CURRENT RESEARCH PROJECTS

2023

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
2023

Introduction

The Baruch Marine Field Laboratory (BMFL), located on Hobcaw Barony in Georgetown County, South Carolina 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 at least 1,915 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 87 projects that were underway during the period from January through December 2023 at the BMFL and the North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB-NERR) by faculty, staff, graduate students, and undergraduates associated with USC and other institutions. USC is the home institution for 57 of the investigators while over 92 investigators representing 39 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 experience conducting research.

This annual report lists all active projects (in random order) along with a summary that includes the title, investigators, affiliations, and an abstract. The majority of studies that involve field measurements and collections are being conducted within the North Inlet and Winyah Bay estuaries.

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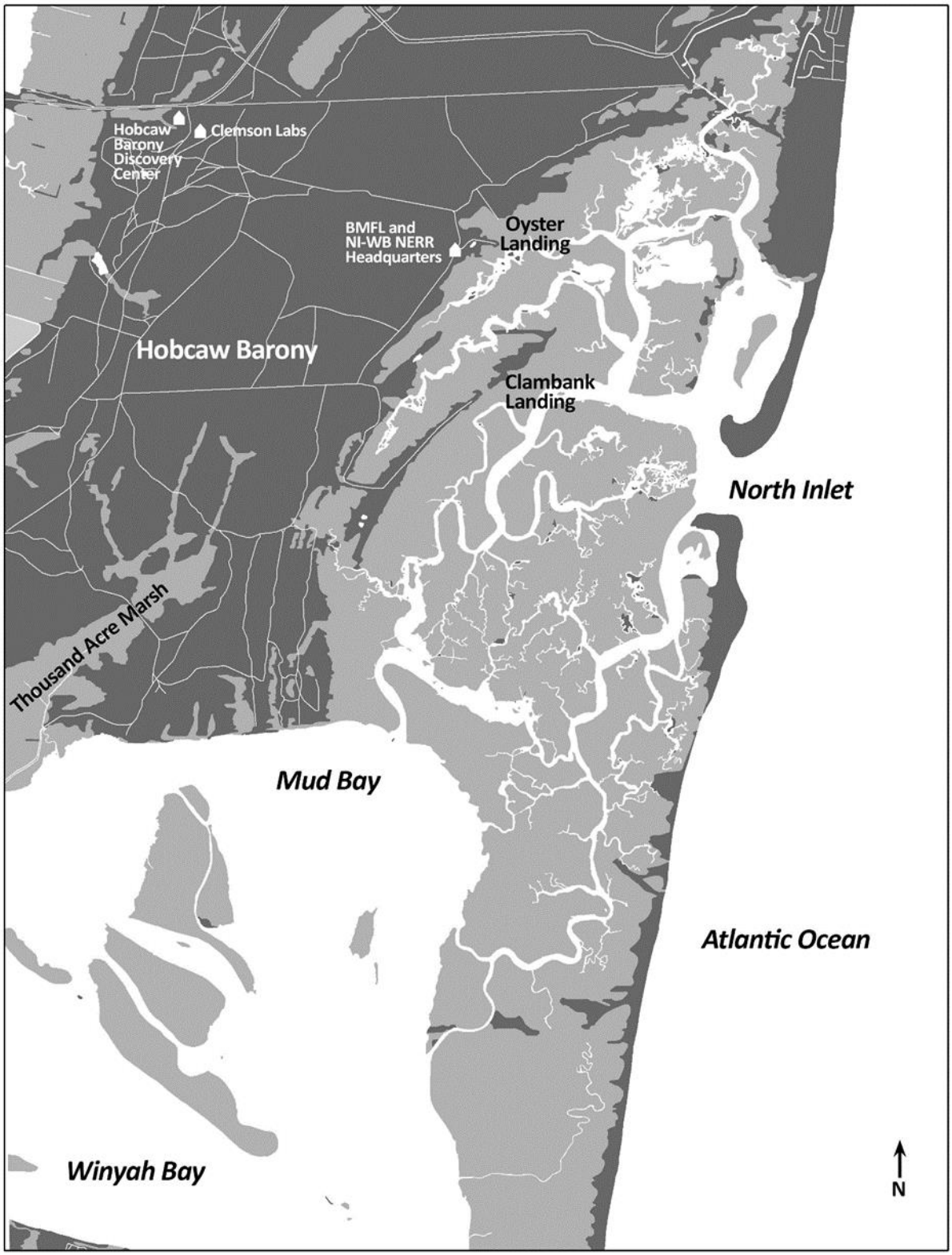

