

# **CURRENT RESEARCH, MONITORING, AND EDUCATION PROJECTS**

**2016 – 2017**

**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 2016 – 2017**

## **Introduction**

The Baruch Marine Field Laboratory (BMFL) has been the center of research activities for scientists and students from the University of South Carolina and dozens of other institutions since 1969. We conservatively estimate that between senior scientist projects and masters and doctoral studies conducted by graduate students, more than 1,000 grant and institutionally-funded projects have taken place at BMFL. This work has contributed substantially to the more than 1,840 peer-reviewed scientific articles, books, and technical reports that have been published since the Baruch Institute was founded. Independent and multi-disciplinary studies have been conducted by biologists, chemists, geologists, oceanographers, and other specialists who share interests in the structure, function, and condition of coastal environments. 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 and improving the condition of estuaries in the face of increasing human activities and changing climate in the coastal zone.

The following annotated list summarizes 72 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 56 of the investigators conducting research at the BMFL. In addition, 81 investigators representing 30 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), SC Sea Grant Consortium, US Department of Energy (US DOE), US Department 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 M. Allen, or Dr. Matthew E. Kimball. Paul D. 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](http://www.baruch.sc.edu)).

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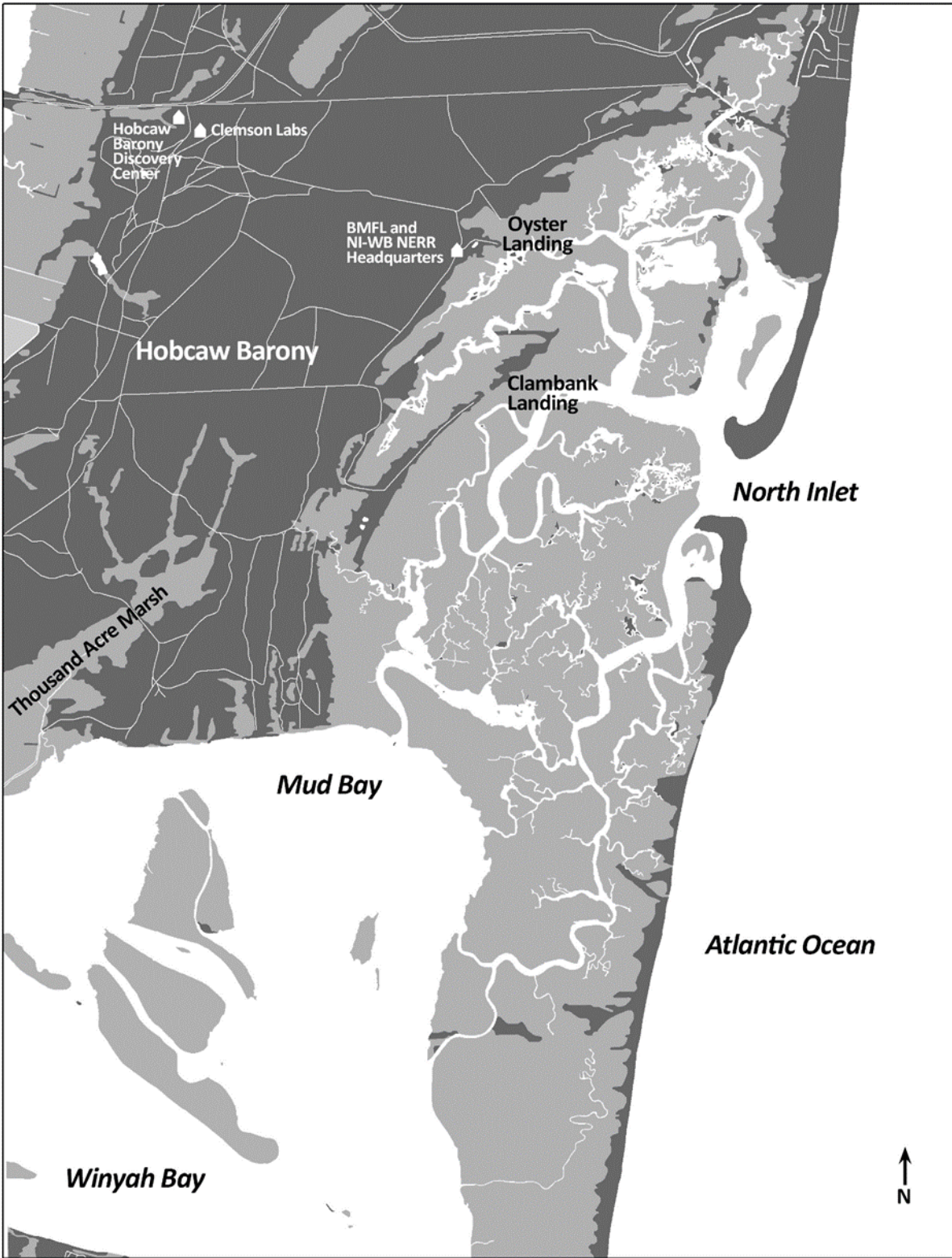
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## **Fluorescent dissolved organic matter dynamics in the North Inlet estuary**

Investigators: Dr. Erik M. Smith, Tracy Buck, and Susan Denham

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

There is growing interest in the use of the inherent optical properties of dissolved organic matter (DOM) as proxies for dissolved organic carbon (DOC) concentrations and biogeochemical cycling in coastal ecosystems. This study employs a fluorescent dissolved organic matter (FDOM) optical probe, recently available as part of Xylem/YSI's EXO water quality sonde, to quantify high-frequency DOC dynamics in the North Inlet estuary. Beginning in August of 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. Initial results have shown that over the majority of FDOM ranges observed to date, FDOM measures can serve as a reliable proxy for DOC concentration once temperature sensitivities and turbidity interferences are accounted for. Ongoing sampling is being conducted to understand the effects of different dissolved organic matter sources on FDOM – DOC relationships as well as the potential issues associated with sample quenching at high FDOM concentrations. 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.

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

Investigators: 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 estuaries. 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 estuary. 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 estuary is required to support them. Dolphin distribution in North Inlet estuary 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.

## **Can oysters be used as an indicator organism to detect pathogens/invasive species that might be present in the coastal marine ecosystem?**

Investigators: Dr. Paul E. Richardson, Olivia Shirley, and Lisa Pieterse

Department of Chemistry and Physics, Coastal Carolina University (SC)

We seek to develop a technique that would give a better indication of an ecosystem's presence/absence of coliphages. Certain filter feeding organisms are known to filter large volumes of water over time, trapping small microscopic organisms. These organisms, oysters being one of them, bioaccumulate these entities in their internal organs, providing an ideal organism to use to detect these coliphages. If we could develop the correct protocols, we could test these filter feeders for the presence of pathogens/invasive species; thus offering a better determination if an ecosystem is free from these disease-causing organisms. This methodology could also be expended beyond bacteriophages (current focus of this research), but also include other disease causing organisms/invasive species (*Perkinsus marinus*, *Haplosporidium nelson*, *Loxothylacus panopaei*, *Megabalanus coccopoma*, *Petrolisthes armatus*, and *Petrolisthes galathinus*) that might be entering into the marine ecosystems. We seek to develop methods to detect microorganisms using known techniques against coliphages as proof of concept for the efficacy of the new technique. Once the new technique has shown to be effective and the parameters of detection have been quantitatively determined, this study will move forward in modifying the technique to detect relevant disease causing organisms.

### **Sea turtle nest monitoring on Hobcaw Barony**

Investigators: Betsy Brabson<sup>1</sup>, Robin Baughn<sup>1</sup>, Wendy Allen<sup>2</sup>, and other volunteers

1 - DeBordieu Colony (Debidue Beach Coordinators), SC

2 - North Inlet–Winyah Bay National Estuarine Research Reserve, 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 miles 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 tidal flooding are carefully relocated to higher areas. Volunteers also inventory nests 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 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, from Hobcaw Beach to North Myrtle Beach. Debidue Beach (Hobcaw Beach to Pawleys 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 South Carolina Department of Natural Resources which oversees the volunteer sea turtle program for the state. Data are also entered and available on the [www.seaturtle.org](http://www.seaturtle.org) website, and include information on a DNA study to track the nesting behavior of individual turtles.

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

Investigators: Dr. Richard Stalter<sup>1</sup>, Dr. Joseph Rachlin<sup>2</sup>, and John Baden<sup>3</sup>

1 - Department of Biological Sciences, St. John's University, (NY)

2 - Lehman College, (NY)

3 - US Army Corps of Engineers, NC, Retired

The vascular flora present in three abandoned rice fields of the Winyah Bay estuary at the Belle W. Baruch Institute for Marine and Coastal Sciences, Georgetown County, South Carolina identified in 1968-1969 was compared with the vascular flora present in 1987-1991, and 2013-2015. Twenty vascular plant species were identified in 1968-1969 and 22 in 2013-2015 at the most saline marsh, Thousand Acre Rice Field. Forty seven taxa were reported at Airport marsh in 1968-1969 and 27 in 2013-2015. Fifty six taxa were reported at Alderly marsh in 1968-1969, while only 41 were identified here in 2013-2015. A parsimony algorithm was used to evaluate the distribution and co-occurrence of vascular brackish marsh species in 3 abandoned rice fields sampled at three intervals, 1968-1969, 1987-1991, and 2013-2015. There was a shift in the flora at the two least saline sites, Alderly marsh and Airport marsh from 1968-69 to 1987-91 and 2013-2015. Three factors, rising sea level, an increase in water salinity plus the invasion of *Phragmites australis* may explain the shift in vegetation in Alderly marsh and Airport marsh, the two least saline marshes. There was a shift in the flora at the most saline site, Thousand Acre Rice Field from 1967-1969 to 1987-1991 and 2013-2015 after the marsh was savaged by Hurricane Hugo in 1989. The invasion of non-native *Phragmites australis* at all sites and the increase in water salinity at all sites best explains the reduction in vascular plant species at Airport and Alderly marshes over the 47 year collecting period.

