CURRENT RESEARCH PROJECTS

2022

Baruch Marine Field Laboratory

North Inlet-Winyah Bay
National Estuarine Research Reserve

University of South Carolina

Belle W. Baruch Institute
for Marine & Coastal Sciences

North Inlet-Winyah Bay
National Estuarine Research Reserve

Current Research Projects
2022

Introduction

The Baruch Marine Field Laboratory (BMFL), located on Hobcaw Barony in Georgetown County, has been the center of research activities for scientists and students from the University of South Carolina (USC) and dozens of other institutions since 1969. We conservatively estimate that more than 1,000 grant and institutionally-funded projects have taken place at BMFL. This work has contributed substantially to the more than 2,000 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 76 projects that were underway during the period from January through December 2022 in the North Inlet and Winyah Bay estuaries by faculty, staff, graduate students, and undergraduates associated with the USC and other institutions. USC is the home institution for 48 of the investigators while over 83 investigators representing 32 other institutions and agencies are carrying out projects through BMFL. Dozens of graduate and undergraduate students assisted scientists throughout the year to obtain hands-on training in field methods and gain experience conducting research.

This annual report lists active projects (in random order) along with a project summary that includes the title, investigators, affiliations, and an abstract. Many of the studies that involve field measurements and collections are being conducted within the North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB NERR).

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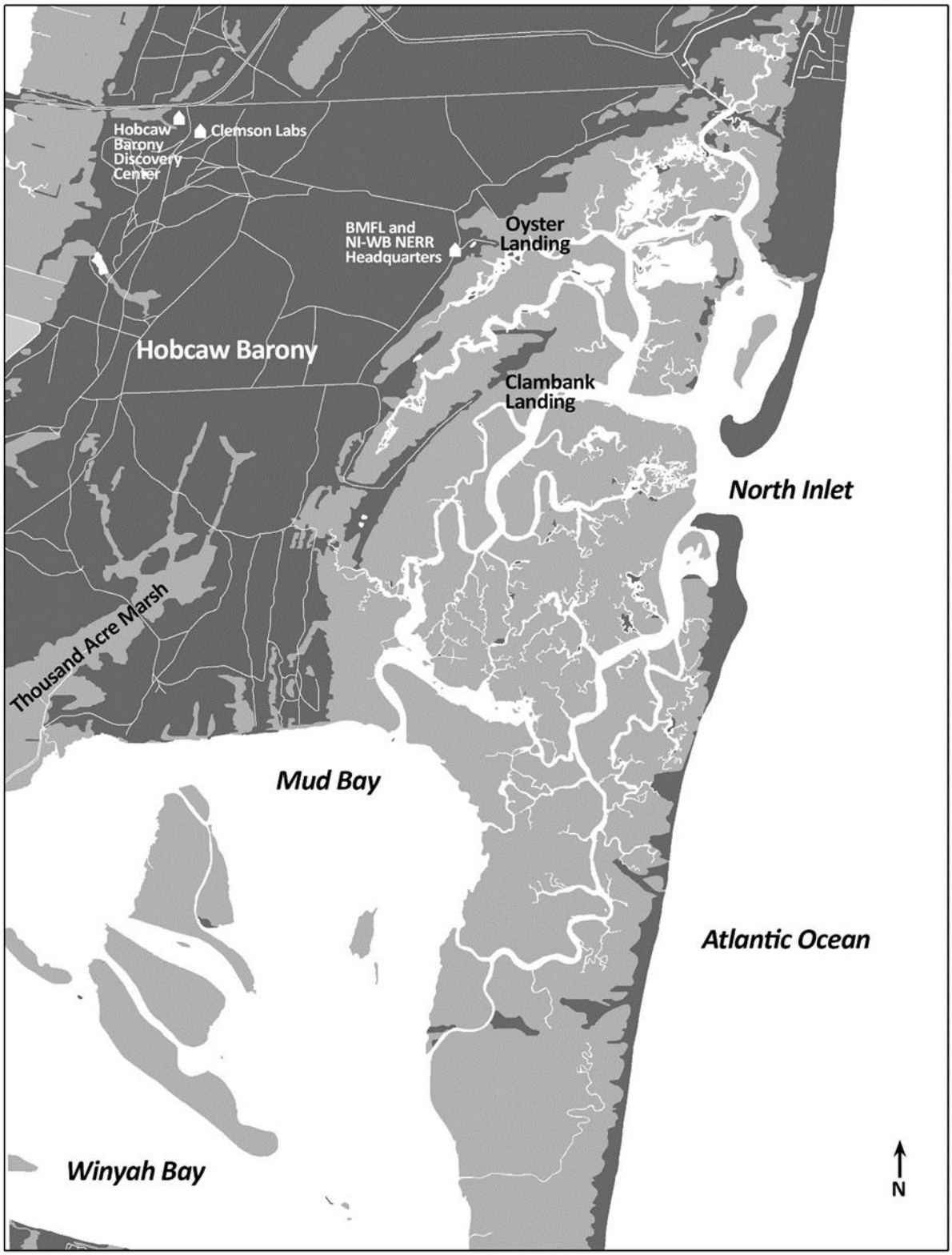

Figure 1: Map of the North Inlet-Winyah Bay estuarine system in Georgetown County, South Carolina.

Ecology, behavior, and population biology of bottlenose dolphins (*Tursiops truncatus*) in the North Inlet estuary and adjacent waters

Investigator: Robert Young

Department of Marine Science, Coastal Carolina University (SC)

This long-term project, begun in 1997, has investigated various questions related to the ecology, behavior, and population biology of bottlenose dolphins in the North Inlet and Winyah Bay (NIWB) estuaries. Using photo-ID and focal follow and transect surveys, we have identified long-term resident dolphins in the NIWB system, including several documented residents of over 20 years. NIWB dolphin abundance can exceed 100 in the summer but declines in winter as dolphins spend more time in coastal water. About 12 to 15 dolphins are core users of the North Inlet estuary, meaning they are sighted more frequently in North Inlet estuary salt marsh creeks than in Winyah Bay. These dolphins consume a significant proportion of the prey fish populations (11-14 metric tons per year) and we estimate that 3-7% of the annual primary production in North Inlet estuary is required to support them. Dolphin distribution in the North Inlet estuary has been correlated with changing patterns of salinity and prey distribution. Mothers with young calves apparently favor low current areas (tidal nodes), and salt marsh residents swim slower and expend less energy while traveling than coastal dolphins. The NIWB dolphins are part of the Northern South Carolina Estuarine System stock, managed under the Marine Mammal Protection Act. We have documented ranging movements south to Cape Romain and north along the coast to Murrells Inlet. Most recently, we developed primers for bottlenose dolphin environmental DNA (eDNA) and demonstrated its utility in identifying dolphin presence and broad patterns of distribution and abundance.

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

Investigator: 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.

Quantifying seasonal vegetation controls on coastal dune volumetric change

Investigators: Peter Tereszkiewicz, Jean Ellis

Department of Geography, University of South Carolina

Coastal dunes—located on the subaerial beach—provide a formidable barrier to storm surge and flooding that protect coastal communities from economic loss. Vegetation-sediment interactions mark a keystone component to understand coastal dune growth and post storm recovery. Traditional methods of monitoring vegetation have resulted in data inconsistencies and qualitative assumptions. The short-term pilot and year-long field studies proposed here will utilize Normalized Difference Vegetation Index (NDVI) and Photochemical Reflective Index (PRI) spectral reflectance sensors to spectrally monitor dune vegetation concurrently with erosion-accretion measurements. Study results will mark a momentous advancement in coastal monitoring and management.

Examination of long-term fish and crustacean use of intertidal salt marsh creeks

Investigators: Bruce Pfirrmann, Matthew Kimball, Dennis Allen

Baruch Marine Field Laboratory, University of South Carolina

Collections of nekton (fishes, shrimps, and crabs) have been made in the Oyster Landing intertidal creek basin from 1984 to the present. The objective has been to track the composition, abundance, biomass, and length distributions of nekton and determine patterns, trends, and factors influencing changes over seasons, years, and decades. Sampling in the intertidal creek basin has consisted of three different protocols focused on intertidal creek nekton assemblages, with all three sampling sites with a 250 m stretch of the creek. From 1984-2003, this effort was based on biweekly seine hauls from an isolated intertidal creek pool (low tide). 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. High tide enclosure collections continued through 2011. In 2012 the sample site shifted to an adjacent isolated section of creek at low tide, where from 2012-2018, sampling focused on documenting shifts in the timing, size, and growth of juvenile transient species. Since 2019, our effort expanded to include the entire nekton assemblage occurring in the tidal creek at low tide. The long-term time series is 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 southeastern US.

Green porcelain crab (*Petrolisthes armatus*) larval biology and phenology

Investigator: Juliana Harding

Department of Marine Science, Coastal Carolina University (SC)

Green porcelain crab (*Petrolisthes armatus*) larval biology and phenology 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. Modern patterns in larval occurrence can be compared to similar information from archived biweekly collections to evaluate potential changes with temperature and annual salinity trends.

