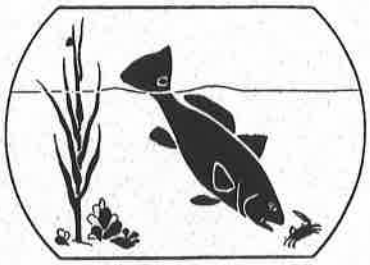


CURRENT RESEARCH PROJECTS

Baruch Marine Field Laboratory and North Inlet-Winyah Bay National Estuarine Research Reserve (NERR), University of South Carolina

Summer 1996 - Spring 1997

More than 475 scientific research projects and 260 student theses and dissertations have been completed by Baruch Institute research associates since 1969. This work has resulted in the publication of more than 1100 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 list summarizes 65 research 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. A wide variety of basic and applied research is represented. Most of the studies which involve field measurements and collections are being conducted within the North Inlet-Winyah Bay National Estuarine Research Reserve (see attached map). Although many other investigators presently use the Field Laboratory to support their studies, the list includes only those projects which make frequent use of the site. Funds for these research projects are provided by a variety of sources, including the National Science Foundation, the National Estuarine Research Reserve System, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the National Marine Fisheries Service, the Department of Energy, the Office of Naval Research, South Carolina Sea Grant, and the SC Office of Ocean and Coastal Resource Management. 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 803-546-3623. Information may also be obtained from the Institute's web site http://inlet.geol.sc.edu, which contains links to many related sites.

LONG-TERM MONITORING AND RESEARCH

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

Investigators: Drs. Bruce Coull and Robert Feller
Marine Science Program, 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 time and locations in the North Inlet Estuary since 1972 (meiofauna) and 1981 (macrofauna). Small invertebrates, less than 500 microns in size, comprise the meiofauna. The meiofauna study was initiated in 1972 and represents the longest

estuarine meiofauna time series in the world. Dozens of macrobenthos species, including a variety of worms and clams, are sieved, identified, and counted in replicated macrobenthos core samples. 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. See map location no. 11 and 12.

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

Investigators: Mark Crane, William Johnson, and Dr. Dennis M. Allen
Baruch Marine Laboratory, USC

An automated weather station with a computerized data acquisition system provides up-to-the-minute measurements of atmospheric and water column parameters. Wind speed, wind direction, air temperature, barometric pressure, solar radiation, and precipitation are measured with sensors mounted on a tower at the pier. Other sensors measure tidal height, conductivity, and water temperature beneath the pier. Records have been gathered for more than 12 years for most parameters and the data have been instrumental in determining how hourly, daily, weekly, seasonal, and annual variations in weather affect other ecosystem characteristics such as nutrient cycling, plant production, and the growth and migrations of animals. The Oyster Landing site is also a National Weather Service installation. See map location no. 3.

Water chemistry: long-term monitoring of tidal water from North Inlet Estuary

Investigators: William Johnson, Dr. L. Robert Gardner, and Dr. Joe Schubauer-Berigan
Baruch Marine Laboratory, Dept. of Biol. Sci., and Dept. of Geol. Sci., USC

Water samples have been collected at various times and locations in the North Inlet Estuary since 1976. Daily collections from 1978 to 1993 have provided an understanding of how weather events, changes in sea level, and other physical factors affect concentrations of nitrogen, phosphorus, and organic compounds in the water column. Other analyses yield data on chlorophyll (an indicator of microscopic plant production) and suspended sediment concentrations in the tidal creeks. In the summer of 1993, automatic samplers were deployed to collect water every two hours over 24 hr periods once every 20 days at two sites in North Inlet and one in Winyah Bay. More than 15 years of daily records are now complimented with finer scale (tidal and diel) measurements of the same parameters. Water chemistry data are incorporated into computer models in an attempt to explain long-term variations in other ecosystem processes such as plant production. See map location no. 3 and 21.

Town Creek zooplankton program: long-term monitoring of holo- and meroplankton assemblages

Investigators: Dr. Dennis M. Allen, Paul Kenny, and Ginger Ogburn-Matthews
Baruch Marine Laboratory, 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 153 micron mesh nets sample 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. In addition to seasonal fluctuations, relationships between population parameters and weather events have been demonstrated. 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 no. 4.

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

Investigators: Dr. James Morris and Robin Krest
Dept. of Biol. Sci. 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 no. 4 and 14.

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 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 1983, 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 which 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 even though the contribution of individual species may vary greatly. Our study in the undisturbed habitats of North Inlet Estuary affords a rare opportunity to understand these ecological processes. See map location no. 5.

Settlement patterns of the Eastern Oyster in the North Inlet Estuary

Investigators: Paul Kenny, Dr. Dennis M. Allen, and Dr. David Bushek
Baruch Marine 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 no. 17.

Spatial and temporal patterns of dermo disease in North Inlet

Investigators: Dr. David Bushek and Russell Holley
Baruch Marine Laboratory, USC

The protozoan parasite *Perkinsus marinus* causes Dermo disease in oysters. The disease is not harmful to humans, but, in many areas, it has a significant impact on commercial and recreational oyster fisheries because it kills large numbers of oysters each year. Seasonal patterns of intensification and remission of Dermo disease on subtidal oysters are well known and have been correlated with several environmental parameters. Still, its effect on estuarine ecosystems, where oysters play a significant role and their reefs form a unique habitat, is poorly understood. We began monitoring the prevalence and intensity of *Perkinsus marinus* in oysters throughout North Inlet in November 1994. Prevalence and intensity follow seasonal patterns observed in other areas, but remain comparatively low. These data, from 21 sites in the relatively undisturbed North Inlet, provide important baseline information for evaluating the complex interactions of this host-parasite interaction in the virtual absence of human influence. Geographic Information System (GIS) analyses will be used to relate these data to physical and chemical data already being collected throughout the inlet. A new study is being developed to compare data from this project with spatial and temporal patterns in Murrell's Inlet.

Long-term monitoring of wading bird nesting on Pumpkinseed Island

Investigators: Dr. Dennis M. Allen, Wendy Allen, and Dr. Joe Schubauer-Berigan, Baruch Marine Laboratory, USC
Dr. Keith Bildstein, Hawk Mountain Sanctuary Association

In conjunction with the nongame 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 nest counts are made 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 the spring following Hurricane Hugo in September 1989. Numbers returned to about 2,000 pairs in 1992 and reached a high of 2,700 in 1993 before decreasing steadily to about 120 pairs in 1996. Unusually dry winter-spring periods in 1995 and 1996 and low nesting was consistent with a relationship established by Bildstein in the 1980's. Tri-colored herons, great egrets, and snowy egrets produced about 2,000 nests each year, and glossy ibis nesting has increased. See map location no. 19.

BIOGEOPHYSICAL AND CHEMICAL PROCESSES

Groundwater dynamics at the forest-marsh boundary

Investigators: Dr. L. Robert Gardner, Dr. Howard Reeves, and Danny Petrecca
Dept. of Geol. Sci., USC

Underground freshwater inflow to tidally dominated estuaries, such as North Inlet, may be substantial. Transects of special pipe wells have been located from within the Hobcaw forest to the edges of tidal creeks. Measurements of salinity, water depth, direction of flow, and head pressure below the marsh and forest will allow researchers to describe the dynamics of groundwater flow. Computer based models will be developed to determine the effects of tidal forcing, evapotranspiration, rainfall, and sea level rise. With a better understanding of the long-term effects of these factors on the coastal water table aquifer, we may be able to predict and alter flow paths and discharge points of contaminants into estuaries. Preliminary results reveal strong upward components of freshwater seepage in the *Juncus*-short *Spartina* zone adjacent to the forest. This suggests that freshwater seepage from the forest inhibits development of hypersaline pore water and thereby prevents *Salicornia* from inhabiting the high marsh adjacent to the forest. See map location no. 13.

