of major intertidal marine habitats (e.g., mud flats, salt marshes, oyster reefs) were investigated experimentally within South Carolina marshes. Such data on the relative quality of coastal habitats are critical for enacting effective coastal conservation strategies. Relative habitat quality was assessed using an experimental, "bioassay" approach to determine differences in growth and survival of target species. G*eukensia demissa*, one of the selected target species, were transplanted into each of the dominant intertidal habitats in the Southeastern US. Appropriate experimental controls such as caging were used to account for ancillary factors (e.g., predation) that would confound assessment of habitat quality differences. Mussels from a single source site were sized prior to placement in the field and then deployed at multiple sites within 1 cm mesh cages placed at similar elevations in mud flat, salt marsh and oyster reef habitats. Growth, change in size (length, width, height) and mass (ash-free dry), and survival of the caged mussels were determined after 12 months. There were no significant differences in linear shell growth among the habitats with the mean increase in length ranging between 10.1 and 12.3 mm, but the yearly increase in tissue ash-free dry mass was significantly different among habitats. Caged mud flat mussels had a greater increase in tissue ash-free dry mass (789.1 mg/G) than either caged salt marsh (769.8 mg/G) or oyster reef mussels (736.6 mg/G). Mussel survival within cages (67 to 81%) was not significantly different among the three habitats. Results suggest that mud flats represent a better quality habitat for *G. demissa* producing greater tissue growth in the absence of predation.

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] John Ferry[2], Dept. of Geological Sciences[1], USC, and Dept. of Chemistry and Biochemistry[2] , USC

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 and the project starts and ends
7/1/01 – 6/31/02

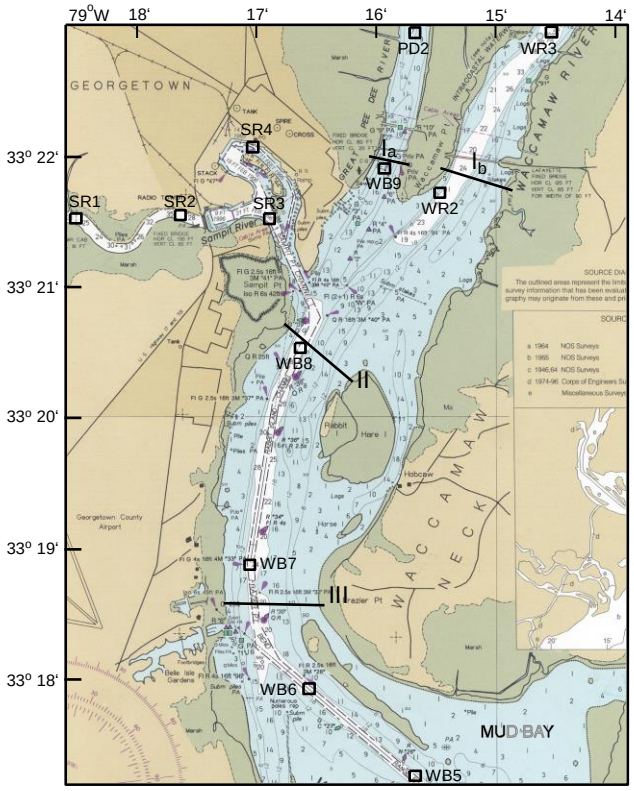



Fig. 1. Detailed map of the mid and upper reaches of Winyah Bay. Station locations of previous work are identified as well as the location of the proposed transects

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

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

Increasing pressure on the coastal environment from industrial operations 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 on organisms at these sites by examining altered gene expression after exposure to single pollutants. We have captured fish from the North Inlet National Estuarine Research Reserve and exposed them in the laboratory to different concentrations of chromium, anthracene, fluoranthene, and pyrene. Thus far, approximately 50 novel genes have been found that are up-or down-regulated in fish exposed in the laboratory. The same pattern of expression has been seen in several of these genes in the fish from the two contaminated areas. These genes, along with other known toxicologically-relevant genes, are being used to build a cDNA array to monitor the patterns of expression and help predict the physiological changes in mummichogs due to chronic contaminant exposure. The cDNA arrays will ultimately aid in risk management and remediation strategies in metal and PAH contaminated areas.