Figure 1: Map of the North Inlet-Winyah Bay estuarine system in Georgetown County, South Carolina.

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 NI-WB 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.

Bathymetric mapping of North Inlet estuary

Investigator: Scott White

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

North Inlet estuary's subtidal creeks will be mapped using a modern GPS-referenced, swath bathymetry system. The SEOE-owned Ping 3dSS sonar unit collects bathymetric (depth) values and seafloor imagery (backscatter) data, and is referenced to the Emlid Reach RS2 PPK GPS system. Data has been collected for Town, Jones, and Debidue creeks in 2023. Parts of Old Man and Bly creeks remain to be mapped. The expected map spatial resolution will be between 1-2 meters for most areas, except in areas of very shallow and complex bathymetry. On-going processing of the data and completion of the maps is expected in 2024.

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 Bay Master Naturalist program 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.

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.

Viable seed production of *Spartina cynosuroides*

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 0-10 psu. 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.

Characterization of oyster cement

Investigators: Jonathan Wilker, Mitchell Meger, Aaron Mena

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.

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 SWMP. 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 Institute's website's Data and Publications page.

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.

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.

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 NI-WB NERR'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.

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.

***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 annually since 2019 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 site in our latitudinal sampling, the North Inlet estuary is an important spot to include in our analyses.

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 in the North Inlet estuary 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.

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

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

1 - Department of Biology, College of Charleston (SC)
2 - 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, then isolating the parasites and describing their morphology as well as sequencing 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.

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

Investigators: Paola López-Duarte[1,2], Taylor Parker[2], Leyna Pence[2], Caitlin Babblerose[2], Ruth Wright[2]

1 - Department of Environmental Sciences and Management, Portland State University (OR)
2 - 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).

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 estuarine 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.

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.

Benthic foraminifera as indicators of ecosystem health in the North Inlet estuary

Investigator: Kelly Gibson

Department of Biological, Environmental, and Earth Sciences, University of South Carolina Aiken

The distribution of benthic foraminifera (single-celled benthic microorganisms that secrete a calcite shell) has been directly tied to environmental parameters such as salinity, nutrient, and dissolved oxygen content. We intend to establish relationships between environmental parameters (i.e. salinity, sediment grain size and organic matter content) in the North Inlet estuary and faunal assemblages of benthic foraminifera by collecting surface sediment samples for faunal and geochemical analyses. North Inlet estuary is relatively pristine and will serve as a baseline with which to compare conditions in estuarine environments with more severe anthropogenic influences/impacts in future studies, both spatially and temporally.

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.

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 cordgrass (*Spartina alterniflora*) dominates the intertidal marsh in the 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.

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

Investigators: Andrew Tweel[1], Denise Sanger[1], Pamela Marcum[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 are located in the adjacent Winyah Bay.

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, these data can be used to create maps of temporal and spatial distribution of waves and currents over the entire Long Bay area. Data from these sites are sent to SECOORA and the National High Frequency Radar Network for integration, display, and dissemination.

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).

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 are 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 NI-WB NERR. 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.

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 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*. Vegetation within pre-defined arrays 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 (~3.6 mm/year) at this site likely accounts for *S. pumilus* being replaced by the more flood tolerant *B. frutescens*.

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.

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 SWMP 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 protocols 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.

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 estuary 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.

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.

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 (NI-WB 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 South Carolina. 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 NI-WB 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.

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

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 multifaceted 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 the 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 the earlier time period. For both 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.