### **Do environmental factors drive diet in salt marsh animals?**

Investigators: Dr. David S. Johnson<sup>1</sup>, Serina Sebilian<sup>1</sup>, and Cynthia Crowley<sup>2</sup>

1 - Biological Sciences, Virginia Institute of Marine Science

2 - University of Vermont

The diet of an animal can be governed not only by food availability but also by other factors such as physical and chemical properties of the environment and biotic interactions. Our goal is to understand the environmental factors that may drive the diet in marsh animals. We sampled fiddler crabs, mudsnails, blue crabs, and insects, will examine their diets and will compare them to environmental variables. These results will help us understand not only the ecology of these organisms, but also how they may respond to rapidly changing environmental conditions due to climate change. We are currently processing samples, with many still in the freezer, so we have no results yet to report.

### **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, and Paul D. Kenny  
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 1984-2003, 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 1996-2003, both the low tide seine and high tide enclosure collections were made on the same day and tide. These efforts demonstrated that although patterns of occupancy of the intertidal basin by species and life stages within species varied, they were predictable according to tide level and time of year. Large, short-term changes in salinity and temperature affected abundance in the intertidal basin, but familiar patterns were quickly re-established. Recent efforts are focused on documenting long-term shifts in the timing and size of juvenile transient species and their growth rates. Our 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.

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

Investigators: Dr. Erik M. Smith and Susan Denham  
North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

As part of the National Estuarine Research Reserve System (NERRS) System-Wide Monitoring Program (SWMP), 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's Data and Publications link: <http://www.baruch.sc.edu/water-quality-chemistry-databases>.

### **Assessing the distribution of the eastern black rail (*Laterallus jamaicensis jamaicensis*) in South Carolina**

Investigators: Christy Hand and Amy Tegeler  
South Carolina Department of Natural Resources

Throughout their range, the distribution and ecology of the eastern subspecies of the black rail is poorly understood. Most of the available information about black rails in the eastern United States comes from incidental observations. In states such as Maryland and Virginia, where standardized historic and current surveys have been conducted, black rail populations appear to be declining rapidly. The eastern black rail is currently candidate for protection under the Endangered Species Act, and information about their current status and distribution is urgently needed to inform the listing decision. Mapping and examining patterns of occurrence during both the breeding and nonbreeding seasons has been identified as a top priority for the assessment and conservation of this species. Intensive call-response surveys were conducted in the coastal region of South Carolina during the 2015 and 2016 breeding seasons (March-June). Black rails were detected at 32 survey points during 2015 and 17 survey points during 2016. Due to concerns about the status of the black rail, call-response surveys also were recently conducted in Maryland, Virginia, North Carolina, and New Jersey. Although northern states historically were strongholds for the species, these recent surveys suggest that South Carolina may currently support a significant portion of the black rails in Atlantic coast states during the breeding season.

### **Painted Bunting monitoring project**

Investigators: Wendy Allen<sup>1</sup>, Dr. Jennifer Plunket<sup>1</sup>, Dr. James Rotenberg<sup>2</sup>, and citizen science volunteers: Bill Brabson, Marsha Green, Marlene Konsek, Pete Little, and Sandy Little

1 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina

2 - Department of Environmental Studies, University of North Carolina Wilmington

Painted Buntings (PABUs) are the most colorful of the migratory songbirds that visit the coast of South Carolina. Adult males sport a royal blue head, neon green back, and red breast and rump. PABUs return to the area mid-April, nest in shrubs near marshes, and migrate south in the fall to central and southern Florida, Cuba, and the Yucatan peninsula of Mexico. Surveys conducted since 1966 have demonstrated a decline in PABUs which lead to the establishment of a monitoring project that includes banding at select sites in the southeast and observations made by citizen scientists. This project, Painted Bunting Observation Team or PBOT, is headed up by scientists at UNC-Wilmington ([www.paintedbuntings.org](http://www.paintedbuntings.org)). The North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB-NERR) served as a PBOT banding site 2007-2012, and has maintained a feeder near the Baruch Marine Field Laboratory (BMFL) since 2007. The NIWB-NERR established a Painted Bunting monitoring project in summer 2014 to document buntings coming to the feeder. Reserve staff and citizen scientists make timed observations of PABUs and record color band combinations, if present. Citizen scientists continue to work with Reserve staff to monitor PABUs on Hobcaw Barony. The project will contribute to a better understanding of PABU longevity, how long they stay during the nesting season, whether they come back to the same site from year to year, and other aspects of their natural history.

### **Maintenance and operation of IOOS/SECOORA priority WERA HF radar sites**

Investigators: Dr. George Voulgaris<sup>1</sup> and William H. Jefferson<sup>2</sup>

1 - School of the Earth, Ocean, and Environment, 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 remotely monitor the ocean surface currents and waves in Long Bay using two high frequency (HF) radar stations. Scientists from the University of South Carolina operate and maintain two US IOOS/SECOORA identified priority WERA system radar sites (Georgetown, SC and Fort Caswell, NC). 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. The results are combined to create maps of temporal and spatial distribution of waves and currents over the entire Long Bay area. Data from these sites are sent to SECOORA and National High Frequency Radar Network for integration, display, and dissemination.

### **Assimilation rates of dissolved organic carbon by photomixotrophic estuarine phytoplankton**

Investigator: Dr. James L. Pinckney

Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

Phytoplankton 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 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. 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 research is to apply a unique <sup>14</sup>C radiolabeling technique to quantify the *in situ* assimilation rates of dissolved organic carbon (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.

## **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)

This ongoing long-term project assesses the abundance and microgeographic and ecological correlations of canebrake rattlesnake (*Crotalus horridus atricaudatus*) occurrence in the approximate 8,000 acres of terrestrial communities of Hobcaw Barony. Observations involve timed road and walking surveys and usage of drift fences and cover boards along with various marking techniques of specimens to assess abundance. Data taken on snake occurrences involve coordinates of specific geographic localities, topography, general and specific ecological characteristics of communities, and variables involving specific microhabitat and seasonal associations. Data taken by others and information on historical land usage at Hobcaw Barony are also utilized. Results currently indicate that a relatively small metapopulation of the canebrake rattlesnake exists on the property, with highest densities in specific and relatively small areas. Hardwood forests and palmetto swamplands bordering upland areas are key ecological components of this species' environment at Hobcaw Barony. The study to date indicates that the current conservation status of the canebrake rattlesnake on the property is poor, and that populations may have declined in the past five years. Management efforts should be made to conserve critical habitats on the property and to minimize disturbance of them. People using vehicles should also be vigilant of snakes on the roads to reduce road mortality of individuals, which has increased in the past several years. Similar information on occurrence and abundance of other reptilian and amphibian species is also used to understand geographic and habitat correlates of herpetofaunal diversity (i.e., species richness) on the property. Hardwood forests and freshwater wetlands, and associated ecotones between these and pine forests, are critical areas for herpetofaunal diversity, with the greatest species richness found in the northern portion of the property. Managed pine forests have had the lowest richness.

## **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 are being quantitatively examined in North Inlet estuary tidal creeks. Hard clam age structure, growth rates and sex ratios continue to be evaluated seasonally and 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.

## **Public and K-12 community education activities – National Estuarine Research Reserve**

Investigators: Beth Thomas and Hannah Sarver

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Educational activities for the general public, K-12 teachers, and students highlighting coastal ecology and integrating findings from research are offered throughout the year. Seasonal schedules of public outreach activities are produced throughout the year, and programs are promoted through informational fliers, newsletters, newspapers, and website ([www.northinlet.sc.edu](http://www.northinlet.sc.edu)), and the Reserve's Facebook page in addition to local online community event calendars. Program offerings include estuarine and beach ecology activities for all ages, biking and kayaking programs featuring coastal ecology, open houses and research lectures, and research-based citizen science programs. Professional Teacher Development opportunities and field trips for K-12 public, private, and homeschool students are also available, as well as job shadowing and research experiences for middle and high school students. Off-site outreach includes presentations to environmental and civic groups, local festivals, special outreach programs at regional libraries and museums, afterschool programs for local elementary and middle schools, science and environmental fairs, and career days. Partnerships with other local environmental education providers, including the Belle W. Baruch Foundation, ACE Basin NERR, SC Department of Natural Resources, SC Sea Grant Consortium, Friends of Coastal South Carolina, the Waccamaw National Wildlife Refuge, and the Coastal Waccamaw Stormwater Education Consortium provide additional opportunities for public education, teacher training, and professional development, as well as staff and resources for enhanced programming and outreach.

## **Geographic variations in larval fish 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<sup>1</sup>, Dr. Kenneth W. Able<sup>2</sup>, Dr. Jeffrey A. Buckel<sup>3</sup>, Dr. Todd Kellison<sup>4</sup>, Dr. Chris Taylor<sup>4</sup>, Dr. Jon Govoni<sup>4</sup>, Dr. Harvey Walsh<sup>5</sup>, and Jonathan A. Hare<sup>5</sup>

1 - Baruch Marine Field Laboratory, University of South Carolina

2 - Rutgers University Marine Field Station and Jacques Cousteau National Estuarine Research Reserve, NJ

3 - Center for Marine Sciences and Technology, Department of Applied Ecology, North Carolina State University

4 - NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, NC

5 - NOAA National Marine Fisheries Service, Woods Hole, MA

Adult fishes which spawn in the ocean during late fall and winter produce 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 have been site specific and of short duration. A collaborative effort among investigators from various locations in the Northeast, Middle Atlantic, and Southeast regions is comparing and interpreting patterns of abundance, timing, and size structure during ingress over multiple years. Our time series of larval fishes from the mesozooplankton collections in the North Inlet estuary appears to be the longest continuous dataset, beginning the 37th year of biweekly collections in January 2017. Time series collections in Beaufort, NC (since 1985) and Great Bay, NJ (since 1989) will contribute to the analyses. Recently, the SC, NJ, and NC partners, which are the founding components of CCOR (Coastal Collaboration on Ocean Recruitment), contributed long-term ichthyoplankton datasets to the SEAMAP website. NOAA-based ocean sampling programs provide data about spawning locations, timing, and cross-shelf distribution of early stage larvae. Changing climate is expected to alter patterns of reproduction, movement, and growth for many coastal fishes, and preliminary analyses suggest that the phenology and growth of some species are responding to increasing water temperatures.