Salt-marsh geomorphology and ecological development: Influence upon habitat linkages within and across ecosystem boundaries

Investigators: Drs. Eric Koepfler and Richard Dame, Daniel Childers, and Bjorn Kjerfve
Coastal Carolina University, Florida Int. University, and Dept. of Biol. Sci., USC

Using aerial imagery, GIS, and image analysis, we are investigating the relationships of salt marsh ecosystem morphology to important resource management characteristics, including habitat extent, habitat quality, and habitat linkages (material flux). Marsh geomorphology, creek network features, and marsh vegetation patterns are quantified by image analysis to generate a series of dimensional (area, length) and non-dimensional (ratio, fractal, diversity) spatial indices. These indices will be compared to fishery landing data and material flux information to determine how marsh estuarine ecosystem morphology influences the support of living marine resources. Multivariate statistical techniques will be utilized to explore the relationship between the marsh estuarine spatial indices and important habitat linkages (material fluxes). Using spatial indices and ancillary data, multivariate models (discriminate analysis and multiple regression) will be constructed to predict material flux dynamics. The major hypothesis of this study is that spatial characteristics reflective of salt marsh maturity control habitat structure [quality] and whole system material flux.

Spatial dynamics of nutrient and sediment removal by riverine wetlands

Investigators: Drs. Joseph P. Schubauer-Berigan, Carol A. Johnston, and Scott D. Bridgham
Baruch Marine Laboratory, USC, University of Minnesota, and Notre Dame University

Estuarine wetlands have important, though unquantified, water quality functions. Large areas of these wetlands have been developed with a resulting loss in water quality benefits. We are studying the spatial attributes of sediment and nutrient removal in two estuarine wetlands with very different sedimentation regimes. Our overall goal is to evaluate the characteristics of riverine wetland soils that maximize sediment and nutrient removal and to determine the relative importance of these sediment and nutrient removal processes within and between wetlands of

different soil types. Specifically, our objectives are: (1) to statistically quantify the spatial distribution of soil properties and processes in riverine wetlands with different soil types, (2) to determine the relative importance of nitrogen and phosphorus removal via sedimentation, organic matter accretion, sorption and gaseous losses, and (3) to develop relationships between these processes and the spatially-distributed soil characteristics.

The effect of bioturbation by fiddler crabs on salt marsh sediments and sediment chemistry

Investigators: Barbara McCraith and Dr. L. Robert Gardner
Dept. of Geol. Sci., USC

Previous studies have suggested that bioturbation by fiddler crabs (*Uca* spp.) may cause seasonal variation in the permeability of salt marsh sediments and, thus, the transport of nutrient-rich porewaters. Bioturbation also suspends marsh sediments that have high levels of adsorbed nutrients which can then desorb into the water column. As a result, bioturbation may play a significant role in controlling the nutrient chemistry of creek waters and, indirectly, the productivity of the salt marsh system. The influence of bioturbation of fiddler crabs on the composition and chemistry of salt marsh sediments is being studied by determining burrow densities, turnover rates, and volumes of displaced sediments, and by nutrient analysis of sediments. The spatial and temporal effect of bioturbation on radioisotope profiles and inventories is also being measured. See map location no. 14.

Microbial nitrogen cycling in estuarine and riverine sediments

Investigators: Dr. Joseph Schubauer-Berigan and Darcy Wood
NI-WB NERR and USC

We are attempting to identify some of the underlying factors regulating nitrogen cycling in estuarine and riverine sediments. Previous research has shown that nitrogen cycling and the nature of the coupling between the water column and the sediments is fundamentally different in marine and freshwater ecosystems. Ammonia concentrations are usually higher in freshwater sediments and, unlike marine sediments, little diffuses out of the sediments into the overlying water. In this study, we are using a variety of experimental approaches to model nitrogen cycling in sediments from a variety of freshwater and marine sites.

Estimation of the sources and fates of organic matter in North Inlet Estuary by a combined chemical: an isotopic approach

Investigators: Dr. Miguel Goni
Dept. of Geol. Sci. and Baruch Institute, USC

The high productivity of salt marsh ecosystems is presumably fueled by primary production from cordgrasses (*Spartina alterniflora*). However, other sources of organic matter, such as phytoplankton, benthic algae, bacteria and land plant detritus, can have significant inputs to these ecosystems. Understanding the roles these various pools of organic matter play in the detrital food chain of salt marshes is of vital importance, especially given the inescapable effects that human activity will and is having on such ecosystems. In salt marshes, organic materials from various biological sources are quickly degraded and modified by grazers and microorganisms. These processes cause significant changes in both the molecular and isotopic composition of the originally deposited organic matter, making it difficult to quantitatively recognize its sources with traditional methods. This study utilizes a new combined approach of molecular level

characterization (CuO oxidation) and compound specific isotope analyses to (1) assess the sources and fates of organic matter in North Inlet Estuary and (2) to estimate what fraction of *Spartina* biomass escapes respiration and is preserved in sediments.

Sediment dynamics and budget of Winyah Bay, a partially-mixed estuary in South Carolina

Investigators: Soraya Patchineelam and Dr. Bjorn Kjerfve
Dept. of Geol. Sci., USC

We are developing a conceptual model of the physical processes that control fine sediment transport in the Winyah Bay estuary, South Carolina. It is hypothesized that physical processes such as gravitational circulation, salt stratification, and tidal processes act to retain the fine sediments discharged into the bay by the rivers within the estuary. The role of each process will be identified through analysis of spatial and temporal variability of salinity, suspended sediments, current speed and direction in the channel and adjacent intertidal areas. Another objective of the study is to establish a sediment budget (sediment sources, sinks, and pathways) for the estuary. Sediment accumulation rates will be quantified through 210Pb analysis.

Origin of sedimentary organic matter in Winyah Bay Estuary revealed by isotopic and molecular tracers

Investigators: Stefka Nikolova and Dr. Douglas Williams
Marine Science Program, USC

This study integrates atomic and molecular tracers to understand sources and distribution of organic carbon in surface and particulate sediments in Winyah Bay, South Carolina. Stable isotope, elemental and biomarker data, collected seasonally, over a 1 year period, will be used to assess the relative contributions of potential terrestrial, salt-marsh and marine sources of carbon. This study will provide new baseline information on biogeochemical cycling in Winyah Bay. We expect that sedimentary organic matter, generally associated with fine sediment fractions, is concentrated in the mid- and upper portion of the bay. During high freshwater discharge vascular plant signals should be predominant in surface sediments, whereas during low freshwater discharge the sedimentary organic carbon should have a primarily planktonic signature. The following two closely related projects will help complete our understanding of organic sources in Winyah Bay See map location no. 22.

Stable isotopic composition of POC from the surface microlayer in Winyah Bay Estuary

Investigators: Karin Gaertner, Stefka Nikolova, and Dr. Douglas Williams
Mar. Science Program, USC

The objectives of this study are to investigate the relative contributions of phytoplankton and macroalgal particulate organic carbon (POC) to the surface microlayer of Winyah Bay and to assess the enrichment of POC and dissolved organic carbon (DOC) in the microlayer relative to the subsurface layer of the water column. During low freshwater discharge (summer and fall), we expect that phytoplankton and macroalgal POC will dominate the lower and middle portions of the bay while the upper bay microlayer POC will reflect vascular plant isotopic and elemental signatures. As freshwater discharge increases in the winter and peaks in early spring, vascular plant POC in the microlayer should extend down to the lower portion of the bay. Particulate organic matter from the surface microlayer of Winyah Bay has been sampled seasonally along a longitudinal gradient in the estuary and in the Sampit and Pee Dee Rivers since February 1996.

The estuarine surface microlayer is biologically and environmentally important because it is enriched in proteins and carbohydrates, which are important sources of food for consumers. The microlayer also concentrates heavy metals and PCB's which can then be easily transferred down the estuarine food chain.

Relationship between grain size distribution and organic carbon content of surface sediments in Winyah Bay, South Carolina

Investigators: Erin Matlack, Stefka Nikolova, and Dr. Douglas Williams
Marine Science Program, USC

The objective of this project is to study the relationship between organic carbon content and grain size distribution of surface sediments of Winyah Bay, Sampit, Pee Dee, and the Waccamaw Rivers. We expect that organic carbon is associated primarily with fine sediments. Surface sediment samples are collected using a Petersen sediment grab, the surface oxic layer carefully removed from the bulk sediment and stored frozen in Whirlpack bags. Prior to analysis, the samples are thawed, soaked overnight in hot Calgon solution, and are then wet-sieved to be split in two fractions: a coarse fraction (>63 u) and fine (mud) fraction (<63 u). After drying (50 C, overnight) the samples are homogenized and are processed with 1 M o-H_3PO_4 to eliminate inorganic carbon (carbonates). Elemental composition of samples will be analyzed on a computer automated Carlo Erba NA1500 elemental analyzer in the Stable isotope lab at University of South Carolina. Grain size analysis will be performed using a conventional sieve method.