Viable seed production of *Spartina cynosuoroides*

Investigators: Richard Stalter[1], John Baden[2], Paul Kenny[3]

1 - Department of Biological Sciences, St. John's University (NY)
2 - US Army Corps of Engineers, Retired (NC)
3 - Baruch Marine Field Laboratory, University of South Carolina

Spartina cynosuroides is a rhizomatous grass that is often a dominant grass in coastal brackish marshes in South Carolina where salinity ranges from 0-10psu. Data related to caryopsis (seed) viability and germination have not been found in a search of the literature. We propose to collect seed of *S. cynosuroides* in the vicinity of Alderly Marsh to determine seed viability and germination. Coastal vegetation including *S. cynosuroides* occurs very narrow bands in brackish marshes characterized by only a few centimeters in elevation. *S. cynosuroides* and its cohorts are threatened by climate change and rising sea levels. This species provides important ecological services, including cover and nutrition for wildlife.

Chemical characteristics of estuarine waters: Long-term monitoring at five sites in North Inlet estuary and Winyah Bay

Investigators: Robert Dunn, Julie Krask, J. Baker Stevens

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 five locations within the North Inlet -Winyah Bay NERR. Water samples are collected every 30 days with ISCO automated water sampling devices 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. Water chemistry data collected in the North Inlet estuary prior to the initiation of the NERRS SWMP sampling (some dating back to 1978) are available via the Baruch website's Data and Publications page.

Seasonal energetics of the blue crab (*Callinectes sapidus*)

Investigators: Blaine Griffen[1], Matthew Kimball[2], Bruce Pfirrmann[2]

1 - Department of Biology, Brigham Young University (UT)
2 - Baruch Marine Field Laboratory, University of South Carolina

The goal of this project is to examine seasonal changes in blue crab individual energetics across age classes and genders. The primary methods used involve physiological analysis of the gonads and hepatopancreas to determine seasonal patterns in size and lipid composition of these organs. This will be used to determine patterns in long-term energy storage and energy allocation towards reproduction. In addition, short-term energy reserves will be assessed using glycogen content of muscle tissues. This information will then be combined with bioenergetics growth models for this species to understand seasonal patterns in the energetics of growth and reproduction.

Transfer of a low-cost tidal wetland water level monitoring system: Hyperlocal calculations of inundation and tidal datums for understanding change and restoration planning

Investigators: Vitalii Sheremet[1], Robert Dunn[2], Megan Tyrrell[3]

1 - Department of Physical Oceanography, Woods Hole Oceanographic Institution (MA)
2 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina
3 - Waquoit Bay National Estuarine Research Reserve, Massachusetts Department of Conservation and Recreation

We deployed a simple and inexpensive system of water level monitoring developed by PI Sheremet; his 'Arm-and-Float' water level instrument uses a HOBO Pendant G accelerometer. These relatively inexpensive, easy to deploy loggers have been used in several types of salt marsh habitats (e.g., pools, creeks and upstream of a tidal restriction) at other NERRs. The principle of operation is based on converting the raw signal of the arm tilt into the elevation of the float relative to a fixed pivot by multiplication by the arm length. In this way, accuracy of 5-10 mm is achieved, which is adequate for calculating tidal datums. A network of 14 arm-and-float loggers was deployed across North Inlet for water level monitoring, and is part of a group of 7 Reserves spanning a range of climactic and tidal regimes which also received arm-and-float loggers. At the conclusion of this project, we will have instrumentation, locally relevant tidal datums, and enhanced understanding of the differences in inundation regime for 14 salt marsh features including creeks, pools, the marsh platform, and upstream from tidal restrictions.

Saltwater intrusion monitoring

Investigators: Alicia Wilson[1], Brooke Czwartacki[2]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Land, Water, and Conservation Division, 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 the North Inlet estuary, as part of the South Carolina Department of Natural Resources long-term coastal monitoring network. Results to date include stratigraphy from the well logs and field observations of hydraulic head and salinity. These field observations also support the development of a regional groundwater flow model.

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

Investigators: Thomas O'Halloran[1], Erik Smith[2]

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_2 and CH_4 exchange at spatial scales large enough (on the order of 20,000 m^2) to capture landscape-level dynamics. The instrumentation is located with the National Estuarine Research Reserve's existing salt marsh monitoring infrastructure within the Crabhaul Creek marsh of the 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.

Characterization of oyster cement

Investigators: Jonathan Wilker, Mitchell Meger

Department of Chemistry, Purdue University (IN)

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.

Public and K-12 education activities: North Inlet-Winyah Bay National Estuarine Research Reserve

Investigators: Beth Thomas, Hayley Fournier

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 the Reserve's website and 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 National Estuarine Research Reserve, South Carolina Department of Natural Resources, South Carolina 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.

Goby and blenny movements, fidelity, and habitat use

Investigators: Juliana Harding[1], Dennis Allen[2]

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 goby (*Gobiosoma bosc*) crested blenny (*Hypleurochilus geminatus*), feather blenny (*Hypsoblennius hentz*), freckled blenny (*Hyposblennius ionthas*), and striped blenny (*Chasmodes bosquianus*) in Crabhaul Creek, North Inlet are being examined. Artificial nesting substrates have been and will continue to be used to describe movement and fidelity patterns of these resident fishes. Regular surveys will provide information on site fidelity and home range as well as demographics, nest substrate preferences, and habitat use patterns of resident fishes.

Using genetic techniques to understand the mechanism behind the expression of circatidal clocks in an estuarine crab

Investigators: Paola López-Duarte, Taylor Parker, Leyna Pence, Caitlin Babblerose

Department of Biological Sciences, University of North Carolina Charlotte

The use of tidal currents to achieve horizontal displacement in the water column is critical to estuarine-ocean migrations for larval and adult forms of countless species. Previous research has established that swimming activity involved in the selective-tidal stream transport in fiddler crab larvae is under endogenous control. However, the mechanism that allows organisms to keep track and accurately predict the tide, the circatidal clock, is not entirely understood. our goal is to take advantage of recent advances in the identification of "clock genes" to better understand how organisms process information regarding tidal phase and periodicity and how that, in turn, results in the expression of tidal rhythms (12.4-hour or 24.8-hour cycles).

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

Investigators: Joshua Stone[1], Dennis Allen[2], Nayan Mallick[1], Bruce Pfirrmann[2], Matthew Kimball[2]

1 - Department of Biological Sciences, University of South Carolina
2 - 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 μm mesh nets collect copepod and small invertebrate larvae, and 365 μm 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 related to fluctuations and trends in the physical characteristics of the estuary. Information is collected for more than 50 taxonomic groups and species which are indicators of the condition and diversity of life in the estuary. Constituents include species of ecological and economic importance to the southeastern US region. Large, long-term decreases in the abundance of small (153 μm) zooplankton and changes in the timing of occurrences of some larval fishes and decapods (365 μm) have indicated responses to a long-term increase in water temperature. We have also observed responses of zooplankton populations to climatic events including El Niño-Southern Oscillation, tropical storm-related reductions in salinity, and drought. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change on estuarine ecosystems and fisheries.

Within-season patterns of larval demersal fish abundance, age, and growth in tidal creeks

Investigators: Juliana Harding[1], Dennis Allen[2]

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

Abundance, age, and growth patterns of demersal oyster reef fish larvae including the naked goby (*Gobiosoma bosc*), crested blenny (*Hypleurochilus geminatus*), feather blenny (*Hypsoblennius hentz*), freckled blenny (*Hyposblennius ionthas*), and striped blenny (*Chasmodes bosquianus*) are being examined. Regular ichthyoplankton collections will be used to describe larval fish abundance and demographics. Fish otoliths will be used to describe age and growth rates. These data will be used in combination with information about goby and blenny larvae cultured at known conditions during 2012 and 2013 to interpret patterns observed in the long-term zooplankton series (1981-present).

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

Investigator: Maeve Snyder

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 National Estuarine Research Reserve, South Carolina Sea Grant Consortium, the Coastal Waccamaw Stormwater Education Consortium, the Clemson University Extension Service, and the Carolina Clear Program.

Predicting ecological risk from military-derived radioactive material via sentinel species monitoring

Investigators: Sarah Donaher[1], Robert Dunn[2], Bruce Pfirrmann[3], Nicole Martinez[1]

1 - Department of Environmental Engineering and Earth Sciences, Clemson University (SC)
2 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina
3 - Baruch Marine Field Laboratory, University of South Carolina

Legacy nuclear sites inherently represent unplanned contamination and loss of institutional memory and therefore pose significant potential harm to human health and the environment. *Geukensia demissa* (Atlantic ribbed mussels) collected from the North Inlet - Winyah Bay National Estuarine Research Reserve will be exposed to radionuclides commonly used in radioluminescent paint at the Clemson Engineering Technologies Laboratory (CETL). This paint was frequently used to mark US Naval ships and buildings, resulting in contemporary contamination of coastal sediments with radioactive objects or paint chips near US Naval shipyards and other sites of military interest. Risk assessments on discrete radioactive material (RAM) are challenging due to large amount of uncertainty in the corrosion rates of such objects, the bioavailability of the radionuclides involved, and ultimate toxicity of these radionuclides to marine biota. Therefore, tissue accumulation, antioxidant response, and changes in gene expression will be monitored in the exposed mussels to quantify the impacts of exposure to radioluminescent paint. This information will inform a framework for the United States Navy (USN) to develop biomonitoring protocols for identifying high priority remediation sites for legacy contamination in coastal military installations.