## **Interspecific competition among some salt marsh perennials in South Carolina**

Investigators: Dr. Richard Stalter<sup>1</sup> and John Baden<sup>2</sup>

1 - Department of Biological Sciences, 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.

## **Coastal training activities in the North Inlet–Winyah Bay National Estuarine Research Reserve: Protecting water and habitat quality through science-based community training**

Investigator: Michelle LaRocco

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Coastal training activities connect local decision makers to the emerging research and scientific knowledge generated to help the decision makers make more informed decisions on coastal environmental issues. The Coastal Training Program provides needs-based workshops, trainings, and tools to decision makers in Georgetown and Horry counties and these efforts especially target county and municipal staff and officials, and those decision makers that strongly influence local land use, such as planners, developers, engineers, and realtors, as well as those with a role in natural resource management within local counties and municipalities. The Coastal Training Program works to protect water and habitat quality in a region of rapidly developing coastal communities by providing science-based training events on the issues of stormwater management and low impact development principles, habitat protection and restoration, coastal hazards and climate change, and other emerging priority issues. The program frequently partners with the ACE Basin NERR, SC Sea Grant Consortium, the Coastal Waccamaw Stormwater Education Consortium, the Clemson University Extension Service, and the Carolina Clear Program.

## **Development of monitoring and assessment tools for nitrogen and phosphorus in South Carolina coastal wetlands II: Hydrological Assessments**

Investigators: Dr. Dianne I. Greenfield<sup>1,2</sup>, Dr. Timothy Callahan<sup>3</sup>, Dr. Denise Sanger<sup>2</sup>, and students

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

2 - South Carolina Department of Natural Resources

3 - Department of Geology and Environmental Geosciences, College of Charleston (SC)

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. Moreover, establishing linkages between urbanization and hydrology is key to understanding nutrient delivery to coastal zones. As coastal SC is experiencing rapid urbanization, this contributes to the deposition and accumulation of nutrients and fertilizers, thus potentially making SC estuaries susceptible to nutrient (particularly N) loading. This project continues our work assessing biological (phytoplankton) responses to various nutrient conditions in the coastal zone. Although experimental studies are focused elsewhere in SC, monitoring of phytoplankton, nutrients, and basic water quality spans the SC coastal zone, including North Inlet–Winyah Bay.

## **How does coastal development impact groundwater inputs to tidal creeks, and how do salt marshes act to mitigate those impacts?**

Investigators: Meghan Shanahan<sup>1</sup>, Baker Stevens<sup>1</sup>, Allison Davis<sup>1</sup>, Dr. Alicia Wilson<sup>1</sup>, and Dr. Erik M. Smith<sup>2</sup>

1 - School of the Earth, Ocean, and Environment, University of South Carolina

2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

The overall goal of this work is to assess the impact of coastal development on groundwater inputs to tidal creeks, and the ability of salt marshes to mitigate changes in groundwater quality. The immediate goal of this project is to find out whether the composition of groundwater in the upland shows any correlation with development, and whether variability of the size of the salt marshes affects the composition of groundwater in the zone of exchange surrounding tidal creeks. We hypothesize that the impact of development will be greatest at sites with large uplands and narrow salt marshes and that sites with wide salt marshes will be buffered from development. We will test these hypotheses by sampling groundwater from nine tidal creeks in South Carolina; Crabhaul Creek will serve as an undeveloped endmember.

## **Silver nanoparticle accumulation and fate in an estuarine bivalve**

Investigators: Shelby V. Butz<sup>1,2</sup>, Dr. R.C. Merrifield<sup>1</sup>, Dr. James L. Pinckney<sup>2</sup>, and Dr. Jamie R. Lead<sup>1</sup>

1 - SmartState Center for Environmental Nanoscience, Arnold School of Public Health, University of South Carolina

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

The overall aim of this project is to quantify the bioavailability, uptake, and bioaccumulation of silver nanoparticles within the aquatic environment as well as the mechanism of uptake and bioaccumulation by aquatic organisms. To achieve this aim we use the Eastern oyster, *Crassostrea virginica*, and novel isotopically labeled core-shell-shell nanoparticles (<sup>107</sup>Ag@Au@<sup>109</sup>Ag). The silver isotope, <sup>107</sup>Ag, contained in the outermost layer, dissolves in media releasing free silver ions while the core material, <sup>109</sup>Ag, remains in nanoparticulate form due to the gold barrier. We hypothesized that biouptake and bioaccumulation are mediated by the free silver ion, and that with the use of stable isotope tracers, the relative contributions of ionic and nanoparticulate silver can be differentiated. Initial test organisms include an estuarine dinoflagellate species and an estuarine bivalve. Future research will couple the bivalve model with a mammalian model to determine trophic transfer rates applied to environmental human health. This study will greatly improve the understanding of how bioaccumulation manifests under environmentally realistic conditions.

## **Hydrology and pollutant removal performance in storm water ponds typical of the lower coastal plain of South Carolina**

Investigators: Dr. Erik M. Smith<sup>1</sup>, Dr. Richard Peterson<sup>2</sup>, Colleen Cohn<sup>1</sup>, Tracy Buck<sup>1</sup>, Susan Denham<sup>1</sup>, and Austin Waldorf<sup>2</sup>

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

2 - School of Coastal and Marine Systems Science, Coastal Carolina University (SC)

South Carolina resource managers and storm water engineers require locally relevant quantitative information on the residential storm water ponds typical of the coastal plain. Storm water ponds, especially detention ponds, are the most common best management practice (BMP) for controlling runoff in coastal South Carolina. Despite their prevalence, there are currently no published studies quantifying the extent to which residential storm water ponds typical of South Carolina's coastal plain can be expected to offer an effective means of moderating hydrologic flows and pollutant loads from developed landscapes. To address this need, the specific objectives of this study are to: 1) Quantify the complete water budget (surface runoff, groundwater input, precipitation, evapotranspiration, storage, and total export) for selected storm water pond at both the precipitation event scale and over the annual scale; 2) Quantify concentrations of total nitrogen, total phosphorus, suspended solids, and fecal indicator bacteria (*E. coli*) in pond outfall waters, relative to input waters, to determine detention pond effectiveness in their ability to remove or retain these pollutants prior to discharge to receiving waters. Research will directly account for the relative roles of both surface piped and over-land sheet flow inputs as well as groundwater flow paths as sources of material delivery to ponds. The study will be conducted in ponds that vary in the degree of impervious surfaces within their catchment area and in the means by which runoff is routed to the ponds. Research results will be incorporated into technical recommendations for regulatory agencies, local storm water managers, pond management professionals, homeowner associations, and the broader scientific community.

## **Saltwater intrusion monitoring**

Investigators: Dr. Alicia Wilson<sup>1</sup> and Dr. William Clendenin<sup>2</sup>

1 - School of the Earth, Ocean, and Environment, University of South Carolina

2 - South Carolina Department of Natural Resources

Knowledge of the location of the freshwater-saltwater interface in coastal aquifers is critical for managing coastal groundwater resources, for predicting saltwater intrusion, and for calculating groundwater-related chemical exchange between aquifers and the coastal ocean. This project installed permanent wells to monitor salinity and saltwater intrusion in the upper (up to 100 ft depth) aquifers at North Inlet, as part of the South Carolina Department of Natural Resources long-term coastal monitoring network. To date, the stratigraphy from the well logs has been used to support the development of regional groundwater flow models by Ph.D. student Tyler Evans. The models are further constrained by hydraulic head and salinity observations from the wells. Monitoring is ongoing.

## **Quantifying biogeographic variation in consumer-plant interaction strengths in salt marsh ecosystems**

Investigators: Rebecca Atkins and Dr. Craig Osenberg

Odum School of Ecology, University of Georgia

The salt marsh periwinkle, *Littoraria irrorata*, can both facilitate and suppress the smooth cordgrass, *Spartina alterniflora*, a dominant and important species in southeastern US salt marshes. Such variation in the sign and strength of this consumer-plant relationship is likely driven by environmental factors that alter plant productivity and consumer biomass. Our study will document large-scale biogeographic variation in *Spartina* (e.g., density, productivity), *Littoraria* (e.g., size-structure, density, biomass), and the strength of their interaction, as well as environmental factors that may modify their interaction (e.g., nutrient availability, sediment composition, elevation, temperature). From July 2015 through October 2016, and at sites from Florida to Virginia, we surveyed twenty five, 0.0625 m<sup>2</sup> plots quarterly and established a field experiment to quantify the strength of the *Littoraria-Spartina* interaction. Experiments consisted of two *Littoraria* density treatments (0 and ambient) and a cage control, each with five replicates per site. Experiments were sampled monthly, assessing the same variables as in the marsh surveys. Results will be used to: 1) quantify spatio-temporal variation in *Littoraria* and *Spartina* population parameters; 2) quantify interaction strength at ambient *Littoraria* densities; and 3) evaluate the role of consumer density and biomass.



## **Eddy covariance flux measurements to quantify salt marsh productivity and its response to environmental variability over multiple time scales**

Investigators: Dr. Thomas L. O'Halloran<sup>1</sup> and Dr. Erik M. Smith<sup>2</sup>

1 - Baruch Institute for Coastal Ecology and Forest Science, Clemson University (SC)

2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Accurate and integrative measures of marsh productivity as well as the sensitivity of marsh production to environmental variability over multiple time-scales are essential to understanding how salt marshes will respond to future environmental and anthropogenic stressors. This study is employing state-of-the-art eddy covariance flux instrumentation (IRGASON, Campbell Scientific) to generate high-frequency (30-minute interval) measurements of terrestrial-atmospheric CO<sub>2</sub> exchange at spatial scales large enough (on the order of 20,000 m<sup>2</sup>) to capture landscape-level dynamics. The instrumentation is located with the NERR's existing salt marsh monitoring infrastructure within the Crabhaul Creek marsh of North Inlet estuary to leverage ongoing data collection of marsh vegetation, surface elevation and tidal inundation, salinity and pore water chemistry, and meteorological data. Results of this study will greatly improve our understanding of marsh sensitivity to environmental variability and change through the development of empirical models relating the integrated response of the salt marsh ecosystem (as gross primary production, ecosystem respiration, and net ecosystem exchange) to environmental variability over temporal scales not previously possible and at spatial scales large enough to integrate landscape-level responses.

