CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS

2013–2014

Baruch Marine Field Laboratory
(BMFL)

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

University of South Carolina

Belle W. Baruch Institute
for Marine & Coastal Sciences

North Inlet-Winyah Bay
National Estuarine Research Reserve

Current Research, Monitoring, and Education Projects
2013–2014

Introduction

Since 1969, Baruch Institute research associates have completed more than 710 scientific research projects at the Baruch Marine Field Laboratory (BMFL), and students have completed hundreds of theses, dissertations, and special research projects. All of this work as well as projects conducted in other locations in SC, the USA, and globally has resulted in the publication of more than 1,685 scientific articles, reports, and books that contribute new information in subject areas ranging from molecular biology to landscape ecology. The accumulating information provides a fundamental understanding of the structure, function, and condition of coastal ecosystems. Results of research projects are used by educators, coastal resource managers, health and environmental regulators, legislators, and many other individuals and organizations interested in maintaining or improving the health of estuaries in the face of increasing human activities in the coastal zone.

The following annotated list summarizes 66 projects currently being conducted at the BMFL by staff, graduate students, and faculty associated with the University of South Carolina and other institutions. The University of South Carolina is the home institution for 43 of the investigators conducting research at the BMFL. In addition, 67 investigators representing 32 other institutions and agencies are carrying out projects at the BMFL. Dozens of graduate and undergraduate students assist scientists throughout the year to obtain hands-on training in field methods and to conduct research.

A wide variety of basic and applied research is represented. The projects are listed randomly and each project summary includes the title, investigators, affiliations, and project abstract. This list includes only those projects that make regular use of the site. Most of the studies that involve field measurements and collections are being conducted within the North Inlet–Winyah Bay National Estuarine Research Reserve (NI–WB NERR).

Funds for these research projects are provided by a variety of sources, including the National Science Foundation (NSF), Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA) National Estuarine Research Reserve System (NERRS) and SC Sea Grant Consortium, US Department of Energy (US DOE), US Dept. of Defense (DoD), Office of Naval Research (ONR), National Aeronautics and Space Administration (NASA), and the SC Department of Health and Environmental Control (SC DHEC). The Friends of the Institute, an independent organization that supports Baruch Institute activities, also provides assistance and the Belle W. Baruch Foundation provides the long-term stewardship of Hobcaw Barony, maintaining it in a natural state for research and education.

For more information, please contact the individual investigator(s), Dr. Dennis Allen, or Dr. Matt Kimball. Paul Kenny facilitates researcher use of the BMFL and is available for training and assistance. All BMFL staff can be contacted at 843-546-3623. Information can also be obtained from the Institute's website (www.baruch.sc.edu).

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Enabling linkages between climate change and ecosystem management: Facilitating access and collaboration to long-term fishery and environmental data

Investigators: Drs. Dennis M. Allen[1], Dr. Kenneth W. Able[2], Dr. Jeff Buckel[3], Dr. Todd Kellison[4], Dr. Chris Taylor[4], Dr. Marcel Riechert[5], Dr. Pat Campfield[6], and Dr. Jon Hare[7]

1 - Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay NERR
2 - Rutgers University Marine Field Station and Jacques Cousteau NERR (NJ)
3 - Center for Marine Sciences & Technology, NC State University
4 - NOAA Center for Coastal Fisheries and Habitat Research (NC)
5 - South Carolina Department of Natural Resources
6 - Atlantic States Marine Fisheries Commission (VA)
7 - NOAA / NEFSC / NMFS, Woods Hole and Narragansett Laboratories (MA)

Investigators at three U.S. east coast sites where ichthyoplankton (larval fish) have been regularly collected for at least 25 years are working together with state and regional fishery management groups to make those long-term data available for use in managing fisheries species stocks. The North Inlet dataset for demersal zooplankton is the longest running and continuous time series for east coast estuaries, and combined with concurrently collected larval fish samples from Beaufort, NC and Great Bay, NJ, unique and valuable information about the relative timing of larval recruitment, duration of spawning periods, relative abundance, and other attributes will be available to inform the development of stock assessment models and other management tools. More than 50 species of larval fishes have been identified from North Inlet so far, and continued processing of archived collections should reveal insights into whether and how species of both economic and ecological importance have responded to changing climatic conditions. Because all three sites are within National Estuarine Research Reserves, long sets of corresponding measurements of environmental variables are available to interpret patterns of larval fish occurrences. Meetings between state and regional fishery management groups will ensure maximum usefulness of the scientific data. The project is funded by the NOAA NERRS Science Collaborative program.

Effects of life histories throughout the annual cycle of tidal marsh sparrows

Investigators: Alyssa Borowske[1], Dr. Chris Elphick[1], Kim Trinkle[2], and Dr. Chris Hill[3]

1 - Ecology and Evolutionary Biology Department, University of Connecticut
2 - Coastal Marine and Wetland Studies Program, Coastal Carolina University (SC)
3 - Department of Biology, Coastal Carolina University (SC)

Saltmarsh (*Ammodramus caudacutus*), seaside (*A. maritimus*), and Nelson's (*A. nelsoni*) sparrows are short-distance migrants whose threatened populations winter exclusively in tidal marshes in the southeastern United States. While closely related and with similar habitat requirements, the three species have different strategies regarding territoriality, monogamy, and parental care, which lead to distinct predictions regarding events and processes throughout the annual cycle. Little is known about migration patterns or survival and condition of these sparrows, but the information will be important for determining in which season, and in which region, conservation efforts should be concentrated. Through extensive mist-netting during the non-breeding period in South Carolina and the breeding period in Connecticut (saltmarsh and seaside only), we use key comparisons between species, within species (separated by sex), and across seasons to investigate differential migration patterns and within-season condition and survival. In North Inlet, we capture sparrows at high tide roosts, visiting each site three times annually, between December and March. We band, weigh, and measure the sparrows, assess fat, muscle, and feather condition, and collect feather samples as a source of DNA for genetic sexing. Non-breeding season data are also collected at sites in North Carolina, Georgia, and Florida.

Assessing the vulnerability of coastal bird species to sea-level rise in South Carolina

Investigators: Nicolette Roach and Dr. Kyle Barrett

School of Agricultural, Forestry and Environmental Sciences, Clemson University (SC)

Our primary research goal is to understand vulnerability of coastal marsh birds in South Carolina to sea-level rise, the landscape variables influencing their survival, and predation and inundation pressures on nesting birds. From March to June 2013, occupancy surveys of clapper rail, black rail, least bittern and seaside sparrows were conducted throughout Winyah Bay and North Santee River, Georgetown. Four transects, each containing nine points, were surveyed three times using an eight minute broadcast vocalization survey derived from a standardized protocol. Five minutes of silence were followed by three minutes of calls: thirty seconds of calls then thirty seconds of silence. In addition, seaside sparrows were observed passively. This methodology was repeated at sites in the ACE Basin region. Marsh

birds are good indicators of habitat quality. Although clapper rails are one of the most abundant rails along the South Carolina coastline little has been done to monitor and study them, even less is known of the elusive black rail. We aim to understand local and landscape-level habitat associations for these birds and project these habitat associations onto future models of the coast following sea-level rise.

Spatial and temporal variability of mercury distribution and cycling in salt marshes

Investigators: Dr. Sarah Rothenberg and Dr. Si Chen

Department of Environmental Health Sciences, University of South Carolina

The purpose of this project is to: 1) Observe the temporal and spatial variability of mercury methylation in salt marsh, 2) Determine the environmental factors that control the variation in mercury methylation, 3) Investigate the mercury transportation and cycling in tidal runoff. This project is motivated by a previous investigation by Dr. Rothenberg who observed that mercury methylation varied temporally and was significantly different between tidal creek and marsh platform in a salt marsh in southern California. We plan to conduct a similar investigation in North Inlet to compare with previous results. We propose to collect time series measurements of pore water and sediment samples over two tidal cycles at a tidal creek, low *Spartina* marsh, high *Spartina* marsh and *Juncus* marsh in order to understand both the temporal and spatial variability. pH and Eh will be monitored in pore water and samples will be collected for analysis of bulk dissolved organic carbon and nitrogen, plant density, roots density, as well as total mercury and methylmercury, in order to determine the effects of various environmental factors on the mercury methylation in salt marshes. In addition, both solid and liquid phase of mercury and methylmercury from surface water will be collected simultaneously and analyzed for pH, DO, etc in order to investigate mercury transport and cycling in tidal runoff. This project investigates mercury cycling in an unpolluted site. The understanding of mercury transport and methylation provided here should be useful as background information for other sites.

Demersal fish habitat use and site fidelity patterns

Investigators: Dr. Juliana M. Harding[1], Dr. Dennis M. Allen[2], Eric Haffey[1], and Kyle Hoffman[1]

1 - Department of Marine Science, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina

Habitat use patterns of demersal oyster reef fishes including naked gobies (*Gobiosoma bosc*), and crested (*Hypleurochilus geminatus*), feather (*Hypsoblennius hentz*), freckled (*Hyposblennius ionthas*), and striped (*Chasmodes bosquianus*) blennies in Crabhaul Creek, North Inlet are being examined. Artificial nesting substrates and passive integrated transponder (PIT) tags have been and will continue to be used to describe habitat use patterns of resident fishes through 2014. Regular surveys will provide information on site fidelity and home range for individual fishes as well as demographics of resident fish populations.

Kleptoplasty in the North Inlet and Winyah Bay estuaries

Investigators: Dr. Megan Cevasco and students

Department of Biology, Coastal Carolina University (SC)

Kleptoplasty is a term used to describe the ability of a heterotrophic host organism to "steal" the photosynthetic organelles (plastids) of its prey. Stolen plastids (kleptoplasts) remain functional within the host for extended periods of time and enable the host organism to photosynthesize and obtain energy through autotrophic CO_2 fixation, as well as from heterotrophic feeding: a condition known as "mixotrophy." Mixotrophy due to the kleptoplastic condition has been shown to have important stabilizing effects on the trophic structuring in ecosystems by increasing the total primary and secondary production in planktonic food webs. In the last decade, multiple foraminifera genera have been found to harbor kleptoplasts; *Elphidium* and *Haynesina* are two of the most common inhabitants of the Western Atlantic estuarine and tidal marsh habitats. The primary aim of this study is to identify and examine the potential ecological contribution of the kleptoplastic condition in the foraminiferal taxa inhabiting North Inlet and Winyah Bay by determining the presence and abundances of kleptoplastic foraminifera. As part of this study, molecular and microscopic techniques will be used to determine the taxonomic identification of the foraminiferal hosts as well as the plastid donors. Exploratory feeding and photo-inhibition experiments will be conducted on subsamples of kleptoplastic foraminifera to assess the prevalence and robustness of the kleptoplastic condition as it contributes to primary production and the tropic ecology of Winyah Bay. Surveys of micro-algal and foraminiferal biodiversity in estuarine habitats will also be undertaken.