Benthic bivalves as potential indicator species for ecosystem climate change effects

Investigators: Juliana Harding[1], Dennis Allen[2]

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

The current project builds on the Baruch Institute's long-term monitoring program describing macrobenthic bivalve trends in the North Inlet estuary. The coupling of modern and historic data allows evaluation of potential changes in species richness and recruitment timing since 1982 related to increasing winter water temperatures. Modern field collections (Bly Creek, Bread and Butter Creek) describing the current status of macroinfauna will be coupled with historic macroinfaunal sample analyses to 1) quantitatively describe infaunal bivalve populations and demographics, and 2) evaluate the potential for increasing water temperatures to change these dynamics and related ecosystem services over decadal scales. This research complements previous and ongoing work describing other North Inlet estuary ecosystem trophic levels and will enhance existing descriptions and predictions of ecosystem function.

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

Investigators: James Morris[1], Karen Sundberg[2]

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.

3-D subsurface modeling of a clastic paleo-shoreface deposit

Investigator: Patrick Duff

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

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, along with vibracore, and a UAS drone survey will be acquired near the Baruch Marine Field Laboratory 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.

Sediment accretion in North Inlet estuary salt marshes

Investigators: James Morris[1], Karen Sundberg[2]

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.

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

Investigators: Erik Smith, Robert Dunn, Julie Krask, J. Baker Stevens, Tracy Buck

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

As part of a National Estuarine Research Reserve (NERR) 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 8 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. 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.

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

Investigator: Juliana 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 including Town, Clambank, Crabhaul, Oyster Landing, Bly, and adjacent smaller creeks. Hard clam age structure, growth rates, biomass, and sex ratios will 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.

Experimental varying of the marsh platform and macrophyte response

Investigators: James Morris[1], Karen Sundberg[2]

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.

Finding the genetic basis of developmental evolution using a marine polychaete

Investigator: Christina Zakas

Department of Biological Sciences, North Carolina State University

The goal of our research is characterizing the extent and distribution of genetic variation that contributes to early development. The estuariane polychaete *Streblospio benedicti* provides a unique opportunity to address this issue because it has two types of mothers who produce distinct offspring that differ in egg size, early development, and larval morphology. It is an ideal genetic model for understanding how transitions in developmental programming evolve. Because early development is strongly influenced by maternal effects, we focus on finding the genetic contribution of maternal background to developmental phenotypes. We integrate aspects of population genetics, quantitative genetics, and developmental biology within a single species to identify how genomic variation influences life-history.

Petrolisthes armatus density and performance along a latitudinal gradient

Investigator: Jeb Byers

Odum School of Ecology, University of Georgia

Petrolisthes armatus is an invasive tropical crab that has spread throughout the southeastern US in the past decades. Its northern distribution seems to have remained close to the North Inlet estuary for many years, perhaps because the crab is limited by low winter temperatures. We have been latitudinally sampling the crab for the past three years to establish information on its distribution and abundance, and also to collect crabs for genetic analyses. In particular we wish to examine whether there is any genetic differentiation in the crab within its invasive range. As the northernmost end point in our latitudinal sampling, the North Inlet estuary is an important spot to include in our analyses.

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

Investigators: Andrew Tweel[1], Denise Sanger[1], Sharleen Johnson[1], David Chestnut[2], Ed Wirth[3]

1 - Marine Resources Division, South Carolina Department of Natural Resources
2 - Bureau of Water, South Carolina Department of Health and Environmental Control
3 - Hollings Marine Lab, National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration (SC)

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. Among the hundreds of sites been sampled statewide, over a dozen are generally located in the North Inlet estuary, and several dozen sites located in the adjacent Winyah Bay.

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

Investigator: Juliana 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, biomass, and reef spatial extent 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.

Shorebird monitoring in the North Inlet estuary

Investigators: Jennifer Plunket, Wendy Allen

North Inlet-Winyah Bay National Estuarine Research Reserve, 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 near high tide by boat and land and through the use of wildlife cameras. Species are identified and counted at sites on Hobcaw Beach, North Island, North Jones Creek, Bosun's Point, and along Clambank Causeway. Survey 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 help to identify key habitat areas within the reserve. 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.

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

Investigators: Isaure de Buron[1], Dennis Kyle[2], Matthew Kimball[3]

1 - Department of Biology, College of Charleston (SC)
2 - Coverdell Center, University of Georgia
3 - Baruch Marine Field Laboratory, University of South Carolina

Blood flukes are pathogenic parasites that infect the cardiovascular system of their definitive hosts. Life cycles of fish and turtles blood flukes use annelids and/or mollusks as intermediate hosts. The objectives of this project are 1) to continue the inventory of blood flukes in the North Inlet estuary and 2) to unravel life cycles of as many of these blood flukes as possible. Methods involve sampling annelids, examining them under the dissecting microscope for the presence of parasites, isolate parasites, describe their morphology and sequence parts of the COI and LSU genes. Larval flukes that infect annelids can be identified only by matching DNA sequences with adult stages found in fish. An effort will be made to survey fish captured in the North Inlet estuary for the presence of blood flukes in order to `match' them with larval stages found in annelids. Preliminary results show a high diversity of these parasites in annelids.

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

Investigators: George Voulgaris[1], William Jefferson[2]

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 and when combined, 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.

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

Investigators: Peter Key, James Daugomah, Grant Burdine

Hollings Marine Lab, National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration (SC)

Long-term ecological monitoring is important to developing fundamental understandings of both biogenic and anthropogenic effects on ecosystem health. This 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. Long-term ecological monitoring data can be used not only to ascertain effects of natural and anthropogenic stressors, but also used in conjunction with GIS and advanced modeling techniques to enhance predictive capabilities. The grass shrimp (*Palaemon 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 the North Inlet estuary is maintained as a long-term reference site for comparison to estuarine sites with other land uses. The Clambank site is also being used as a long-term monitoring reference site for Ocean Sampling Day, an international collaboration to collect water samples from the Earth's oceans and rivers.

The National Estuarine Research Reserve System Centralized Data Management Office

Investigators: Dwayne Porter[1,2], Melissa Ide[3], Jennifer Kessee[3], Amber Knowles[3], Brooks Folk[3], Lee Shutt[3], Dan Ramage[2], William Jefferson[1], Julia Britton[3], Tracy Buck[3], Jeremy Cothran[2]

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 - Centralized Data Management Office, National Estuarine Research Reserve, University of South Carolina

NOAA's National Estuarine Research Reserve System (NERRS) acknowledges the importance of both long-term environmental monitoring programs and data and information dissemination through the support of the NERRS System-Wide Monitoring Program (SWMP). The goal of the SWMP is to "identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purpose of contributing to effective national, regional and site-specific coastal zone management." This comprehensive program consists of three phased components: estuarine water quality monitoring (phase I), biodiversity monitoring (phase II), and land-use and habitat change analysis (phase III). The Centralized Data Management Office (CDMO) was established in support of the System-Wide Monitoring Program involving 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 programs, and other education, monitoring, and research programs.

Atlantic brief squid (*Lolliguncula brevis*) population biology and growth rates in North Inlet estuary

Investigator: Juliana Harding

Department of Marine Science, Coastal Carolina University (SC)

Atlantic brief squid (*Lolliguncula brevis*) play an ecological role within estuarine habitats as upper level consumers. Biology, demographics, age structure, and growth rates of Atlantic brief squid are being quantitatively examined in North Inlet estuary within and across years, and subsequently evaluated in the context of environmental data. These descriptions will be integrated with parallel descriptions of other trophic levels to provide a multi-year perspective on ecosystem food web dynamics.

Effect of wrack accumulation on salt marsh vegetation near Clambank Landing in the North Inlet estuary

Investigators: Richard Stalter[1], John Baden[2]

1 - Department of Biological Sciences, St. John's University (NY)
2 - US Army Corps of Engineers, Retired (NC)

In 2013 we initiated a second study of salt marsh vegetation along an elevation gradient beginning with the most flood tolerant taxon, *Spartina* (*Sporobolus) alterniflora* and ending with the least flood tolerant taxon, *S. pumilus* was covered with 15-25 cm of wrack, duplicating the natural deposition of wrack on the marsh by tides and storms. Contiguous controls were left uncovered. Generally, 6 months were needed for the wrack to decompose and be carried away from the arrays by tides. During this time the buried vegetation was killed. We have monitored the time it takes for the pre-existing vegetation to invade and cover the bare soil where the original vegetation was killed. Generally, it takes between 2 and 3 years for the original marsh taxa to invade and cover the wrack impacted sites. After 3 years the salt marsh vegetation on the wrack impacted sites is indistinguishable from the contiguous controls. We have observed that the least flood tolerant taxon, S. *pumilus* has been gradually replaced by more flood tolerant *Borrichia frutescens*, at arrays covered with wrack in an earlier study initiated in 2004. Salt marsh vegetation exists along very narrow elevation gradients. Thus saltmarsh vegetation distribution is an excellent indicator of sea level rise. Gradual sea level rise (3.6mm/year) at this site between 2004 and 2022 likely accounts for *S. pumilus* being replaced by the more flood tolerant *B. frutescens*.