## **Prey selection and its relation to digestive energetics of the diamondback terrapin (*Malaclemys terrapin*)**

Investigators: Dr. Scott L. Parker<sup>1</sup> and Amanda DiBella<sup>2</sup>

1 - Department of Biology, Coastal Carolina University (SC)

2 - Coastal, Marine, and Wetland Studies Program, Coastal Carolina University (SC)

Diamondback terrapins are important mesopredators in estuarine ecosystems of the eastern United States and accordingly may play an important role in regulating salt marsh species diversity and ecosystem function. Diet of terrapins consists largely of invertebrates, and in South Carolina, periwinkle snails (*Littoraria irrorata*) constitute up to 79% of their dietary volume, followed by crustaceans such as Fiddler Crabs (*Uca pugnax*) and blue crab (*Callinectes sapidus*). The aim of this project is to conduct the first comparative study on diamondback terrapin prey selection and effect of prey species on terrapin digestive performance. To achieve this aim, we will quantify the diet of wild terrapins in the field by analysis of fecal samples and conduct an electivity analysis to determine whether prey choice is random or selective. In the laboratory, we will conduct a prey selection study to determine whether terrapins exhibit a preference for periwinkles, crabs, or fish when prey items are equally available. In addition, we will determine energetic content of periwinkles, fiddler crabs and finger mullet and measure digestive efficiency of each prey species. Results will provide information on how diamondback terrapins exploit nutritional resources in their environment. Additionally, these results will provide essential preliminary data for calculating an energy budget for diamondback terrapins for use in estimating the impact of terrapin predation on invertebrate prey species.

## **Mechanisms for thermal tolerance in an estuarine cnidarian**

Investigator: Dr. Adam Reitzel

University of North Carolina Charlotte

Estuarine species like the starlet sea anemone, *Nematostella vectensis*, experience large fluctuations in temperature, requiring wide temperature tolerances, and at the same time, have a natural distribution along a pronounced thermal cline (Atlantic coast of North America), which may promote the evolution of different temperature optima and tolerances in populations. Previous research with *Nematostella* has shown extensive genetic variation, some of which is strongly segregated between populations, and large differences in phenotypic variation in response to both acute and chronic temperature, both of which vary with site of collection, consistent with adaptation to temperature. North Inlet-Winyah Bay represents the most southern location where successful collections for this species have occurred in recent decades and individuals from this site appear to have elevated thermal tolerance. We are using field-deployed temperature loggers coupled with seasonal field samples to compare mean and maximum temperatures with the growth and gene expression for this species. Results will be compared with *N. vectensis* collected from sites as far north as Nova Scotia to understand the genetic processes that allow these estuarine specialists to adapt and respond to their dynamic temperature environments.

## **Distributions of the human pathogen *Vibrio parahaemolyticus* in surficial sediment**

Investigators: India Gartmon, Savannah Klein, Shannon Pipes, and Dr. Charles R. Lovell  
Department of Biological Sciences, University of South Carolina

*Vibrio parahaemolyticus* causes gastroenteritis after ingestion of raw or undercooked shellfish, primarily oysters. Low *V. parahaemolyticus* densities ( $>10^1$  CFUs  $g^{-1}$ ) in water and oyster samples are common, while  $10^4 - 10^5$  cells is considered high risk in oysters by the FDA. We examined *V. parahaemolyticus* numbers in flocculent surficial estuarine sediment that is easily re-suspended and can then be ingested by filter feeding invertebrates, including oysters. These sediments also support large populations of eukaryotic microalgae which co-occur with *V. parahaemolyticus*. Sediment cores (1cm depth) were taken from an oyster bed and from nearby consolidated sediments in the North Inlet, SC estuary to determine *V. parahaemolyticus* densities. Sampling was performed bimonthly May – October. Samples were sectioned vertically into 1 mm segments and plated onto a standard plating medium, TCBS agar. Presumptive *V. parahaemolyticus* counts were as high as  $10^6$  CFUs/g in the upper two mm of sediment while mm 9 and 10 had counts as low as  $10^3$  CFUs/g. Photopigment analyses revealed large populations of phototrophs and correlations between high *V. parahaemolyticus* densities and specific algal taxa were examined. Occurrence of high numbers of *V. parahaemolyticus* in the upper two mm of sediment assures that these organisms can be easily re-suspended by currents. Correlations between benthic microalgae and *V. parahaemolyticus* may potentially contribute to prediction of outbreaks.

## **An integrative, multi-disciplinary approach to inform numeric nutrient criteria in South Carolina coastal wetlands**

Investigators: Dr. Dianne I. Greenfield<sup>1,2</sup> and Dr. Timothy Callahan<sup>3</sup>

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

2 - South Carolina Department of Natural Resources

3 - Geology and Environmental Geosciences, College of Charleston (SC)

This work will provide regulatory agencies with targeted information regarding physical and biological responses affecting nitrogen (N) and phosphorus (P) levels in South Carolina coastal wetlands. This information will become an integral tool for numeric nutrient criteria and associated management decisions. Excess levels of N and P are associated with eutrophication in aquatic systems. Yet, surprisingly little is known about linkages between hydrology and biological responses to N and P in SC coastal wetlands, particularly up- and downstream associations, representing a critical gap in the ability to provide managers with information necessary for nutrient regulation. Given continued development along the SC coast, a multi-disciplinary approach that integrates hydrology, nutrient evaluations, and biological responses across spatial and temporal scales will be crucial for conserving wetland quality and establishing numeric criteria. We invoke a multi-agency partnership to assess how hydrology and up/downstream processes drive biological responses (phytoplankton growth) to N and P along coastal SC using an intensive field sampling and experimental approach. Specifically, we will (1) monitor surface and groundwater delivery, nutrients and key biological indicators (chlorophyll *a*, phytoplankton), (2) conduct field experiments to determine wetland-specific phytoplankton responses to nutrient loading and (3) perform watershed-scale analyses of land use patterns.

## **Green porcelain crab larval biology and phenology**

Investigators: Dr. Juliana M. Harding<sup>1</sup> and Dr. Dennis M. Allen<sup>2</sup>

1 - Department of Marine Science, Coastal Carolina University (SC)

2 - Baruch Marine Field Laboratory, University of South Carolina

The biology and phenology of the green porcelain crab (*Petrolisthes armatus*) will be described with field collections. Weekly zooplankton tows will be used to monitor the presence and stages of crab larvae. Larval morphology will be described from field caught specimens. This information will add to the understanding of this invasive (extended geographic range) species' occurrence in the North Inlet estuary. *Petrolisthes armatus* larvae first occurred in biweekly zooplankton collections in the mid-1990s and little is known about the timing, periodicity, and duration of larval production. Similar information can be extracted from archived biweekly collections during their period of occurrence to determine if there have been shifts in the patterns over the years.

### **Sediment accretion in North Inlet estuary salt marshes**

Investigators: Dr. James Morris<sup>1</sup> and Karen Sundberg<sup>2</sup>

1 - Department of Biological Sciences, 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 below ground biomass due to enhanced decomposition now that below ground 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.

### **Analyzing zinc and copper levels in *Fundulus heteroclitus***

Investigators: Dr. Julia Baker, Kristine Giang and Scarlet Leigh

Division of Business, Mathematics and Sciences, Columbia College (SC)

Zinc and copper are two crucial trace metals that can directly affect the health of fish. Both zinc and copper are also essential trace dietary minerals for humans but can cause adverse health effects in cases of over exposure. These metals when found in marine environments can be absorbed by fish and concentrate into different organs such as the gill and liver. The concentration of zinc and copper in fish can provide information on the health of marine environments in which they live. The fish that will be used for this research, *Fundulus heteroclitus*, or mummichog, is abundant along the Eastern coast of the United States and has been used in numerous environmental studies. Fish will be collected from the pristine environment of the North Inlet estuary at Hobcaw Barony and the more polluted waters of nearby Georgetown Harbor. The zinc and copper concentrations in these two populations will then be measured using atomic absorption spectroscopy. Data from this research will be compared to results from previous studies investigating parasite load and immune response to organic pollutants in *Fundulus heteroclitus* to provide a more complete picture of the health of the marine environment in the North Inlet estuary and Georgetown Harbor.

### **Killifish behavioral changes due to arsenic exposure**

Investigators: Dr. Lisa Bain<sup>1</sup>, Dana Symkowicz<sup>1</sup>, and Katey Schwendinger<sup>2</sup>

1 - Department of Environmental Toxicology, Clemson University (SC)

2 - Department of Biological Sciences, Clemson University (SC)

Arsenic is a drinking water contaminant in many parts of the world, and millions of people are exposed to concentrations above the current drinking water standard. Exposure to arsenic during embryogenesis is associated with neurodevelopmental effects such as reduced social skills, impaired spatial memory, and depressive or anxiety-like symptoms. However, the mechanisms by which arsenic is causing these effects are unknown. We have previously used killifish (*Fundulus heteroclitus*) to determine the effects of embryonic-only arsenic exposures on muscle growth/development and found statistically significant reductions in growth 4-6 months later, in addition to reduced ability to detect odorants. The purpose of this study is to determine how early life exposure to arsenic causes these changes in growth and behavior, and the mechanisms behind the olfactory system or nervous system. Adult killifish will be collected from the Baruch Marine Field Laboratory for manual fertilization of embryo at Clemson University. Embryonic exposures will range from 0-800 ppb arsenic, and hatchlings will be raised in clean water for 4 weeks. At 0, 2, and 4 weeks post-hatch, behavioral tests for odorant responses will be performed, followed by euthanasia and collection of the brain, olfactory epithelium, and olfactory bulb for immunohistochemical analysis of sensory neurons. A 96-hour adult exposure (0-5 ppm arsenic) will also be performed to observe injury and recovery of the olfactory epithelium. After assessing behavioral responses to odorants, one half of the adult fish sample set will be euthanized, while the remaining fish will be allowed to recover for 7 days.