Sediment volume change and accretion in a salt marsh

Investigator: Dr. James Morris
Dept. of Biol. Sci., 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 to be 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.

BIOLOGY AND ECOLOGY

Use of flooded marshes by migratory fishes and crustaceans

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

The movement of a diverse assemblage of fishes, shrimps, and crabs into intertidal habitats with flooding tides is widely recognized, but quantitative information regarding the structure and dynamics of these migrations is scarce. In this study, the timing and magnitude of movement of swimming and crawling fauna onto the vegetated marsh surface is measured using two sampling strategies. One set of measurements makes use of replicate nets buried at different elevations along a transect extending from the tidal creek bank to the high marsh; they are lifted at different stages of the tide to determine distributions of different species and life stages. Another series of collections is made by entrapping all motile fauna within a larger area of flooded marsh and determining the taxonomic and life stage composition of the nekton as they leave the area with

the ebbing tide. These monthly collections are paired with the long-term nekton seine collection at Oyster Landing. Together, these studies are revealing temporal and spatial partitioning of the use of the habitats and previously unsuspected relationships among the species sharing the nursery. Weather conditions, depth, and time of day influence the way the migratory fauna use the marsh. Additional studies on diets and food availability will provide insights into growth and production patterns for species which forage on the flooded intertidal zone. See map location no. 5.

RUI Creek Project: The role of oyster reefs in the structure and function of tidal creeks

Investigators: Drs. Richard Dame, Eric Koepfler, Dennis Allen, David Bushek, Don Edwards, Bjorn Kjerfve, Alan Lewitus, Joe Schubauer-Berigan, Theo Prins, and Ms. Leah Gregory
Baruch Institute, Marine Field Laboratory, and Dept. of Statistics, USC and Coastal Carolina

Oyster reefs are present in great abundance in small tidal creek systems of the southeastern United States. Oyster reefs interact with and modify both the biological and physical characteristics of tidal creek ecosystems by: altering water flow, providing increased hard surface area for other organisms, filtering large amounts of particles including plankton and detritus, and increasing the recycling of materials. Through these and other activities, oyster reefs may strongly regulate the structural and functional nature of tidal creek systems. This project offers a multidisciplinary, integrated field and laboratory design to address the role of oyster reefs in regulating the structure and function of tidal creek systems. A statistically robust, replicated system design, consisting of eight tidal creeks, will be used to partition the biological and physical effects exerted by oyster reefs upon tidal creek biota. In phase one, the biotic influences will be examined by comparing creeks possessing oyster reefs with creeks in which oyster reefs have been carefully removed. In phase two, the influence of oyster reef dams upon creek flow and water residence time will be addressed. Numerous supportive studies will be conducted on plankton, bacteria, motile animals, nutrient cycling, and metabolism. This study will advance scientific understanding regarding the interaction between benthic filter feeding systems and the biological and physical components of tidal creeks. The study will investigate the consequences of the removal of oyster reefs, a process that has occurred on a large scale due to human influences in other areas and will advance our understanding of the impacts of sea level rise on benthic and pelagic communities in shallow coastal ecosystems. Finally, this project with its coupling of an undergraduate university, a research university, and a field laboratory will provide up-to-date and hands-on training for a number of excellent undergraduates and future scientists. See map location no. 15 and 16.

Relationships between oyster reefs, nekton, and zooplankton within small intertidal creeks: a NSF CREEK Project Substudy

Investigators: Drs. Dennis M. Allen and David Bushek
Baruch Marine Field Laboratory

As one of the substudies associated with the NSF CREEK Project, this effort focuses on the relationship between oyster reefs in small intertidal creeks and the fishes, motile macroinvertebrates, and zooplankton which occupy the habitat. During representative tidal cycles and season, changes in the composition, abundance, biomass, and length frequencies of all nekton will be measured at each of the eight study creeks. Zooplankton will also be compared among the creeks during this first year to establish baseline characteristics of the transitory fauna. Similarities and differences in fauna among creeks with similar oyster biomass/tide volume ratios

will be established before oysters are removed from four of the eight creeks in the second year. Since little is known about either the spatial variations in nekton use of these nursery habitats or the relationships between most estuarine fishes and oyster reefs, the study will provide important new knowledge pertinent to resource and ecosystem management. Undergraduate students from Coastal Carolina University will participate in the research program.

The effect of salinity on the growth and development of larval estuarine dependent fishes

Investigators: Dr. V. Pernell Lewis
Dept. of Biol. Sci. and Marine Science Program, USC

Salinity may be a major environmental factor influencing the utilization of estuaries by larval fishes. The goal of this study is to examine the role of salinity in determining the distribution of larval fishes within the estuary. The energetics of growth in three different salinities (2, 12 and 35 ppt) for three common species (Atlantic menhaden, spot, and southern flounder) will be determined. Metabolic rates, proximate composition, and growth rates will be among the primary variables measured to assess the effect of salinity on these larval fish. Their distribution in Winyah Bay and North Inlet will also be determined relative to salinity zones. Salinity preference will be determined in the laboratory using a salinity gradient test.

Temporal feeding habits of white shrimp, *Penaeus setiferus*, in a South Carolina tidal creek

Investigators: Dr. Robert Feller and Amber Shematek
Dept. of Biol. Sci. and Mar. Sci. Prog., USC

The goal of this study is to determine if feeding activity of white shrimp changes with either light levels or tidal height. In the laboratory, colors of fluorescently labeled bait are offered to shrimp held in individual enclosures. Each color is available for consumption for ten minutes. All feeding behaviors during the sample hour are recorded, including the location the colored bait in the shrimps' guts. Gut passage time is observed directly and used to guide experiments in field enclosures. Results will indicate whether white shrimp concentrate feeding activity at night, as is currently hypothesized, and may be valuable to the shrimping and aquaculture industries.

Storm induced salinity pulses in the estuary and effects on larvae

Investigators: Courtney Richmond and Dr. Sarah Woodin
Dept. of Biol. Sci., USC

Precipitation events and subsequent runoff from coastal watersheds result in changes in tidal creek water salinities. The timing, frequency, and magnitude of freshwater inflows may have implications for the survival and development of planktonic larvae in the tidal creeks. In laboratory experiments, larvae at various stages of development have been exposed to different salinity regimes to determine how different kinds of salinity events affect the animals' well being. An understanding of the impacts of rapid changes in water quality on invertebrate recruitment processes is of interest to the management of both developed and natural watersheds.

Production, degradation, and biotic effects of noxious chemicals generated by some benthic invertebrates

Investigators: Drs. Sarah Woodin, Charles Lovell, David Lincoln, and Pernell Lewis
Dept. of Biol. Sci. and Marine Science Program, USC

Measurements of the production and degradation of bromophenols, noxious organic compounds which affect other animals, are being made in Debidue Creek. The chemicals are produced by polychaete and acorn worms. Field and laboratory experiments are being conducted to determine the effects of these biogenic compounds on the recruitment of invertebrates (settlement of planktonic larvae to the contaminated sediments) and predation by fishes. Additional studies are characterizing the responses of populations of bacteria to the presence of the chemicals around the worm burrows. These compounds are similar to another group of compounds (chlorophenols) released by pulp mills and other industries. The studies will reveal how estuarine organisms react to long-term exposures to contaminants of these types. See map location no. 7.

Molecular ecology of biohalogenation and dehalogenation

Investigators: Kevin Fielman, Dr. David Lincoln, and Dr. Sarah Woodin
Dept. of Biol. Sci., USC

Halogenated aromatic compounds are important pollutants in a variety of industrial processes. Similar compounds are also produced naturally by a wide variety of marine organisms. We are examining the extent to which the capacity of organisms to produce and degrade naturally-occurring halogenated organic compounds determines the biological impact of pollutants in marine benthic communities. DNA probes developed from common worm species which contain high concentrations of halogenase and/or dehalogenase will be used to compare the potential for halophenol metabolism of organisms at three sites: one with native worm species which produce large quantities of bromophenols, a nearby site which has substantial chlorophenol contamination from sulfate-process paper pulp mill effluent, and a control site lacking halophenols. These studies will allow us to assess the activities and potentials for halogenases and dehalogenases to influence benthic community species composition and enable us to determine if these characters are important determinants of organism survival and persistence in polluted habitats. See map location no. 7.