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

Investigators: Robert Dunn, J. Baker Stevens, Julie Krask

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

As part of the NERR 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 and Winyah Bay waters, and provides base-line data critical for various studies of biological and physical processes in these estuaries. 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.

Construction of biodegradable floating treatment wetland utilizing wood and bamboo

Investigators: William Strosnider[1], Travis Tasker[2], Levi McKercher[1], Sam Downs[1], Tyler Gobert[2], Kendra Zaruba[2], Lily Currie[2]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Environmental Engineering Program, Saint Francis University (PA)

The purpose of this research is to develop new designs for floating treatment wetlands (FTWs) that utilize natural and biodegradable materials to support plant growth and improve water quality. In this work, we designed and built biodegradable and durable wood and bamboo floating rafts embedded with coir fiber mats, which are subsequently planted with *Pontederia cordata*. Multiple iterations of these FTWs have been deployed in Kimbel Pond and continue to be monitored to determine the longevity of the floating mats. The benefits and success of constructing FTWs out of more natural, biodegradable, and ubiquitous materials could reduce the costs of FTWs and allow for more resilient plant and biological communities.

Decapod crustacean population dynamics and fishery trends in the North Inlet-Winyah Bay estuarine system

Investigators: Robert Dunn, Julie Krask, J. Baker Stevens

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

Despite the economic and ecological importance of decapod crabs within estuarine ecosystems, fisheries for blue and stone crabs in South Carolina currently have relatively little management. To better understand the status of crab populations within the waters of North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB NERR), we will conduct quarterly trap-based surveys to collect data on blue and stone crabs. Although blue crabs have been extensively studied elsewhere, there is relatively little information regarding their recent population dynamics in estuaries of S.C. For example, the most recent estimates of multiple blue crab vital rates are decades old, and environmental conditions along our coast have likely changed since previous data were collected. The goal of this survey is to estimate crab abundance (catch per unit effort), sex ratio, size distribution, length-weight relationships, and reproductive condition, within NIWB NERR, as well as spatial and temporal variation in these parameters. We will also conduct monthly counts of crab pot buoys within the Reserve to estimate fishing effort in individual creeks and understand spatio-temporal variation in fishing effort.

South Carolina BioDiscovery Biofouling Project

Investigators: Beth Thomas, Hayley Fournier

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

The South Carolina BioDiscovery Project is a STEM (science-technology-engineering-math)-based citizen science education initiative initiated in 2019 and designed to provide hands-on exploration of biofouling communities that colonize in fresh and saltwater environments, connecting students and teachers along a watershed and/or across the state through the collection of biodiversity monitoring and water quality data via an online data portal where teachers, students and citizen science volunteers share their findings through a network of sampling locations across the state. Project activities address South Carolina State Science Standards for grades 1-12 and engage STEM skills through the design of biofouling equipment, incorporation of data collection technology, calculation of biodiversity and water quality indicators, and engagement in the scientific process. The North Inlet-Winyah Bay National Estuarine Research Reserve will serve as a partner hub location for the project. Education staff will conduct monthly monitoring of the fouling discs and share these activities via a variety of virtual outreach programs for K12 and public audiences and will submit monthly data via an online date portal. The saltwater monitoring location at Oyster Landing offers online access to water quality information, including real-time readings, and NOAA tide gauge and other citizen science monitoring data such as the SE Phytoplankton Monitoring Network, and a freshwater location at the pond dock at the USC BMFL Kimbel complex will offer additional data on freshwater fouling communities and convenient access to the outdoor classroom shelter for conducting field sampling activities with K12 and public groups.

The extraordinary visual systems of snapping shrimp and the armor that protects them

Investigators: Alexandra Kingston[1], Daniel Speiser[2]

1 - Department of Biological Science, University of Tulsa (OK)
2 - Department of Biological Sciences, University of South Carolina

Snapping shrimp (Decapoda: Alpheidae) are an exciting system in which to study integrative neurobiology because they have armor, termed the orbital hood, that protects them from supersonic high-amplitude pressure waves, better known as shock waves. This is the only armor, natural or engineered, known to protect an animal from shock waves. The morphology of the orbital hood may be key to its protection, but it may also create challenges for the visual system situated beneath it. The visual system of snapping shrimp functions faster than that of any other aquatic animal. We aim to learn how orbital hoods protect snapping shrimp from shock waves and why snapping shrimp have evolved such fast vision.

Evaluation of monthly grazing rates of *Ilyanassa obsoleta* on microbenthic organisms in the North Inlet estuary

Investigators: Brittany DeArmitt[1], James Pinckney[2], Juliana Harding[3], Joshua Stone[2]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Department of Biological Sciences, University of South Carolina
3 - Department of Marine Science, Coastal Carolina University (SC)

The eastern mud snail, *Ilyanassa obsoleta*, is found at densities of 100's of individuals m^{-2} on soft sediments in the intertidal zones of estuaries. These obligate deposit feeders consume microalgae, detritus, larvae, meiofauna, and macrofauna in the surface layers of sediments with possible trophic impacts on benthic microalgal (BMA) biomass. The goals of this study were to quantify mud snail grazing on BMA biomass, observe the variation in monthly and seasonal grazing rates, and evaluate the relationship between atmospheric temperatures and grazing rates. The sites for this experiment were two mudflats in the Oyster Landing Creek basin of North Inlet estuary. Two different methods were used; *in-situ* enclosures placed at each site (June 2021-September 2021) and in-vitro plastic containers filled with mud and snails from each site (November 2021- May 2022). Biweekly, sediment samples before and after *I. obsoleta* grazing opportunity were collected and analyzed for BMA biomass using high-performance liquid chromatography or fluorometry. There was not a statistically detectable difference between grazed and ungrazed corrected average daily differences in mean BMA biomass/chlorophyll *a*, and neither corrected mean monthly grazing rates nor mean seasonal grazing rates differed significantly. There was not a clear relationship between the median experimental temperatures and the corrected average daily difference in mean chlorophyll a of the grazed plots or the corrected average daily *I. obsoleta* grazing rates. *I. obsoleta* grazing effects could change the BMA biomass, leading to changes in other trophic levels within the temperate estuary ecosystem but the direction and magnitude of these grazing effects are still unclear.

Phytoplankton monitoring - community science project

Investigators: Jennifer Plunket, Maeve Snyder

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

Community scientists will monitor the North Inlet estuary and surrounding coastal waters for potentially harmful phytoplankton. The National Phytoplankton Monitoring Network (PMN) is a community-based network of volunteers that monitor marine phytoplankton and harmful algal blooms (HABs). The PMN enhances the Nation's ability to respond to and manage the growing threat posed by HABs by collecting important data on species composition and distribution in coastal waters and creating working relationships between volunteers and professional marine biotoxin researchers. The North Inlet-Winyah Bay NERR Phytoplankton monitoring project will monitor the North Inlet estuary and surrounding coastal waters for potentially harmful phytoplankton. Participants will collect and assess samples twice a month. Results will be reported to the National Phytoplankton Monitoring Network.

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

Investigators: Robert Dunn, J. Baker Stevens, Julie Krask

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 through the CDMO website. 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.

Salt marsh seasons phenology monitoring - community science project

Investigator: Jennifer Plunket

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

Phenology is the study of the timing of seasonal plant and animal life-cycle events, including the flowering of plants, ripening of fruit, the emergence of insects, and migration of birds. Life-cycle events influence the abundance and distribution of organisms, which affects food webs, ecosystem services, and global cycles of water and carbon. The timing, duration and intensity of these events are sensitive to seasonal and long-term changes in temperature and precipitation. Monitoring phenological events can aid in the assessment of the vulnerability of species, populations, and ecological communities to ongoing climate change. Volunteers with the Salt Marsh Season Phenology Community Science Project will record observations of plant phenology and wildlife activity for selected species at designated salt marsh monitoring trails. Volunteers will visit designated monitoring sites along the trails on a weekly basis. Following a written protocol, the phenological stages (e.g., leaf break, flower buds) will be recorded for marked plants within the site. Volunteers will also listen and watch for selected bird species and conduct a visual inspection for insect species. Over time this will provide information for research on how species are adjusting to shifts in season and sea level rise occurring as the climate changes.

Quantifying the impacts of recreational harvest on mobile oyster reef fauna

Investigators: Robert Dunn[1], Mercer Brugler[2], Lillian Doll[3]

1 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina
2 - Department of Natural Sciences, University of South Carolina Beaufort
3 - South Carolina Honors College, University of South Carolina

This project aims to investigate the effects of fishery harvest (`oyster picking') on oyster reef faunal biodiversity. At four oyster reef locations within North Inlet, which span a range of fishery harvest, we have deployed oyster shellbaskets buried into the reef matrix. Shellbaskets are made of the bottom of a plastic basket holding loose, weathered oyster shells, and shellbaskets are left in the field for ~4 weeks and then swapped. Mobile fauna that inhabit oyster reefs colonize the shells and sediment that accumulate within the basket. After 4 weeks in the field, these organisms are sieved from the shells and mud. At the time of shellbasket retrieval, environmental DNA (eDNA) water samples are also collected from on the reef, off the reef, and from a water bath holding the shellbasket. This BACI design will provide baseline information regarding the effects of recreational oyster harvest on the community of organisms inhabiting reefs. Ultimately, this project will contribute to the implementation of ecosystem-based management via enhanced understanding of the effects of a culturally important recreational fishery on target and non-target ecosystem components.