Development of monitoring and assessment tools for nitrogen and phosphorus in South Carolina coastal wetlands

Investigators: Dr. Dianne Greenfield[1,2], Dr. Robert Van Dolah[2], and students

1 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
2 - South Carolina Department of Natural Resources

It is generally accepted that elevated levels of nitrogen (N) and phosphorus (P) are associated with eutrophication in a wide range of aquatic systems. Yet, surprisingly little is known about how variable nutrient levels affect phytoplankton community composition and the resultant primary productivity of coastal South Carolina estuaries. Elucidating the interactions between estuarine nutrient levels and phytoplankton communities in SC is central to understanding ecosystem function. In addition, this relationship is especially timely since coastal SC is experiencing rapid urbanization which contributes to the deposition and accumulation of nutrients and fertilizers, thus potentially making SC estuaries susceptible to nutrient loading, particularly from N. The goal of this project is to assess biological (phytoplankton) responses to various nutrient conditions across the SC coastal zone. Methods include interannual field monitoring and both field and laboratory experimentation. One of the experimental field sites is Thousand Acre Marsh (TA), on Hobcaw Barony. At TA, we are conducting seasonal, 48-hr nutrient addition bioassays over a 2-year time frame to assess phytoplankton community responses to a variety of nutrient conditions. This is accompanied by ISCO-based autosampling (24 hrs) and water quality data from deployable YSIs. Results will not only help us better understand the nutrient conditions of TA, they will also assist regulating agencies in establishing numeric criteria for nutrient inputs to the SC coastal zone.

Community restoration through artificial oyster reef construction at Bly Creek in North Inlet estuary, SC

Investigators: Thomas Funk and Dr. Keith Walters

Department of Marine Science, Coastal Carolina University (SC)

The proposed research activities within the North Inlet–Winyah Bay NERR are designed to assess the potential effects of oyster reef construction on reef development and reef-associated fishery species in a tidal system with widespread existing oyster reefs. Restoration involves placing locally collected shell stock from the waters surrounding the Baruch Marine Field Laboratory which has been quarantined appropriately to prevent disease transmission. Shell will be transported to the proposed restoration site along Bly Creek in mesh bags. Two reefs approximately 15 m^2 each were constructed in the low intertidal zone in late May 2013. Pre-restoration fishery sampling began in April 2013 and will continue until November 2013. Fishery sampling will consist of pull tray, settlement tray (0.3 x 0.4 m), spat collectors (clay tiles ≈ 9.6 cm^2), baited killitrap, and gill net samples. Constructed reef development will be monitored yearly in the fall as part of the curriculum in Coastal Carolina University's Marine Ecology class. If the ongoing assessment suggests constructed reefs are not developing sufficiently along the trajectory of a natural reef, plans will be made to remove the constructed reefs and return the intertidal area to preconstruction conditions. North Inlet estuary tidal creeks are critical to the project because, as a pristine system, the estuary is a natural control or reference location.

Secondary effects of rhizocephalans on the physiology and behavior of flat-backed mud crabs

Investigators: Benjamin Belgrad[1], Benjamin Toscano[2], Burns Newsome[1], and Dr. Blaine Griffen[1,2]

1 - Marine Science Program, University of South Carolina
2 - Department of Biological Sciences, University of South Carolina

The parasitic rhizocephalan barnacle *Loxothylacus panopei* is known to alter the behavior and morphology of the flat-backed mud crab (*Eurypanopeus depressus*) so that the crab can better brood the parasite's eggs. However, the secondary effects of these alterations to the crab have only recently been examined, with some studies suggesting that parasitic infection lowers crab functional response. This project seeks to determine how parasitic infection lowers the functional response by determining if the parasite modifies the metabolic and digestive rates of the crab as well as cause other behavioral changes. Metabolic and digestive rates for infected and uninfected crabs collected at Oyster Landing (33° 20.9883'N 79° 11.3285'W) and Clambank (33° 20.0375'N 79° 11.5757'W) were measured and behavior was monitored both in the lab and at the field locations. Because such changes can affect how the crabs interact with their environment and can alter predator-prey interactions, preliminary results suggest that parasitic infection has many more indirect effects on the saltmarsh ecosystem than previously ascribed.

Incorporation of a non-native seaweed into the food-web of southeastern estuaries

Investigators: Linsey Haram and Dr. James E. Byers

Odum School of Ecology, University of Georgia

This research focuses on the impacts of an invasive species, the seaweed *Gracilaria vermiculophylla*, on the food-web structure and ecosystem function of southeastern salt marsh estuaries. The fundamental question of this research is: How is this introduced species utilized by native consumers within the mudflats? The objectives of the project are to: 1) determine what abiotic conditions control *G. vermiculophylla*'s seasonal abundance; and 2) determine what organisms consume both live and decaying *G. vermiculophylla*. Every three months seasonal abundance surveys are performed at three sites within North Inlet, looking for changes in biomass of the exotic seaweed. Controlled laboratory feeding trials using different invertebrate and fish consumers are also conducted. The consumption of *G. vermiculophylla* is compared to that of *Spartina alterniflora* and *Ulva lactuca*, two native primary producers. Feeding assays are divided into three blocks: no-choice, choice, and control treatments. A total of 10 replicates are executed per treatment per consumer species, resulting in 50 replicates per invertebrate species. Each replicate is run in an individual container within the seawater flowthrough system. This procedure is applied for both live and decayed (sun-dried) primary producers. This project elucidates the role that *G. vermiculophylla* plays within the estuarine food web. The seasonal surveys last for two years from October 2012 to October 2014, while the feeding trials cease at the end of 2013.

Hard clam (*Mercenaria mercenaria*) population dynamics in North Inlet estuary tidal creeks

Investigator: Dr. Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Hard clam (*Mercenaria mercenaria*) populations play an ecological and structural role within tidal creek habitats. The population biology and dynamics of hard clams will be quantitatively examined in North Inlet tidal creeks with high density and low density oyster populations (live and shell). Hard clam age structure, growth rates, and sex ratios will be compared among these creeks. These population descriptors will be combined with measurements of environmental variables to describe clam population dynamics in tidal creeks and their effects on habitat structure within the creeks over multi-year time scales.

Aerial instrument array and ground-based LIDAR for integrated field studies of coastal system structure and processes

Investigators: Dr. Dennis M. Allen[1], Dr. James T. Morris[2], Dr. Scott White[3], Dr. Raymond Torres[3], Dr. James Pinckney[4], Dr. Dwayne Porter[2,5], Dr. Matthew E. Kimball[1], and Dr. Dianne Greenfield[2,6]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
3 - Department of Earth and Ocean Sciences, University of South Carolina
4 - Department of Biological Sciences and Marine Science Program, University of South Carolina
5 - Department of Environmental Health Sciences, University of South Carolina
6 - SC Department of Natural Resources

We have developed an imaging instrument array to measure and integrate physical, environmental, and biological data collected with instruments mounted on a tethered balloon (helikite) and on the ground. These instruments will provide new and unique insights into structure and processes at spatial and temporal scales not previously possible. Airborne hyperspectral, thermographic, and video cameras and a portable spectrophotometer will enable the mapping and quantification of primary productivity, temperature, suspended materials, water movement, animal distributions, and landscape features at scales of centimeters to kilometers and over a wide range of time periods. Ground-based LIDAR will provide three-dimensional topographic imagery of tidal marshes, creek basins, mudflats, oyster reefs, beaches, and other features. Landscape mapping and repeated measurements will be used to investigate factors affecting changes in topography, geomorphology, tidal inundation, plant distributions, productivity, and physiological states. Coupled with extant long-term time series measurements and process-oriented field experiments, the imaging instruments will be used to address impacts and mechanisms of change due to storms, warming temperatures, persistent droughts, sea-level rise, and other climate related factors. The instrument array is intended to encourage new research activity and collaborations among BMFL-resident, USC campus-based, and visiting scientists from other institutions.

Evaluation of changes in the phenology of demersal fishes, oysters, and their interactions

Investigators: Dr. Juliana M. Harding[1] and Dr. Dennis M. Allen[2]

1 - Department of Marine Science, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina

We are examining the effects of changing temperature on the phenology of demersal fishes (e.g., *Gobiosoma bosc*, *Chasmodes bosquianus*) and Eastern oyster (*Crassostrea virginica*). Demersal fish and oyster population biology within the Town Creek and Clambank Creek systems will be described throughout 2012-2014. Standard qualitative and quantitative methods will be used to describe adult densities, demographics, and biomass on a seasonal basis in concert with focused examination of fish nesting and larval biology in the creeks. Plankton collections from these creeks during 2012 and 2013 will supplement existing historic and modern mesozooplankton collections and enable us to evaluate phenological changes. Cultured fish larvae will be used to examine the predator-prey interaction with respect to prey type and predator age. Data collected during 2012 established a baseline for comparison with subsequent data collected during 2013 and 2014.

Assessing the status of MacGillivray's seaside sparrows, *Ammodramus maritimus macgillivraii*, in South Carolina

Investigators: Dr. Chris Hill and students

Department of Biology, Coastal Carolina University (SC)

MacGillivray's seaside sparrow is a habitat specialist bird, nesting and wintering exclusively in tidal marshes from North Carolina to northern Florida. South Carolina's extensive tidal marshes are at the core of the range of this taxon, but the status of passerine birds nesting in these marshes is poorly monitored by systematic national monitoring efforts such as the Breeding Bird Survey. This project seeks to collect basic information on occurrence, nesting, and demographics of MacGillivray's seaside sparrow in South Carolina. Key parts of the project will be (i) a statewide survey for breeding McGillivray's seaside sparrows and (ii) an investigation of known wintering sites for seaside sparrows to determine to what extent winter habitat use by seaside sparrows (which may be local MacGillivray's or visiting migrants from more northerly-breeding subspecies) predicts suitability for breeding by the species. The marshes at North Inlet will be included in the statewide survey for this species in the breeding season (April-August). In addition, this project will build on an existing dataset of seaside sparrows banded in the winters of 2009-2013 in South Carolina marshes by doing both breeding season point counts (as part of the statewide survey) and more intensive breeding season searches near existing winter banding sites for birds banded in previous winters.

Spatial, thermal, and nesting ecology of diamondback terrapins (*Malaclemys terrapin*) in North Inlet estuary, SC

Investigators: William B. Hills[1] and Dr. Scott L. Parker[2]

1 - Coastal, Marine & Wetland Studies Program, Coastal Carolina University (SC)
2 - Department of Biology, Coastal Carolina University (SC)

There are two objectives of our study: 1) utilize radio-tracking and thermal data-logging technology to collect spatial and time-series data for male and female terrapins in order to better understand the relationship between thermal regulation, spatial location, and activities throughout the summer nesting season, and 2) use GPS nest locations from field surveys to create a GIS nest habitat model. Thermal characteristics of the environment are important to the survival and daily function of reptiles, requiring regulation of internal body temperatures (Tb) relative to external environmental temperatures. Our research indicates terrapins use a variety of microhabitats within the salt marsh on a daily and seasonal basis to regulate Tb via behavioral thermoregulation. For example, terrapin bask to increase Tb, or use water to reduce Tb, or burial in mud to achieve relatively stable Tb. While carapace temperatures may undergo wide fluctuations on a daily basis, overall both male and females maintained equal daily mean temperatures of approximately 26.5°C, equal maximums of 39.5°C, while males had a lower minimum (14.5°C) than females (18.5°C). Our study located terrapin nests (n = 224) for the purposes of building a habitat model capable of predicting likely hot spots. Input variables were derived from available public datasets, such as Light Detection and Ranging (LiDAR) data (elevation, slope, aspect), land classification attributes (soil, wetland, landuse) provided through various land agencies, and digitization of aerial imagery.

