

## SUMMARY OF CURRENT RESEARCH PROJECTS

Baruch Marine Field Laboratory, University of South Carolina

Summer 1995 - Spring 1996

More than 400 scientific research projects and 250 student theses and dissertations have been completed by Baruch Institute research associates since 1969. This work has resulted in the publication of more than 1000 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 53 research projects currently being conducted by staff, graduate students, and faculty associated with the Baruch Institute. A wide variety of basic and applied research is represented. Most of the field-oriented studies listed are based in the North Inlet-Winyah Bay National Estuarine Research Reserve. Specific research sites are indicated for most of these projects on the attached map. A larger, more detailed display may be found in the lobby of our main Laboratory building. Although many other investigators presently use the Field Laboratory to support their studies, the list includes only those projects which make most 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. For more information, please contact the individual investigators, Dr. Dennis Allen, or Dr. David Bushek at 803-546-3623.

### **LONG-TERM MONITORING AND RESEARCH**

#### 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 locations 4 A-B.

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

Investigators: Danny Taylor, Dr. Dennis M. Allen, and Dr. Joseph Schubauer-Berigan  
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 10 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. 1.

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

Investigators: William Johnson, Dr. James Morris, 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 locations 2 A-C.

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

Investigators: Dr. Dennis M. Allen, Paul Kenny, and Chris Spruck  
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. 3.

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 1981. Small invertebrates, less than 90 microns in size, comprise the meiofauna. The meiofauna study was initiated in 1973 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 locations 20 A-B.

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

Investigators: Ginger Ogburn-Matthews, Paul Kenny, Chris Spruck, and Dr. Dennis 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 Allen, and Dr. David Bushek  
Baruch Marine Laboratory, USC

Oyster reefs are an important component of the estuarine ecosystem that 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. 6.

Dermo disease in North Inlet: spatial and temporal epizootiology in various host species

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 has a significant impact on the commercial and recreational oyster fisheries because it kills large numbers of oysters each year. Seasonal patterns of intensification and remission of Dermo disease on oysters are well known and have been correlated with several environmental parameters. In contrast, little is known about the parasite's effect on populations of other host species (about a dozen have been identified), nor its effect on the estuarine ecosystem. Last fall we began monitoring the prevalence and intensity of *Perkinsus marinus* in a

variety of invertebrates throughout North Inlet. Prevalence and intensity declined during the winter and spring in oysters, but are expected to rise during the summer. Infections were absent in all other organisms examined.

#### Long-term monitoring of white ibis nesting

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

An annual census of white ibis and other nesting birds is being conducted on Pumpkinseed Island to determine relationships between year to year variations in nesting, spring rainfall, and other conditions. The number of white ibises breeding at the site plummeted from an average 7,000 pairs in the 1980's to zero nesting birds in 1990 following Hurricane Hugo. Use of the island increased in 1991 with 500 pairs observed, 2,500 pairs were seen in 1992, and 4,000 pairs used the site in 1993. Numbers decreased to about 1,000 in 1994 and 150 in 1995. Historically, nesting has been linked to spring rainfall which affects the availability of prey in nearby freshwater swamps where adults must procure "salt-free" food for their young. Spring 1995 was one of the driest in recent decades. See map location No. 7.

### **BIOGEOPHYSICAL AND CHEMICAL PROCESSES**

#### Groundwater dynamics at the forest-marsh boundary

Investigators: Dr. L. Robert Gardner, Dr. Howard Reeves, Pete Thibodeau, and Bob Pickard  
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. 8.

#### 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. 9.

#### Tidal and Diurnal Variations in Wave Characteristics and Their Relationship to Morphology on Two Beaches in South Carolina

Investigators: James MacMahan  
Department of Geological Sciences, USC

This study will quantify the ratio of wave power ( $\text{kg m s}^{-3}$ ) between high and low tide at Dewee's Island, SC (an erosional beach system) and at the Isle of Palms, SC (a depositional beach system). Wave power varies tidally and diurnally, and it is thought that the ratio of wave power between high and low tides determines if the beach is erosional or depositional. It is hypothesized that if the ratio is large, the beach will more likely be erosional. The study will also model the effects of shoaling and refraction for these two barrier island shores to evaluate changes in wave power. As a part of my project, I have designed and constructed a digital wave sensor. Four wave sensors will be deployed for 28 days sampling at 1 Hz every hour for fifteen minute bursts on the two beaches.

### Microbial nitrogen cycling in estuarine and riverine sediments

Investigators: Dr. J. Schubauer-Berigan and D. 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.