Painted bunting (*Passerina ciris*) breeding survey

Investigators: Jennifer Plunket, Wendy Allen

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

The project goal is to estimate the number of painted buntings utilizing the edges of North Inlet estuary marshes as nesting habitat during the breeding season. A point count method is utilized that involves 5 minutes of listening for calling male buntings at fixed intervals along a prescribed route. Summer 2022 marked the fifth year of this survey. The plan is to continue this breeding bird survey of painted buntings each year so that changes in numbers can be detected for this species of high concern in South Carolina. The point count methodology is consistent with North American Breeding Bird Surveys and a population assessment of painted buntings conducted in the southeast, 2007-2009, thus allowing for comparisons with other studies.

Seasonal microbial dynamics in the North Inlet-Winyah Bay estuarine system

Investigators: Xuefeng Peng[1], Bruce Pfirrmann[2], William Strosnider[2], James Pinckney[3]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Department of Biological Sciences, University of South Carolina

Microbial communities play a major role in determining ecosystem functions. Technological advances in DNA sequencing and bioinformatics have enabled the discovery of new lineages and functions of life and how they are shaped by the environment. Nevertheless, it remains challenging to link the composition and activity of microbial communities to the physical environment they are an integral part of. Decades of environmental monitoring at four stations in the North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB NERR) make them an ideal location to study the interactions between microbial communities and the physical environment with seasonal dynamics. The NIWB NERR has been home to many ecological studies in coastal ecosystems, but little is known about the microbial communities in the NIWB NERR due to the paucity of microbial investigations to date. The main objectives of this project include: 1) Determine the microbial community composition and functions at the genome level using shotgun metagenomics; 2) Identify links and feedback between microbial communities and the physical environment by analyzing the microbial data along with the physicochemical data collected from the long-term environmental monitoring at the NIWB NERR; and 3) Cultivate representative fungal strains from the NIWB NERR that play a major role carbon and nitrogen cycling.

Detecting impacts from climate change across multiple scales: A national synthesis of tidal marshes

Investigators: Chris Peter[1], Erik Smith[2], Robert Dunn[2]

1 - Great Bay National Estuarine Research Reserve, New Hampshire Fish and Game Department
2 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina

Building upon two NERRS Science Collaborative catalyst projects that established a prototype methodology for standardizing, visualizing, and analyzing tidal marsh monitoring data, this project proposes a detailed, national-scale synthesis of tidal marsh responses to climate change, specifically changes in marsh vegetation community responses to sea level rise (SLR). National Estuarine Research Reserves (NERRs) are uniquely situated to address this topic, given our decade-long monitoring focused on understanding effects of changing sea levels and inundation regimes on coastal habitats. Accelerated rates of SLR and shifts in marsh vegetation communities have occurred nationwide, however a dedicated nationwide synthesis has yet to be conducted. Using a variety of NERR datasets, the researchers will quantify climate-induced shifts in marsh integrity and resilience at local to national scales that document ecological responses and inform best management practices. Additionally, shifts in species ranges and patterns of diversity across latitudes and biogeographic regions will be investigated. The proposed work will provide: 1) insight on how climate change is affecting marshes nationwide, 2) NERRs-specific templates and automated tools for data analysis and visualization, 3) transferable utility to other organizations with marsh monitoring datasets, 4) transferable utility to other coastal habitats (seagrass, mangroves), and 5) a framework for guiding and facilitating other national-level research.

Benthic microalgal ecology of salt pannes in North Inlet estuary

Investigator: James Pinckney

Department of Biological Sciences, University of South Carolina

The purpose of this research will be to investigate the ecology of benthic microalgal (BMA) communities in the unvegetated salt pannes of the North Inlet estuary. This is an exploratory project to determine biomass, productivity, and community composition of BMA in the bare, sandy patches within the *Spartina* marsh. The overall goal is to determine the potential contribution of this habitat type to marsh primary production.

Zooplankton trait response to climate change: the case of North Inlet estuary, SC

Investigators: Nayan Mallick, Joshua Stone

Department of Biological Sciences, University of South Carolina

Rising temperatures due to anthropogenic climate change is adversely affecting aquatic biota in multifaced ways. Change in body size, a dominant trait controlling ecosystem function, is one of the pervasive consequences of elevated temperature. We investigated change in body size of two mesozooplankton groups, copepoda and chaetognatha, from spring to early summer (March – July) for two decades (1981-1990 and 2010- 2019). Biweekly mesozooplankton samples were collected using 153 µm mesh net from the North Inlet estuary, a designated NERR site. Over the last four decades (1981-2020) temperature increased about 1.5°C in this estuary. Interannual variability in body size anomaly was evident for both the taxa examined but chaetognatha showed strong variability among years (Adj R^2: 0.51, $p = 0.01$) in first decade (1981-1990). Body size of both taxa was significantly larger (Mann Whitney U test, $p < 0.001$) in the latest decade (2010-2019) compared to first decade. For both the taxa, body size on average decreased significantly seasonally from spring to early summer during the latest decade. Temperature was negatively correlated with body size of both groups, but a stronger relationship was observed for copepods (Adj R^2: 0.31, $p < 0.001$). These findings have important ramifications for predator populations especially larval fish as their feeding is limited by gape size.

Spatial and temporal variation in salt marsh crab communities

Investigator: Robert Dunn

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

Salt marshes provide habitat for numerous species of decapod crustaceans, in particular those commonly referred to as fiddler crabs (*Uca* spp.), mud crabs (*Panopeus* spp.), and those in the genus *Sesarma*. Marsh crabs can be highly abundant and perform numerous ecosystem functions, including bioturbating marsh sediments, consuming algae and detritus, and serving as a link within food webs between primary producers and upper-level consumers. Long-term crab population monitoring will provide insight on the ability of crabs to affect marsh vegetation both directly and by interacting with sea level rise. Crab species vary in size, diet, and behavior, which may affect their impacts on vegetation and marsh geomorphology. This project will use pitfall trap-based sampling for mobile fauna, paired with non-invasive burrow counts and physical measurements of environmental parameters (sediment characteristics, elevation, and porewater chemistry).

Role of salinity in perfluorooctane sulfonate (PFOS) bioconcentraion between aquatic species and the differential regulation of transporters in *Fundulus heteroclitus*

Investigators: Tyler Davis, Bill Baldwin, Peter van den Hurk, Charlie Rice

Department of Environmental Toxicology, Clemson University (SC)

Salinity is a physiochemical property of water that can potentially enhance PFOS accumulation due to the presence of ions such as Ca^{+} and Mg^{2+} in the water; however, the difference in PFOS bioconcentration between freshwater and saltwater fish is not well studied. An estuarine fish species, *Fundulus heteroclitus* (mummichog), is known for its adaptation to both hypertonic and hypotonic environments, which makes it an ideal organismal model to determine differences in the bioconcentration of PFOS in saltwater compared to freshwater in the same species. Mummichog were adapted to both saltwater (23-26 ppt) and freshwater (moderately hard water; 0.143 ppt) conditions for 30 days before being treated with PFOS for 20 days to determine if bioconcentration of PFOS is higher in the liver, gills, and muscle of saltwater mummichog compared to freshwater-acclimated mummichog.

Oyster drill (*Urosalpinx cinerea*) population dynamics in North Inlet estuary

Investigator: Juliana Harding

Department of Marine Science, Coastal Carolina University (SC)

Atlantic oyster drills (*Urosalpinx cinerea*) play an ecological role within tidal creek oyster reef habitats. Oyster drill population dynamics, distribution, age structure, and growth rates are being quantitatively examined in North Inlet estuary tidal creeks (e.g., Town, Clambank, Debidue, Bly, Crabhaul, Oyster Landing) and combined with measurements of ambient environmental variables. The resulting population descriptions will provide information on oyster drill population dynamics and applied to quantitative descriptions of oyster drill and oyster (*Crassostrea virginica*) population biology and demographics in the context of environmental conditions across multi-year time scales.