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.

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 PMN to be incorporated into larger-scale examinations.

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 (CDMO), 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.

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.

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.

Benthic microalgal ecology of salt pannes in the 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.

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 (NI-WB NERR) make them an ideal location to study the interactions between microbial communities and the physical environment with seasonal dynamics. The NI-WB NERR has been home to many ecological studies in coastal ecosystems, but little is known about the microbial communities in the NI-WB 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 NI-WB NERR; and 3) cultivate representative fungal strains from the NI-WB 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 their 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 NERRs 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.

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).

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 2023 marked the sixth 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.

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.

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 (2022-2023). 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.

Monitoring change in salt marsh vegetation distribution and biomass using UAS-derived multispectral imagery in the North Inlet estuary

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.

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.

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]

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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.

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.

The BMFL – University of Dayton ETHOS Service Collaborative

Investigators: William Strosnider[1], Sai Kasuba[2], Madelaine Blincoe[2], Elliot Alexander[2], Kelly Bohrer[3], Scott Schneider[3]

1 - Baruch Marine Field Laboratory, University of South Carolina
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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 Engineers in Technical Humanitarian Opportunities of Service Learning (ETHOS) 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.

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.

Nitrous oxide production by salt marsh sediment fungi: its significance and mechanisms

Investigators: Xuefeng Peng, Annie Bourbonnais, Birch Lazo-Murphy, Madeleine Thompson, Sydney Staines, Hannah Lewis
School of the Earth, Ocean, and Environment, University of South Carolina

Nitrous oxide is a potent greenhouse gas and ozone-depleting substance released from natural and agricultural environments. Coastal wetlands are one of the largest natural sources of nitrous oxide to the atmosphere, with most of the gas flux attributed to microbial processes in the sediment. In soil environments, fungi are significant contributors to nitrous oxide production, but in coastal wetlands the role of fungi is largely unknown. This project examines the role of understudied fungi in nitrous oxide production in salt marshes under varying environmental conditions in isolated fungal cultures and field-collected salt marsh sediments. Research findings are expected to improve future climate predictions and guide the restoration and management of salt marsh habitats to reduce nitrous oxide production. In addition to research training graduate and undergraduate students, this project will enhance scientific and conservation training to local high school students from diverse backgrounds through a partnership with a local zoo.

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], Clare Escamilla[2]

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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 deployed FTWs at various scales in brackish waters to assess plant survivability, nutrient removal rates, and water quality improvements following installation. Many plant species were screened across several nutrient and salinity concentrations at greenhouse scale to determine those species suitable for field scale FTW application. Three field scale FTWs were constructed and applied to several brackish, coastal retention ponds of varying trophic status near Mt. Pleasant, SC, and nutrient concentrations and water quality parameters rigorously monitored both pre- and post-FTW application (1 y each) to assess any changes in response to FTW deployment. In 2023, several workshops focused on how to install and harvest FTWs were provided to pond management professionals (e.g., Clemson Extension staff), local conservation officers (e.g., Town of Mount Pleasant Waterworks, SC Sea Grant Consortium), and local residents who were interested in using FTWs as a tool to improve stormwater retention pond water quality and aesthetics. This project will continue through Summer 2024, however preliminary results indicate that salinity tolerance is a major key for plant survival and growth, and that local residents respond positively towards FTW applications in residential stormwater ponds.

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 US 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.

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)

Salt marsh 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 salt marsh 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 in 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.

Automated moth community sampling to determine adult niche divergence

Investigators: Eric LoPresti, Tad Dallas

Department of Biological Sciences, University of South Carolina

Processes that allow diversity at local scales ultimately drive diversity of life on earth. Therefore, determining how similar species coexist in a community is a critical question in both theoretical and empirical community ecology. Using modern imaging and pattern recognition technology, we will investigate moth community dynamics and coexistence at multiple varied sites throughout Hobcaw Barony along several axes of niche separation. Specifically, investigator-designed automated and solar-powered moth samplers will be deployed across a mixture of habitat types to investigate moth communities across seasonal, diel resource, and spatial axes.