## **BIOLOGY AND ECOLOGY**

### Use of flooded marshes by migratory fishes and crustaceans

Investigator: Dr. Dennis Allen, Paul Kenny, Ginger Ogburn-Matthews, and Chris Spruck  
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 with lift nets. Replicate nets buried at different elevations along a transect extending from the tidal creek bank to the high marsh are lifted at predetermined stages of the tide to capture tidal migrants. The zonation and patchiness of animals varies among species and life stages. 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. 10.

### The distribution and abundance of white shrimp postlarvae *Penaeus setiferus*

Investigator: Jon Porthouse and Dr. Robert Feller  
Dept. of Biol. Sci. and Mar. Sci. Prog., USC

The goal of this study is to determine if, and to what extent, postlarvae of the white shrimp *Penaeus setiferus* utilize the vegetated marsh surface. An array of drop nets throughout the *Spartina alterniflora* zone are used in conjunction with plankton tows and epibenthic sled tows in the associated tidal creek during night-time high tides to determine the abundance and distribution of these organisms. Results will aid in understanding sources of mortality for the young size classes of this valuable commercial species. See map location No. 11.

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

Investigators: Jennifer L. Halls and Dr. Robert Feller  
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, five 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 of

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.

#### 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.

#### 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. 12.

### 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. 12.

### Chemically mediated interactions in a sedimentary assemblage

Investigators: Dr. Charles Lovell, Dr. Sarah Woodin, Dr. David Lincoln, and Charles Steward  
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. 12.

### 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.



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.

Larval settlement and cannibalism in oysters: Potential vs. realized predation by a suspension feeder

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

Larval recruitment often determines the abundance and distribution of benthic invertebrates. Frequently, chemical cues mediate settlement site selection while larval predation controls the numbers of potential recruits. Oyster larvae are known to settle gregariously; however, adult oysters are suspension feeders and will ingest large prey. Therefore, larval cannibalism may control oyster recruitment and population dynamics. This study demonstrates that larvae of oysters actively settle in response to waterborne compounds released by adult conspecifics and adult oysters readily consume conspecific larvae (with nearly 100% post-capture mortality). Using dye visualization and Laser Doppler Velocimetry, it was determined that oysters act as passive suspension feeders under natural flow conditions; therefore, the step limiting the magnitude of cannibalism is the delivery of larvae to the gape of the oyster. Observations of settling behavior among feeding adults reveals that <3% of the larvae passing within 5 mm of the outer shell margin are delivered to the mantle cavity, so capture is rare. It appears that the settlement behavior of oyster larvae to waterborne cues not only aids in settlement site selection but may also help to prevent cannibalism.

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.

#### 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. See map location No. 13.

#### Chemical Ecology and Marine Carnivory: The role of free amino acids as natural feeding attractants

Investigators: John E. Commins and Dr. Richard K. Zimmer-Faust  
Dept. of Biol. and Mar. Sci. Prog., USC

The general consensus is that low molecular weight substances (amino acids, nucleotides and nucleosides, quaternary ammonium compounds, and organic acids) are the principal chemical attractants in aquatic environments. However, behavioral assays in natural habitats have never demonstrated the ability of such compounds to invoke chemotactic responses in aquatic animals at concentrations and release rates of natural prey. We have been investigating the chemical attraction of the mud snail *Ilyanasa obsoleta* to mixtures of dissolved free amino acids (DFAA), replicating the leakage rate and concentrations of amino acids from carrion of two naturally occurring snail prey items, the hard clam *Mercenaria mercenaria* and the fiddler crab *Uca pugilator*. Our results indicate that DFAAs in natural aquatic habitats can induce a feeding response in the mud snail. However, the scope of such attraction is limited due to the low production levels of amino acids from certain mud snail prey. We have also demonstrated that chemical attraction is not dependent upon amino acid composition, but rather the total amount of DFAAs present in carrion prey sources. Furthermore, we have shown that flux (the number of molecular encounters over time) governs the success of animals to actively locate prey items. Currently, we are developing a method to characterize odor plumes emanating from carrion sources in a natural tidal creek habitat through fast temporal scale measurements via the use of microelectrodes and a computer recording system to sample a low molecular weight electrochemical (dopamine).