Monitoring change in salt marsh vegetation distribution and biomass using UAS-derived multispectral imagery in North Inlet, South Carolina

Investigators: Brittany Morse, Erik Smith

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

Coastal marsh responses to increasing rates of sea level rise and episodic storm events are spatially variable, depending on a range of local factors. The National Estuarine Research Reserve System (NERRS) uses a suite of standardized ground-based measurements to track marsh response to sea level rise across the different estuaries represented by the NERRS. To increase both the temporal frequency and spatial resolution of its marsh monitoring program, The North Inlet-Winyah Bay NERR is now supplementing these ground-based efforts with data collection from Uncrewed Aerial Systems (UAS) and analysis workflows developed in a collaborative effort among the six Southeastern and Caribbean NERRs. Beginning in 2020, a UAS (DJI Matrice 200 v2) equipped with a multispectral sensor (MicaSense Altum) was flown on a bimonthly to monthly basis to collect data on vegetation community distributions and biomass across the marsh platform of the landward-most creek basin of the North Inlet estuary. Of all indices tested, the Normalized Difference Vegetation Index (NDVI) produced the strongest predictive relationship with live biomass, based on comparisons with clipped vegetation harvested seasonally across the elevation gradient. This relationship was then used to quantify spatially-explicit seasonal growth curves and biomass distributions as a function of marsh elevation. Integrating the use of UAS into monitoring protocols greatly expands the scale and resolution of assessment, enabling an improved understanding of salt marsh vegetation dynamics.

Investigation of high-energy storm events and their impact on carbon storage in tidal wetlands of South Carolina

Investigators: Kelly Lazar, Gavin Gleasman

Department of Environmental Engineering and Earth Sciences, Clemson University (SC)

The disturbances which tropical storms impose on coastal carbon cycling in tidal wetlands are currently unidentified. High-energy storms have the potential to either disturb the storage of carbon with increased erosion or inhibit carbon storage through increased deliverance of organic matter accompanied by an increase in post-storm sedimentation. The objective of the proposed research is to discern the effects high-energy storm events impose on the ability of tidal wetlands to sequester carbon during storm events by utilizing in-situ CO2 flux measurements and analyzing a historical sediment record through paleotempestological methods, to ultimately improve carbon budgets for South Carolina’s coastal wetlands.

Visual ecology of the green porcelain crab *Petrolisthes armatus*

Investigators: Madison Janakis, Daniel Speiser

Department of Biological Sciences, University of South Carolina

Conditions for visual signaling in aquatic environments vary drastically depending on local factors such as depth, sediment type and weather conditions. Tidal creeks, for example, are challenging environments for visual signaling due to frequent high levels of turbidity. High turbidity increases light scattering, which lowers the contrast of images and reduces sighting distances. Tidal creeks can also be spectrally narrow, which decreases the ability of animals to distinguish color signals. Given these challenges, how do the inhabitants of tidal creeks reliably send and receive visual signals? We hypothesize that animals use polarized signals and polarization-sensitive vision to enhance the reliability of visual communication in turbid, spectrally narrow environments such as tidal creeks. To explore this hypothesis, we are investigating the visual ecology of *Petrolisthes armatus*, an invasive porcelain crab (Decapoda, Anomura, Porcellanidae) abundant in the North Inlet estuary. *P. armatus* has a pair of maxillipeds (feeding appendages) with iridescent turquoise spots which they can voluntarily hide or reveal. These spots reflect polarized light and we propose porcelain crabs use them for interspecific visual signaling. We are currently investigating how the polarization of these visual signals may increase the distance at which *P. armatus* can communicate visually in the turbid tidal creeks in which they live.

Long-term changes in fish assemblage diversity and abundance in the Winyah Bay estuary

Investigators: Matthew Kimball, Bruce Pfirrmann

Baruch Marine Field Laboratory, University of South Carolina

The lack of research on fish assemblages in the Winyah Bay estuary is limiting our ability to detect, examine, and understand the local and regional impacts of climate change on the ecological structure and function of the North Inlet-Winyah Bay estuarine ecosystem in South Carolina. Over the last 35 years we have detected significant changes in larval and juvenile fish assemblages in the North Inlet estuary. However, no such examination has yet occurred for fish assemblages in the Winyah Bay estuary; in fact, only two studies have focused on fish assemblages in the Winyah Bay estuary. Seasonal juvenile fish assemblages were only (and last) examined for two full years in 1977-1978. Therefore, the objective of this research is to examine the juvenile fish assemblages of the Winyah Bay estuary following the same sampling methods and protocols employed back in late 1970s. Using a 20 ft otter trawl net of the same specifications, fishes will be collected monthly (one 20-minute trawl) at each of the nine sample sites covering the bay and rivers for two full calendar years. This is a unique opportunity to replicate the methods and protocols of a prior study that will allow for a 1:1 comparison with the historic collections from over 40 years prior.

Engaging the African American community and acknowledging the Black experience at the Baruch Marine Field Laboratory

Investigators: William Strosnider[1], Steve Williams[2], Tameria Warren[3], Patti Burns[2], Lynn Hanson[4], Bruce Pfirrmann[1]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Georgetown County Public Library, Georgetown, SC
3 - School of the Earth, Ocean, and Environment, University of South Carolina
4 - Baruch Institute for South Carolina Studies, Francis Marion University (SC)

This project seeks to uncover, acknowledge, and honor the contributions that enslaved individuals made in creating the landscape that now houses the Baruch Marine Field Laboratory. In collaboration with the University of Dayton, efforts will be made to intensify engagement with local African American communities, gather primary sources concerning the Black experience on the land, and integrate this new information into current and future USC courses.

The BMFL – University of Dayton ETHOS Service Collaborative

Investigators: William Strosnider[1], Elizabeth Reidel[2], Camryn Justice[2], Daniel Schermaier[2], CJ Levy[2], Kelly Bohrer[3], Scott Schneider[3]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - School of Engineering, University of Dayton (OH)
3 - The ETHOS Center, University of Dayton (OH)

Beginning in 2021, the Baruch Marine Field Lab (BMFL) established a partnership with the University of Dayton's ETHOS (Engineers in Technical Humanitarian Opportunities of Service Learning) Center, becoming a host site for undergraduate and graduate engineering students participating in the ETHOS program. With an overall goal of engaging with underrepresented communities to promote multiculturalism and environmental justice in Georgetown County, specific initiatives undertaken by participating students to-date include: 1) providing technical assistance to expand the food production capacity of regional food gardens within the county and 2) supporting the re-opening and proper memorialization of the historic African American Myrtle Grove Cemetery in Georgetown's West End. While in residence at BMFL, ETHOS students have also engaged in "Greening BMFL projects" including decreasing the CO^2 footprint of the seawater system, designing, and implementing rainwater collection, composting, and raised bed gardening.

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

Investigators: Dwayne Porter[1,2], Melissa Ide[3], Jeremy Cothran[2], Jennifer Kessee[3], Amber Knowles[3], Brooks Folk[3], Lee Shutt[3], Dan Ramage[2], Julia Britton[3], Tracy Buck[3]

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 - Centralized Data Management Office, National Estuarine Research Reserve, University of South Carolina

The 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 University of South Carolina's (USC) 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.

Evaluation of juvenile nekton growth and intertidal creek nursery function

Investigators: Juliana Harding[1], Dennis Allen[2], Robert Young[1]

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

Intertidal creeks provide important nursery habitat for a variety of juvenile transient nekton. Demographics and growth rates were evaluated for selected nekton collected from similar creeks within North Inlet estuary within years and across years during 2006-2008. The same sites will be sampled seasonally to describe demographics and growth for young of the year spot (*Leiostomus xanthurus*) and pinfish (*Lagodon rhomboides*). These ubiquitous estuarine species represent different trophic levels and may be good indicator species for food web function. Fish standard length (mm) and biomass (g dry tissue) will be quantified. Otoliths will be used to describe within year growth rates and recruitment periodicity for both species. Creek-specific fish metrics will be used for within and across year comparisons of nekton growth in the North Inlet estuary intertidal creeks. These comparisons will provide valuable context for North Inlet estuary tidal creek habitat value and trophic dynamics at different spatial and temporal scales that can be applied to similar estuarine nursery habitats.

Guiding successful applications of floating treatment wetlands in brackish coastal ponds

Investigators: William Strosnider[1], Sarah White[2], Amy Scaroni[3], Matthew Kimball[1], Levi McKercher[4], Andrea Landaverde[2], Clare Escamilla[2,] Cailee Sprouse[3]

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2 - Department of Plant and Environmental Science, Clemson University (SC)
3 - Department of Forestry and Conservation Science, Clemson University (SC)
4 - Department of Biological Sciences, University of South Carolina

Floating treatment wetlands (FTWs) are a low cost, low maintenance option for removing nutrients from eutrophic ponds, however their use in brackish waters is limited. Therefore, this project aims to deploy FTWs at various scales in brackish waters to assess plant survivability, nutrient removal rates, and water quality improvements following installation. Many plant species will be screened across several nutrient and salinity concentrations at greenhouse and mesocosm scale to determine those species suitable for field scale FTW application. Field-scale FTWs will be constructed and applied to several brackish, coastal retention ponds of varying trophic status near Mt. Pleasant, SC, where nutrient concentrations and water quality parameters will be rigorously monitored pre- and post-FTW application to assess any changes in response to FTW deployment. A multitude of workshops and trainings will be provided to pond management professionals, local conservation officers, and all others who are interested in using FTWs as a tool to improve retention pond water quality. Anticipated benefits resultant of this project include improved understanding of the suitability of FTWs for nutrient removal in brackish waters, increased public engagement in urban water quality restoration efforts, and training for several graduate and undergraduate students.