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

Investigators: Dr. Peter Key, Dr. Michael Fulton, James Daugomah, and Blaine West

NOAA Center for Coastal Environmental Health and Biomolecular Research (SC)

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

Tide-dependent predation patterns of fishes in shallow estuarine creeks

Investigators: Matthew R. Helms[1], Dr. Robert F. Young[1], and Dr. Dennis M. Allen[2]

1 - Department of Marine Science, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina

While large active predatory fishes such as drum, bluefish, flounder, rays, ladyfish, jacks, and sharks, which are important to trophic and ecosystem function as well as to commercial and recreational endeavors, are known to populate tidal creeks and salt marshes, their distribution and foraging behavior relative to small intertidal and tributary creeks are poorly understood. We will examine assemblages of piscivores in main creek channels both adjacent to intertidal creeks and adjacent to straight banks throughout the tidal cycle. At various tidal stages, custom-built trotlines baited with live minnows will be deployed in the main channels at both habitat types. The resulting catch data will allow us to infer the times when predators are randomly dispersed throughout the inlet ecosystem and when they are focusing on the intertidal habitats in which prey items may have taken refuge. Preliminary work from 2011 has given promising results, and indicates that predators tend to be both more abundant overall and more prevalent near small intertidal creeks during the timeframes closer to slack low tide. Fifteen pairs of tidal creeks and straight banks throughout North Inlet have been selected for full field testing during the summers of 2012 and 2013.

Examination of swimming abilities of common salt marsh fishes

Investigators: Dr. Matthew E. Kimball, Dr. Kevin M. Boswell, and Dr. Lawrence P. Rozas

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Marine Science Program, Department of Biological Sciences, Florida International University
3 - NOAA / NMFS / SEFSC, Estuarine Habitats and Coastal Fisheries Center (LA)

Salt marshes are physically and environmentally dynamic aquatic environments, with near constant fluctuations in water depth, flow direction, and flow velocities. Numerous fish species use salt marsh habitats during single or multiple life history stages, and nektonic life stages must rely on swimming abilities to confront and adapt to these ever-changing natural conditions. Further, because many coastal and marsh habitats are under some form of management that regulates water flow, fishes may experience unnatural aquatic conditions such as increased flow velocities at critical marsh access points (e.g., a water control structure in a levee system). Considering this, the swimming abilities of fishes, particularly juveniles, are likely an important factor guiding and limiting their distribution in salt marshes. While the swimming abilities of riverine fish species have been extensively evaluated, the swimming abilities of common salt marsh fishes are largely unknown. We propose to determine the critical swimming speed for juveniles (< 100 mm total length) of common salt marsh nekton species (e.g., mullet, spot, croaker, silver perch, etc.) using a laboratory swim tunnel. The swimming performance of fishes is generally related to fish size (length), and critical swimming speed increases with fish length, therefore by swimming a range of juvenile sizes for each species we expect to accurately determine the relationship between swimming speed and size for the target species.

The conservation status of the canebrake rattlesnake at Hobcaw Barony, with identification of key areas for conservation of its herpetofauna

Investigator: Dr. Allan L. Markezich

Department of Natural Sciences, Black Hawk College (IL)

As a continuation of an ongoing long-term project, this effort assesses the abundance and microgeographic and ecological correlations of canebrake rattlesnake (*Crotalus horridus atricaudatus*) in the approximate 8,000 acres of terrestrial habitat of Hobcaw Barony. Field sampling involves timed road and walking surveys and usage of drift fences and cover boards along with various specimen marking techniques to assess abundance. Snake occurrence data include coordinates of specific geographic localities, topography, general and specific ecological characteristics of communities, and variables involving specific microhabitat and seasonal associations. Data from other studies and historical land usage at Hobcaw Barony are also utilized. Preliminary conclusions indicate that a relatively small metapopulation of this species exists on the property, with highest densities in specific and relatively small areas. Hardwood forests and palmetto swamplands bordering upland areas are key components of its environment. While severe droughts in several recent years may have reduced observed occurrences and movement, data indicate that the current conservation status of the canebrake rattlesnake in Hobcaw Barony is poor. Similar information on other reptilian and amphibian species is also gathered in this project in order to understand geographic and habitat correlates of herpetofaunal diversity (i.e., species richness). Results indicate that hardwood forests and freshwater wetlands, and associated ecotones between these and pine forests, are critical for herpetofaunal diversity. The area of greatest species richness has been found to be in the northern portion of the property; managed pine forests have had the lowest. Further sampling will aid in canebrake rattlesnake and overall herpetofaunal diversity conservation at Hobcaw Barony.

Effect of wrack accumulation on salt marsh vegetation

Investigators: Dr. Richard Stalter[1] and Dr. John Baden[2]

1 - St. John's University (NY)
2 - US Army Corps of Engineers (NC; Retired)

In this first study of the effect of wrack on the survival of salt marsh vegetation in a SC salt marsh, the objectives are to 1) investigate the effect of wrack coverage on salt marsh vegetation in five vegetation zones in a SC salt marsh, and 2) to monitor seedling establishment and survival in plots in five arrays during the growing season (2004 to present). Four arrays consisting of a string of permanent marsh plots were established in the in March 2004. A fifth array was established in a pure stand of *Spartina alterniflora* in March 2005. Each array was 1.8 m wide and consisted of eight 1.0 x 1.8 m plots in a row parallel to the water's edge. Within each of these plots, a central 0.5 x l.0 m sample plot was marked off, surrounded by a 0.25 m wide buffer zone including a 0.5 m buffer between adjacent sample plots. In early March 2004, wrack was collected and placed at a thickness of 15 cm (and held in place with 6.5 cm fish net) on each array except for one control plot. Sampling occurs throughout the growing season (April through October), with vegetation within each examined experimental and control plot sampled (stem count per species) with three randomly located 20 x 20 cm quadrats located within the larger plots. Vegetation of all species within each quadrat is cut at ground level to determine standing crop (grams of vegetation/m^2). Preliminary analyses indicate that with the exception of *Spartina patens*, all salt marsh species experienced l00% kill after wrack cover for two months. *Spartina patens* experienced a 50-75% reduction in density, though some *S. patens* survived wrack cover for a period of one year. We continue to assess survival of wrack impacted plants and monitor recruitment and growth in specific wrack impacted zones.

An index for estimating abundance of juvenile gag, *Mycteroperca microlepis*

Investigators: Dr. Marcel Reichert and Paulette Mikell

Marine Resources Research Institute, South Carolina Department of Natural Resources

Gag grouper (*Mycteroperca microlepis*) spawn once a year with peak activity occurring during late March and early April along the southeast US coast. Gag larvae are planktonic for extended periods of time (mean = 43 days) before entering estuarine waters along the US east coast. Postlarval gag (mean size of 14 mm) enter SC inlets on flood tides during April and May each year. Juvenile gag are most commonly found associated with oyster banks and shell rubble. Young-of-the-year gag remain in estuarine waters throughout the summer months and move offshore as water temperatures decrease in the fall. The primary goal of this project is to develop a monitoring program to provide an annual index of juvenile abundance to predict future year class strength and serve as a management tool. Other

objectives are to develop a method to estimate abundance of juvenile gag in estuarine nursery areas and describe factors that might be responsible for recruitment success. Sampling is conducted using Witham collectors (i.e., air-conditioner filter material folded over a PVC frame) deployed in tidal creeks (1 m below the surface, 30 m apart) at selected locations, landward of the ICW. Each site consists of four Witham collectors that will be sampled three times per week from mid-March through mid-June or until gag no longer recruit to this particular gear type. Gag will be measured (mm TL) and individuals will be brought back to the lab to confirm identification, as there is the possibility of confusing gag postlarvae with black grouper (*Mycterperca bonaci*). All bycatch organisms will be identified to the lowest taxonomic level and released.

Sea turtle nest monitoring on Hobcaw Barony

Investigators: Betsy Brabson[1], Robin Baughn[1], Wendy Allen[2], and other volunteers

1 - DeBordieu Colony (Debidue Beach Coordinators)

2 - North Inlet–Winyah Bay NERR, Baruch Marine Field Laboratory, University of South Carolina

Nesting activity of the threatened loggerhead sea turtle, *Caretta caretta*, on the Hobcaw Barony portion of Debidue Beach has been monitored by trained volunteers, May-October, since 1992. This 2.2 mile stretch of undeveloped beach, owned by the Belle W. Baruch Foundation, provides important nesting habitat for sea turtles and shorebirds. Volunteers walk the beach each morning during the turtle nesting and hatching period, record information on false crawls and nests, and protect nests from predators with screening. Nests laid in areas subject to flooding by tides are carefully relocated to higher areas. Volunteers also conduct nest inventories 72 hours after the major hatch has occurred to determine hatching success of each nest. Inventories, usually conducted in the evening, typically draw large crowds of interested visitors and provide an excellent opportunities to educate others about sea turtles. The volunteers are members of the South Carolina United Turtle Enthusiasts (SCUTE), which covers the northern beaches of the state, stretching from Hobcaw Beach to North Myrtle Beach. Debidue Beach (Hobcaw Beach to Pawley's Inlet) typically accounts for 30-50 % of all nests in the north coastal region. Reports summarizing nesting activity and success for Debidue Beach and the entire SCUTE region are prepared and submitted to the SC Department of Natural Resources that oversees the volunteer sea turtle program for the state. Data are also entered and available on the www.seaturtle.org website, and include information on a DNA study to track the nesting behavior of individual turtles.

Assimilation rates of dissolved organic carbon by photomixotrophic estuarine phytoplankton

Investigators: Dr. James L. Pinckney

Department of Biological Sciences and Marine Science Program, University of South Carolina

Phytoplankton, traditionally viewed as primary producers at the base of aquatic food webs, provide an energy source for higher trophic levels. However, some phytoplankton species function as both primary producers and heterotrophic secondary consumers. Phytoplankton that are photosynthetically competent but also take up AND assimilate organic compounds are classified as facultative mixotrophs or, more simply, photomixotrophs. Unfortunately, we currently have few estimates of the proportion of the phytoplankton community that function as photomixotrophs, their rate of secondary production, or their temporal variation in abundance. Current paradigms about trophodynamics in marine systems do not consider this potentially important "alternative" pathway for energy flow for phytoplankton. The implication is that we may be missing a significant, fundamental process that affects carbon cycling and trophodynamics in estuarine systems. Furthermore, changes in the DOC composition due to anthropogenic alterations may result in changes in phytoplankton community structure and possibly promote the proliferation of harmful algal bloom species. In terms of ecosystem function, even moderate rates of photomixotrophy could potentially alter our current understanding of phytoplankton productivity, overall C turnover, competitive interactions, and energy transfer in estuarine environments. The proposed research will use a novel approach to provide quantitative measures of the in situ rates and magnitudes of "facultative heterotrophy" in natural, estuarine phytoplankton communities over seasonal time scales in a representative estuarine ecosystem. The purpose of the proposed research is to apply a unique 14C radiolabeling technique to quantify the in situ assimilation rates of DOC by estuarine photomixotrophs and estimate the amount of DOC converted to phytoplankton biomass by photomixotrophy over seasonal time scales. This information will provide new insights into carbon dynamics in estuaries, the contribution of DOC to estuarine food webs, and the importance of photomixotrophy in determining the structural and functional characteristics of estuarine phytoplankton communities.