Chemically mediated interactions in a sedimentary assemblage

Investigators: Dr. Charles Lovell, Dr. Sarah Woodin, Dr. David Lincoln, and students
Dept. of Biol. Sci., 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 bacteria populations are being conducted using biochemical and radiotracer techniques. Phospholipid fatty acid analyses and DNA restriction fragment length polymorphism studies are providing insights into microbial community ecology. Field and laboratory measurements indicate that long-term exposure to biologically produced bromophenols has selected for microbial populations which can mineralize these compounds. Such bacteria populations may provide a means of identifying chemically impacted sites and may be useful in clean up efforts (bioremediation). See map location no. 7.

Hydrodynamic transport of larvae and chemical cues

Investigators: Christopher Finelli and Dr. David Wethey
Dept. of Biol. Sci., USC

The influence of tidal current flow on (1) the deposition and erosion of invertebrate larvae and (2) transport processes controlling distribution of chemical odorants is being studied in the field and laboratory. Field experiments relate settlement of planktonic larvae on surfaces to physical and chemical characteristics at the boundary layer. Laboratory flume experiments allow for precise measurements and observations on how microscopic invertebrate larvae respond to different physical conditions and chemical cues. The information will be useful to the understanding and control of biological fouling problems and applicable to aquaculture.

Marine microbial biofilms: A structuring matrix for microbial processes and transformations

Investigators: Alan W. Decho
Dept. Env. Health Sci., USC

The formation of biofilms constitutes a requisite step for colonization and/or biofouling of surfaces by macroorganisms such as barnacles, oysters, etc. Biofilms consist of microbial cells surrounded by a matrix of large mucous molecules (exopolymers). These polymers stabilize the attachment of microorganisms to surfaces and afford protective and sorptive properties to the cells. Ongoing biofilm studies are geared in three basic process and environmental directions: (1) Sorption studies are examining how exopolymers may bind dissolved nutrients and localize microbial extracellular enzyme activities close to cells; (2) The protective effects of exopolymers in binding, concentrating, and detoxifying metals and organic contaminants are being examined; and (3) Applied studies are examining the role of specific biofilms in mediating the settlement and metamorphosis of oyster larvae.

Chemical induction of oyster larval settlement

Investigators: Dr. Richard Zimmer-Faust, Alan Decho, James Eckman, and Dr. Kenneth Browne
Baruch Institute, USC; Dept. of Biol., UCLA; School of Public Health, USC;
Skidaway Institute of Oceanography

The involvement of a waterborne chemical cue in settlement induction of oyster larvae has been debated for more than a half of a century, yet no one has identified such a compound. Work from our lab on seawater filtered by Atlantic oysters, *Crassostrea virginica*, demonstrates that there is indeed a chemical cue responsible for oyster larval settlement. This cue belongs to a class of peptides with an approximate molecular weight of 500-1000 g/mol with an arginine residue at the carboxy-terminus. Our current work involved (1) isolation and identification of molecules from the mantle fluid and bath water of mature oysters which fit these and related criteria, (2) how bacterially-produced exopolymers control the chemistry of settlement substrates through surface contour and controlled adsorption-desorption of settlement inducing compounds, (3) field experiments testing the efficacy of an artificial peptide inducer, glycyl-glycyl-arginine, and oyster larval collectors on oyster larval settlement in a natural estuarine environment, and (4) dynamic modeling of the release of chemical settlement inducers from the oyster larval collectors. The results of these studies will constitute a major step in understanding the role of waterborne chemical cues and how they interact with substrate-adsorbed cues as agents regulating larval colonization of the benthic environment. See map location no. 17.

Chemosensory ecology of oyster larvae: Benthic-pelagic coupling

Investigators: Dr. Richard K. Zimmer-Faust, Mario N. Tamburri, and Alan W. Decho
Dept. of Biol. Sci., USC

Habitat colonization by planktonic larvae is a critical factor regulating population dynamics of marine benthic invertebrates. The chemical properties of marine environments provide important cues used by larvae to select settlement sites. Our results demonstrate a clear association between presence of a dissolved chemical stimulus and rapid behavioral response by oyster larvae. Dissolved substances released by adult conspecifics cause downward-directed swimming in the water column and attachment to substratum by larval oysters (collectively defined herein as "settlement"). As indicated by natural products, chemistry and laboratory behavioral assays performed in still water and flume flow, oyster larval settlement inducers are low molecular weight (LMW) peptides with arginine at the C-terminus. Settlement by oyster larvae in response to seawater collected at field sites correlates positively with the concentration of LMW arginine-peptides. Preliminary evidence further suggests that the peptides evoking oyster larval settlement are those also eliciting metamorphosis. We are currently testing the hypothesis that adsorption of LMW arginine-peptides to exopolymers in bacterial biofilms is a key agent regulating larval metamorphosis. Chemical induction of either settlement or metamorphosis might thus be determined by the availability of LMW arginine-peptides in either dissolved or particulate form.

Chemoreception in turbulent flow: how blue crabs find their prey

Investigators: Dr. David Wethey, Dr. Richard Zimmer-Faust, Dr. N. Dean Pentcheff, and Chris Finelli
Dept. of Biol. Sci., USC

Chemical scents associated with animals are moved by tidal currents. Scents can serve as cues for predators seeking food. In this study, the dynamics of odorant transport in water flowing through tidal creeks and *Spartina* marshes is continuously recorded. Dyes are mixed with odorant chemicals so that measurements of mixing rates and plume formations can be made with videotape recorders. Field and laboratory studies will help develop an understanding of how crabs use sight, touch, and smell to locate food. The information will be useful in developing and testing foraging and biophysical theory.

Population genetics of *Perkinsus marinus*

Investigators: Drs. David Bushek, Kim Reece, and John Graves
Baruch Marine Laboratory, USC and Virginia Institute of Marine Science

The protozoan parasite *Perkinsus marinus* has been decimating oyster populations from Virginia to Texas for nearly 50 years. Recent outbreaks of this parasite have occurred as far north as Massachusetts. We are trying to determine the genetic population structure of *P. marinus* to better understand the mechanisms of its dispersal. Isolates of *P. marinus* have been collected from individual oysters at several spatial scales and cultured *in vitro*. A genomic library has been constructed and several regions identified with enough variability to differentiate isolates. Several primer sequences were designed to amplify these variable regions with the polymerse chain reaction. Techniques were developed to produce monoclonal cultures and preliminary restriction fragment length polymorphism analysis has produced several interesting discoveries. For example, we now know that *P. marinus* is diploid (contains two sets of chromosomes) and that isolates from the recent northern range expansion are closely related,

suggesting they spread from the same region. Additional knowledge of the population genetic structure will help identify mechanisms of dispersal, provide a means to evaluate the effectiveness of management strategies designed to reduce the spread of various parasite strains, and provide a mechanism to enforce management regulations.

Chlorine tolerance of *Perkinsus marinus*

Investigators: Dr. David Bushek, Russell Holley, and Megan Kelly
Baruch Marine Field Laboratory, USC

Perkinsus marinus represents a major problem for oyster stock enhancement, management, and restoration efforts as it causes extensive oyster mortality. Human transport of oysters and subsequent disposal of infected tissues into estuarine and marine waters may exacerbate the problem by spreading virulent races. Therefore, we are exploring methods to kill *P. marinus* prior to disposal of *P. marinus*-contaminated materials. *In vitro* cultured parasites and infected oyster tissues are exposed to various dilutions of household bleach, freshwater, or high temperature for 0.5, 4 and 18 hours. Neutral red viability assays and post-treatment proliferation are used to measure the effectiveness of each method. Results with laboratory cultures indicated that standard bleach sterilization procedures, which use chlorine concentrations of 10-25 ppm, are ineffective against this pathogen, but higher concentrations (300-400 ppm) are effective. Alternatively, 1 hour exposures to fresh water or 1 hour incubation of cultured parasites in FSW or culture medium at 50° C is effective. The next step is to test these methods on parasites embedded in tissues which will likely require higher chlorine concentrations, higher temperatures, or longer incubation times due to protection from the surrounding tissue.