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

Investigators: Dr. Dennis M. Allen and Paul D. 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  $\mu\text{m}$  mesh nets collect copepod and small invertebrate larvae, and 365  $\mu\text{m}$  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 Niño) and drought. Analysis of the 153  $\mu\text{m}$  fraction has indicated a steady decrease in total small zooplankton, especially copepods, over the past 36 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 shrimp and fish production observed for some species may be related to increasing water temperature. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change.

## **Multi-scale satellite remote sensing for salt marsh mapping**

Investigator: Dr. Cuizhen (Susan) Wang  
Department of Geography, University of South Carolina

Satellite remote sensing provides an effective tool in mapping salt marshes and assessing their changes from local to state levels. This study is a seed project funded by the Sea Grant Consortium in 2016. It initiates an experimental study to test the feasibility of multi-scale, multi-source free satellite imagery to map salt marshes and their species composition in the North Inlet-Winyah Bay National Estuarine Research Reserve (NI-WB NERR). The field trip on May 26, 2017 was to conduct the first field survey for collecting GPS locations points of *Spartina* and *Juncus* for accuracy assessment from a Landsat8 OLI Image (acquired on 8/21/2014) and a high-resolution WorldView-3 high-resolution image (acquired on 10/17/2014). No destructive measurements were designed. In the future, the invasive *Phragmites* will also be classified from satellite imagery. If the classified maps can be validated, we will apply the remote sensing approach to mapping salt marsh distributions along the South Carolina coasts, and to projecting marsh migration under the pressure of sea level rise and land development. The outputs of this study could be used to assist environmental resilience of coastal wetlands in South Carolina.

## **Experimental varying of the marsh platform and macrophyte response**

Investigators: Dr. James Morris<sup>1</sup> and Karen Sundberg<sup>2</sup>  
1 - Department of Biological Sciences, 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 above ground and below ground allocation patterns and quantify where the bulk of below ground 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 above ground and below ground productivity. In recent years, replicates have been selectively harvested such that we now have an age treatment in addition to the elevation treatment. The frequency of inundation results in significant variation in stand densities and plant heights, and we are observing different biomass allocation patterns with time. 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.

## **Soundscapes of the marsh creeks at Baruch: Estuarine animals that make sounds and the pattern of sound production over tidal and diurnal cycles**

Investigators: Dr. Joseph J. Luczkovich<sup>1</sup>, Dr. Cecilia S. Krahforst<sup>2</sup>, Dr. Mark W. Sprague<sup>3</sup>, Phillip DeVille<sup>3</sup>, Dr. Juliana M. Harding<sup>4</sup>, and Dr. Dennis M. Allen<sup>5</sup>

1 - Department of Biology, Institute for Coastal Science and Policy, East Carolina University (NC)

2 - Coastal Resources Management Program, East Carolina University (NC)

3 - Department of Physics, East Carolina University (NC)

4 - Department of Marine Science, Coastal Carolina University (SC)

5 - Baruch Marine Field Laboratory, University of South Carolina

Sound is produced by many marine animals in the course of their daily activities, especially during mating periods, and can be used to understand changes in habitat use, activity patterns, seasonal migrations and other behaviors. We deployed recording hydrophones singly and in arrays with a multi-channel field recorder to record sounds produced by invertebrates, fishes and other animals in marsh creeks near Oyster Landing and Clambank long-term monitoring sites in the North Inlet-Winyah Bay NERR at the Baruch Marine Field Laboratory during May and June 2017. In addition, we identified several unknown sound-producing species using laboratory acoustic and video observations. We identified sound production by five species suspected to be soniferous but previously undocumented to make sound. These include: striped benny, freckled blenny, crested blenny, bighead sea robin, and leopard searobin. In addition, we recorded sounds from naked gobies, spotted sea trout, Atlantic croaker, silver perch, oyster toadfish, and snapping shrimp. Overall, we recorded soundscapes continuously for over 72 hours and multiple tidal cycles at Oyster Landing and Clambank stations. We are examining the patterns of variation of sound production on these recordings by the species listed above with respect to changes in tide level, diurnal cycles, temperature, dissolved oxygen, and other water quality metrics. Analysis of the recorded sound files is underway using a variety of acoustic and signal processing algorithms. Preliminary conclusions include more sound produced by striped blennies at night than during the day at Oyster Landing and more soniferous species present at Clambank.

## **Blood fluke parasites in the North Inlet estuary: Diversity and life cycles**

Investigators: Dr. Isaure de Buron<sup>1</sup> and Dr. Dennis Kyle<sup>2</sup>

1- Department of Biology, College of Charleston (SC)

2- Department of Global Health, University of South Florida

Blood flukes are pathogenic parasites that infect the cardiovascular system of their fish hosts. Their life cycle uses annelids as intermediate hosts. The objectives of this project are 1) to determine which species of fluke infects seatrout in the North Inlet estuary compared to other South Carolina estuaries and 2) to sample annelids regularly throughout the year in order to unravel the specifics of the life cycles of these particular parasites. This study will also allow us to determine a potential seasonal pattern of infection by the flukes in seatrout and will give us insight into the diversity of blood flukes in the North Inlet estuary.

## **Creating a shared understanding of the specific vulnerabilities of southeastern coastal habitats to climate change impacts**

Dr. Jennifer Plunket<sup>1</sup>, Michelle La Rocco<sup>1</sup>, Dr. Erik M. Smith<sup>1</sup>, Hope Sutton<sup>2</sup> and Whitney Jenkins<sup>2</sup>

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

2 - North Carolina National Estuarine Research Reserve

The NI-WB NERR and the North Carolina NERR are collaborating on a project to explore how climate change will affect southeastern salt marshes. We will use the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH) as a framework for answering site-specific questions about how anticipated changes in climate will interact with non-climate stressors (invasive species, nutrients, sedimentation and erosion, and contamination) to impact the future ecological function of salt marshes as habitat. The CCVATCH is a decision support tool that uses an expert elicitation process to incorporate existing information on climate change impacts with knowledge of local conditions. Project participants include local land managers, researchers, and reserve staff, who collaboratively determine the degree of vulnerability of a specific habitat area to defined climate change impacts and stressors, using a facilitated process outlined in the CCVATCH Guidance Document. Intertidal salt marsh habitat in North Inlet, Murrells Inlet, and marshes at the four component sites of the North Carolina NERR will each be assessed by local teams. The intent of this process is to highlight opportunities for increasing the resilience of habitats through current or potential management and conservation actions.

## **Novel inexpensive instrumentation for long term monitoring of water levels and ground movement in salt marshes**

Investigators: Dr. Vitalii A. Sheremet<sup>1</sup> and Dr. Erik M. Smith<sup>2</sup>

1 - NOAA , Northeast Fisheries Science Center

2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

An array of six inexpensive tidal gauges and six ground movement detectors is proposed to be deployed at the North Inlet-Winyah Bay National Estuarine Research Reserve. We would like to expand our recent observations at the Waquoit Bay National Estuarine Research Reserve and contrast the effects of different marsh morphology and much larger tidal range. The question is whether the sediment accretion in the marsh is rapid enough to keep up with the sea level rise caused by the climate change. Several Surface Elevation Tables (SET) were established at the Waquoit Bay Reserve and other Reserves to monitor the long term evolution. Recently, we realized that the ground movement caused by tide flooding the marsh needs to be taken into the account. Both the tide gauges and the ground movement detectors are designed by the PI for the project and are based on inexpensive stock Onset Computer Accelerometer Loggers. We propose to make a pilot deployment for a period of 1-2 months in order to record one complete tidal cycle with 1 minute sampling intervals. The observations will allow us to document the propagation of tides within the reserve and corresponding expansion of the top surface of the marsh. The ultimate goal is to develop an observation protocol that could be applied throughout the whole National Estuarine Research Reserve System.

## **Goby and blenny movements, fidelity, and habitat use**

Investigators: Dr. Juliana M. Harding<sup>1</sup>, Dr. Dennis M. Allen<sup>2</sup>, and students

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*), Crested Blenny (*Hypleurochilus geminatus*), Feather Blenny (*Hypsoblennius hentz*), Freckled Blenny (*Hypsoblennius ionthas*), and Striped Blenny (*Chasmodes bosquianus*) in Crabhaul Creek, North Inlet estuary are being examined. Artificial nesting substrates and passive integrated transponder (PIT) tags have been and will continue to be used to describe movement and fidelity patterns of these resident fishes. Regular surveys and recaptures of tagged fishes will provide information on site fidelity and home range as well as demographics and habitat use patterns of resident fish populations.

## **South Carolina Estuarine and Coastal Assessment Program (SCECAP)**

Investigators: Dr. Denise Sanger<sup>1</sup>, Martin V. Levisen<sup>1</sup>, Stacie Crowe<sup>1</sup>, Dr. Robert F. Van Dolah<sup>1</sup>, and David E. Chestnut<sup>2</sup>

1 - South Carolina Department of Natural Resources

2 - South Carolina Department of Health and Environmental Control

The South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) have been conducting an ongoing comprehensive collaborative coastal monitoring program (South Carolina 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. The SCECAP program, combined with the other cooperating programs, provides a number of 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 2016, over 700 sites have been sampled statewide, with 10 located in the North Inlet estuary and an additional 33 stations located in the adjacent Winyah Bay.