Collaborative development of novel remote sensing workflows for assessing oyster reef structural and demographic characteristics to inform management and restoration

Investigators: Peter Kingsley-Smith[1], Erik Smith[2], Robert Dunn[2]

1 - Marine Resources Research Institute, South Carolina Department of Natural Resources
2 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina

Overharvesting oyster reefs threatens their sustainability, reducing the amount of shells available as substrate for oysters and other reef-dwelling organisms and diminishing resilience to additional stressors. To protect and enhance oyster reefs, resource managers in the southeast must decide when and where to enact fishery closures or plant substrate, typically relying on conventional monitoring approaches for reef distribution and demographics. These approaches, often boat-based surveys or *in situ* quadrat sampling, are time consuming and are limited by spatial scale. Managers have expressed a need for rapid, standardized, and quantitative measures to assess reef condition to direct management and restoration actions. Reserve staff from multiple southeastern NERRs are also interested in monitoring changes in oyster reefs over time within reserves, expanding on oyster monitoring that currently ranges from non-existent to a combination of mapping and *in situ* monitoring. This project will evaluate Uncrewed Aircraft Systems (UAS) as a tool for providing quantitative measures of intertidal Eastern oyster (*Crassostrea virginica*) reef structural and demographic metrics and changes to reefs in response to natural and anthropogenic factors. The project team will implement an integrated and collaborative process with intended users in the southeastern U.S. to generate UAS workflows for quantifying oyster reef structural and demographic characteristics. By working closely with intended users to develop data products and analyses, the project will support improved interstate collaboration for oyster management and enhanced technical capacity to conduct UAS-based oyster reef assessments.

Using marsh organs to investigate the interactive effects of sea level rise and eutrophication on plant-microbe interactions within the *Spartina* root zone.

Investigators: Johanna L'Heureux[1], Julia Feldman[1], Jen Bowen[1], Karen Sundberg[2], Robert Dunn[3]

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2 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
3 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina

To better understand how salt marsh carbon dynamics will respond to environmental change, we must look to the communities of microbes within marsh sediments that are known to regulate biogeochemical reactions. Belowground microbial communities are especially influenced by vegetation because photo-assimilated carbon is secreted out of roots, greatly impacting microbial structure and activity within the rhizosphere. One way to assess how rhizodeposits exhibit control on microbes within the rhizosphere is through the application of stable isotope probing (SIP), which allows for labelled photosynthate to be traced into the microbes that consume the rhizodeposits. To understand the effects of sea level rise and nutrient enrichment on *Spartina alterniflora* rhizodeposit production and microbial community composition, I performed a $^{13}CO_2$ labeling experiment at North Inlet-Winyah Bay NERR using marsh organs - platforms in the field containing planters at different elevations. *S. alterniflora* plants in the marsh organs were labeled for five consecutive days for three hours each day before being harvested. Preliminary analyses reveal that leaf, root, and sediment samples from labeled pots are significantly enriched with ^{13}C. Additionally, analyses of porewater samples showed that environmental conditions in pots differed between treatments. By identifying microbes that are enriched with ^{13}C and comparing them across treatments, we will gain a better understanding of how sea level rise and fertilizer runoff are affecting carbon cycling in salt marshes.

Dynamic camouflage in the grass shrimp *Palaemonetes vulgaris*

Investigators: Nicholas Steichmann, Daniel Speiser

Department of Biological Sciences, University of South Carolina

Camouflage's effectiveness is limited to environments which match the subject's approach to concealment. Two approaches to camouflage are background matching and transparency. Neither method is effective under all conditions, so to stay concealed in variable environments, many organisms change their appearance in response to environmental cues. We are investigating what cues cause decapod crustaceans to change their approach to camouflage and the physiological methods they use to change their appearance. We are addressing these questions using the grass shrimp, *Palaemonetes vulgaris*, which is abundant in the North Inlet estuary. Grass shrimp are mostly transparent with pigment-packed organs termed chromatophores distributed throughout their carapace. These chromatophores expand and contract as grass shrimp experience different light conditions. Like most decapod crustaceans, grass shrimp have a pair of main eyes with superposition optics. Unlike most decapods, they also have an accessory eye with apposition optics positioned at the margin of each main eye. In other shrimp species, the accessory eyes have neural connections to endocrine organs in the eyestalks containing hormones that control pigment distribution within the chromatophores. Using environmental light recordings, behavioral experiments, electrophysiology, and neurohistological approaches, we are testing how the main and accessory eyes of grass shrimp contribute to their dynamic camouflage responses to shifting environmental conditions.

Coupled ecological-geomorphological response of coastal wetlands to environmental change

Investigators: Brad Murray[1], Marco Marani[2], Sonia Silverstri[3]

1 - Nicholas School of the Environment, Duke University (NC)
2 - Department of Civil, Architectural and Environmental Engineering, University of Padova (Italy)
3 - Department of Biological, Geological and Environmental Science, University of Bologna (Italy)

Saltmarsh vegetation influences marsh vegetation and vice versa. Currently, we understand the importance of vegetation and organic matter accumulation in the marsh accretion process; however, we do not understand how the spatial distribution of vegetation affects saltmarsh dynamics. To this end, we employ field sampling, remote sensing and numerical modeling to better understand the impacts of the spatial distribution of vegetation on saltmarsh dynamics. We collect LiDAR and multispectral data along with a simultaneous field survey of the distribution of vegetation associations, above and belowground biomass, vegetation characteristics and organic carbon content of the soil at the North Inlet estuary, South Carolina. The goal is to use remote sensing data to retrieve aboveground biomass and estimate the belowground biomass to provide a spatially distributed assessment of the vegetation biomass across the marsh. From this and an estimate of organic carbon content from soil analyses, the combined carbon stock of the salt marsh is estimated. The field analysis will also be used to inform a numerical model of marsh dynamics that helps us understand the vulnerability of the marsh as rates of sea level rise increase.

Evaluating nitrogen removal strategies to improve stormwater management practices in coastal South Carolina

Investigators: Annie Bourbonnais[1], Erik Smith[2]

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

Nitrogen is the macronutrient limiting primary productivity in coastal waters, such that excess nitrogen can result in coastal eutrophication, harmful algal blooms and dissolved oxygen impairment, both in coastal South Carolina and globally. Nitrogen is also increasingly recognized as the nutrient limiting algal production in freshwater ecosystems, specifically including stormwater ponds. Although ponds are generally effective at retaining and removing most of the phosphorus and other particulate and particle-associated pollutants prior to discharge to receiving waters, they are often much less effective at removing nitrogen and other dissolved pollutants. Improving nitrogen removal performance in ponds and other stormwater control measures (SCMs) is thus essential for effective water quality management associated with coastal development. In practice, this will depend on the ability to maximize biogeochemical nitrogen removal through improved pond design and retrofits to existing ponds. However, specific mechanisms responsible for net nitrogen removal and the factors that affect their variability within and among various SCMs remains poorly resolved. A comprehensive assessment of nitrogen transformation rates in various types of SCMs represents a critical information need in the application of SCM design recommendations and management practices for promoting effective nitrogen retention for water quality protection in coastal South Carolina.

Understanding the effects of environmental variability on penaeid shrimp population dynamics in the southeast US

Investigators: Robert Dunn[1], Matthew Kimball[2], Joshua Stone[3], Juliana Harding[4], Maeve Snyder[1], Bruce Pfirrmann[2]

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

Shrimp reside in estuaries during multiple life-stages, and because shrimp life history occurs on an annual scale, populations are sensitive to changes in environmental conditions and available habitat. Two species, white and brown shrimp, constitute the bulk of commercial shrimp landings along the southeast U.S. Atlantic coast. Commercial shrimp landings have been highly variable over the past two decades with the effects of environmental factors on shrimp abundance remaining unclear. To better understand changes in shrimp abundance in response to environmental variability due to changing climate conditions, weather events, and habitat modifications, we will utilize ongoing, long-term data collections within estuaries across South Carolina and Georgia, conduct additional sampling for shrimp and benthic infauna, and implement manipulative laboratory and field experiments targeting brown and white shrimp and their benthic infaunal prey. These efforts will leverage NERR System Wide Monitoring Program environmental data and infrastructure. Using a multi-faceted research approach based on iterative guidance from end users, we will explore the importance of different estuarine habitat types and variable environmental conditions on shrimp populations, information which is critical to future management of this multi-million-dollar fishery.

A keystone grazer drives salt marsh carbon storage and recovery

Investigators: Serina Wittyngham[1], Yaping Chen[2], David Johnson[3], Matthew Kirwan[1]

1 - Coastal & Ocean Processes Section, Virginia Institute of Marine Science
2 - Department of Ecology, Sun Yat Sen University (China)
3 - Ecosystem Health Section, Virginia Institute of Marine Science

Consumers can directly (e.g., consumption) and indirectly (e.g., trophic cascades) influence carbon cycling in blue carbon ecosystems. Previous work found that large grazers have a positive or neutral effect on carbon stocks, yet, small grazers, which remove plant biomass and alter sediment properties, remain an understudied driver of carbon cycling. We used field-derived and remote sensing data to quantify the effects of the keystone grazer, *Sesarma reticulatum*, on carbon stocks, flux, and recovery in the salt marshes of three coastal U.S. states: Virginia, South Carolina, and Georgia. *Sesarma* fronts led to a carbon loss of around 40-70% and *Sesarma* front migration rates accelerated over time. Despite latitudinal differences, front migration rate had no effect on carbon stocks, flux, or time to replacement. When we included *Sesarma* disturbance in carbon flux calculations, we found it may take 5-100 years for marshes to replace lost carbon, if at all. Combined, we show that small grazers cause a net loss in carbon stocks as they move through the landscape, and irrespective of migration rate, these grazer-driven impacts persist for decades. This work showcases the significant role of consumers in carbon storage and flux, challenging the classic paradigm of plant-sediment feedbacks as the primary ecogeomorphic driver of carbon cycling in blue carbon ecosystems.