DNA damage in marine invertebrates exposed to natural and anthropogenic stressors

Investigators: Michel L. Gielazyn[1], Drs. Stephen E. Stancyk[1, 2], Amy H. Ringwood[3], and Walter Piegorsch[4]
Marine Science Program, USC[1], Department of Biological Sciences, USC[2], SC DNR Marine Resources Research Institute[3], Department of Statistics, USC[4]

Estuaries, the critical nursery, spawning and feeding grounds for many organisms are frequently the first to receive contaminants introduced into the marine environment. Exposure to these organic and inorganic pollutants coupled with natural stressors can result in decreased growth, fecundity, and/or survivorship for exposed organisms. Biomarkers can be used to identify cellular level effects of stress, which range from depletion of compounds that protect the cell, such as glutathione, to direct damage of DNA. The focus of our current research is examining DNA damage in marine invertebrates from Charleston Harbor and North Inlet estuaries, as a result of exposure to both natural and anthropogenic stressors. We are using single cell gel electrophoresis, or the comet assay, to detect DNA damage in different tissues. Currently, we are primarily working on oysters and adapting the comet assay for use with tissues from this organism. Our future research will be concerned with assessing the practicality of using the comet assay, in combination with other biomarkers, in marine habitats for environmental monitoring. See map location 17

Impact of various management strategies and boat wakes on oyster bed condition and recovery rates

Investigators: Drs. Loren Coen[1] and David Bushek[2], and Nancy Hadley[1] and David Whitaker[1]
South Carolina Department of Natural Resources[1] and Baruch Marine Field Laboratory, USC[2]

Fishing Stamp purchasers and commercial fisherman utilize the state's oyster and clam resources as a fishery. We currently have little quantitative information on how long it takes heavily fished areas that undergo annual and significant harvesting or areas hit with large die-offs to regain the productivity and ecological value as nursery habitat for functionally important fishes. This information is critical to the development of effective oyster management strategies. Recent concerns have also arisen regarding the impact of boat wake disturbance on tidal creek habitats, including oyster reefs. This study will evaluate the impacts of oyster harvesting, oyster die-offs and boat wakes on the stability and recovery of oyster reefs. To accomplish this objective we are (1) examining recruitment, growth, and survival of oyster spat as an indicator of recovery and recruitment potential on shell repletion and natural sites and then (2) following recovery of manipulated sites after simulated harvesting, repletion, and/or major population die-offs and finally (3)examining the impact of boat wakes in tidal creeks and their interaction with shell replenishment stability and development. This work will build upon ongoing oyster studies by MRRI staff, in conjunction with researchers at USC's Baruch Lab. This study will provide scientists and research managers with information on the impact harvesting levels, boat wakes and die-offs have on habitat quality, resource sustainability and resource recovery.

Impacts of selected contaminants on Perkinsus marinus

Investigators: Drs. David Bushek[1], Dwayne Porter[2] and Jennifer Cardinal[1].
Baruch Marine Field Laboratory[1], Baruch Institute[2]; USC

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*.

Using the National Estuarine Research Reserve System platform to prevent and control invasions by exotic decapod crabs.

Investigators: Dr. David Bushek and Mary Jo Hartman, BMFL and NI-WB NERR
Dr. Drew Lohrer, National Institute of Water And Atmospheric Research, New Zealand
Dr. Maurice Crawford, NOAA Estuarine Reserves Division
Dr. Steve Rumrill, South Slough NERR
Dr. Kerstin Wasson, Elkhorn Slough NERR

Non-indigenous species are introduced to U.S. estuaries on a daily basis and are considered a potent economic and ecological threat to the coastal zone. This project takes advantage of the National Estuarine Research Reserve System network to establish a proactive surveillance and management program for invasive decapod crabs at four northwestern and five southeastern NERR sites. The focus on invasions by decapod crabs is relevant, as several species have established breeding populations along both the Atlantic and Pacific coasts of the U.S. A web site is being created to disseminate findings and raise awareness in addition to flyers, identification cards and other means of distributing information. A major means of disseminating the information to managers is inclusion of results into the NERRs Coastal Training Program and its Coastal Decision Maker Workshops. This is a pilot project for an unprecedented effort within the Reserve System that aims to encourage a nationally coordinated System-Wide Invasions Prevention and Control Program. This project is funded by NOAA's Aquatic Nuisance Species Task Force: July 2002 – June 2003