Quantifying ecological responses following floating treatment wetland application in brackish stormwater ponds

Investigators: William Strosnider[1], Matthew Kimball[1], Joshua Stone[2], Amy Scaroni[3], Sarah White[3], Levi McKercher[2]

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

Floating treatment wetlands (FTWs) are a biological treatment strategy used to improve the water quality of impaired retention ponds, however these constructed floating plant beds may also provide habitat for a diverse range of terrestrial and aquatic fauna. Therefore, the purpose of this study is to quantify community responses of phytoplankton, zooplankton, arthopods and other aquatic macroinvertebrates, fishes, amphibians, reptiles, and birds to FTW applications in brackish stormwater ponds in Mount Pleasant, South Carolina. A variety of collection methods were used in 2023, and will continue in 2024, to determine whether FTWs represent critical habitats or ecological traps for various taxa. Results obtained through project completion will inform pond management professionals, homeowner associations, engineers, and scientists how terrestrial and aquatic communities may respond to FTW applications, allowing for them to make an educated decision on how to design FTWs to meet their unique project goals. In 2023, a diverse range of fauna were observed interacting with FTWs, including turtles, ducks, shorebirds, and alligators. However, many dead grass shrimp, white shrimp, white mullet, and striped mullet were also found on top of FTW mat matrices, indicating that the quality of habitat provided by FTWs is likely species-specific.

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 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 the Baruch Marine Field Lab 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.

Oyster Landing Creek as essential fish habitat for juvenile transient fishes?

Investigators: Juliana Harding[1], Matthew Kimball[2], Bruce Pfirrmann[2]

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2 - Baruch Marine Field Laboratory, University of South Carolina

Estuaries provide important nursery habitat for juvenile transient nekton. Integrated seasonal descriptions of age, growth, and energy flow are required for a comprehensive assessment of organism-habitat interactions. These interactions aid in establishing a baseline for ecosystem-based management, Essential Fish Habitat (EFH), in particular. Biweekly juvenile transient fish collections from Oyster Landing Creek are being used to quantitatively evaluate seasonal trends in demographics, age, growth, and standard biological condition indices. Spot (*Leiostomus xanthurus*) and pinfish (*Lagodon rhomboides*) are being analyzed. The integration of environmental and biological data types at an annual scale will provide information for multiple EFH levels for these fishes. These data will provide necessary context for the North Inlet estuary to potentially serve as a reference estuary for EFH evaluations in other locations using these juvenile transient nekton.

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

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

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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]

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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 US 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 the North Inlet estuary and other 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 NERRs 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.

Seasonal variability of dissolved organic matter concentration composition

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

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2 - School of Earth, Ocean, and Environment, 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. 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 2023, BMFL provided material for sequencing from their ongoing trawl and seine surveys in the North Inlet-Winyah Bay estuarine system (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.

Facilitating the transition to non-plastic natural material use within the coastal zone

Investigators: Mariah Livernois[1], Bruce Pfirrmann[1], Sarah White[2], Scott Schneider[3], Brooke Saari[4], Joshua Robinson[5], Sarah Pedigo[4], Susan Lovelace[4], Robert Lowe[6], Amanda Guthrie[4], Matt Gorstein[4], Mark Dugo[7], Michael Carabajales-Dale[8], William Strosnider[1]