### **Drivers of sediment accumulation and nutrient burial in residential storm water detention ponds**

Investigators: William Schroer<sup>1</sup>, Dr. Claudia Benitez-Nelson<sup>1</sup>, Dr. Erik M. Smith<sup>2</sup>, and Dr. Lori Ziolkowski<sup>1</sup>

1 - School of the Earth, Ocean, and Environment, University of South Carolina

2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Storm water wet detention ponds are widely utilized as control structures to manage runoff waters during storm events. Ponds are prevalent features in the South Carolina coastal plain and across the country. Over time sediments accumulate in ponds, which is significant for two reasons. First, SC state mandates require ponds be dredged when sediment accumulation displaces pond volume, thus reducing storm water retention capacity. Second, burial of carbon and nutrients in sediments represents long term sequestration of potential environmental pollutants. The project goal is to determine driving factors of sediment accumulation in ponds and to quantify burial rates. Our results show sediment accumulation rates in residential storm water ponds are much slower than previously thought, which suggests the requirement of frequent dredging be reconsidered. Though sediment accumulation rates are low, they show a strong positive correlation with catchment impervious surface coverage. Biomarker assay results seem to indicate accumulation rates are driven by the burial of terrestrial biomass. Pond sediments were found to be very rich in carbon, nitrogen, and phosphorus, exhibiting burial rates comparable to natural lakes. Though individual ponds are small, they are abundant and could, collectively, represent significant regional nutrient storage.

### **Linkages between intertidal creek geomorphology and nekton use determined from Terrestrial Laser Scanning**

Investigators: Alex Gorr<sup>1</sup>, Dr. Scott White<sup>1</sup>, Dr. Matthew E. Kimball<sup>2</sup>, Dr. Dennis M. Allen<sup>2</sup>, and Kyle Houser<sup>2</sup>

1 - School of the Earth, Ocean, and Environment, University of South Carolina

2 - Baruch Marine Field Laboratory, University of South Carolina

Previous work in 1997-1999 examining nekton use in 8 intertidal creek tributaries of Clambank Creek revealed variations in geomorphology (e.g., depth, bank steepness, etc.) correlated to abundance of resident and transient nekton. The nature of these patterns suggests nekton actively select creeks with preferred geomorphic characteristics, which has implications for essential fish habitat, conservation, and restoration efforts. To examine the stability of the intertidal creek geomorphology and the consistency of nekton habitat preferences, the geomorphology of these same 8 intertidal creeks was measured again 15 or more years later. Geomorphological characteristics originally measured in 1997 using traditional surveying techniques were re-measured in 2016 using terrestrial laser scanning, and seasonally starting in early 2017 to allow comparison of small seasonal changes within creeks and large, decadal changes among creeks. The goal of this study is to determine if and how much the geomorphology of these creeks has changed over the years.

### **The Winyah Bay Master Naturalist Program: Transforming community members into active stewards of our diverse South Carolina habitats**

Investigator: Dr. Jennifer Plunket

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

The Winyah Master Naturalist course is designed to train community members to become active volunteer stewards of our coastal environment. Participants gain skills in nature interpretation, research methods, and resource protection through 12 day-long field classes occurring on Fridays from March to June. The course involves field trips with expert interpreters to the mountains, forests, swamps and marshes that make South Carolina a unique and beautiful classroom for the nature enthusiast. Students will learn to ‘read’ the landscape through developing an understanding of the geology, ecology and human impacts on natural habitats. Participants completing the course and 30 hours of approved volunteer work will receive a Master Naturalist certification and will be eligible to join a local chapter and participate in advanced volunteer training courses. Participants do not need to have a background in the natural sciences; a diversity of backgrounds, skills and interests is welcomed.

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

Investigators: Tracy Buck and Dr. Erik M. Smith

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

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 three 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 creek-bank to forest-edge transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in and 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 non-destructive 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. Elevation data (mm scale vertical resolution) for each plot is determined at biannual intervals to allow for the calculation of duration and frequency of tidal inundation at each plot.

## **Root zone salinity in salt marshes**

Investigators: Dr. Alicia Wilson and Carolyn Ryan

School of the Earth, Ocean, and Environment, University of South Carolina

The overarching goal of this project is to develop models to predict root zone salinity in salt marsh soils. Numerical models failed to reproduce porewater salinity from diffusion-sampler datasets collected by James Morris (USC), so this project augmented those measurements with new monitoring by rhizon samplers. In current work, rhizon samplers, diffusion samplers, and models each generate different results. We hypothesize that these differences arise because the different field methods access water of different residence times, and the current model does not account for dual-domain transport. We will continue collecting rhizon samples at Morris's LTREB long-term monitoring site and will construct dual-domain numerical models.

## **Tag retention, survival, and growth of juvenile pinfish (*Lagodon rhomboides*) tagged with 8 and 12 mm Passive Integrated Transponder (PIT) tags**

Investigators: Dr. Matthew E. Kimball, Dr. Marvin M. Mace III, and Eric R. Haffey

Baruch Marine Field Laboratory, University of South Carolina

While in the estuary, fishes often move within the mosaic of multiple interconnected habitats that include the vegetated marsh surface, marsh ponds and pools, intertidal and subtidal creeks, and open-water habitats. Historically it has been difficult to track the movement of juvenile fishes (e.g., < 100 mm TL) as they move within this habitat mosaic. Recent advances in passive integrated transponder (PIT) tagging technology have led to the development of small PIT tags that can be used with juvenile fishes. However, little is known about the effectiveness of using PIT tags to track the majority of common estuarine fishes. Therefore we examined the survival, growth, and tag retention of juvenile pinfish (*Lagodon rhomboides*), ranging in size from 54-78 mm standard length, tagged with 8 mm and 12 mm PIT tags held in the flow-through seawater laboratory at the Baruch Marine Field Laboratory. Tagged pinfish survival was high, with only three out of 24 tagged individuals dying (on days 2, 23, and 25), and all control fish (n = 12) surviving the 62 day experiment. Tag retention was also high for pinfish with only three lost tags during the experiment; one pinfish tagged with an 8 mm tag (on day 4) and two tagged with 12 mm tags (on days 11 and 13). PIT tags appeared to have no impact on pinfish growth as the mean weight of control and tagged fish was similar each week throughout the 9-week experiment.



### **The “hot” oyster: An apparently healthy oyster containing elevated levels of *Vibrio parahaemolyticus***

Investigators: Savannah Klein and Dr. Charles R. Lovell  
Department of Biological Sciences, University of South Carolina

Outbreaks of the pandemic, emergent human pathogen *Vibrio parahaemolyticus* are increasing in size and frequency, and are occurring at higher latitudes. An estimated 34,000 cases of *V. parahaemolyticus* gastroenteritis occur per year in the US. This could be a significant underestimate, as most cases do not require hospitalization. Symptoms of *V. parahaemolyticus* gastroenteritis occur 24 to 72 hours after ingestion of raw or undercooked seafood, usually oysters. Constant monitoring of *V. parahaemolyticus* densities within oysters is required. Relatively little is known regarding *V. parahaemolyticus* loads in individual oysters as monitoring protocols usually entail homogenizing several oysters together. We are determining pathogenic *Vibrio* densities in individual South Carolina oysters. Oysters were collected from two sampling sites; a site of commercial oyster harvest (Whale Branch in Beaufort, SC) and a non-commercial comparison site (North Inlet estuary at the Baruch Marine Field Lab in Georgetown, SC). The majority of oysters (98%) contained levels of *V. parahaemolyticus* deemed safe for consumption. However, two oysters contained much higher *V. parahaemolyticus*. These “hot” oysters contained densities of *V. parahaemolyticus* that were approximately 100-fold higher than average. Current FDA protocols for detection of *V. parahaemolyticus* require homogenizing a dozen oysters together, which might result in dilution of *V. parahaemolyticus* from the “hot” oysters to acceptable levels.

### **Shorebird monitoring in the North Inlet estuary**

Investigators: Wendy Allen<sup>1</sup>, Dr. Jennifer Plunket<sup>1</sup>, and Paul D. Kenny<sup>2</sup>  
1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina  
2 - Baruch Marine Field Laboratory, University of South Carolina

Shorebirds (Aves: Charadriiformes), are a diverse group of birds including plovers, sandpipers, curlews and oystercatchers. Of the more than 50 different species that occur in North America, more than half are considered a species of concern or “highly imperiled” due to declining numbers. A shorebird monitoring effort was initiated in the spring of 2016 to assess populations of shorebirds in the North Inlet estuary, primarily during migration periods, March – June and July – October. Shorebird surveys in the North Inlet estuary are conducted biweekly during these periods by boat and land near high tide. Species are identified and counted and data is entered into a database using protocols established by the International Shorebird Survey (ISS) administered by the Manomet Center for Conservation Services. Color-marked individuals are also noted. This project will help establish baseline information on the species and numbers of shorebirds utilizing the North Inlet estuary during periods of migration and will compliment winter shorebird surveys that are conducted each year. It will also feed into the larger ISS database that includes information from about 1,200 locations in North America that is contributing to a better understanding of shorebird population numbers, key stopover locations, migratory routes, and other aspects of shorebird life histories.

### **Stock structure of spotted seatrout: Assessing genetic connectivity at its northern latitudinal limits**

Investigators: Dr. Jeffrey A. Buckel<sup>1</sup>, Dr. Timothy A. Ellis<sup>1</sup>, and Dr. Jan R. McDowell<sup>2</sup>  
1 - Center for Marine Sciences and Technology, Department of Applied Ecology, North Carolina State University  
2 - Virginia Institute of Marine Science, Department of Fisheries Science, College of William and Mary

Spotted seatrout (*Cynoscion nebulosus*) are one of the most economically important marine recreational fish species in the United States. Although heavily studied throughout the center of the species’ geographic range, including in the northern Gulf of Mexico and along the Atlantic coast of Florida, there exists limited information on the stock structure of spotted seatrout in North Carolina and Chesapeake Bay. Based on tag-return data, populations in both North Carolina and Virginia were considered one unit stock in North Carolina’s recent stock assessment. However, no comprehensive genetic analysis of spotted seatrout at its northern latitudinal limits has occurred, which is essential to determining if the current North Carolina spotted seatrout assessment is using an appropriately defined unit stock. We will use sensitive genetic markers (i.e., microsatellite loci) to assess the spatial and seasonal demographic independence of spotted seatrout inhabiting estuaries in North Carolina and Chesapeake Bay. In addition, we will expand our analysis to include samples collected from estuaries in South Carolina, Georgia, and Florida, in order to better understand the genetic connectivity of spotted seatrout throughout the US South Atlantic.