Estuary flushing and water residence time as a controlling factor of the oyster parasite *Perkinsus marinus*

Investigators: Dr. David Bushek, Russell Holley, and Forest Davidson, III
Baruch Marine Field Laboratory, USC

Mechanisms triggering epizootics of *Perkinsus marinus* are poorly understood. Temperature and salinity are clearly important factors that influence spatial and temporal patterns with both high temperature and high salinity favoring parasite proliferation. Quite surprisingly, *P. marinus* does not appear to be a problem in the high salinity estuaries of South Carolina where water temperatures are relatively warm throughout much of the year. One reason may be the high flushing rates of most South Carolina estuaries. These ecosystems tend to be tidally dominated which means that a large proportion of the water is flushed out to sea and replaced with each tidal cycle. Transmissible stages of the parasite may be flushed from the estuary before finding a suitable host. To test this hypothesis, we are examining the transmission rate of *P. marinus* among oysters and the intensification of infections in oysters held in raceways with different flushing rates. Results will lead to a better understanding of mechanisms that control parasite transmission and the development of epizootics.

Brittlestar population studies: use of skeletal growth rings as markers

Investigators: Drs. William Dobson and Stephen Stancyk
Appalachian State University 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. In this study, animals from

natural populations are sized, marked with dyes, and returned to the same area. Replaced animals are confined in large plastic cores so that the same individuals can be relocated every three months and brought into the lab for inspection. The goal is to determine the efficacy of using growth rings in vertebral ossicles as markers for aging individuals and for correlating age bands to temporal events which may alter brittlestar growth. This information will help quantify the importance of brittlestars in estuarine ecosystems and provide means of quantifying effects on brittlestar growth. See map location no. 8.

Symbiosis of the pea crab with two polychaete worms

Investigators: Michael Grove and Dr. Sarah Woodin
Dept. of Biol. Sci., USC

Symbiotic relationships between the pea crab, *Pinnixa chaetopterana* and its host polychaetes *Chaetopterus variopedatus* and *Amphitrite ornata* are being investigated on tidal flats in Debidue Creek. Growth rates of the animals are being measured in the field and in the lab and correlated with acoustic Doppler flow probe measurements which quantify the effects of the crabs on the hosts' pumping activity. Crabs have been shown to locate new hosts by responding to conspecific odors. Frequent movement between hosts is necessitated by high host mortality as indicated by long-term mapping of host populations. The final phase of the work will investigate the genetic relationships of crab populations occupying tubes of the two host species. This work will be useful in understanding evolutionary trends in marine symbiosis. See map location no. 9.

Evolutionary history of diapause in harpacticoid copepods

Investigators: Regina Wetzer and Dr. Bruce C. Coull
Mar. Sci. Prog., USC

The harpacticoid copepod, *Heteropsyllus nunni* Coull, originally described and abundant in North Inlet, is one of two marine harpacticoid copepods that undergoes diapause by encysting. All other harpacticoids that are known to encyst are from freshwater. Using mitochodrial DNA analyses (PCR amplification), this project will determine the phylogentic relatedness of *Heteropsyllus* and all the other species. Results will be used to determine whether encystment has evolved once and *Heteropsyllus* is a recent marine invader or encystment evolved twice in the *Harpacticoida*: once in freshwater and once in the marine environment.

Fatty acid composition of marine free-living benthic nematodes and copepods

Investigator: Dr. Bruce C. Coull
Mar. Sci. Prog., USC

Juvenile bottom feeding fishes eat meiofauna and they select copepods over nematodes, even though nematodes are 5 times more abundant. Fishes require certain polyunsaturated fatty acids for adequate growth. It is hypothesized that copepods have these fatty acids while nematodes do not, primarily because they feed on different microbes. Collections are ongoing quarterly to collect and prepare nematodes and copepods for fatty acid analyses to test the hypothesis that this selective feeding may be an evolutionary adaptation to optimal foraging for the necessary fatty acids.

Microbial mediation of environmental stresses

Investigators: Dr. Charles Lovell, Yvette Piceno, and George Matsui
Dept. of Biol. Sci., USC

This project examines nitrogen fixing bacterial (NFB) communities associated with the salt marsh cordgrass, *Spartina alterniflora* and environmental stresses affecting them. Stress factor gradients in salt marshes result in a transition from highly productive tall form *Spartina* at the banks of tidal creeks to less productive short form plants at higher elevations. Differences in rhizosphere NFB, essential symbiotes of *Spartina*, due to the differing environmental stresses may help explain the observed pattern of plant distribution and productivity. Field NFB communities will be experimentally manipulated through a reciprocal transplant experiment. We have profiled the nitrogen communities associated with roots of tall and short *Spartina* and have found clear differences between these communities. We are currently examining correlations between environmental stressors, rates of N_2 fixation, plant productivity, and NFB community structure in order to define the influence of NFB communities on *Spartina* productivity. See map location no. 14.

Microbial food web structure/function in North Inlet

Investigators: Drs. Alan Lewitus and Eric Koepfler,
Baruch Marine Laboratory, USC and Coastal Carolina University

This study examines the seasonal variability in microbial food web dynamics in North Inlet. In particular, we are focusing on the influence of two factors important to regulating microbial food web structure; nutrient supply and grazing pressure. Our protocol is to incubate natural samples in treatments designed to differentiate between nutrient and grazing effects (e.g. ammonium or glycine addition; prokaryotic vs. eukaryotic inhibitors; dilution), and follow time-course changes in chlorophyll, bacterial numbers, and phytoplankton community composition. We are finding pronounced seasonal differences in the response of bacteria and phytoplankton to nutrient additions and grazer effects. For example, during the summer when both groups peak in abundance, their growth is limited by grazing and not inorganic nutrients. In contrast, phytoplankton growth was controlled by nutrient supply (ammonium) in the winter. The results will be useful in understanding how estuarine ecosystems function and how their production is controlled.

Trophic interactions of ambush predator dinoflagellates in estuarine microbial food webs

Investigators: Drs. Alan Lewitus and JoAnn Burkholder
Baruch Marine Laboratory, USC and North Carolina State University

With the recent advent of improved sampling, fixing, and detecting procedures in microbial ecology, heterotrophic dinoflagellates have emerged as an ecologically important and trophically diverse group. Included in this group are the so-called "ambush predators", species that occur as benthic dormant cysts in the absence of prey (algae, protozoa, or fish), but excyst into flagellated cells, swarm up from the benthos, and devour any detected prey. Information on the abundance of ambush predator dinoflagellates is scant. However, one toxic species (*Pfiesteria piscicida*) has been discovered throughout southeastern U.S. estuaries (including Charleston Harbor), and was the causative factor in >50% of North Carolina fish kills documented since 1991. Our work will focus on the role of this species (also called the "phantom dinoflagellate") in estuarine food webs, specifically determining its saprotrophic response to fish, the impact of its grazing activity

on natural prey populations, and its effect on growth, fecundity, and survival of potential microfaunal predators.

The role of alternative respiration in phytoplankton

Investigators: Dr. Alan Lewitus and Dr. Todd Kana
Baruch Marine Laboratory, USC, Horn Point Environmental Laboratory, UMd, and Coastal Carolina University

In the variable estuarine environment, phytoplankton frequently experience shifts in resource availability that affect intracellular energy levels. When conditions lead to energy overproduction (e.g. the transition from dark [night] to bright [day] light), phytoplankton use a variety of metabolic processes to get rid of the excess energy. One such energy-dissipating mechanism is alternative respiration. Studies at the Baruch Field Lab compare the presence and expression of the alternative pathway in phytoplankton from North Inlet. Laboratory measurements on the activity and capacity of alternative respiration under varying light, nutrient, and organic substrate conditions will yield insight into the role of the pathway in phytoplankton. The distribution of alternative respiration in field populations also will be determined using a monoclonal antibody to the main enzyme of the pathway. Ultimately, the feasibility of using alternative pathway expression as a physiological stress indicator will be explored.