Estuary-Net Project - National Estuarine Research Reserve System

Investigators: Wendy Allen and Beth Thomas
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 System

Investigators: Wendy Allen and Beth Thomas
Baruch Marine Field Laboratory, USC

Educational activities that integrate findings from research are offered throughout the year. Marsh-side chats 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 Baruch Institute's Web Site at: www.baruch.sc.edu

Coastal Training Program for Decision-Makers

Investigators: Wendy Allen, Laura Schmidt, and Beth Thomas
Baruch Marine Field Laboratory, USC

The North Inlet – Winyah Bay NERR has been offering workshops on coastal issues for decision-makers for several years in cooperation with the ACE Basin NERR and the SC Office of Ocean and Coastal Resources Management (SC-OCRM). This has been part of a nation-wide effort among Reserves to provide the latest scientific information and technology to people involved in making decisions that affect coastal resources. These efforts have evolved into a Coastal Training Program (CTP) that most of the 25 NERR sites are in the process of developing this year. The North Inlet – Winyah Bay NERR is working with the ACE NERR, SC-OCRM, the SC Sea Grant Consortium and the NOAA Coastal Services Center to chart a course for this effort that includes establishing a coordinating committee, conducting a market analysis of training providers and a needs assessment of potential audiences, developing a strategy and implementation plan, and designing and implementing training programs tailored to meet regional needs. During this transitional period as the CTP develops, we will continue to offer three workshops a year on coastal issues. Agendas and some of the presentations from past workshops are available on the Baruch Institute web site.

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]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health

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:

(1) estuarine water quality monitoring,
(2) biodiversity monitoring, and
(3) 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 09/01/01-08/31/02 by NERRS/NOAA/Dept. of Commerce.

Development and Support of a National Spatial Data Infrastructure (NSDI) Node at the Belle W. Baruch Institute for Marine Biology and Coastal Research

Investigators: Dr. Dwayne E. Porter[1,2], Sam Walker[1] and Ginger Ogburn-Matthews[1]

USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health

This project supports the development of a data and metadata search node in support of national data infrastructure activities and the environmental data management activities of the Baruch Institute. This project is funded from 08/01/01-07/31/02 by the United States Geological Survey.

## 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. Much of these data may be obtained via our web site 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.

### Town Creek zooplankton program: 20 years of continuous monitoring

Investigators: Dr. Dennis M. Allen[1], Dr. Steve Stancyk[2], Paul Kenny[1], and Ginger Ogburn-Matthews[1]
Baruch Marine Field Laboratory[1], Department of Biological Sciences and Marine Science Program[2], USC

Collections have been made at the same location, stage of tide, and time of day using the same sampling technique every two weeks since 1981. Oblique tows with 153 micron mesh nets collect copepod and small invertebrate larvae, and 365 micron epibenthic sled 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 extended period 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 #1.

Oyster Landing Basin seine collection program: long-term monitoring of fish, shrimp, and crab populations

Investigators: Ginger Ogburn-Matthews, Paul Kenny, and Dr. Dennis M. Allen
Baruch Marine Field Laboratory, USC

Relatively little is known about what and how natural factors affect the extent to which young-of-the-year animals use shallow marsh habitats. An understanding of natural variability in abundance, growth, and production rates is essential to evaluate and adjust human impacts on habitats and populations. Since 1984, we have made biweekly collections in the same tidal creek pool to determine seasonal and interannual variations in the abundance, biomass, and length distributions of animals using this nursery habitat. Seine samples have been processed for information that will provide insights into relationships between more than 60 species of fishes and decapod crustaceans and physical characteristics of the system. Although abundances of all species vary between seasons and years, their timing of arrival and departure from the nursery habitat and their rates of growth are very predictable. Estimates of secondary production indicate little year-to-year variation in total production, which suggests that capacity use of the habitat occurs most years. Our analyses indicate that the number of postlarval recruits from ocean spawning grounds is the primary determining factor for annual production for most species; variations in environmental conditions within the nursery are secondary factors. See map location #2.