#### Partial characterization of chemical attractants mediating a marine predator-prey interaction

Investigators: Steven Viscido, Dr. Kenneth Browne, Daniel Schar and Dr. Richard Zimmer-Faust  
Dept. of Biol. and Marine Science Program, USC

Chemical cues play an important role in attracting marine predators to prey. In this investigation, we are working to identify the substances released by infaunal clams that encourage predation by blue crabs. Both field and laboratory bioassays have been developed to determine the molecular structures of prey attractants evoking crab searching and feeding responses. Compounds released by living clams into seawater are used as the source of attractant

material. Freshly caught crabs are fitted with small backpacks consisting of two thin polyethylene tubes threaded in plastic guides glued onto the dorsal shell and chemical stimuli are delivered to one side of the head. Rapid hollow fiber dialysis and bioassay has demonstrated that the attractants are < 1000 molecular weight. The attractants are also principally ethanol soluble, degraded by acid hydrolysis, and at least partially digested by peptidases cleaving amino acids residues from the C-terminus. We are currently testing an hypothesis that the principal attractants are either low molecular weight peptides or glycopeptides. Selective enzyme degradations are now being used as probes to more completely identify the structural features of these attractant molecules. Results from this project will provide important insight on fundamental mechanisms regulating marine predator-prey interactions.

#### Physical cues for loggerhead sea turtle nest location

Investigators: Bonnie Willis and Dr. Eric Koepfler  
Coastal Carolina University

The objective of this project is to determine if thermal cues, beach slope, water content, and sand granulometry affect the location of nesting by loggerhead sea turtles. At four neap and four spring tides, ten beach transects will be analyzed for water content and temperature every two meters from the dune face to three meters below the last high tide mark. Weekly measurements of temperature and water content will be taken from four equidistant locations around turtle nests at a depth of 18 cm. Three diel measurements of transects and turtle nests will be taken during the nesting period. Temperature and water content will be analyzed every three hours for twelve hours at three preselected transects. Temperature and water content will also be analyzed every two hours for twenty-four hours at three preselected nests. Beach slope and sand granulometry will be measured three times over the nesting period. Grainulometry samples will be taken at the three selected nests and beach slope will be measured along every transect. Results will be correlated with the distribution and abundance of nests in an effort to understand the importance of these physical parameters in the selection of nesting sites.

#### 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 microscopic protozoan *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* are being collected from individual oysters at several spatial scales and cultured *in vitro*. A genomic library has been constructed and is currently being searched for regions with enough variability to differentiate isolates. Restriction fragment length polymorphism and DNA sequence analysis will then be used to determine population structure using the *in vitro* cultured isolates. Results will help identify the source population(s) of the recent northern range expansion and the mechanisms of dispersal. Knowledge of the population genetic structure will also 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.

Infectivity and virulence of wild and laboratory strains of *P. marinus*

Investigators: Dr. Susan Ford, Marnita Chintala, and Dr. David Bushek  
Haskin Shellfish Laboratory, Rutgers Univ. and Baruch Marine Laboratory, USC

The recent development of *in vitro* to culture methods for *Perkinsus marinus* has significantly improved our ability to study this devastating oyster parasite and its interaction with the eastern oyster *Crassostrea virginica*. We are comparing the response of oysters to *P. marinus* from laboratory cultures against parasites collected directly from infected oysters. Preliminary results indicate that cultured cells are both less infective and less virulent than wild cells. Infectivity and virulence are lost immediately upon *in vitro* culture. Differences in recognition of the parasite cells appears to be a primary cause. Oysters reject cultured cells 10 to 50 times more frequently than wild cells when feeding. Regardless of cell type, infectivity increases with inoculation methods that bypass natural barriers to infection. For example, injection into the adductor muscle, which bypasses the sorting mechanisms of particles entering the mouth, generates heavier infections than injecting cells into the shell cavity. Continuing studies are comparing chronic (natural) vs. acute (laboratory) exposure.

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. 14.

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 chaetoptera* 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 under known feeding regimes in the laboratory. The initial stages of the relationship are being examined by observing larval crab settlement in the field as well as in the laboratory where chemical and physical conditions can be manipulated. Video, doppler flow probe, and oxygen measurement techniques are used to quantify the effects of crabs on water flow, food capture, and oxygen consumption of the worms. The work will be useful in understanding evolutionary trends in marine symbiosis. See map location No. 15.

### Microbial mediation of environmental stresses

Investigators: Dr. Charles Lovell and Yvette Piceno  
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 developed the necessary molecular tools and are currently profiling the microbial nitrogen communities associated with roots of tall and short *Spartina*. Correlations between environmental stressors, rates of N<sub>2</sub> fixation, plant productivity, and NFB community structure will be determined, allowing definition of the influence of NFB communities on *Spartina* productivity. See map location No. 16.

### Microbial food web structure/function in North Inlet

Investigators: Dr. Alan Lewitus, Dr. Eric Koepfler, Gloria Lyons, Scott Sellers, and Bonnie Willis  
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 piscimorte*) has been discovered throughout southeastern U.S. estuaries (including Charleston Harbor), and was the causative factor in >30% 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, Dr. Todd Kana, Scott Sellers, Gloria Lyons, and Bonnie Willis  
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 I. 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. J. Schubauer-Berigan and D. 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.