An investigation into the trophic ecology of the deposit-feeding, burrowing brittlestar *Microphiopholis gracillima*

Investigators: Dionne Hoskins
Mar. Sci. Prog., USC

Bacterial exopolymer secretions (EPS) often form dense mats (biofilms) at the sediment/water interface which may be consumed in significant amounts by benthic infauna. The burrowing brittlestar *Microphiopholis gracillima* is known to feed on small organics at the surface. This study, divided into three phases, will determine the typical feeding behavior of *Microphiopholis*, exploring the depth of its feeding activity in sediments, its food preference, and the role of bacterial exopolymers in its diet. In Phase I, food is presented at discrete depths. Subsequent gut analysis will reveal if feeding has taken place and should establish a feeding depth range. Phase II experiments will introduce different food types in the feeding range determined in Phase II. In Phase III, toxins will be placed in the feeding area for trophic transfer studies. Brittlestars are expected to feed throughout the sediment column and to consume significant quantities of bacterial exopolymers in addition to a variety of other detrital organics. Evidence to support these hypotheses may substantiate additional theories involving the ability of the microbial community to pass pollutants to higher trophic levels through biofilms.

Microbial community structure and phenotypic diversity

Investigators: Dr. Joseph Schubauer-Berigan and Darcy Wood
NI-WB NERR and USC

Bacteria play an important role in the transformation of matter and nutrients in ecosystems and are an important component of microbial food webs, yet little is known about the community structure and diversity of this group in the environment. We plan to use a BIOLOG identification system, based on community-dependent patterns of substrate utilization, to examine bacterial phenotypic community composition and diversity in water from sites in North

Inlet-Winyah Bay National Research Reserve. We also are developing methods to characterize bacterial communities in sediments.

Interspecific competition among some salt marsh perennials in South Carolina

Investigators: Drs. Richard Stalter and John Baiden
St. John's University, NY

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. 14 and 20.

HUMAN IMPACTS: HABITAT ALTERATION, POLLUTION, AND MANAGEMENT

Effects of coastal development on watershed ecology

Investigators: Drs. C.M. Aelion, Matt Wahl, Hank McKellar, Tom Williams, and Tomohiro Kawaguchi
Dept. of Env. Health Sci., USC, Baruch Forest Science Institute, CU, and Baruch Marine Laboratory, USC

Surface water runoff from small coastal watersheds is being measured and analyzed to quantify differences in systems with different management scenarios. Rain gauges and flow control structures on each stream in North Inlet and Murrells Inlet watersheds record information on runoff. Water samples are collected during and following storm events. The quality, quantity, and timing of stormwater runoff is being compared to groundwater quality and the rise and fall of the water table. A computer-based model which takes into account the geomorphology, percent impervious surface, vegetation, and other physical characteristics of the watershed, will be developed to help predict timing and magnitude of runoff and nutrient loading. Preliminary results suggest significantly different runoff patterns between forested and suburbanized watersheds. The suburbanized site exhibited increases in the frequency and magnitude of runoff events. The suburbanized site also had higher mean concentrations of suspended sediment, nitrate/nitrite, and orthophosphate and lower concentrations of dissolved organic carbon. Groundwater observations indicate strong upwelling at both sites suggesting a significant groundwater contribution to storm runoff. Both sites exhibited a threshold water table level below which rainwater input went into groundwater recharge. See map location no. 1.

Effect of urbanization on iron bioavailability to phytoplankton

Investigators: Drs. Alan Lewitus, Tomo Kawaguchi, and Jack Ditullio
Baruch Marine Laboratory (USC), Dept. Environmental Health (USC), University of Charleston

Iron has long been recognized as an essential growth requirement for phytoplankton. Although iron is generally abundant in coastal regions, only limited fractions can be assimilated

by phytoplankton because bioavailable iron species are highly unstable in oxygenated seawater. One way in which iron bioavailability can be enhanced is by chelation to dissolved organic matter (DOM). We hypothesized that urbanization-associated deforestation in Murrells Inlet caused a reduction of iron bioavailability to estuarine phytoplankton by decreasing the supply of forest-derived DOM (i.e. the iron chelation source). To test the hypothesis, we are comparing Murrells Inlet with North Inlet, a forested estuary, by combining (1) measurement of ambient iron composition in the estuaries, (2) a bioassay of iron availability using natural populations transferred to filtered water from the estuary and incubated under treatments varying in iron (EDTA-FE, natural organically-bound Fe), nitrogen (NO_3, NH_4), and PO_4 content, and (3) a bioassay on cultured phytoplankton (iron-starved cultures of *Synechococcus, Cylindrotheca closterium,* and *Phaeodactylum*) transferred to water from each estuary amended as above. If our hypothesis proves correct, that organically-bound iron produced by coastal forests plays an important role in maintaining iron bioavailability, then the potential effect of forest clearing on the quality and quantity of stream dissolved organic material should be an important consideration in coastal zone management strategies.

Agricultural pesticide runoff in tidal creeks and its effects on microbial loop communities

Investigators: Marie DeLorenzo and Dr. Alan Lewitus
Baruch Marine Laboratory, USC

Agricultural pesticide runoff is a known contributor to non-point source pollution in estuaries. Microbial communities play an important role in nutrient cycling and may be a sensitive, early indicator of environmental stress due to pesticides. The goal of the study is to characterize the microbial loop as it exists under pristine estuarine conditions and determine how pesticides may affect it. Microbial communities from North Inlet will be collected using artificial substrates, transported to the laboratory, and placed in test containers. Individual components of the microbial loop will be selectively blocked with inhibitors (antibiotics, DCMU, cycloheximide) and the target communities will then be exposed to a range of pesticide concentrations. Bacterial productivity (incorporation of ^{3}H-methyl thymidine), phototrophic productivity (incorporation of ^{14}C-sodium bicarbonate), phototrophic biomass (chlorophyll a), bacterial abundance, and the diversity of phototrophs and heterotrophic ciliates and flagellates will be measured. The experiment will be repeated with three different pesticides: atrazine, endosulfan, and chlorpyrifos.

Mid-Atlantic regional demonstration project to evaluate the impact Best Management Practices (BMP) on the nonpoint source pollution of coastal waters

Investigators: Drs. Joseph P. Schubauer-Berigan and Dennis M. Allen
North Inlet-Winyah Bay National Estuarine Research Reserve and Baruch Marine Laboratory, USC

The primary purpose of the demonstration project is to develop and test an *in situ* method for assessing the performance levels of best management practices for reducing non-point source inputs of pollutants. The project is supported and coordinated by several NOAA offices (OCRM, ORCA, CCEH) and, within each of the participating states (SC, DE, NC), the Coastal Zone Management Agency and a NERR are collaborating. The overall goal is to assist states in developing, implementing, and evaluating management measures used to reduce nonpoint pollutants and improve coastal water quality. A water and sediment quality monitoring program is being established to measure the amounts of nutrients, suspended solids, and xenobiotics entering the test sites and to quantify the impacts of BMP's on biotic organisms and communities

downstream. The NI-WB NERR component will evaluate the effectiveness of the combined draining, tiling, and landscaping methods used in recently constructed golf courses along the Waccamaw River. See map location no. 23 and 24.

The effects of golf course management on benthic macroinvertebrate community structure

Investigators: M. Elizabeth Horton, Drs. Joseph P. Schubauer-Berigan, Bruce C. Coull, and G. Thomas Chandler
Marine Sci. Program, Baruch Marine Field Lab, Dept. of Mar. Science, and School of Public Health, USC

This study is part of a larger project to evaluate the effectiveness of Best Management Practices (BMPs) at reducing nonpoint source pollutants, improving water quality, and protecting aquatic habitats. Specifically, this research hopes to quantify biotic responses to different land use and golf course management practices such as draining, tiling, retention, and landscaping. A modified biological index which measures the reaction of freshwater macroinvertebrates to such management practices will be the endpoint utilized to represent ecosystem health. After determining the impacts on community structure, specific interactions between the chemical environment and the biota will be investigated using techniques including semipermeable membrane devices (SPMDs) and toxicity tests with reproductive endpoints. See map location no. 23 and 24.