Long-term monitoring of wading bird nesting on Pumpkinseed Island

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]

In conjunction with the non-game species biologists of the SC Department of Natural Resources, we census wading bird nesting activity on Pumpkinseed Island located in the Mud Bay region of Winyah Bay. Following a tradition initiated in 1979 by Peter Frederick, Keith Bildstein, and associates, white ibis nests are counted or estimated in April-May of each year 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 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. Tri-colored herons, great egrets, and snowy egrets produced about 2,000 nests each year, and numbers of glossy ibis and tri-colored herons nests on Pumpkinseed are some of the highest in the state. See map location #4

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

Investigators: Jennifer Keesee, Tracy Buck, Paul Kenny
Baruch Marine Field Laboratory, USC

A fully functional meteorological station (a 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 12 years for most parameters. See map location # 5

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

Investigators: Jennifer Keesee
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 a Centralized Data Management Office for quality assurance and quality control. The parameters measured include: temperature, salinity, depth, pH, dissolved oxygen, and turbidity. See map location nos. 5, 6A, 6B, 6C for datalogger deployment locations.

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

Investigators: William Johnson[1], Drs. Bob Gardner[3], Jim Morris[2], and Tracy Buck[1]
Baruch Marine Field Laboratory[1], Department of Biological Sciences [2], and Department of Geological Sciences[3], USC

Chemical analyses of NI-WB estuarine water samples began in the late 1970's. Since 1993, ISCO automated water sampling devices have been used to collect water samples at regular intervals over 2 complete tidal cycles. Once every 20 days, the ISCO samplers take a sample at predicted low tide and then sample every 2 hours and 4 minutes for a period of 24:48 (hr:min). With more than 150 such deployments now logged at multiple sites, baseline water chemistry is fairly well understood at this Reserve. The chemical analyses performed produce data on suspended solids, dissolved organic

carbon, total nitrogen, ammonium, nitrate-nitrite, total phosphorus, orthophosphate, and chlorophyll *a*. At present, the water chemistry data are collected from the same four locations where YSI dataloggers record complementary environmental data (see above). Efforts to merge and synthesize these separate data sets are presently underway. See map location #'s 5, 6A, 6B, 6C.

National Atmospheric Deposition Program (NADP)

Investigators: Jennifer Keesee
Baruch Marine Filed Laboratory, USC

The North Inlet – Winyah Bay NERR has established a precipitation chemistry monitoring site in North Inlet Estuary and now collects atmospheric deposition data according to NADP/National Trends Network (NTN) protocols. The work is made possible by the USEPA National Estuary Program and the SC Department of Health and Environmental Control. This partnership was formed because of the desire to better represent coastal areas in our nation's deposition monitoring networks and because the NI-WB Reserve wants to better understand the atmospheric deposition of nutrients and pollutants into an otherwise pristine marsh 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 #5

Decapod monitoring in an intertidal oyster reef system (Oyster Landing) Investigators:

Investigators: Dr. Drew Lohrer[1] and Mary Jo Hartman[2]
NIWA Laboratory, New Zealand, and Marine Science Program[2], USC

Decapods are monitored quarterly in an intertidal oyster reef habitat at Oyster Landing. This monitoring effort was initiated to track the invasion of North Inlet Estuary by *Petrolisthes armatus*, a subtropical anomuran crab not seen in North Inlet prior to 1998. Additionally, the arrival of other invasive crabs is anticipated (e.g., *Hemigrapsus sanguineus*--a Japanese shore crab currently spreading south from North Carolina, *Charybdis hellerii*--an Indo-Pacfic crab spreading north from Florida, and *Hemigrapsus penicillatus*--a Japanese shore crab currently invading oyster reef habitats in Europe). Monitoring will allow detection of these species shortly following their arrival and may improve the odds of eradication should that course of action be chosen. Monitoring will also provide baseline data from which to calculate impacts of these aliens should they become established. See map location #2

Recruitment of sessile invertebrates at Clambank Creek Dock

Investigators: Drew Lohrer, Sarah Foose[2]
NIWA Laboratory, New Zealand, and Baruch Marine Field Laboratory, USC[2]