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Materials employed by coastal economic sectors such as aquaculture, habitat restoration, and water quality protection are dominated by plastics, contributing to an ever-increasing marine debris problem. Natural materials (e.g., coir, jute, wattle, wood, hemp) have a long history of traditional use in these sectors, but have been largely displaced by non-biodegradable proprietary alternatives (e.g., plastics and associated composites) that accumulate and persist in marine and estuarine environments as debris and microplastics. The need for new approaches blending traditional ecological knowledge with modern engineering has led to innovative applications of natural materials, which show promise for reducing plastic pollution within coastal environments. However, these alternatives cannot gain traction with stakeholders until proven effective and logistically viable in their specific climate, tidal regime, photooxidative, and economic setting. Our study aims to explicitly test the efficacy, performance, and economic viability of natural alternatives to plastics in coastal South Carolina economic sectors via quantitative testing from lab to mesocosm to field pilot scales at BMFL and in the North Inlet-Winyah Bay estuarine system, as well as other coastal sites. This work is being conducted in close collaboration with industry partners, state agencies, nonprofit organizations, and historically disenfranchised communities. Through stakeholder workshops and directed interviews, we aim to identify natural solutions of the past and present and provide evidence of their efficacy and utility through rigorous testing. These experiments are being designed to produce quantitative results that inform the development of permitting and management strategies that support methods using natural, traditional materials.

Stable isotope insights on the spatiotemporal dynamics of food webs in the North Inlet-Winyah Bay estuarine system

Investigators: Ryan Rezek[1], Bruce Pfirrmann[2], Matthew Kimball[2]

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Trophic diversity is a critical component of functional diversity, underpinning ecosystem resilience and stability. It reflects the variety of feeding relationships and energy flow pathways within an ecosystem, crucial for maintaining biodiversity and ecosystem services. This research takes place in the North Inlet-Winyah Bay estuarine system and focuses on analyzing the stable isotopes of carbon, nitrogen, and sulfur in primary producers and consumers across broad trophic guilds to deepen our understanding of food webs in this dynamic ecosystem. To characterize spatiotemporal variation of the community-wide food web structure, samples are collected from trawls and seines from diverse habitats, including bay, riverine, and tidal creek areas. This approach aims to elucidate the significance of primary producers in the diets of consumers and how this relationship fluctuates over time, with a particular emphasis on seasonal changes. The study also investigates large consumers that utilize the estuary as a nursery ground, providing insights into their dietary habits. To achieve these objectives, Bayesian stable isotope mixing models are employed to estimate the proportional contributions of various food sources to consumer diets and identify shifts in trophic diversity, enhancing the resolution of the food web structure within this estuarine environment.

Using satellite images and AI to detect and track salt pannes and dieback in southeastern marshes

Investigator: Jacob Simon

Department of Marine Sciences, University of Georgia

Unvegetated areas in salt marshes are important to study given the key role played by foundation species like *Spartina alterniflora* in maintaining marsh elevation through accretion, as well as having implications for loss of stored carbon in exposed marsh sediments. The formation and longevity of two common unvegetated features in marshes (salt pannes and dieback zones) are thought to be driven by hydrological and climactic factors, including inundation frequency, rainfall, evapotranspiration, among others. This work aims to use cutting edge methods to identify and track these features. A field campaign in summer of 2023 identified 73 salt pannes and dieback zones in the North Inlet estuary, and collected GPS locations and observational data for each. Future work involves training a semantic segmentation algorithm to recognize both feature types from high resolution satellite imagery. Once trained, the algorithm can quickly annotate many images of the site, allowing for the creation of a time series of images containing size and location of every salt panne and dieback zone. In doing so, I hope to identify which factors are most significant in driving these unvegetated features, and how these features may change with different inundation and weather regimes as seas rise and climate changes. I also hope to find hotspots for dieback in the North Inlet estuary, as well as look for evidence of landward migration of salt pannes with sea level rise.

Considering floating treatment wetlands as habitats for estuarine fishes

Investigators: Levi McKercher[1], William Strosnider[2], Gabrielle Ziegler[3]

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Floating treatment wetlands (FTWs) are an innovative, nature-based approach to improve water quality in freshwater or brackish ponds, however they may also provide suitable habitat for aquatic organisms such as fish. As many coastal ponds support diverse fish communities, the purpose of this research is to quantify fish associations with miniature FTWs deployed in 110-L simulated pond mesocosms in the BMFL seawater lab. This study will examine mummichog (*Fundulus heteroclitus*) behavior following the deployment of several FTWs of various monoculture designs (e.g., *Spartina alterniflora*, *Spartina patens*) for comparison against a non-vegetated FTW control mat. We will observe whether mummichog occupy or avoid FTW root systems over many 1 h long trials. Additionally, we will repeat these trials with the addition of a mature blue crab (*Callinectes sapidus*) to determine how predator introduction influences mummichog behavior towards FTWs. Results from this study will determine the potential habitat value FTWs may provide for a common estuarine fish in the presence and absence of a common estuarine predator, providing data-driven evidence of FTW habitat value which has largely been assumed in contemporary literature.