Meiofaunal microcosms to detect pollution

Investigators: Drs. G. Thomas Chandler and B.C. Coull
Mar. Sci. Prog., USC

Microcosms of entire meiofaunal communities are collected in North Inlet mud and transported to the laboratory in Columbia. Selected microcosms are dosed with contaminants and total community structure response is monitored. Cultured harpacticoid copepods are added to certain contaminated microcosms and their population success monitored. The goal is to determine how contaminants alter community structure so that we may better understand contaminant effects and also detect contamination problems via changes in community structure.

Development of a predictive model for assessing wetland alterations

Investigator: Drs. Dwayne E. Porter, F. John Vernberg, and Winona Vernberg
Baruch Institute, USC

The goal of this study is to assess and compare changes in wetland acreage in the relatively pristine North Inlet Estuary versus the urbanized Murrells Inlet Estuary. Using the tools of Geographic Information Processing (GIP), a spatial model is being developed to assess not only physiographic alterations, but also alterations allowed under regulatory permitting programs. This study utilizes Geographic Information Systems (GIS), remote sensing and digital image processing, and Global Positioning Systems (GPS) for database development, model development, and validation. By comparing the two estuaries, a better understanding of the potential impact of urbanization on coastal wetlands will be gained.

Implementation and validation of coastal NPS pollution model

Investigators: Dr. Dwayne E. Porter and Christopher Corbett
Baruch Institute and Marine Science Program, USC

This investigation develops an integrated NPS/GIS model to characterize and quantify differences in runoff between an urbanized watershed in Murrells Inlet and an undeveloped forested watershed in North Inlet. The NPS model simulates surface water runoff, transport of nitrogen and phosphorous compounds, sediment erosion and deposition, and chemical oxygen demand (COD). High nutrient levels can result in eutrophication of receiving waters, sediments carry large quantities of adsorbed pollutants, and high COD levels threaten organisms in the water. Calibration of the coastal NPS model will enable predictions of individual storm runoff for both watersheds on a seasonal basis. The impact of proposed changes in land use and land cover can also be modeled. Knowledge of how nonpoint source components behave as they are transported through a watershed will provide a foundation for future NPS studies.

International research project on flatfish ecology. Quantitative growth dynamics of flatfish as a test of the recruitment hypothesis

Investigators: Dr. John Mark Dean, Dr. Robert Feller, and Marcel Reichert
Baruch Institute, USC

Habitat alteration is considered the greatest long-term threat to marine fisheries productivity, but there is a lack of direct information on the interaction of habitat and recruitment of juvenile fish in their nursery grounds that resource managers can use in policy development and implementation. This study, part of an international cooperative project by the University of South Carolina, North Carolina State University, Louisiana State University, University of Puerto Rico, and the Netherlands Institute for Sea Research, tests whether recruitment of juvenile flatfish is limited by differences in habitat quality. Since July 1993, quantitative monthly sampling has been conducted to determine the species distribution, abundance, and age structure of juvenile flatfish populations in two adjacent areas with presumed differences in habitat quality (North Inlet and Winyah Bay). Growth, determined on the basis of information extracted from the otoliths, will be used as a measure of habitat quality because it integrates both biological and physical factors. Increment formation in the otoliths will be validated in laboratory experiments and growth rates determined for at least three flatfish species at various temperatures. See map location no. 10 and 18.

Modeling the impacts of anthropogenic and physiographic influences on grass shrimp in localized salt marsh estuaries

Investigators: Dr. Dwayne E. Porter, Dr. Don Edwards, Ben Jones, and Geoff Scott
Baruch Institute, USC and Southeast Fisheries Science Center-Charleston
Laboratory National Marine Fisheries Service, NOAA

The complexity and severity of ecological impacts associated with coastal growth demands that resource managers explore new spatial analytical techniques combined with multi-disciplinary scientific expertise for proactive coastal zone management. Arising from these environmental concerns and the identified need for adequate databases and integrated models, an ongoing long-term study of the impacts of urbanization on localized coastal estuaries of the southeastern United States was initiated in 1990. A goal of the Urbanization and Southeastern Estuarine Systems (USES) study is to examine the role of Geographic Information Processing (GIP) to integrate data and scientific expertise for the identification, assessment, and modeling of

anthropogenic and physiographic relationships within coastal estuaries. This goal is being achieved through the implementation and utilization of a multi-agency Geographic Information System (GIS) and the development and validation of spatially explicit models. This work involves spatial modeling efforts that incorporate land use and land cover characteristics with fisheries data to assess and predict the impacts of anthropogenic and natural influences on key species that inhabit critical estuarine habitats. A spatial assessment of two small, high-salinity estuaries suggests that upland development adjacent to critical estuarine habitat limits the population size and distribution of adult and larval grass shrimp (*Paleomenetes pugio*). Modeled spatial distributions of adult populations suggest estuarine "deserts" -- wetlands and stream reaches adjacent to commercial and residential land use void of natant fauna. This approach is being developed for coastal resource managers to predict the impact of proposed landscape modifications prior to occurrence of changes.

Kriging in estuaries

Investigators: Dwayne E. Porter, Don Edwards, and Ben Jones
Baruch Institute, USC

Geostatistical models are becoming an essential tool for understanding the spatial distribution of biological and chemical species in estuaries. These methods can construct statistically optimal predictions for data at unobserved locations using a relatively small, spatially explicit sample. The prediction at any given location is a weighted average of the sample values, where the weights depend on the distances between the sample sites and target locations. For most geostatistical settings, distances are computed using Euclidean distances, i.e. "as the crow flies". For measurements made in estuarine streams, however, intuition suggests that distances between sites should be measured in-stream, i.e. "as the fish swims". This study has been evaluating the relative accuracy of various kriging methods for predicting contaminant levels and water quality conditions in North Inlet and Murrells Inlet.

Hydrophobic organic contaminants in rivers and estuaries: colloidal phases

Investigators: Todd Cowan and Dr. Tim Shaw
Dept. of Chem. and Biochem., USC

Current sampling schemes fail to distinguish hydrophobic organic contaminants distributed between the dissolved and colloidal phases. It has been postulated that descriptions of the "speciation" of hydrophobic compounds in natural waters should include not only dissolved and particulate fractions but also a component sorbed to a colloidal fraction. Significance of this colloidal material to the fate of contaminants depends on the following factors: (a) identity and concentration of colloidal matter; (b) nature of the interaction between contaminants and colloidal matter; and (c) mobility of colloidal matter in an aqueous environment. We plan to evaluate the contribution of the colloidal phase fate and transport of organic contaminants by measuring partition coefficients for the particulate and colloidal phases in Winyah Bay and the rivers that feed it. In addition, we plan to characterize any changes in each phase as it experiences an increase in the salinity of its environment. It is postulated that this may be a possible sink or capturing mechanism for organic contaminants in Winyah Bay. See map location no. 22.

Predicting toxicity and degradability of Quadricyclane, fluorocarbon ethers, and their analogs

Investigators: Drs. Suhbash Basak, Keith Lodge, and Joseph P. Schubauer-Berigan
University of Minnesota and Baruch Marine Field Laboratory, USC

In many instances of chemical risk assessment, one has to predict the toxic potential of molecules in the face of limited or unavailable test data. Many industrial chemicals have been subjected to minimal or no testing. Under these circumstances, a three-tier strategy for the risk assessment of chemicals has been proposed: (1) critical evaluation of test data, (2) identification of potential analogs of a chemical, and (3) estimation of properties using quantitative structure-activity relationship (QSAR) models. In this project, we plan to: (a) select analogs of the chemicals of interest to the Air Force (quadricyclane, fluorocarbonethers) from data bases containing high quality experimental data on properties like aquatic toxicity (LC50), mutagenicity, toxicity to microorganisms, biodegradability, redox potential, etc., (b) carry out SAR studies of the set containing the chemical and the group of selected analogs using physical organic, topological, molecular mechanics, and quantum chemical approaches, and (c) determine selected physicochemical and environmental properties of a number of critical chemicals and their metabolites in order to validate predictive SAR models.