Depredation of diamondback terrapin (*Malaclemys terrapin*) nests in North Inlet estuary, SC: A study of the predators and the cues they use to locate nests

Investigators: Samuel A. Buzuleciu[1] and Dr. Scott Parker[2]

1 - Coastal Marine and Wetland Studies Program, Coastal Carolina University (SC)
2 - Department of Biology, Coastal Carolina University (SC)

The purpose of this study is to identify predators and determine the cues they use to locate diamondback terrapin nests in the salt marshes of North Inlet, SC. Three terrapin nesting areas will be monitored both in person and through use of motion activated camera traps to observe any nest depredation events. A manipulative study will also be conducted in which simulated nests will provide insights to cues used by predators in locating eggs. In accordance with a technique from similar studies, sand infused with the scent of a female terrapin will serve to create simulated nests. Simulated nests will be constructed at three intervals during the nesting season, from May to July. Depredation rates for nests in other diamondback terrapin studies have exceeded 90%. This study will ascertain factors of predation pressure on diamondback terrapin in North Inlet. We will garner knowledge on terrapin nesting behavior as well as the behavior, cues and deterrents affecting nest predators. This information can be applied to management strategies improving nest protection for this and other species of beach nesting turtles in the region.

Improving management of coastal habitats: Testing a tool to assess the vulnerability of coastal habitats to climate change impacts

Investigators: Dr. Jennifer Plunket[1] and Dr. Kiersten Madden[2]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve
2 - Mission-Aransas National Estuarine Research Reserve

Climate change will significantly affect the coastal zone through changes to sea level, storm severity and frequency, erosion and sediment supply, invasive species, freshwater inflows, and water quality, potentially causing the degradation or loss of habitats that perform critical ecosystem services for coastal communities. Coastal land managers need methods to identify habitats that are likely to be adversely affected by climate change in order to make informed decisions about habitat management actions and restoration projects. Climate change vulnerability assessments can support decision making by providing managers with methods of identifying which habitats are likely to be most affected by projected changes in climate as well as insight as to why these habitats are likely to be vulnerable. This project will use a collaborative process to pilot and refine a climate change vulnerability assessment tool, the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH). Local habitat managers, decision-makers and researchers will be engaged in a series of workshops to apply the CCVATCH to generate vulnerability scores for selected coastal habitats at pilot sites at the North Inlet–Winyah Bay and the Chesapeake Bay, Virginia, National Estuarine Research Reserves. The results of this project will be used to refine the CCVATCH and will be incorporated into guidance documentation accompanying the tool. This will better allow the tool to be used by other Reserves using a similar collaborative approach involving habitat managers and decision-makers seeking to understand the potential impacts of climate change on coastal habitats of ecological and economic importance.

Long-term changes in zooplankton in the North Inlet estuary and relationships with climate change and variability

Investigators: Dr. Dennis M. Allen, Ginger Ogburn-Matthews, and Paul Kenny

Baruch Marine Field Laboratory, University of South Carolina

Collections have been made at the same location, stage of tide, and time of day every two weeks since 1981. Oblique tows with 153 micron mesh nets collect copepod and small invertebrate larvae, and 365 micron epibenthic sled tows capture larval fishes, shrimps, and crabs and other large zooplankton species. Seasonal and interannual changes in abundance, diversity, and species composition of the assemblages in Town Creek are documented and correlated to fluctuations in the physical characteristics of the estuary. Information is collected for more than 50 taxonomic groups and species. Recent analyses of the large zooplankton component have shown that although the composition and overall densities have not changed significantly, there have been large and consistent responses to climatic events including ENSO (El Nino) and drought. Analysis of the 153 fraction has indicated a steady decrease in total small zooplankton, especially copepods, over the past 31 years. Reductions in river inflow, nutrient discharges, and related densities of phytoplankton best explain the major reductions in copepods and larvae of resident invertebrates in the plankton. Changes in the timing of larval production for some species have been observed. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change.

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

Investigators: Dr. Denise Sanger[1], George Riekerk[1], Martin V. Levisen[1], Dr. Robert F. Van Dolah[1], and David E. Chestnut[2]

1 - South Carolina Department of Natural Resources
2 - South Carolina Department of Health and Environmental Control

The SC Department of Natural Resources (SCDNR) and the SC Department of Health and Environmental Control (SCDHEC) have been conducting a comprehensive collaborative coastal monitoring program (SC Estuarine and Coastal Assessment Program; SCECAP) since 1999. The goal of SCECAP is to annually monitor the condition of the state's estuarine habitats and associated biological resources. SCECAP integrates measures of water and sediment quality with multiple measures of biological condition at a large number of sites throughout the state's coastal zone. It also expands historical monitoring activities that have primarily focused on open water habitats (e.g., bays, sounds, tidal rivers) to include an assessment of conditions in tidal creeks, which serve as important nursery habitat for many species. Many of these tidal creeks are also the first point of entry for non-point source runoff from upland areas and therefore can provide an early indication of anthropogenic stress. The SCECAP program, combined with the other cooperating programs, provides a number of direct and indirect benefits including 1) the ability to identify areas of estuarine habitat that are impaired or degraded with respect to a suite of sensitive biological, chemical, and physical measures; 2) a cost-effective standardized protocol that is used by both SCDNR and SCDHEC that is consistent with protocols used in other US coastal states, thus allowing better regional prioritization of stressors and impacts; 3) more comprehensive periodic reports on the condition of water quality and habitat condition throughout the state's coastal zone than could be accomplished by the individual programs alone. As of the summer 2013, more than 677 sites have been sampled statewide, with 8 located in the North Inlet estuary and an additional 29 stations located in the adjacent Winyah Bay.

A forty-five year comparison of the vascular flora at three abandoned rice fields, Georgetown, South Carolina

Investigators: Dr. Richard Stalter[1] and Dr. John Baden[2]

1 - St. John's University (NY)
2 - US Army Corps of Engineers (NC; Retired)

The objective of this study is to inventory the vascular flora at three brackish marshes: Airport, Alderly and Thousand Acre Rice Field on Hobcaw Barony. We are also investigating the distribution of vascular plant species at Thousand Acre Rice Field along an elevation gradient. To accomplish this, we are surveying plant species and recording the elevation of each taxon above the most flood tolerant species, *Spartina alterniflora*. After collecting and identifying the vascular plant species present at each marsh, species composition at the three marshes will be compared with previously gathered species composition data: J. Baden thesis (1971), a second study of the flora of the marshes following Hurricane Hugo (September 1989) in 1990-1991, and a third study in 2002-2006. Vascular plant species collections at each of the marshes began April 2013 and will continue through June 2015. A small sample of each taxon will be collected, pressed and mounted on an herbarium sheet as voucher material to be housed at the A. C. Moore Herbarium, USC. Only one sample/taxon will be collected as reference material. Soil samples from each of the marshes will be collected; mineral analysis will be performed by the Nutrient Analysis Laboratory, Cornell University. The significance of this study is that it documents and compares vascular plant species composition at three brackish marshes over a 45-year period (1969-2015). There are few long-term studies of this kind and fewer where the same investigators follow up their work over 45 years of study.

Quantitative descriptions of oyster (*Crassostrea virginica*) population biology in North Inlet estuary

Investigator: Dr. Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Oyster (*Crassostrea virginia*) population biology sets the foundation for maintenance and persistence of the biogenic habitat as well as the associated trophic communities and ecological services. These dynamics respond to a variety of factors functioning at time scales ranging from days to decades. This research describes basic oyster population parameters including recruitment intensity and periodicity as well as density, demographics, and condition index at Oyster Landing and Clambank. Environmental data will be collected concurrently and integrated with the biological data. The integrated data sets will be examined in the context of available historic data and documented environmental changes across decadal time scales.

The effects of salinity, pH, and dissolved oxygen on the sensitivity of PCR identification of the T4 bacteriophage in estuarine water

Investigators: Dr. Paul Richardson and students

Department of Chemistry, Coastal Carolina University (SC)

Bacteriophages have been used as indicators to predict the presence of pathogenic bacteria in drinking, waste, and recreational waters; and coliphages are as adequate an indicator of fecal pollution as are actual coliform counts. Little is known about the survival and persistence of bacteriophages in saline environments; however, recent research has shown that phages are sensitive to temperature, chemical treatments, and salinity. The lower number of bacteriophages present in salt water requires a sensitive detection method to be an effective indicator. A PCR protocol developed for ideal laboratory conditions will be evaluated to determine whether seawater properties affect the sensitivity of this PCR method. This study's focus is to determine the effect of the different water characteristics on the sensitivity of the PCR identification of virus particles; this will allow a detection threshold to be determined on environmental samples and further test the sensitivity of the protocols developed. This study will further elucidate the effect seawater (salinity, pH, and dissolved oxygen content) has on bacteriophage levels in an estuary.

Effect of autotomy on *Panopeus herbstii* body temperature and mortality

Investigators: Cristián J. Monaco and Benjamin J. Toscano

Department of Biological Sciences, University of South Carolina

Our project's objective is to evaluate the combined effects of temperature fluctuations and autotomy on *Panopeus herbstii* populations that inhabit intertidal oyster reefs in North Inlet estuary. Research will involve both field and laboratory experiments and observations. Temperature measurements are being continuously recorded using I-buttons deployed at different heights and depths to estimate microhabitat thermal variability. Every ~2 mo we are doing population surveys on a reef located ~200 m away from the Oyster Landing weather station. Through those surveys we are estimating density, proportion of autotomized individuals, microhabitat use, number of burrows, and sex ratio. Field experiments include caging 20 individuals in independent minnow traps for periods of 3-4 weeks to examine how autotomy might interact with environmental temperature to determine crab mortality. Cages will be set on mud flats adjacent to Oyster Landing. These experiments will be conducted twice a year, during winter and summer seasons. Laboratory experiments, which will be conducted in Columbia, SC, are being designed for assessing organism's thermal tolerance levels.

The flora of Indian shell mounds in North Inlet estuary, South Carolina

Investigators: Dr. Richard Stalter[1], Dr. Chester B. DePratter[3], and Dr. John Baden[2]

1 - St. John's University (NY)
2 - US Army Corps of Engineers (NC; Retired)
3 - South Carolina Institute of Archaeology and Anthropology

The objective of this study was to investigate the vascular flora at four Indian clam shell middens in North Inlet and nearby marshes. We investigated the distribution of vascular plant species at the shell middens along an elevation gradient at Clambank and nearby sites. To accomplish this we surveyed the plant species with a surveyor's transit and stadia pole at each midden; elevation of each taxon was recorded above the most flood tolerant species, *Spartina alterniflora*. Sixty-seven taxa were identified at the four large middens and several smaller clam midden sites, with all specimens housed as reference material at the herbarium at the A. C. Moore Herbarium, USC. Species present at these middens will be compared with those found at shell ring sites in South Carolina by Stalter et al (1999). Field work was initiated July 2009 and terminated October 2012, with species preservation, data analyses, and write-up continuing through Fall 2013. A small sample of each taxon was collected, pressed and mounted on a herbarium sheet as voucher material. Only one sample/taxon was collected as reference material. Soil samples from two of the shell middens were collected; mineral analysis will be performed by the Nutrient Analysis Laboratory, Cornell University. Cores were taken from 20 large coastal red cedars, *Juniperus virginiana*, to determine the age of this taxon on the shell middens. Annual ring counts were analyzed at Columbia University's Lamont Doherty Laboratory. Annual ring counts of *Juniperus* did not exceed 110 years. The oldest *J. virginiana* may have invaded the middens after the hurricane of 1893.