Settling plates (black PVC panels, 10 cm x 10 cm, n=4) are suspended from Clambank Creek Dock and are exposed to the estuarine waters for 1 week at a time. All invertebrates are identified and counted each week throughout the entire year. The timing and abundance of recruitment differs for each of the 6-12 species that settle on these panels. The data have aided the interpretation of several related manipulative experiments examining community development and the fate of recently settled life-stages. See map location #6B

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

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

Regular (biweekly or monthly) collections of two size fractions of animals which 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 #'s 7A, 7B

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 which 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 location #'s 2 and 8

Settlement patterns of the eastern oyster in the North Inlet Estuary

Investigators: Paul Kenny and Dr. David Bushek
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 which influence the population. See map location # 9

Monitoring Coastal Wetland Change And Modeling Ecosystem Health In South Carolina Using Advances In Remote Sensing Digital Image Processing.

Investigators: Drs. Dwayne E. Porter[1,2], J.R. Jensen[3], Cassandra Coombs[4] and Jeff Allen[5]
USC's [1]Baruch Institute for Marine Biology and Coastal Research and [2]The School of Public Health, and the [3]Department of Geography, and the [4]Department of Geology, College of Charleston, and the [5]Strom Thurmond Institute, Clemson University

As part of the remote sensing team, we support NASA's strategic enterprise in Mission to Planet Earth by examining natural and human induced environmental change. Working with researchers from the College of Charleston, Clemson University and NOAA's Coastal Services Center, we are conducting remote sensing/change detection of wetland ecosystems in South Carolina. We have been, and are, in the process of

collecting in situ data and correlating it with various remotely sensed data. Our goal is to produce biophysical distribution maps and quantitative modeling of an ecosystem's health. Specifically, the questions we, as a team, have posed include the following:

1. Can remote sensing methods be used to measure the health of the wetlands using LAI (leaf area index) and biomass?
2. Can we assess pattern ecological succession in wetland environments using remotely sensed data?
3. Can natural and anthropogenic factors that influence marsh erosion rates be quantified?
4. What is the amount of wetlands loss?
5. What is the greatest contributor to wetland erosion?

This project is funded from 04/01/97 – 03/31/03 by NASA

Sea Turtle Nest Monitoring on Debidue Beach/Hobcaw Barony

Investigators: Betsy Brabson[1] and Robin Baugn[1] (Debidue Beach Coordinators), Wendy Allen[2], Susanne Haertel[2], Julian Lewis[2], Carrie Lucas[3], and other volunteers
DeBordieu Colony[1], Baruch Marine Field Laboratory, USC [2], Baruch Forest Science Institute of Clemson University[3]

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 #10

Long-Term Sediment Fluxes in Tidal Marsh: Forcing and Spatial Variability

Investigators: Dr. George Voulgaris [1,2] , and Steppen Murphy[1]
Dept. Geol. Sci.[1], and Mar. Sci. Prog[2] , USC

The salt marshes along the southeastern U.S. coast are in a delicate balance between vertical rates of sediment accretion and relative sea level rise. Short-term sediment flux studies in the region indicate a net export of suspended sediment out of salt marsh systems despite the necessity for these marshes to import sediment in order to keep pace with relative sea level rise. Suspended sediment concentration data collected daily through the Long-Term Ecological Research Program (LTER) are utilized in this study in order to investigate how long-term sediment dynamics vary throughout the marsh basin. The objective of this study is to identify the relative importance of different processes including tidal range, rainfall, winds, water temperature and river discharge in effecting suspended sediment concentrations in different salt marsh channels.

The analysis involves the utilization of suspended sediment concentration data collected daily at 3 sites in the marsh basin at approximately 1000 hrs EST for periods between 10 to 15 years. Hydrodynamic data (sea surface elevation and currents) are collected and analyzed so as to predict past tidal phases when samples were collected. The latter is done in order to determine how suspended sediment concentration fluxes vary with respect to the tidal cycle. Water samples collected during periods of different rainfall, tidal range, wind conditions, seasons, and freshwater discharges are used to develop "representative" suspended sediment concentration relationships over a tidal cycle for each of the respective forcings. This project is funded by the Department of Geological Sciences, University of South Carolina.

South Carolina Estuarine and Coastal Assessment Program

Investigators: Drs. R. F. Van Dolah and D. E. Chestnut
South Carolina 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. See map location #11

# Research Locations in North Inlet