EDUCATIONAL AND SERVICE PROJECTS

Project Interface: A multi-year, multi-disciplinary program for the integration of undergraduate research and learning

Investigators: Drs. Doug Williams, Dwayne Porter, Gail Kineke, David Bushek and Ms. Stefka Nikolova
Dept. of Geology, Mar. Sci. Prog., and the Baruch Institute

Project Interface is a goal-oriented program for undergraduates to attain the skills of scientific thinking, methods, and communication through (1) individualized learning in an environment of collaborative team learning, (2) faculty and graduate student "coaching" and mentoring, and (3) a progression of integrated research and educational experiences. The program exposes students to the excitement of discovery, and the "Quest for understanding" through meaningful research. An on-going training program (with the scientific theme of "Biogeochemical cycling and benthic-pelagic coupling at the marine and freshwater interface in Winyah Bay, South Carolina) lets undergraduate students learn at their own pace while more experienced students assume leadership roles as they gain knowledge and maturity. The students learn to overcome the fear of not knowing everything and become comfortable with the strategies that more senior scientists use for integrating information from a variety of sources and disciplines. From this process, each student attains an ability to exercise critical thinking and obtain a higher understanding of complex scientific problems. The project's goals and objectives are consistent and complimentary to appropriate regional and national scientific and educational initiatives.

The COASTeam Program: A unique course in Marine Science for Elementary teachers

Investigators: Wendy Allen, Dr. Phil Astwood, Dr. Leslie Sautter, and Dr. Robert Young
Baruch Marine Laboratory, USC; Center for Science Education, USC; College of Charleston; Coastal Carolina University;

The COASTeam Program is a unique year-long graduate level course in marine science funded by the South Carolina Sea Grant Consortium, in which teams of elementary teachers, or

COASTeams, are trained in marine science concepts and hands-on activities. Each COASTeam represents an elementary school committed to improving the integration of marine science into the science and non-science curricula. The objectives of the program are to: (1) increase confidence levels of teachers with respect to teaching marine science; (2) bridge existing gaps between teachers and scientists; (3) disseminate marine science education materials developed specifically for South Carolina teachers; (4) create regional networks of schools that have participated in the COASTeam Program to increase facility and resource sharing; and (5) assist and encourage each participating school to move toward permanent integration of marine science into the school's curriculum. Twenty five teachers from Georgetown County are participating in the COASTeam Program sponsored by the Baruch Institute.

Estuary-Net Project - National Estuarine Research Reserve System

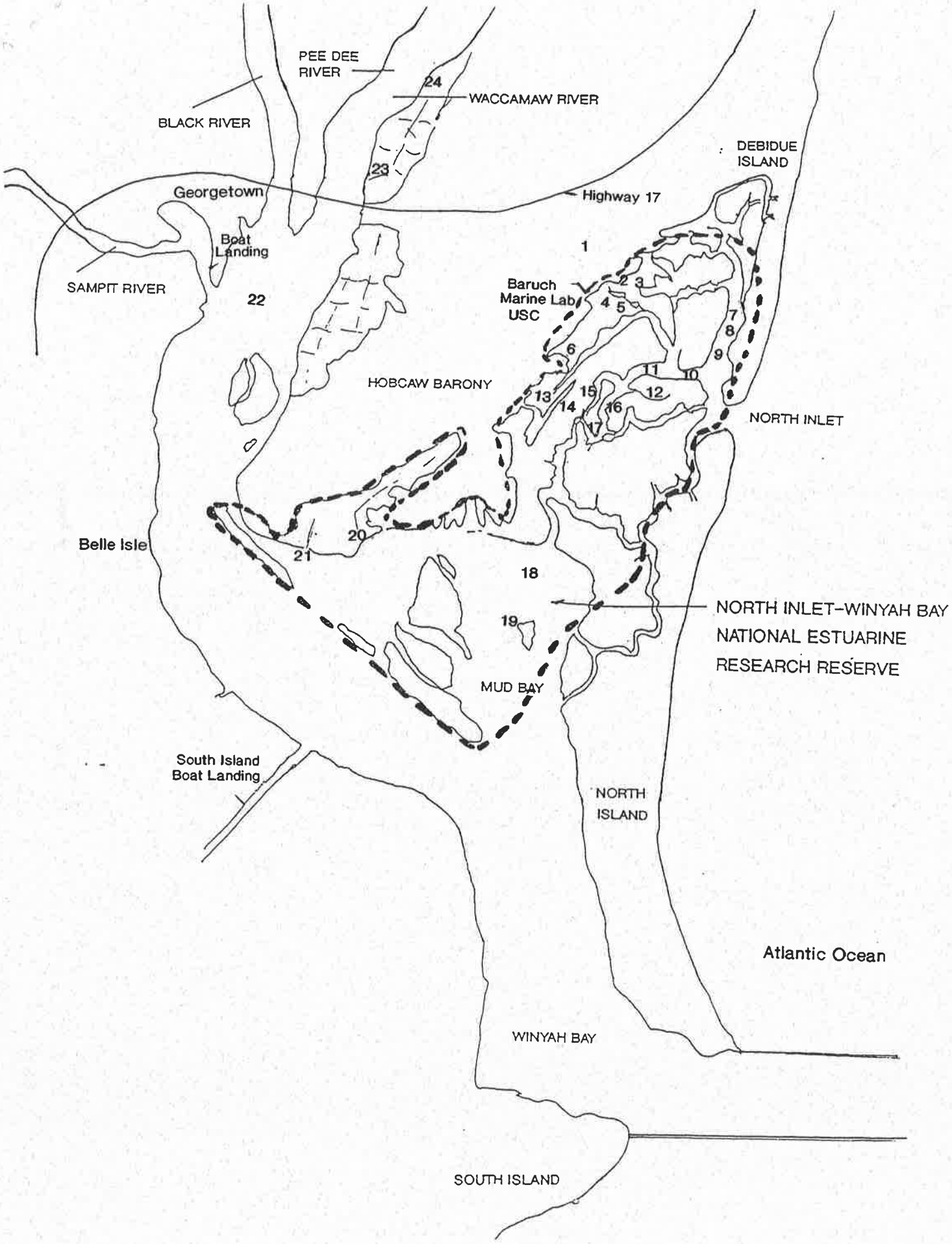
Investigators: Wendy Allen, Elizabeth King, Dr. Joseph Schubauer-Berigan, and Beth Thomas
North Inlet-Winyah Bay NERR and Baruch Marine Laboratory, USC

Estuary-Net is a national educational telecommunications project that investigates non-point source pollution and supports watershed management. Education materials were created for this project by Wells National Estuarine Research Reserve (NERR) in Maine to provide a framework through which high school classrooms and volunteer groups become researchers for their community in its effort to solve watershed management problems. Instructional units are inquiry-based, experiential, learning-style sensitive, interdisciplinary, and relevant. Activities are designed for grade eight to adult. High school students conduct hands-on investigations in the classroom and field to learn about water quality in their watersheds and estuaries. Classes form partnerships and share collected information with each other, researchers at participating NERR sites across the US, local officials, and state coastal zone management programs through the Internet. The teams also work towards solving non-point source pollution problems in their regions. Students gain an understanding of their connection to and the importance of estuaries, and the impact upland activities have on these ecosystems.

Centralized Data Management Office in support of the System-wide CZM/NERRS Environmental Monitoring Program in the National Estuarine Research Reserve System

Investigators: Dwayne E. Porter, Dennis Allen, Ginger Ogburn-Matthews, Mark Crane, and Jeff Jefferson
Belle W. Baruch Institute for Marine Biology and Coastal Research, USC

NOAA's National Estuarine Research Reserve System (NERRS) has recognized the importance of both long-term environmental monitoring programs and data and information dissemination with the implementation of the NERRS System-wide Coastal Zone Managers/NERRS Environmental Monitoring Program. This program has been established 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 planning analysis. The Centralized Data Management Office (CDMO) was established in support of the System-wide CZM/NERRS Environmental Monitoring Program. The purpose of the CDMO, housed at the North Inlet-Winyah Bay, SC NERR, is the development, implementation, and management of the basic infrastructure and data protocol to support the assimilation and exchange of data, metadata, and information within the framework of NERRS sites, state coastal zone management programs and NOAA/OCRM, as well as other state and federally-funded education, monitoring, and research programs.


PEE DEE
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NATIONAL ESTUARINE
RESEARCH RESERVE
MUD BAY
South Island
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ISLAND
Atlantic Ocean
WINYAH BAY
SOUTH ISLAND