Sediment accretion in North Inlet estuary salt marshes

Investigators: Dr. James Morris[1,2] and Karen Sundberg[2]

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

The objective of this study is to understand how the elevation of the marsh surface is regulated. A major hypothesis being tested is that eutrophication initiates a sequence of changes in the sediments, beginning with a decrease in volume due to enhanced decomposition of organic matter. In fact, sediment accretion in experimentally fertilized marsh plots has increased. This is probably due to an increase in sedimentation caused by a higher density of plant stems in fertilized plots. Marsh plots were fertilized from 1996 or 2001 until 2004. A surface elevation table (SET) is used to measure marsh elevations in low and high marsh *Spartina alterniflora* plots approximately monthly. Currently we are looking at the effect of decreasing eutrophication on marsh surface elevation, and we hypothesize that there will be a decrease in volume of belowground biomass due to enhanced decomposition now that belowground production is no longer stimulated. Results of a model linking plant production and sedimentation with sea level indicate that the marsh maintains its elevation with respect to mean sea level for a range of rates of sea-level rise, up to a threshold. The elevation of the marsh platform with respect to mean sea level is inversely proportional to the rate of sea-level rise.

Experimental varying of the marsh platform and macrophyte response

Investigators: Dr. James Morris[1,2] and Karen Sundberg[2]

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

The objective of this study was to design a simple experiment to investigate how varying the marsh platform in relation to mean sea level would affect macrophyte production, stand dynamics, and biomass allocation patterns of salt marsh plants. One specific goal was to ascertain aboveground and belowground allocation patterns and quantify where the bulk of belowground biomass was located in relation to marsh elevation and sea level. The experiments were initiated in 2003. Currently there are three marsh planters ('marsh organs'), each with six treatment platform levels that span the upper half of the tidal range, and six replicates per treatment. In general, the marsh organs are planted in March with salt marsh plugs (currently *Spartina alterniflora*) collected nearby; stem height measurements are obtained monthly as an estimate of standing biomass; and plants are harvested at the end of the growing season, to determine aboveground and belowground productivity. In recent years, replicates have been selectively harvested such that in 2013 there are 1-, 2-, 3- and 4-yr replicates. The frequency of inundation results in significant variation in stand densities and plant heights, and we are observing different biomass allocation patterns with time. While macrophyte production may not vary with treatment, these changes in stand densities and macrophyte morphology may have profound effects on the ability of salt marshes to accrete allochthonous sediments and maintain pace with sea-level rise. Furthermore, allocation patterns may ultimately influence net annual primary productivity within salt marshes.

Interspecific competition among some salt marsh perennials in South Carolina

Investigators: Dr. Richard Stalter[1] and Dr. John Baden[2]

1 - St. John's University (NY)
2 - US Army Corps of Engineers (NC; Retired)

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 were 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*. *Spartina alterniflora* was able to invade the *J. roemerianus* zone when the latter was removed from land that it originally occupied in the marsh. *Juncus* marginally invaded the *S. alterniflora* zone when the latter was removed. *Juncus* did not transplant well; almost 100 % of the transplanted *J. roemerianus* died even when dug up and replanted in place.

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

Investigators: Dr. James Morris[1,2] and Karen Sundberg[2]

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

Salt marsh grass, *Spartina alterniflora*, dominates the intertidal marsh in North Inlet estuary. Regular measurements of grass density and height allow for estimates of growth and primary production rates in both control and fertilized plots. Abiotic conditions that are measured include pore water salinity, phosphate, ammonium, sulfide and iron concentrations to provide insights into factors that affect production. Large monthly and interannual variations in the amount of organic material produced by the cordgrass are related to such factors as sea level and precipitation patterns. This time series was initiated in 1986.

Education activities – National Estuarine Research Reserve

Investigator: Beth Thomas

North Inlet–Winyah Bay National Estuarine Research Reserve

Educational activities that highlight coastal ecology and integrate findings from research are offered throughout the year. A seasonal schedule of activities is produced 3-4 times per year, and programs are promoted through informational fliers, Reserve newsletters, newspapers, and event calendars on both NI-WB NERR's website (www.northinlet.sc.edu) and Hobcaw Barony's website (www.hobcawbarony.org), as well as on their respective Facebook pages and other local community event online calendars. Program offerings include estuarine and beach ecology programs for all ages, biking and kayaking programs that feature coastal ecology, open houses and research lectures, and research-based programs in which participants assist scientists with long-term monitoring programs and volunteer monitoring efforts. Field trips for K-12 students, homeschool students, and special groups such as Elderhostel, Boy and Girl Scouts, 4H clubs, and church groups are also available, as well as job shadowing and research experiences for middle and high school students. Off-site outreach includes events such as the annual Winyah Bay Heritage Festival and Huntington Beach State Park's Wildlife and History Day, summer reading programs at Georgetown County library branches, summer programs with Chapin Library (City of Myrtle Beach) and The Children's Museum of South Carolina, afterschool programs for local elementary and middle schools, science and environmental fairs, and career days. Partnerships with other local environmental education providers including the ACE Basin NERR, SC Department of Natural Resources, SC Sea Grant Consortium, Centers for Ocean Science Education Excellence-Southeast (COSEE-SE), SEWEE Association, the Waccamaw National Wildlife Refuge, and the Coastal Waccamaw Stormwater Education Consortium provide opportunities for teacher training and professional development, and shared staff and resources for enhanced programming and outreach.

Geographic variations in larval spot (*Leiostomus xanthurus*) ingress to estuaries: Long-term patterns of arrival times, abundance, and size distribution from South Carolina to Massachusetts and relations to climate change

Investigators: Dr. Dennis M. Allen[1], Dr. Kenneth W. Able[2], Dr. Tim Targett[3], Dr. Eric Hilton[4], Dr. Jeff Buckel[5], Dr. Todd Kellison[6], Dr. Chris Taylor[6], Dr. Jon Govoni[6], and Dr. Jon Hare[7]

1 - Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay NERR
2 - Rutgers University Marine Field Station and Jacques Cousteau NERR (NJ)
3 - University of Delaware
4 - Virginia Institute of Marine Science, The College of William and Mary
5 - Center for Marine Sciences & Technology, NC State University
6 - NOAA Center for Coastal Fisheries and Habitat Research (NC)
7 - NOAA / NEFSC / NMFS, Woods Hole and Narragansett Laboratories

In most estuaries along the US Atlantic and Gulf of Mexico coasts, the spot, *Leiostomus xanthurus*, is one of the most abundant epibenthic fishes. Adults spawn in the ocean during late fall and winter, producing larvae that arrive at inlets and then transform into bottom-feeding juveniles that inhabit salt marsh and other shallow estuarine habitats until fall. Most studies on the early life stages of this keystone species have been site specific and of short duration. A recently developed collaborative effort among investigators from various locations in the Northeast, Middle Atlantic, and Southeast Regions will compare and interpret patterns of abundance, timing, and size structure during ingress over multiple years. Our time series of spot larvae from the mesozooplankton collections at North Inlet appears to be the longest continuous dataset, with the 34th year of biweekly collections beginning in January 2014. Time series

collections in Beaufort, NC (since 1985), Great Bay, NJ (since 1989), DE (since 2006), and VA (since 2007) will contribute to the analyses. Data from ocean sampling programs will add to our interpretation of patterns of spawning, cross shelf movement, and mechanisms of change on a large spatial scale. Also, data on the occurrences and sizes of juvenile spot are being assembled from estuaries from New England to Florida. Changing climate is expected to alter patterns of reproduction, movement, and growth for many coastal fishes, and preliminary analyses indicate phenological and growth responses to increasing temperatures.

Assessing aeration as a means of improving stormwater pond performance and reducing organic loading to the coastal zone

Investigators: Dr. Erik Smith[1,2], Dr. Tammi Richardson[3,4], Michelle Evans[1,2] and Lauren Hehman[4]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - North Inlet–Winyah Bay National Estuarine Research Reserve
3 - Department of Biological Sciences, University of South Carolina
4 - Marine Science Program, University of South Carolina

Reducing the impacts of detention ponds as non-point sources of oxygen demand to coastal waters requires reducing phytoplankton growth within the ponds. This project seeks to provide a quantitative assessment of aeration as a means of modifying phytoplankton productivity, community composition, and concentrations of dissolved organic carbon and nutrients in stormwater detention ponds. The study involves the use of controlled field manipulation experiments to assess phytoplankton productivity and community composition, biological oxygen demand (BOD), and nutrient responses to aeration in stormwater ponds at two coastal SC locations. The field study will involve quantifying effects of aeration using a set of whole-pond manipulations following a BACI (Before-After Control-Impact) experimental design. Methodological parameters employed include measurements of vertical profiles of water column physical properties and irradiance, primary productivity using ^{14}C, HPLC-based analyses of total phytoplankton biomass and community composition, light and epifluorescence microscopy (for verification of pigment-based taxonomy), time-series of oxygen consumption (BOD5), particulate and dissolved organic C and N analyses, and inorganic N and P analyses. Effects of aeration on measured response variables will be analyzed by repeated measures ANOVA with period (before – after) and location (control – impact) as factors for the field data. If successful, this project will provide quantitative support for the use of an alternative to the more commonly used toxic algicides in controlling nuisance phytoplankton growth in stormwater detention ponds as well as promote the use of aeration as a means of reducing nutrient and organic matter loading to sensitive coastal waters.

Short-term sediment deposition on tiles with organic matter loss-on-ignition and grain size analysis

Investigators: Ni An[1], Dr. Rhawn Denniston[2], Dr. Erik Smith[3,4], Tracy Buck[3,4], and Dr. Anand Jayakaran[5]

1 - Rogers Fellow in Environmental Science, Cornell College (IA)
2 - Department of Geology, Cornell College (IA)
3 - Baruch Marine Field Laboratory, University of South Carolina
4 - North Inlet–Winyah Bay National Estuarine Research Reserve
5 - Baruch Institute of Coastal Ecology and Forest Science, Clemson University (SC)

The Rogers Fellow in Environmental Science Program at Cornell College, Iowa provides undergraduate majors in any science discipline with an opportunity to participate in an immersive field experience at the University of South Carolina's Baruch Marine Field Laboratory. The Fellow interacts with and receives guidance from researchers at the field laboratory and their home institution advisor. Ni An, undergraduate geology major, was the 2013 Rogers Fellow. To coincide with her major interests, An's fellowship focused on short-term sediment deposition on tiles deployed in the emergent marsh zone. During summer 2013, An participated in a long-term research project in the North Inlet estuary designed to gain a better understanding of spatial and temporal sediment dynamics and composition within the salt marsh along natural elevation gradients and along a marsh chronosequence. Within the context of the broader ongoing project, An examined the relationships among total sediments, sedimentation rate, surface elevation, and plant density for all experimental plots during the summer. During this short period, significant correlations were observed between sedimentation rate and elevation as well as grain size and elevation. These results will be added to the long-term time series for more comprehensive future analyses over larger temporal scales.

Plantation Path – Establishing and monitoring usage and impacts of an experiential environmental education foot trail

Investigators: Beth Thomas[1], Richard Camlin[2], and Dr. Jennifer Plunket[1]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve
2 - Belle W. Baruch Foundation

An experiential education area that can be accessed by foot was established away from long-term research sites to take visitors (K12 and adults) for estuary field trips and other guided environmental education programming and allow participants to experience a variety of coastal habitats via a looped walking trail. An area near 3rd Boundary and Crabhaul roads was selected for the site and includes easy access for bus parking and is in close proximity to the BMFL (for safety concerns and restroom access). The trail supplements the marsh boardwalk to allow users to experience habitats outside the confines of the boardwalk and to accommodate larger group sizes (~65-70 participants). With the help of BMFL's Research Resource Specialist and the NERRS Stewardship Coordinator, a trail was creating in early 2011 using staff and volunteers. Stations have been established to mimic research and monitoring plots and are used to conduct student research. With assistance and guidance from the NERR Stewardship Coordinator, education staff will monitor the impacts of visitor use over time and continue maintenance of the trail throughout the year.