Seasonal dynamics and selectivity of copepod grazing in the North Inlet estuary

Investigators: Nayan Mallick, Joshua Stone, Jay Pinckney

Department of Biological Sciences, University of South Carolina

The primary goal of this project is to investigate seasonal copepod feeding dynamics using experimental approach. As copepods are a conspicuous group of mesozooplankton, they can exert top-down control on microzooplankton and phytoplankton. Quantifying the magnitude of control is essential in understanding the transfer of energy through the food web. Mesocosm experiments will be conducted in the BMFL seawater lab to quantifying copepod feeding and selective grazing in different seasons (winter, spring, summer and fall). We will be using a suite of methods - HPLC, ChemTex and FlowCam to understand copepod control over microzooplankton and phytoplankton. Our expectation is that we will be able to provide evidence of differential feeding of copepods when prey type fluctuates.

Not all nitrogen: quantifying the effects of different nitrogen forms on marsh resilience to environmental change

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Research on salt marsh response to anthropogenic N loading has resulted in contrasting results: addition of N can increase plant biomass and enhance sediment trapping, thus increasing marsh accretion rate; or, increased anthropogenic N can decrease marsh organic matter accumulation and soil strength, promoting marsh collapse. We hypothesize that in salt marshes receiving nitrate, microbes outcompete marsh primary producers, promoting nitrate respiration, and accelerating decomposition of marsh organic matter. To quantify how environmental N availability alters responses of the coupled plant-microbe system to nitrate and ammonium additions compared to site-specific controls, we will conduct paired plot-level nutrient enrichment experiments at Plum Island LTER, MA and at the North Inlet estuary, SC wherein nitrate and ammonium will be added at a range of concentrations for two years. We will measure effects of N addition relative to controls on marsh carbon storage and accretion, nitrogen cycling, and on marsh plant and microbial responses. To determine how differences in hydroperiod alter the responses of the plant and microbial communities to different forms of N, we will perform marsh organ experiments at both locations, where N form is crossed with elevation to assess how variation in elevation alters the responses of the plant and microbial communities to different forms of N. The resulting data can be used in a new generation of the Marsh Equilibrium Model that incorporates how future N inputs will alter the capacity of marshes to keep pace with sea-level rise.

High-energy storm events and their impact on carbon storage in the North Inlet estuary

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Tidal wetland environments play a vital role in the global carbon cycle by offsetting atmospheric carbon dioxide concentrations through their natural physiochemical processes of high autotrophic productivity, allochthonous organic matter deposition, anoxic soils, and continuous accretion which promotes carbon sequestration with long-term storage at the land-ocean margin. High-energy storms have the potential to disturb known tidal wetland carbon cycle behavior with periodic pulses of elevated erosion altering stored carbon concentrations during storm events, followed by high organic matter deposition post-storm event. The objective of our research is to identify the influence of high-energy storms on carbon cycling within the North Inlet-Winyah Bay estuarine system's tidal wetlands. Historical and modern methods are employed to analyze variation in carbon dioxide flux and carbon storage associated with storm events. Soil core collection and paleotempestology methods are conducted to reconstruct variability in frequency and intensity of historical high-energy storm events using geological proxies such as sedimentological characterization, foraminiferal analysis, and quantification of carbon concentrations. Novel soil gas monitoring stations and sediment tiles are deployed within Town Creek and No Man's Friend Creek in the North Inlet estuary; identifying active variation in carbon dioxide flux and carbon cycling during modern high-energy storm events. The successful investigation of high-energy storm's influence on carbon cycling within the North Inlet-Winyah Bay estuarine system will ultimately improve coastal carbon budget estimations and the understanding of the role of tidal wetlands in carbon-climate feedbacks.