## **Why do schooling fish seeking refuge in an intertidal creek pool change their shoaling behavior over the diel cycle? An *in situ* behavioral experiment**

Investigators: Dr. Guillaume Rieucan<sup>1</sup>, Dr. Kevin M. Boswell<sup>1</sup>, Dr. Dennis M. Allen<sup>2</sup> and Dr. Matthew E. Kimball<sup>2</sup>

1 - Marine Sciences Program, Florida International University

2 - Baruch Marine Field Laboratory, University of South Carolina

Little is known regarding the role of fluctuations in abiotic factors (e.g., salinity, tide level, turbidity, tannic vs. marine water) on the behavior and dynamics of estuarine forage fish and the resultant interactions with their predators. As a 2016 Visiting Scientist at BMFL, my main objective was to examine the role of risk perception on the schooling dynamics of fish that seek refuge in intertidal pools in salt marshes. This research builds upon recent collaborative work that demonstrates that during low tides, fish occupying an intertidal creek pool refuge aggregated in larger schools at night than during daytime; suggesting that refugee fish can adjust their collective behavior in response to changes in either abiotic factors or predation risk over the diel cycle. To ascertain the reason behind this behavioral shift, we conducted an *in situ* experiment in September 2016 in the North Inlet estuary in the same intertidal creek pool examined earlier. We tested whether aggregated fish remaining in the pool during low tides modify their swimming behavior and collective tendency when placed in situations perceived as more dangerous. We artificially modified the perception of risk by changing the visual background (placing a white-net to cover the bottom of the pool). Using advanced high-resolution imaging sonar (ARIS), we monitored and examined schooling dynamics of fishes in the pool. We expect that changes in schooling dynamics under the white net condition would suggest that the school-level adjustments are primarily triggered by anti-predatory considerations rather than foraging activities or energetic demands.

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

Investigators: Dr. Erik M. Smith and Tracy Buck

North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

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 in the North Inlet estuary. 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 NERR Central Data Management Office, and made available in near real time at <http://cdmo.baruch.sc.edu>. For most parameters, records have been collected for more than 20 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.

## **Recruitment and habitat use of early life stage tarpon (*Megalops atlanticus*) in South Carolina estuaries**

Investigators: Dr. Matthew E. Kimball, Dr. Marvin M. Mace III, and Eric R. Haffey

Baruch Marine Field Laboratory, University of South Carolina

Our study was designed to examine early life stage tarpon (*Megalops atlanticus*) recruitment, habitat use, and residency in coastal environments near the northern limit of their distribution in the western Atlantic Ocean. We employed a multi-faceted approach to: 1) collect ingressing larval tarpon on nighttime flood tides at multiple sites, 2) document larval and juvenile tarpon use of natural high marsh pools, and 3) examine juvenile tarpon movement and behavior in managed marsh impoundments, all in the North Inlet-Winyah Bay estuarine system of South Carolina, USA. The timing of recruitment (June through November) and size of larvae (mean  $\pm$  standard deviation =  $23 \pm 3$  mm standard length [SL]) during estuarine ingress was similar to that reported from other subtropical locations in the region. Soon after recruiting into the system, larval and small juvenile tarpon ( $51 \pm 24$  mm SL) co-occurred in high marsh pools from July to November, and large juveniles ( $201 \pm 34$  mm SL) were also present in marsh impoundments during this same time period. An increase in tarpon length over time during their residency in high marsh pools and the relatively large size they attain in marsh impoundments indicate these environments may function as favorable nursery habitats. As water temperatures decreased during October and November, juvenile tarpon emigrated from these estuarine habitats. Tarpon appear to use a variety of estuarine habitats in coastal South Carolina from summer through late fall during their early life stage development.

### **Evaluating intertidal oyster reef restoration success**

Investigators: Dr. Keith Walters, Thomas Funk, and students  
Department of Marine Science, Coastal Carolina University (SC)

A series of oyster reefs, shell-filled mesh bags, were created within inlets (Hog, Murrells, and North) and swash tidal creeks (Whitepoint, Singleton, and Withers) to evaluate the success of reef restoration efforts. In the North Inlet estuary, reefs were created within Bly Creek in June 2014 and, along with coincident natural reefs, have been the focus of graduate and undergraduate researchers and CCU classes (e.g., Marine Ecology). The following data were or continue to be collected to evaluate constructed reef development and assess the ability of inlet and swash constructed and natural reefs to attract and support important fishery species: (1) yearly oyster spat recruitment; (2) numbers, sizes, and distribution of oysters on constructed and natural reefs; (3) numbers and species richness of resident and transient nekton associated with reefs; (4) short-term predation on reef-resident bivalve and decapod fauna. Although oyster recruitment onto reefs is similar, preliminary results suggest inlet oysters survive better as juveniles and live longer as adults compared to swash creek populations. Nekton seasonally captured during high tides within baited minnow traps, pull traps, and gill nets indicate constructed reefs are colonized quickly. Survival of tethered bivalve and decapod individuals within mudflat and constructed and natural reefs documented initial differences in structural complexity and the role of complexity in the survival of reef-resident taxa. The ongoing studies are providing valuable experiences for students, identifying demographic differences that influence reef development, and demonstrating the value of reef restoration efforts to intertidal resident and transient taxa.

### **GPR investigation of clastic paleo-shoreface deposit**

Investigators: Patrick Duff and Jacob Burstein  
School of the Earth, Ocean, and Environment, University of South Carolina

Clastic deposition in the continental and near shore environment is widely recognized as complex, and is controlled by allogenic and autogenic processes that include sea level change, tectonics, tidal energy, and surface morphology. The complex depositional architecture of these deposits has implications for groundwater flow, nutrient fluxes, and sensitivity to human environmental impact. Close examination of modern shallow marine deposits can also help us better understand similar ancient deposits, including their internal structure and relationship to other passive margin deposits. A series of Ground Penetrating Radar (GPR) lines will be acquired at the Baruch Marine Field Lab on Hobcaw Barony, as one field site within the coastal plain of South Carolina to investigate the internal structure and stratigraphy of a variety of a recent shoreface deposit, as well as to serve as an experiment in the application of GPR to sedimentological and stratigraphic research. The high resolution imaging made possible by GPR investigations of modern sedimentary deposits will illuminate the internal stratigraphy and sedimentary of the deposit, as well as depth to water table and any potential local salt water intrusion.

### **Decadal-scale assemblage changes of subtidal creek fishes in the North Inlet estuary**

Investigators: Dr. Matthew E. Kimball, Dr. Dennis M. Allen, and Paul D. Kenny  
Baruch Marine Field Laboratory, University of South Carolina

Estuaries support abundant and diverse fish assemblages, and serve as important nursery grounds for early life history stages of many species. Changes in environmental, physical, and biological factors, potentially operating at multiple temporal and spatial scales, may alter fish assemblages over time. A biweekly trawl survey was conducted from 1981 to 1984 as part of a Long Term Ecological Research (LTER) monitoring program to examine the salt marsh fish assemblage of the North Inlet estuary. Using identical protocols at the same tidal creek, sampling was re-initiated for another 4-year period (2013 - 2016) to determine if any changes occurred in the composition and demographics of the fish fauna between the two periods. Preliminary comparisons of the two datasets revealed significant changes in fish assemblages. Overall, the number of species was similar for the two sampling periods, but the recent total catch was five-fold lower than in the 1980s. Of the ten most abundant species collected, eight declined in abundance. Bay anchovy, the most abundant species during the 1980s, saw a 140-fold decrease in abundance and is now nearly absent. Other species were dominant in catches during both periods (e.g., spot, Atlantic brief squid, Atlantic croaker), but collected in much-reduced numbers at present. The five most abundant species that accounted for 92% of the total catch each year in the 1980s, now account for 65%. Additional planned analyses will evaluate relationships between changes in the nekton assemblage and environmental conditions 30 years later.

## **The effects of inhibited carbonic anhydrase on the phytoplankton communities in coastal waters**

Investigators: Eilea Knotts<sup>1</sup> and Dr. James L. Pinckney<sup>2</sup>

1 - Department of Biological Sciences, University of South Carolina

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

Carbon concentrating mechanisms (CCMs) are used by phytoplankton in order to concentrate dissolved inorganic carbon (DIC) within their cells. These adaptations were evolved to enhance uptake of DIC at present surface water concentrations. However, mechanisms, such as the carbonic anhydrase enzyme (CA), are active, energy-consuming processes that may become redundant in the future due to increased concentrations of CO<sub>2</sub> in surface waters. In order to gain a better understanding of the carbonic anhydrase enzyme, recent studies have investigated the CA enzyme through the use of inhibitors: acetazolamide (AZ) and ethoxzolamide (EZ). Most of our knowledge is based on individual cultures or oligotrophic water samples. However, there are few studies that look at the mechanism's effects on estuarine phytoplankton communities and none have measured the *in situ* effects on community composition. Using bioassays of natural phytoplankton communities, our research will explore how community composition is altered when the competitive advantage of the CA enzyme is reduced. These changes will be monitored with measurements of chlorophyll *a* fluorescence, cell abundances, microscopy, photopigments, nutrients, and the inhibitors: AZ and EZ. This study will provide a better understanding of how the CA enzyme impacts the composition of phytoplankton communities in coastal waters.

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

Investigator: Dr. Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Oyster (*Crassostrea virginica*) 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, disarticulation rates, Dermo prevalence and intensity, and biomass at sentinel sites in the Town, Clambank, Crabhaul, Debidue, and Bly Creek basins. 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 National Estuarine Research Reserve System Centralized Data Management Office**

Investigators: Dr. Dwayne E. Porter<sup>1,2</sup>, Melissa Ide<sup>3</sup>, Jennifer Kesse<sup>3</sup>, Amber Knowles<sup>3</sup>, Brooks Folk<sup>3</sup>, Lee Shutt<sup>3</sup>, Dan Ramage<sup>2</sup>, and William H. Jefferson<sup>1</sup>

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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 29 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.