Coastal Waccamaw Stormwater Education Consortium (CWSEC) core education provider – National Estuarine Research Reserve

Investigators: Beth Thomas and Michelle LaRocco

North Inlet–Winyah Bay National Estuarine Research Reserve

Reserve public education and Coastal Training Program (CTP) staff participate as core education providers of the Coastal Waccamaw Stormwater Education Consortium (CWSEC). Created in 2004 as a partnership among Clemson University's Carolina Clear Program, North Inlet–Winyah Bay NERR Coastal Training and NERR Public Education Programs, Coastal Carolina University's Waccamaw Watershed Academy, Winyah Rivers Foundation's Waccamaw Riverkeeper Program, and Murrells Inlet 2007 & Beyond (now Murrells Inlet 2020), the Consortium was formed to provide a clearinghouse for stormwater education resources for local Municipal Separate Storm Sewer Systems (MS4) communities in Horry and Georgetown counties. Together, Consortium educators offer a variety of outreach activities and resources designed to maximize the efficiency of stormwater education efforts in the northeastern SC coastal region by using a regional/watershed approach to help local MS4s meet NPDES Phase II Permit requirements for public stormwater education and outreach (http://cwsec-sc.org).

Size-structured predator-prey interactions in intertidal oyster reefs

Investigators: Benjamin J. Toscano[1] and Dr. Blaine D. Griffen[1,2]

1 - Department of Biological Sciences, University of South Carolina
2 - Marine Science Program, University of South Carolina

The mud crab, *Panopeus herbstii*, is an important predator of bivalves in North Inlet estuary intertidal oyster reefs. Individuals within *Panopeus* populations span a range of body sizes that co-occur in high densities, and their population size structure varies seasonally due to recruitment pulses and size-selective winter mortality. Using a combination of field and laboratory experiments, our research explores how such ontogenetic functional variation in *Panopeus* determines their interactions with the oyster reef community. This research will provide a better understanding of how size-structure in populations can scale up to influence population and community dynamics. Field experiments are conducted in intertidal oyster reefs in the vicinity of Oyster Landing and lab experiments are conducted in the wet laboratory.

Characterization of oyster cement

Investigators: Dr. Jonathan Wilker[1] and Paul Kenny[2]

1 - Department of Chemistry, Purdue University (IN)
2 - Baruch Marine Field Laboratory, University of South Carolina

Marine species such as mussels, barnacles, and oysters produce adhesive and cement materials for affixing themselves to surfaces. The strong bonding, wet adhesion capabilities, and biological origin of these materials indicate promise for developing new biomedical materials such as surgical glues and dental cements. In an effort to develop such

applications, we are beginning by characterizing adhesive materials produced by marine organisms. Prior studies have determined some of the key chemical reactions and bonding motifs used by mussels for production of their adhesive. For the current project, our main objective is to characterize the chemistry within the cement of the Eastern or Atlantic oyster *Crassostrea virginica*. Oysters are collected near the Baruch Marine Field Laboratory and then grown in laboratory aquaria. Chemical methodologies are used to analyze the cement, including wet chemistry and spectroscopic techniques. Insights gained will provide both fundamental understanding of how a marine biological material functions as well as providing insights for the design of new biomedical adhesives.

The National Estuarine Research Reserve System Centralized Data Management Office

Investigators: Dr. Dwayne E. Porter[1,2], Melissa Ide[3], Jennifer Kessee[3], Amber Knowles[3], Brooks Folk[3], Lee Shutt[3], Dan Ramage[2], and Jeff Jefferson[1]

1 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
2 - Arnold School of Public Health, University of South Carolina
3 - Baruch Marine Field Laboratory, University of South Carolina

NOAA's National Estuarine Research Reserve System (NERRS) acknowledges the importance of both long-term environmental monitoring programs and data and information dissemination through the support of the NERRS System-wide Monitoring Program (SWMP). The goal of the SWMP is to "identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purpose of contributing to effective national, regional and site specific coastal zone management." This comprehensive program consists of three phased components: estuarine water quality monitoring (phase I), biodiversity monitoring (phase II), and land-use and habitat change analysis (phase III). The Centralized Data Management Office (CDMO) was established in support of the System-wide Monitoring Program involving 28 sites around the US and Puerto Rico. The purpose of the CDMO, housed at the North Inlet–Winyah Bay NERR, is the management of the infrastructure and data protocol to support the assimilation and exchange of data, metadata, and information within the framework of NERRS sites, coastal zone management (CZM) programs, and other education, monitoring and research programs.

Determining the role of estuarine 'swashes' on water quality impairment along the Grand Strand of South Carolina: Impacts of land use and stormwater runoff

Investigators: Dr. Erik Smith[1,2], Angie Defore[1,2], Dr. Richard Peterson[3], Dr. Susan Libes[3], Dr. Richard Viso[3], Dr. Denise Sanger[4], Dr. Jennifer Plunket[2], and M. Richard Devoe[5]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - North Inlet–Winyah Bay National Estuarine Research Reserve
3 - Center for Marine and Wetlands Studies, Coastal Carolina University (SC)
4 - South Carolina Department of Natural Resources
5 - South Carolina Sea Grant Consortium

Recently, the occurrence of episodic hypoxia has been documented in the nearshore waters of Long Bay, South Carolina. These events have occurred directly off the Grand Strand, an urbanized beachfront resort community encompassing the greater Myrtle Beach metropolitan area, located along the central portion of Long Bay. Evidence suggests discharges from a series of estuarine tidal creeks (locally known as swashes) may play a prominent role as sources for inputs of organic matter and nutrients fueling oxygen demand leading to hypoxia in these waters. This research will address this knowledge gap by: quantifying terrestrial inputs of nutrients and organic matter associated with surface stormwater runoff and groundwater inputs to selected swashes of the Grand Strand under both dry weather and stormflow conditions; establishing the link between terrestrial nutrient loading under contrasting flow conditions and the net organic matter production occurring within swashes; and determining the subsequent net tidal export of material (magnitude and forms) from these swashes. Through a collaborative effort between scientists and managers, the results of this project will provide the scientific justifications necessary for enabling the development of effective management strategies that improve and protect coastal water quality, particularly with respect to hypoxia, in Long Bay.

Naked goby (*Gobiosoma bosc*) and striped blenny (*Chasmodes bosquianus*) reproductive biology and early life history

Investigators: Rachel M. Tremont[1], Dr. Juliana M. Harding[1,] and Dr. Dennis M. Allen[2]

1 - Department of Marine Science, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina

The reproductive biology and early life history for two common oyster reef fishes, the naked goby (*Gobiosoma bosc*) and striped blenny (*Chasmodes bosquianus*), were investigated in North Inlet tidal creeks during 2012 and 2013. Fishes were sampled from Bly, Crabhaul, Clambank, and Town creeks. Gonadosomatic indices (biomass and ash-free dry weight, g) have been calculated for adults of both species based on monthly collections. Naked goby and striped blenny nesting activity was described during the spawning seasons. Naked goby and striped blenny larvae were cultured at standard densities and prey concentrations from hatch through settlement. Larval period duration (d), settlement size (total length, mm), and growth (mm d-1) at ambient temperatures (°C) were determined using cultured nests during the 2012 and 2013 spawning seasons. Increasing water temperatures throughout the spawning season may decrease time to settlement and settlement size. Larvae that settle earlier and at smaller sizes may be more vulnerable to predation and less able to compete for resources.

Selective advantage of pathogenic *Vibrio parahaemolyticus* in the Eastern oyster (*Crassostrea virginica*)

Investigators: Dr. Charles R. Lovell[1,2], Savannah Klein[1], and Katherine Haney[1]

1 - Department of Biological Sciences, University of South Carolina
2 - Marine Science Program, University of South Carolina

Bacteria in the genus *Vibrio* are marine organisms that have the potential to become human pathogens when ingested in raw or undercooked seafood. Oysters act as a vector for *Vibrio* disease because they can concentrate the bacteria during filter feeding. This project will investigate the density of both benign and pathogenic vibrios in oysters in the North Inlet estuary, a relatively pristine salt marsh. Oysters will be sampled during warmer times of the year to coincide with periods of maximum *Vibrio* growth and cooler periods to obtain baseline measurements. During sampling, 10-15 oysters will be collected from Oyster Landing and then brought back to Columbia for processing in the Lovell lab. Oysters will be washed, shucked, and homogenized. The homogenized mixture will then be plated on a *Vibrio* selecting medium. The number of pathogenic strains of vibrios reared from oysters will be enumerated. Our hypothesis is that pathogenic vibrios are positively selected for in this niche.

Fluorescent dissolved organic matter dynamics in North Inlet estuary

Investigators: Alexandra Norelli[1], Tracy Buck[2,3], Susan Denham[2,3] and Dr. Erik Smith[2,3]

1 - Marine Science Program, University of South Carolina
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - North Inlet–Winyah Bay National Estuarine Research Reserve

There is growing interest in the use of the inherent optical properties of dissolved organic matter (DOM) as proxies for DOM concentrations and biogeochemical cycling in coastal ecosystems. This study seeks to assess the utility of the fluorescent dissolved organic matter (FDOM) optical probe newly available as part of Xylem/YSI's EXO water quality sonde to quantify high-frequency DOM dynamics in the North Inlet estuary. Beginning in August 2012 an EXO equipped with an FDOM probe together with temperature, salinity, pH, dissolved oxygen and turbidity probes has been deployed at the Oyster Landing long-term monitoring station of the North Inlet–Winyah Bay National Estuarine Research Reserve (NERR). Specific study objectives for 2013 are to: 1) quantify and develop correction factors for the inherences of FDOM measurements in North Inlet due to temperature and turbidity; 2) quantify relationships between FDOM measures and both absorbance-based measures of chromophoric dissolved organic matter (CDOM, the more traditional optical measure of DOM) and dissolved organic carbon (DOC, determined directly by high-temperature combustion methods) in both in situ samples as well as in samples from defined DOM sources to the estuary (drainage from terrestrial uplands, drainage of salt marsh pore-waters, and phytoplankton-derived DOM). This study will allow the temporal dynamics of DOC, the largest pool of organic carbon in marine waters, to be resolved at frequencies not previously possible.

Nekton assemblage structure in a subtidal creek: Comparing species composition, relative abundance, and size distributions with those found 30 years ago

Investigators: Dr. Matthew E. Kimball, Dr. Dennis M. Allen, and Paul Kenny

Baruch Marine Field Laboratory, University of South Carolina

Beginning in 1981 as part of the original LTER monitoring program, fishes, shrimps, crabs, and squids were trawled from subtidal bottoms every two weeks. The program continued until fall 1984 when the nekton monitoring effort was shifted to the intertidal basin at Oyster Landing. Occasional trawl collections at the original site at Town Creek (south of the zooplankton station) and other locations in recent years indicated some obvious changes in the fauna inhabiting the relatively deep channel bottoms in North Inlet. Because detailed data records from the 1981-84 study are still available (e.g., Baruch Institute report by Ogburn et al. 1988), we decided to reestablish the biweekly collection program from spring to fall starting in 2012. A comparison of 2012 data with the older records showed that abundances of bay and striped anchovies, brief squid, spot and hardhead catfish were much lower, whereas abundances of pinfish, Atlantic spadefish, southern stingrays, and bluntnose stingrays were much greater. Other differences were also noted with the 2012 fish catches being less abundant than in 1981 through 1984. The renewed biweekly effort continued in 2013 and is planned for the next two years to establish a comparable time frame and to interpret whether changes in environmental and other faunal datasets can explain the apparent shift in subtidal channel nekton 30 years later.