Monitoring of water and sediment as an indicator of non-point source runoff in South Carolina watersheds

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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, there is the complexity of differentiating anthropogenic effects of chemical and biological contaminants in aquatic ecosystems from natural background effects. 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 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.

Evaluating oyster reefs as habitat: Comparing the utility of ecological metrics to assess ecosystem function

Investigators: Matthew Kimball[1], Robert Dunn[2], Shelby Ziegler[3], Jeb Byers[3], Mercer Brugler[4], John Carroll[5], Wil Atencio[5], David Eggleston[6], Daniel Bowling[6], Justin Ridge[7], Rachel Guy[8], Nicole Dix[9], Bruce Pfirrmann[1], Mary Margaret Pelton[1]

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Oyster reefs provide habitat for a diverse and productive community of organisms within estuaries, including Reserves across the National Estuarine Research Reserve System (NERR). Traditional techniques to quantify the value of reefs as habitat are labor intensive and difficult to replicate at multiple sites, which limit the ecological information they can provide. We propose to examine estuarine fauna use of oyster reefs in four NERRs from NC to FL, including the NI-WB NERR, using emerging methods that will provide unique ecological information (associated metrics in parentheses): High-Resolution Acoustic Imaging (faunal abundance, size, behavior), Stable Isotope Analysis (food web structure, source of primary production), eDNA Metabarcoding (species composition, disease presence), and Oyster Disease Assays (disease presence, prevalence, and burden). We will apply these methods alongside traditional sampling to compare their utility in evaluating oyster reef habitat function and assess their capacity to address Reserve management needs associated with oysters. During two planned workshops, our team will generate targeted research questions to be addressed and develop a proposal to be submitted for future funding opportunities. Finally, in addition to NERR end users, we have engaged resource managers to evaluate the potential for data produced by these ecological evaluation methods to feed directly into management of coastal habitats and fishery resources.

Trait variability in a South Carolina salt marsh grass species facing impacts from climate change

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Halophytic plants thrive in highly saline environments due to their physiological adaptations. Examples of adaptations include sequestering salt in specialized glands, selective ion exclusion, and ion secretion. Furthermore, these adaptations allow halophytes to exhibit phenotypic plasticity in response to a changing environment at different spatial and temporal scales. The governing thresholds of how much an individual plant or population can respond to salinity levels are not well understood. The ability to be phenotypically plastic could indicate the invasion of a species when environmental conditions pass a survivorship threshold. The goal of this project is to provide preliminary data on trait variability in *Spartina alterniflora*, a dominant grass species in South Carolina salt marshes, along multiple transects in the North Inlet-Winyah Bay National Estuarine Research Reserve, Georgetown, SC. Trait variability data will elucidate this species's range of morphologies along salinity gradients, an environmental variable that is changing due to saltwater intrusion and increasing storm surges. Here, we document trait variability in regional populations and identify those traits that potentially change in response to different edaphic conditions. Describing/quantifying trait variability in our regional populations will allow us to predict the persistence likelihood of this species under future edaphic conditions and if there is a survivorship threshold. Overall, this research will improve our fundamental understanding of salt marsh resilience to global change and its contributions to South Carolina's ecosystem services and natural resource production.