## **HUMAN IMPACTS: HABITAT ALTERATION, POLLUTION, AND MANAGEMENT**

### Effects of coastal development on watershed ecology

Investigators: Matt Wahl, Dr. Hank McKellar, Dr. Tom Williams, Dr. H. Aelion, Dr. Tomohiro Kawaguchi, and William Johnson  
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. 17.

### Development of a predictive model for assessing wetland alterations

Investigator: Dwayne E. Porter, Dr. F. John Vernberg, and Dr. 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: 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.

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. 19.

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. 18 A-C.

Meiofaunal microcosms to detect pollution

Investigators: Drs. G.T. 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.



### Species composition of meiofauna in contaminated Murrells Inlet sediment vs North Inlet sediments

Investigators: Nicholas Schizas and Dr. B.C. Coull  
Mar. Sci. Prog., USC

The Murrells Inlet and North Inlet Estuaries are similar in size and geography, but Murrells Inlet has been extensively developed and urbanized. To complement a large study that is examining the effects of urbanization, we are comparing meiofauna species in contaminated vs non-contaminated sediments. After species composition is determined, we will experimentally manipulate the communities to determine the resilience of dominant species.

### Cycling and biological accumulation of organic contaminants in Winyah Bay

Investigator: Dr. Tim Shaw  
Dept. of Chemistry, USC

Typically, fine grained sediments are reservoirs for contaminants such as PCBs, reflecting the history of pollutant input to the bay system. These sediments are observed as contaminant hotspots in several areas of Winyah Bay. In contrast, pesticides are quite soluble and vary as a function of seasonal river runoff. Our goal is to determine if these contaminant sources produce measurable and persistent exposure to the local population through elevated concentrations in local waters and/or in local fish. Our first task will be to measure organic pollutants in sediment, water, and fish samples from sites of varying contaminant load in Winyah Bay. Levels of contamination in bay samples will be compared to more pristine samples from North Inlet. Next, we will use radioisotopes to measure the rate of contaminated sediment transport out of the bay and ultimately make estimates of the persistence of the reservoir of contaminants.

### 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 river and estuarine waters and impact of locculation of dissolved organic matter as a capturing mechanism for organic contaminants.

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

Investigators: Drs. Subhash 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.

#### Trophic transfer of an organophosphate pesticide from benthos to fish

Investigators: Lisa DiPinto, Teresa Donelan, and Dr. Bruce Coull  
Marine Science Program, USC

Spot are dominant fishes in local estuaries that obtain their food by sieving small benthic invertebrates from mouthfuls of sediment. Meiobenthic copepods exposed to contaminants may facilitate the transfer of pollutants from sediments to fishes. In this laboratory study, radio labeled Azinphosmethyl (a pesticide) is added to sediments where it is taken up by copepods. The copepods are then fed to juvenile spot. Subsequently, the concentration and localization of the chemical in the fish are determined with liquid scintillation chromatography. One goal is to develop a model system to trace the path of contaminants through estuarine food webs. Another is to develop an assay technique which will be more sensitive and less expensive than existing ones. The results will provide insights into physiological processes at the cellular and tissue levels.

#### Development of two-dimensional fluorescence for environmental monitoring of contaminants

Investigators: Dr. M.L. Myrick, Dr. K.S. Booksh, A.R. Muroski, M.D. Lovelace, and A.E. Fritz  
Dept. of Chemistry, USC

Aromatic hydrocarbons (originating from both natural and man-made sources) are pervasive environmental contaminants of estuarine waters. Conventional methods for detecting aromatic hydrocarbons in water (e.g. gas chromatography - mass spectrophotometry) rely on transporting water samples to a laboratory for analysis that often requires a week or more to complete. While extremely sensitive and accurate, such cumbersome and expensive procedures prevent extensive study of transport phenomena for aromatic compounds in aquatic environments. Fluorescence is an extremely sensitive method for detecting certain aromatic compounds. Specific wavelengths of light excite these compounds to a higher energy state, causing them to fluoresce (i.e. emit light at a different wavelength) which can be measured and used to identify the compound. Detection limits typically approach or exceed 1 ppb. At the Baruch Marine Laboratory, we have been developing instrumentation and analysis methods for a new type of fluorescence spectroscopy, Excitation-Emission-Matrix (EEM) spectroscopy to enable near-real-time measurements of aromatic hydrocarbon contaminants in the field. EEM spectroscopy employs a range of excitation and emission wavelengths simultaneously. The resulting EEM spectrum has the format of an "image" rather than a "spectrum", and contains sufficient information to differentiate contributions from distinct chemical species in the mixture, including pesticides and naturally occurring materials like humic acids.