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

Investigators: Dr. Erik Smith and Tracy Buck

Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay National Estuarine Research Reserve

As part of the NERRS System-Wide Monitoring Program, the physical characteristics of the water in four tidal creeks of the North Inlet–Winyah Bay NERR has been monitored using YSI 6600 ESD data loggers since 1994. These data loggers are deployed at 0.5 m above the sediment surface and record water depth, temperature, salinity, pH, dissolved oxygen, and turbidity at 15 min intervals throughout the year. The instruments are calibrated and deployed according to strict NERRS protocols. The consistent, long-term collection of this physical data allows for the characterization of short-term variability and long-term change in North Inlet waters, and provides baseline data critical for various studies of biological and physical processes in the North Inlet estuary. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control. Data can be accessed via the CDMO website (http://cdmo.baruch.sc.edu).

Ecological role of bottlenose dolphins in North Inlet estuary and adjacent waters

Investigator: Dr. Rob Young and students

Department of Marine Science, Coastal Carolina University (SC)

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

Individual personality and community interactions

Investigators: Dr. Blaine D. Griffen and students

Marine Science Program and Department of Biological Sciences, University of South Carolina

Indirect interactions are common in ecological communities and are often propagated through communities via changes in individual behavior. However, many species exhibit large variation in individual behavior, with animals displaying different personality types. Individual animals often select habitat based on these personalities. Our work examines how individual personality influences the propagation of indirect interactions within food web interactions in oyster reef communities, and specifically, how personality alters the way that trophic interactions occur in different parts of the reef. This work is being conducted in tidal creeks within North Inlet and using wetlab facilities at BMFL. Results of this work will clarify community interactions and will improve our ability to predict the outcome of trophic dynamics.

Understanding the effects of sea-level rise on coastal freshwater wetlands

Investigator: Dr. Scott Neubauer

Department of Biology, Virginia Commonwealth University

Coastal wetlands are important habitats that buffer terrestrial-aquatic interactions and can exert a significant influence on processes in adjacent coastal waters. One of the more certain impacts of global climate change is sea-level rise, which will move the salt gradient upriver into historically freshwater wetlands. The overall focus of this project is on tidal freshwater wetlands, greenhouse gas emissions, and interactions with future climate change (i.e., sea-level rise and salt water intrusion). From June 2008 toNovember 2011, experimental plots in a tidal freshwater marsh on the Waccamaw River were dosed with diluted seawater, with porewater salinities in the +salt plots ranging from 2 to 5, versus <0.2 for control plots. Calculations based on measured CO_2 and CH_4 fluxes from the marsh suggest that net ecosystem production (NEP) is likely to decline as salt water moves into tidal freshwater regions, but that the driving factor in decreasing NEP is lower plant production rather than increased ecosystem respiration. Plant and microbial communities and soil properties were all affected by the long-term saltwater intrusion. Periodic reassessments of the plots are being conducted.

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

Investigators: Dr. Erik Smith and Tracy Buck

Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay National Estuarine Research Reserve

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

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

Investigators: Beth Thomas[1] and Dr. Dennis M. Allen[2]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve
2 - Baruch Marine Field Laboratory, University of South Carolina

The Reserve currently participates in several community enhancement and stewardship activities and assists in river and marsh cleanups, leads recycling programs for elementary students and afterschool programs, and assists with a local monofilament recycling program in partnership with the SC Department of Natural Resources. Dr. Allen is serving on the Morgan Park Task Force, which is spearheading the revitalization of a historical site and community park located where the Sampit River intersects Winyah Bay. Ms. Thomas oversees the monofilament recycling program at five locations within the City of Georgetown.

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

Investigators: Dr. Erik Smith and Susan Denham

Baruch Marine Field Laboratory, University of South Carolina and North Inlet–Winyah Bay National Estuarine Research Reserve

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

North Inlet estuary benthos program: Long-term monitoring of benthic macrofauna

Investigators: Paul Kenny, Ginger Ogburn-Matthews, and Dr. Dennis M. Allen

Baruch Marine Field Laboratory, University of South Carolina

A long-term time series for benthic macrofauna that started in 1981 is being continued. Collections of animals that live in the shallow subtidal mud bottom of Bread and Butter Creek, North Inlet estuary were made every two weeks until 2002. Without direct grant support to continue, the time series, the effort was reduced and collections have been made at quarterly intervals since then. The macrofauna consists mostly of polychaete and oligochaete worms, bivalves, and small crustaceans which demonstrate annual cycles of abundance, peaking in late winter/early spring and reaching much lower levels in late summer/early fall. A companion series of collections of the meiofauna, a much smaller and more numerous group of bottom dwelling organisms, was made until 2008; see the Baruch website for more information. Measurements of physical conditions in the water, sediment, and air at the time of macrofauna collection help investigators determine causes of these variations in abundance over time. Total macrobenthos is negatively associated with salinity, water temperature, and chlorophyll values. Long-term trends for the spring season show that the macrobenthos increased over the first 30 years, while abundance in the fall season decreased over the same period. In addition to providing an indication of how this critical faunal community is responding to changing climate conditions, data from undisturbed North Inlet habitats provide a baseline to which other areas, including contaminated areas, can be compared. These studies also are an opportunity to examine the recruitment dynamics of soft-bottom benthic organisms.

Impact of salt water intrusion on C storage in temperate tidal freshwater wetlands: Assessing the amount, age, and fate of mobilized C

Investigators: Dr. Scott Neubauer and Dr. S.L. McCallister

Department of Biology, Virginia Commonwealth University

Rising sea levels, reduced precipitation in watersheds, and global increases in water consumption may result in widespread saltwater intrusion into tidal freshwater wetlands (TFWs). The movement of saline water into these historically freshwater ecosystems is likely to impact organic carbon cycling, including plant productivity, the decomposition of roots and litter, and the metabolism of soil microbial communities. The overall goal of this project is to understand how saltwater intrusion will impact the fate of organic carbon in TFWs, with multiple wetlands selected in both South Carolina and Virginia. This goal will be addressed by collecting soils from a matrix of TFWs, to cover a range of soil types, plant communities, and potential responses to saltwater intrusion. The fate of exchangeable organic carbon will be studied using a series of concentration, kinetic, and characterization measurements. Whole soil organic carbon pool incubations are designed to determine total effects of saltwater intrusion on soil decomposition and the underlying biogeochemical pathways. Mesocosm experiments, using a C_4 plant/C_3 soil design, will allow the integrated system-level effects to saltwater intrusion to be determined while also partitioning autotrophic and heterotrophic responses. Field measurements of soil CO_2 will assess in situ effects on organic carbon sources and ages.

NERR emergent vegetation bio-monitoring: Effects of sea level on the spatial dynamics of salt marsh vegetation communities in North Inlet estuary

Investigators: Tracy Buck and Dr. Erik Smith

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

As part of a NERRS system-wide initiative, the North Inlet–Winyah Bay NERR is monitoring salt-marsh emergent vegetation with the aim of quantifying variability in salt marsh macrophyte community spatial structure (species composition, relative abundance, and biomass) along elevation gradients, from creek bank to upland edge, in response to changes in tidal height and flooding frequency due to sea-level rise. Long-term monitoring is conducted in accordance to established NERRS protocols using a stratified sampling approach of fixed transects and repeated measures within permanent sample plots. This consists of two marsh segments with 3 fixed transects and 20 sampling plots per transect. Surface Elevation Tables (SETs) have also been established adjacent to the lower and higher elevations of the transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in vegetation and tidal dynamics. Sampling within each permanent plot includes percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by nondestructive sampling techniques; water table height at low tide; porewater salinity; and nutrient and sulfide concentrations. Soil organic content and bulk density adjacent to each plot were determined in 2008 and will be resampled at 3-year intervals. Elevation data (mm scale vertical resolution) for each plot are determined at biannual intervals to allow for the calculation of duration and frequency of tidal inundation at each plot.

Tide level: Long-term monitoring of tides at Oyster Landing pier in Crabhaul Creek

Investigators: Ginger Ogburn-Matthews[1], Tom Mero[2], and Lewis Lapine[3]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - NOAA / NOS / OPSD
3 - South Carolina Geodetic Survey

The tide gauge measures water level in reference to MLLW in Crabhaul Creek (Oyster Landing Pier) every six minutes. The data are transmitted to NOAA via NOAA's Geostationary Operational Environmental Satellites (GOES), making the data available online in near real-time (one hour delay). Data are available to the public, and are useful in showing tidal anomalies, observing sea-level rise, and modeling local phenomenon in North Inlet estuary. This state-of-the art tide gauge is accurate to ±3 mm with a resolution of ±1 mm and is part of the National Ocean Service (NOS) National Water Level Observation Network (NWLON), where NOS oversees all data management and most web products. Real-time data for North Inlet are available online from NOAA (http://tidesonline.nos.noaa.gov/geographic.html). In addition, verified historical data for Oyster Landing tide gauge (Station ID 8662245) are also available (http://tidesandcurrents.noaa.gov/stationhome.html?id=8662245). Monthly plots, site photographs, and documentation can be viewed on the Baruch Institute website (www.baruch.sc.edu). Updated elevations for the Oyster Landing tide gauge are available from NOAA (http://tidesandcurrents.noaa.gov/datums.html?id=8662245).

Consequences of developmental timing on population structure in the pyramidellid snail *Boonea impressa*

Investigator: Paula Teichholtz

Museum of Zoology, Department of Ecology and Evolutionary Biology, University of Michigan

Unlike most marine gastropod species, which display uniformity in developmental characteristics of their offspring, the pyramidellid snail *Boonea impressa* exhibits striking differences in hatching time and larval planktonic period duration in different populations. Populations of this species in the Gulf of Mexico hatch late with a short or non-existent planktonic period, while populations on the Atlantic coast hatch early with a much longer planktonic period. This creates the potential for vast differences in larval dispersal distance between populations and could lead to reproductive isolation of some populations and even eventual speciation without significant geographic isolation. Investigating the mechanisms of how development differs between populations in this species and what effect those differences have on gene flow and population structure will help us to better understand the process of speciation and the evolution of developmental characteristics in marine invertebrates. The goals of this project are 1) to evaluate the developmental timing of *B. impressa* populations along the southern Atlantic coast of North America and 2) to collect samples of Atlantic coast *B. impressa* for molecular genetic study. Adult *B. impressa* individuals will be collected from intertidal and shallow subtidal oyster reefs, with some individuals being immediately preserved and others maintained for

observation in seawater systems to determine the timing of major developmental milestones. Gene sequences from preserved *B. impressa* (including previously obtained sequences from Gulf of Mexico populations) will be compared in order to assess the degree of gene exchange and reproductive isolation between populations and to evaluate whether some populations may be separate species. If populations with low dispersal potential (characterized by long times to hatching and short larval planktonic periods) appear to be significantly reproductively isolated from nearby populations with higher dispersal potential (characterized by short times to hatching and long planktonic periods), it would suggest that inter-population differences in developmental characteristics could eventually lead to speciation in marine invertebrates.