Drone Lidar deep learning for fine-scale bare earth surface and 3D marsh mapping in intertidal estuaries

Investigators: Susan Wang[1], Grayson Morgan[2], James Morris[3]

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2 - Department of Geography, Brigham Young University (UT)
3 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

Tidal marshes are dynamic environments providing important ecological and economic services in coastal regions. With accelerating climate change and sea level rise (SLR), marsh mortality and wetland conversion have been observed on global coasts. For sustainable coastal management, accurate projection of SLR-induced tidal inundation and flooding requires fine-scale 3D terrain of the intertidal zones. The airborne Lidar systems, although successful in extracting terrestrial topography, suffer from high vertical uncertainties in coastal wetlands due to tidal effects. This study tests the feasibility of drone Lidar leveraging deep learning of point clouds on 3D marsh mapping. In an ocean-front, pristine estuary dominated by *Spartina alterniflora*, drone Lidar point clouds, and infield marsh samples were collected. The RandLA-Net deep learning model was applied to classify the Lidar point cloud to ground, low vegetation, and high vegetation with an overall accuracy of around 0.84. With the extracted digital terrain model and digital surface model, the cm-level bare earth surfaces and marsh heights were mapped. This experiment demonstrates a multi-step operational procedure to deploy drone Lidar for accurate, fine-scale terrain and 3D marsh mapping, which provides essential base layers for projecting wetland inundation in various climate change and SLR scenarios.

Seasonal variability of dissolved organic matter concentration composition

Investigators: Gwen Hopper[1], Claudia Benitez-Nelson[2], Erik M. Smith[3]

1 - Department of Chemistry and Biochemistry, University of South Carolina
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In the United States Southeast, climate change is projected to cause significant shifts in the environment. This includes rising sea levels, increased frequency and intensity of storm events, as well as fluctuations in the duration and intensity of seasons. Dissolved organic matter (DOM) varies seasonally; over the course of dry and wet periods, increasing and decreasing temperatures, and varying amounts of litterfall. Because the quality of DOM can impact aquatic systems and DOM quality, and reactivity, is a function of its source, assessing seasonal shifts in DOM can help predict future climate impacts on our waterways. In June and December of 2022, we examined concentrations of DOM from various land-use types and determined the quantity, composition, and lability of DOM over a 42-day incubation period. Samples were collected from urban drainages, urban stormwater ponds, brown- and black-water rivers, forested wetland drainages, and forested upland drainages, totaling 10 sites within the Greater Winyah Bay watershed in South Carolina. Dissolved organic carbon (DOC) and nutrient concentrations are not expected to vary significantly seasonally, however, the complexity and thus lability of DOM is projected to shift to a less bioavailable pool when transitioning from the summer to the fall. This could be a result of increased leaf litter and cooler fall temperatures; however, expected results could potentially be impacted by (1) temperatures and weather that are uncharacteristic of either season and (2) differences in land-use practice such as how land cover in developed and undeveloped areas is managed throughout the year.

Expanding collections of the Chesapeake Bay Barcode Initiative (CBBI): The first comprehensive genetic library for fish and invertebrates of the Mid-Atlantic US

Investigators: Matthew Ogburn[1], Robert Aguilar[1], Scott Smith[2]

1 - Smithsonian Environmental Research Center (MD)
2 - Division of Marine Fisheries, North Carolina Department of Environmental Quality

DNA barcoding is a powerful tool to investigate biodiversity, phylogenetic relationships, food webs, wildlife forensics, and ecosystem services. The ecological utility of genetic reference libraries is greatly improved when they are validated, possess vouchers and detailed metadata, and are regionally based. Although the Chesapeake Bay (CB) is the largest estuary in the United States and a major focus of early fisheries research, there has been minimal genetic sequencing effort and a paucity of museum collections in the last century. Since 2012, we have been compiling the first comprehensive barcode libraries for fish (*COI* and 12*S*) and invertebrates (*COI*) of the greater CB/mid-Atlantic region, collectively known as the Chesapeake Bay Barcode Initiative (CBBI). Associated with each sequence are photographic, tissue, DNA, and museum vouchers and detailed metadata. All vouchers are housed in the Smithsonian National Museum of Natural History's collections and sequences and metadata are publicly available via GenBank and BOLD. In 2022, BMFL provided material for sequencing from their ongoing trawl and seine surveys (e.g., Leatherjacket *Oligoplites saurus*, Highfin Goby *Gobionellus oceanicus*, Irish Pompano *Diapterus auratus*). These collections increased the taxonomic and geographic breadth of the CBBI and helped address biogeographic uncertainty regarding native and introduced estuarine species.

Neonate Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) relative abundance and body condition in two South Carolina estuaries varying in urbanization

Investigators: Rileigh Hawk[1], Daniel Abel[1], Matthew Kimball[2], Robert Young[1], Eric Rosch[1]

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

Urbanization near estuaries has been shown to affect the growth and survival of juvenile sharks using these systems as a nursery. North Inlet and Murrells Inlet, South Carolina, are similarly-sized, tidally-dominated, bar-built estuaries with extensive *Spartina*-lined tidal creeks, but differ in degree of human impact. To examine potential differences in neonate shark abundance and growth between a developed estuary, Murrells Inlet, and a protected estuary, North Inlet, neonate *R. terraenovae* (n = 52) were captured on hook-and-line gear from May to September 2022. Sharks were measured for length and girth, weighed, sexed, and released. Noise pollution between the two estuaries was investigated using hydrophone recordings. Relative abundance of neonate *R. terraenovae* was much greater for North Inlet (n = 45) than for Murrells Inlet (n = 7). However, body condition, weight-length relationships, girth-length relationships, and growth rates of the neonate sharks did not differ between the estuaries. Elasmobranch diversity was greater for Murrells Inlet than North Inlet, though bony fish diversity was equal between estuaries. Analysis of sound found no difference in the total loudness or the sound power of the recordings for shark hearing frequency ranges. Although the difference in urbanization between estuaries did not affect the growth and body condition of *R. terraenovae*, the drivers behind the difference in abundance of neonates are still unclear.

Temporal habitat partitioning and resource competition between congeneric shrimp: testing for density-dependent growth and mortality

Investigators: Robert P. Dunn[1], Matthew E. Kimball[2], Bruce W. Pfirrmann[2], Drew Bruck[3], Willa Lane[4], Isabel Hubbard[5]

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3 - Rogers Fellow in Environmental Science, Cornell College (IA)
4 - School of Marine Science and Policy, University of Delaware
5 - School of the Earth, Ocean, and Environment, University of South Carolina

Habitat partitioning can promote coexistence of closely related competitors. Two congeneric shrimps (brown shrimp, *Penaeus aztecus*, and white shrimp, *Penaeus setiferus*) that utilize estuaries in the southeastern US temporally partition much of their nursery habitat occupancy during the growing season. However, these species also experience a period of overlap at the respective tails of their nursery residence period. Throughout the nursery residence period, when conspecific abundance is high, density-dependent processes may reduce growth and increase mortality, but the relative importance of these interactions remains underexplored. During summer 2022, we conducted manipulative laboratory experiments with brown and white shrimp individually to test if conspecific density affected growth and mortality in juvenile penaeid shrimp. In each experiment, shrimp were maintained for 15 days at ecologically relevant densities (12.5 - 37.5 m-2) and individually PIT-tagged to follow growth trajectories. Density-dependent growth occurred in brown shrimp but not white shrimp. Conspecific density did not affect survival probability in either species, while initial mass was an important predictor of mortality, with smaller shrimp exhibiting a higher mortality likelihood. Our results suggest that changing environmental conditions within coastal zones could lead to density-dependent impacts on some demographic rates but not others for these key estuarine shrimps.

Local adaptation of the sea anemone *Nematostella vectensis* to viruses and bacteria

Investigators: Adam Reitzel, Hannah Justin, Sydney Birch

Department of Biological Sciences, University of North Carolina Charlotte

The goals for this NSF funded project are to identify mechanisms for how the estuarine anemone Nematostella vectensis regulates the microbes that it interacts with and how these may vary between individuals. We exposed anemones from different geographic locations to natural sea water and then preserved them for sequence-based analysis of their microbiome and virome. Research at Baruch involved a 2 week mesocosm exposure of anemones to water from the salt pannes where Nematostella naturally lives. We are now generating sequence data for the identification of these microbes and viruses and how these communities differ for anemones with different genetic backgrounds.

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