### **Indirect predation effects on bivalve filtration rates within South Carolina intertidal oyster reefs**

Investigators: Dr. Keith Walters, Dr. Eric Koepfler, and students  
Department of Marine Science, Coastal Carolina University (SC)

Studies designed to examine the indirect effects of resident and transient decapods on bivalve filtration rates have been conducted within the North Inlet estuary since September 2012. Our purpose is to: 1) determine if the presence and taxonomic identity of decapod predators affects bivalve filtration and significantly reduces a reef's ability to improve water quality; 2) establish if predator mechanical and/or chemical cues affect bivalve filtration behavior; 3) determine if predator presence or injured conspecifics equally affects bivalve filtration. To model the effect of indirect species interactions on oyster reef filtration capacity a series of controlled, manipulative experiments are being conducted within 20-L tanks (n>5). Bivalves and decapods collected from North Inlet are used to create treatments for various experiments that are run over normal high tide intervals (~6 hr). Draw-down or initial minus final readings for chlorophyll and total particulate organic matter are recorded during experiments. Determination of decapod indirect predation effects on bivalve filtration will increase the accuracy of oyster reef ecosystem services estimates.

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

Investigators: Dr. James Morris<sup>1</sup> and Karen Sundberg<sup>2</sup>  
1 - Department of Biological Sciences, 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.

### **Physical characteristics of estuarine waters: Long-term monitoring in the North Inlet and Winyah Bay estuaries**

Investigators: Dr. Erik M. Smith and Tracy Buck  
North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

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 have been monitored using YSI data loggers since 1994. A new, fifth site in the mainstem of Winyah Bay was added in 2016. 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 site in Winyah Bay has data loggers deployed in both surface and bottom waters to account for the vertical stratification that exists in this location. 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 base-line 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/>.

### **Terrestrial response to sea level rise as detected through dendrochronology, geomorphology, and hydrology**

Investigators: Dr. Raymond Torres<sup>1</sup> and Dr. Richard Keim<sup>2</sup>  
1 - School of the Earth, Ocean, and Environment, University of South Carolina  
2 - School of Renewable Natural Resources, Louisiana State University

We propose to evaluate the rates of salt marsh advance into the terrestrial landscape using dendrochronology. The corresponding tree ring chronology will be used to assess rates of geomorphic change of the terrestrial and intertidal landscapes and the patterns and dynamics of surface and near surface freshwater and salt water flows.

## **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, Charleston, 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 Oyster Landing site within North Inlet estuary 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.

## **A collaborative science program for the National Estuarine Research Reserve System: Working with end users throughout the applied research process**

Investigators: Dr. Dwayne E. Porter<sup>1,2</sup>, Melissa Ide<sup>3</sup>, and Jeremy Cothran<sup>1</sup>

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 NERRS Science Collaborative (NSC) supports integrative environmental and social research for improved community decision making. The NERRS Centralized Data Management Office (CDMO), housed at the Baruch Marine Field Laboratory, is the lead for USC's involvement in the establishment and administration of the NOAA NERRS Science Collaborative (NSC). The NSC is led by researchers at the University of Michigan, Stanford University, and USC. The CDMO role is the transfer of key knowledge and lessons learned to others, potentially benefiting NERRS as well as local, state and federal coastal management decision makers and educators; and delivery of highly credible, valid and relevant scientific results and data that are both timely and universally accessible.

## **Development and validation of an ecological model to investigate the effect of tidal height and blue crab predation on spatial distribution and growth of saltmarsh bivalves**

Investigators: River Dixon<sup>1</sup> and Dr. Blaine D. Griffen<sup>2</sup>

1 - School of the Earth, Ocean, and Environment, University of South Carolina

2 - Department of Biological Sciences, University of South Carolina

As a filter feeder, the saltmarsh bivalve *Guekensia demissa* obtains maximal energy intake when it attaches to the substrate lower on the tidal slope. Here, it is covered by tide for longer periods of the day relative to being higher on the slope, and can therefore spend more time feeding and growing. This region also represents maximal mortality risk for the bivalves due to predation by the blue crab *Callinectes sapidus*. *C. Sapidus* is limited in foraging area by tidal cover, so minimizing predation risk for a bivalve means attaching to substrate higher on the slope. The balance of these two factors leads us to predict a "sweet spot" for *G. demissa*; an area which is optimal for bivalve growth and survival. In other words, a region that is low enough on the tidal slope for the bivalves to feed for a significant part of the day, but high enough that blue crabs do not have enough tidal cover time to consume them. Finding a bivalve's optimal balance between these two important factors creates a spatial distribution that can be predicted by an ecological model we have developed in NetLogo. We are currently conducting transect surveys of *G. demissa* size, growth, and abundance across 200m stretches of marsh on Goat Island in order to validate the predictions generated by our model.

## **Co-evolution of complex traits associated with key innovation: Armor and vision in the snapping shrimp *Alpheus heterochaelis* and *Alpheus normanni***

Investigators: Dr. Alexandra Kingston and Dr. Daniel Speiser  
Department of Biological Sciences, University of South Carolina

Snapping shrimps are a morphologically diverse and speciose group of crustaceans in which the evolution of a key morphological innovation, the snapping claw, is accompanied by the evolution of sophisticated armor. This armor, called an orbital hood, partially or totally conceals the eyes of snapping shrimps to protect them from the explosive collapse of cavitation bubbles produced by their snapping claws. The morphology of the orbital hood has led to the long-standing hypothesis that snapping shrimps are blind, even though they have well-developed eyes. To study the co-evolution of complex traits associated with the origin of key innovation, we will utilize the snapping shrimps *Alpheus heterochaelis* and *Alpheus normanni*, to 1) examine the material properties of orbital hoods, and 2) test whether orbital hoods may be associated with reduced visual function. We will measure transmittance of the orbital hood to determine if vision may be restricted by the presence and material of the hood. We will also use electroretinography to study the physiology of the visual system. We expect that the presence of an orbital hood provides protection to the eyes and results in restricted vision but that snapping shrimps have a functional visual system that allows for coarse vision in their natural habitat. The presence of a protective orbital hood in an animal with such a powerful weapon provides opportunities to examine relationships between weaponry and armor, and evolutionary tradeoffs that result from such specialized morphological traits.

### **Characterization of oyster cement**

Investigators: Dr. Jonathan Wilker<sup>1</sup> and Paul D. Kenny<sup>2</sup>  
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.

### **Investigating the consumption rates of the stone crab, *Menippe* spp.**

Investigators: Eric Hancock<sup>1</sup> and Dr. Blaine D. Griffen<sup>2</sup>  
1 - School of the Earth, Ocean, and Environment, University of South Carolina  
2 - Department of Biological Sciences, University of South Carolina

In order to complete a bioenergetics model for the stone crab, consumption rates across a range of temperatures need to be measured. Metabolic, growth, and regeneration rates already exist for the species but food consumption rates vary widely based on individual studies. During eight trials conducted between October 2015 and September 2016, crabs were collected from Clambank Creek. Once taken from the traps/burrows, crabs were tagged using B-tags and recorded for size, weight, and health data. A 24-hour starvation period preceded the beginning of each trial. Within this 24-hour period, sufficient oysters were gathered from the nearby saltmarsh. Then oyster clumps were washed, dried, and weighed. The oyster clumps and crabs were randomly assigned cages so that each cage had ~3,100 grams of oyster and all but three cages had a crab. These cages were placed into subtidal waters around Oyster Landing, marked with buoys, and remained undisturbed for one week. Once removed, crabs were immediately be separated from oysters to prevent farther consumption. Oyster clumps and shell fragments were cleaned of all mud, dried, and weighed (then returned to the saltmarsh). Individual crabs were released after any change in number of legs missing unless a crab's consumption rate was abnormally high or low, which warranted further examination of tissues in the laboratory. A consumption rate formula was calculated based on carapace width and water temperature to be used in the completed bioenergetics model.

### **Estuarine crab diversity along the US east coast**

Investigators: Dr. Jeb Byers<sup>1</sup>, Julie Blaze<sup>1</sup>, Kaitlin Kinney<sup>2</sup>, Linsey Haram<sup>1</sup>, Jeff Beauvais<sup>1</sup>, and Alex Lee<sup>1</sup>

1 – Odum School of Ecology, University of Georgia

2 – School of Environment and Natural Resources, Ohio State University

Crabs are one of the dominant taxa dependent on oyster reefs for food and habitat. Crabs in turn shape oyster populations. Throughout oysters' distributional range, the composition of crab species and abundance likely varies dramatically. We intend to catalog crab species, abundance, and demography and determine how these properties vary with latitude. We also intend to correlate how crab communities correlate with oyster reef traits. These analyses will indicate the strength of physical-biological coupling and species interaction strength at a biogeographical scale.

### **Effect of wrack accumulation on salt marsh vegetation, Baruch Institute, Georgetown County, South Carolina**

Investigators: Dr. Richard Stalter<sup>1</sup>, A. Jung<sup>1</sup>, A. Starosta<sup>1</sup>, John Baden<sup>2</sup> and M. D. Byer<sup>3</sup>

1 - Department of Biological Sciences, St. John's University (NY)

2 - US Army Corps of Engineers, NC, Retired

3 - Division of Natural Resources, Gateway National Recreation Area, National Park Service, Staten Island, NY

In March 2004, four arrays in different types of salt marsh vegetation were covered with 15-20 cm of wrack secured in place, in an attempt to duplicate the natural deposition of wrack on the marsh by tides and storms, and to quantify and extend anecdotal observations and the results of previous studies. A control plot in each array was left uncovered; another plot was covered with only 2-3 cm. The wrack was removed from one plot in each array at one, two, four and seven month intervals. One month of wrack coverage appeared to have little effect on either density or standing crop, recorded seven months after initial covering, of the principal marsh species. Above ground parts of these species, with the exception of *Spartina patens* and *Borrchia frutescens*, appeared to be killed or extremely inhibited after two months, but not as much as the 15-20 cm wrack mat treatment. We continue to assess survival of wrack impacted plants and monitor recruitment and growth in specific wrack impacted zones.



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