HF radar surface current measurements in Long Bay

Investigators: Dr. George Voulgaris[1] and Dr. Dana Savidge[2]

1 - Marine Science Program, and the Department of Earth and Ocean Sciences, University of South Carolina
2 - Skidaway Institute of Oceanography (GA)

The objective of this study is to remotely monitor the ocean surface currents and waves in Long Bay using two new High Frequency radar (HF radar) stations. Scientists from the University of South Carolina, in collaboration with the Skidaway Institute of Oceanography and assistance from the University of North Carolina at Wilmington, have recently set-up these two stations. One station is located on Hobcaw Barony (33°21'19.60"N, 79° 9'12.56"W) and the other station is located at Caswell Beach, NC (33°53’25.18”N, 78° 1'40.64"W). Each station remotely measures the surface ocean currents up to 120 miles offshore and when combined create maps of temporal and spatial distribution of waves and currents over the entire Long Bay area. The data collected from this installation are critical in helping scientists understand the development of phytoplankton blooms along the outer shelf that are seen by scientists in satellite imagery. During the summer, development of phytoplankton is related to eddies generated by the Gulf Stream and could cause low oxygen conditions. However, the mechanisms for bloom development during the winter are not well known yet. Phytoplankton blooms in the winter actually prove to be beneficial, as they could provide a favorable feeding environment for larval fishes. Additionally, the data collected are in support of the National Radar Network funded by IOOS. The two stations are set-up and data collection is ongoing.

The ecological consequences of woody plant encroachment in coastal wetlands

Investigators: Dr. Ilka C. Feller and Dr. Marguerite Toscano

Smithsonian Environmental Research Center (MD)

Our objective is to investigate patterns of nutrient allocation and ecological stoichiometry of woody and herbaceous wetland plants growing in the same soil along a latitudinal gradient encompassing temperate salt marshes and tropical mangroves along the Atlantic coast of North America. Globally, woody plants are encroaching on grasslands. A shift in dominancy from herbaceous to woody plants is expected to alter the structure and functioning of ecosystems. This project will explore the ecological consequences of woody plant encroachment in coastal wetlands. Studies have shown pronounced differences in the elemental stoichiometry of plant biomass and nutrient allocation as a result of site differences in nutrient availability, phylogeny, and growth form. Nitrogen (N) to phosphorus (P) ratios are of particular concern when describing ecosystem productivity since they play such an important role in plant growth and ecosystem functioning. In wetlands, the N:P ratios of salt marsh plants provide the detrital basis for subsequent nutrient cycling. Thus, a shift in dominance from herbaceous to woody growth forms could alter fundamental ecological processes in the systems. To analyze differences in nutrient allocation of woody shrubs and herbaceous salt marsh species, we will compare the elemental stoichiometry of leaves, stems, roots and reproductive tissue of adjacent pairs (n = 5) of plants (herbaceous vs. woody) rooted in the same soil. This tissue will be dried and subsequently analyzed for C:N:P. Results of this study will be used to understand the ecological consequences of woody plant encroachment in coastal wetlands.

Conservation physiology of *Crassostrea virginica* in the North Inlet–Winyah Bay NERR

Investigators: Catherine Bowler and Dr. Sean Place

Department of Biological Sciences, University of South Carolina

To examine the effects of preselected environmental parameters on oysters in various regions of the North Inlet–Winyah Bay NERR, *C. virginica* individuals will be collected from four separate populations, two of which are found in the tidal channels near Oyster Landing in North Inlet and two located in the southern region of Winyah Bay. Three separate sampling events will be conducted between October 2013 and April 2014 to capture the oysters' transition from peak summer climate through fall and into winter. During each trip, measurements of seawater parameters (temperature, salinity, pH, and oxygen) will be made at each sample site. Between sampling events, field data will be analyzed and whole animal measurements will be taken. Respirometry will be used to observe the effects of increasing temperature on metabolic rate in ten randomly selected individuals from each population. The remaining five individuals will be sacrificed and dissected to evaluate differences in metabolic capacity among the populations. Among the enzymes that will be measured is citrate synthase (CS), and lactate dehydrogenase (LDH), an anaerobic metabolic enzyme.5.Protein carbonyls will be measured to assess cellular damage indicative of oxidative stress. Lastly, physiological analyses will be paired with water quality measurements using a correlation analysis to establish whether or not habitat has a significant impact on the physiological health of *C. virginica* in the North Inlet–Winyah Bay NERR.

Fish and crustacean use of marshes and intertidal creeks: Population and community level changes and relationships with weather and climate-driven changes in conditions within the nursery

Investigators: Dr. Dennis M. Allen, Dr. Matthew E. Kimball, Paul Kenny, and Ginger Ogburn-Matthews

Baruch Marine Field Laboratory, University of South Carolina

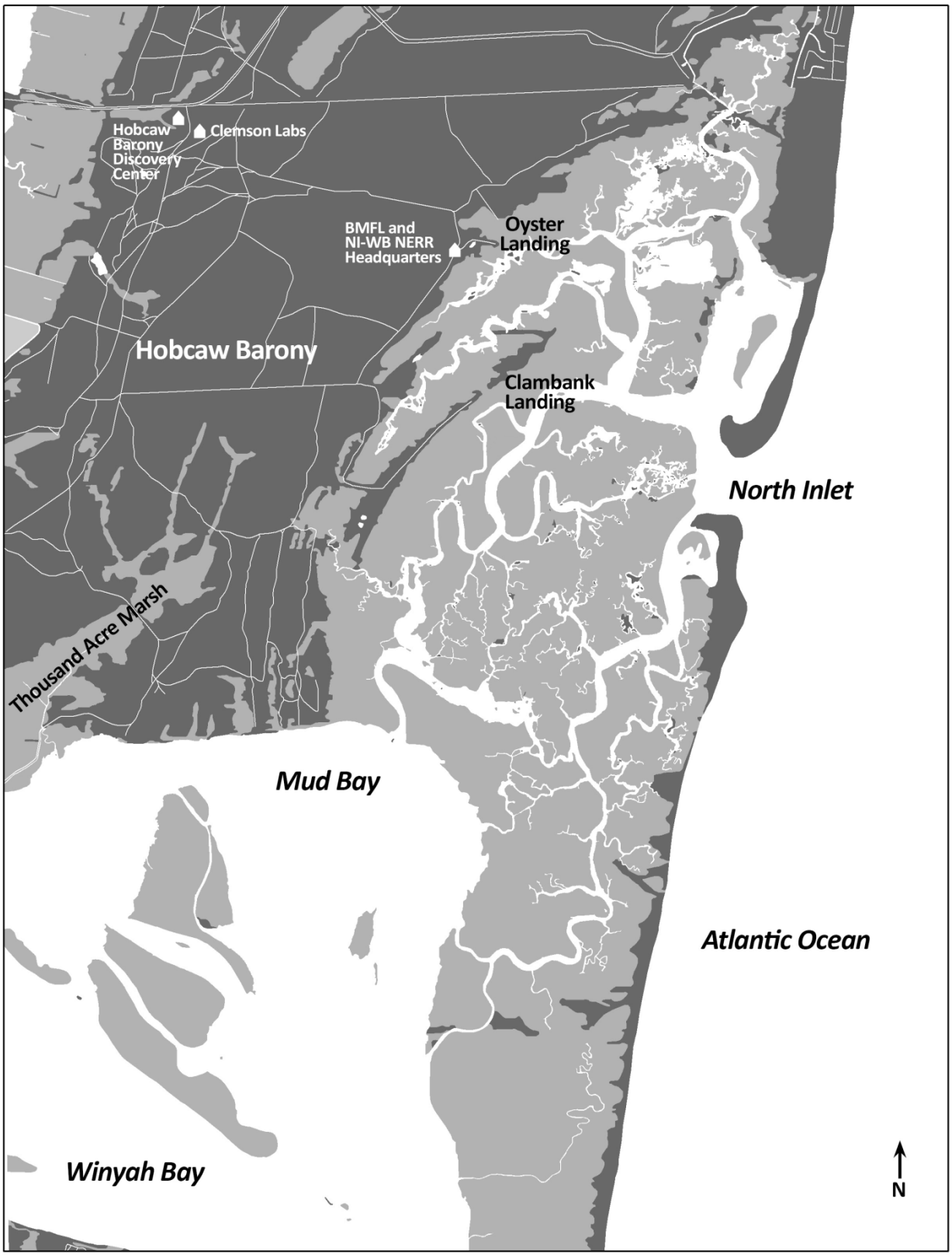
Collections of nekton (fishes, shrimps, and crabs) have been made in the Oyster Landing marsh-creek basin since 1984. The objective has been to track the composition, abundance, and biomass and length distributions of nekton and determine patterns, trends, and factors influencing changes over seasons, years, and decades. From 1984 to 2003, this effort was based on biweekly seine hauls from an isolated pool (low tide) in the intertidal creek. In 1996, we started a new time series from the flooded marsh surface (high tide) adjacent to the creek. From 1996 to 2003, both the low tide seine and high tide enclosure collections were made on the same day and tide. From 1984 to 2003, overall abundance in the low tide catch increased, evenness decreased, water temperatures increased, and salinity decreased. For spot, the most abundant fish every year, increasing abundance, earlier arrival in the spring, and decreasing size at arrival and a decreasing growth rate were observed through 2003. From 2003 to 2011, total nekton abundance decreased while salinity increased. Since 2012, the effort has been reduced and focused on documenting the timing and size of ingressing juvenile transient species and their growth rates. These long-term time series are unique within the Southeast region and are becoming increasingly important as we interpret impacts of global climate change on nekton populations and the shallow water habitats that are essential to their development. The results are used to inform the management of salt marsh-estuaries, watersheds, and fisheries in the region.

Seasonal differences in highly unsaturated fatty acids (HUFA) in late stage broods and zoea larvae of blue crab (*Callinectes sapidus*) in North Inlet estuary

Investigator: Dr. Stephen A. Borgianini

Department of Natural Science, University of South Carolina Beaufort

In a previous study of the local crab species *Uca minax*, the concentration of some essential fatty acids in newly hatched zoea was found to vary seasonally. This study will assess whether there are qualitative and quantitative differences in highly unsaturated fatty acids in *Callinectes sapidus* broods and first stage larvae over the reproductive season. Fatty acid content is being used as a measure of the nutritional condition of adult *C. sapidus*. Crabs under physiological (salinity and temperature) stress are more likely to use up lipid reserves, especially essential fatty acids such as omega-3s. The fatty acid methyl ester profiles will be compared among early, mid-season, and late season broods and zoea to assess if water temperature affects the provisioning of eggs and newly hatched offspring. Water temperature directly affects many metabolic processes and this cost may be reflected in lipid storage and catabolism. It is difficult to directly compare the nutritional condition of adults since their lipid profiles vary considerably over an individual's molt cycle. Ovigerous females and their broods should be physiologically similar with respect to their molt cycle. The differences, if any, in bioenergetic cost across the reproductive season may be reflected in the ability of the female to provision her offspring with a sufficient quantity and type of fatty acids to ensure their viability.


Hobcaw Barony Discovery Center
Clemson Labs
BMFL and NI-WB NERR Headquarters
Oyster Landing
Hobcaw Barony
Clambank Landing
North Inlet
Thousand Acre Marsh
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