Plant-mediated methane dynamics in managed and unmanaged coastal wetlands

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Rising methane (CH_4) emissions in recent decades are partially attributed to larger fluxes from wetlands which represent a major source of uncertainty in the global CH_4 budget. Across wetland types, vegetation influences CH_4 production, consumption, and transport with the magnitude and direction of these effects depending on plant physiology and abiotic context. However, plant-mediated CH_4 dynamics have rarely been explored in the context of impounded wetlands where restricted tidal flow can stimulate CH_4 production. Here, we assess the potential for differences in biotic and abiotic conditions between a tidal salt marsh and a nontidal impounded wetland to affect the mechanisms underlying plant-mediated CH_4 dynamics. To accomplish this, we quantified gas fluxes from three chamber types in which CH_4 dynamics were 1) influenced by above and belowground plant biomass, 2) influenced by belowground biomass only, or 3) not influenced by plant biomass. To explore the potential for abiotic conditions to mediate the role of plants in driving CH_4 fluxes at diurnal and seasonal scales, we measured CH_4 fluxes from each chamber type beginning before sunrise and ending after sunset once a month for one year. Overall, we found that plants played an important role in driving CH_4 fluxes across our salt marsh and impounded wetland sites, but the mechanisms underlying plant-mediated fluxes varied between sites based on the time of day and the day of year that samples were collected. These results suggest that complex interactions between abiotic and biotic properties drive belowground interactions between plants and microbial communities, affecting C cycling dynamics and CH_4 fluxes. We highlight the importance of continuing to study these mechanisms across environmental gradients to understand how CH_4 fluxes from managed and unmanaged coastal ecosystems will respond to climate change.

Impacts of storm events on phytoplankton communities in the North Inlet estuary

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This study aimed to characterize the response of phytoplankton communities following large storm events in tidal creek systems. Specifically, we were interested in what may drive an increase in productivity following large precipitation events. Two hypotheses were proposed: (H1): resident phytoplankton communities will respond to salinity and nutrient changes associated with fresh-water terrestrial run-off entering the estuary and (H2): the phytoplankton community shifts composition during storm events either from introduction of freshwater taxa or suspension of benthic microalgae. To test these two hypotheses, we developed both an experimental and observational approach. For the experiment, natural cultures of phytoplankton collected at the Oyster Landing pier were subjected to an array of conditions which mimicked different features of a large rainfall event. Observations of phytoplankton and other microplankton were also collected at high temporal frequency during both non-storm and storm periods. For all samples, whether observational or experimental, microplankton were split to be processed using either HPLC or FlowCam. HPLC provided bulk pigment data attributable to major phytoplankton group while FlowCam provided individual images of microplankton which can be used to calculate biomass attributable to a higher taxonomic resolution. Preliminary findings suggest that storm events and associated freshwater inputs can stimulate diatom growth, but this response is species specific. Additionally, new taxa from freshwater systems can be flushed into the estuary.

The benthic microalgal subsidy in the North Inlet estuary

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Accurate quantification of estuarine ecosystem net primary production (NPP) is essential for understanding and modeling energy flow and trophodynamics in these critical habitats. Much is known about NPP by phytoplankton and *Spartina* in southeastern US estuaries, but few studies have accurately quantified the annual contribution of benthic microalgae (BMA) to ecosystem NPP. In the few ecosystems where annual BMA NPP has been roughly approximated, BMA biomass and NPP usually exceeds that of phytoplankton on an m^2 basis and is the same order of magnitude as *Spartina*. However, a major limitation of previous studies is that estimates of estuarine BMA NPP have been based on specific habitat types (e.g., mudflats, sandflats, *Spartina* zones, etc.), without regard for the critical role that tidal elevation plays in BMA photophysiology and NPP. The effects of tidal elevation on BMA NPP must be accounted for when extrapolating local rates to ecosystem scales and making comparisons with other major primary producers. The central idea in this research is that BMA NPP is a non-linear function of tidal elevation and therefore BMA NPP must be measured at different tidal elevations to accurately scale rates to the ecosystem level. The purpose of this research is to provide accurate measures of BMA NPP along the intertidal elevation gradient to determine the BMA contribution to estuarine ecosystem NPP processes. This research is transformative in that it will provide the first ever elevation-specific measures of ecosystem-level BMA contributions to total NPP. These measures will be coupled to a GIS digital elevation model to estimate ecosystem level BMA NPP. We will further explore a variety of sea-level rise scenarios to predict impacts on the spatial and magnitude changes in BMA NPP. This research will produce novel spatial and elevation-specific measures of system-wide intertidal estuarine BMA biomass and NPP. Our results will provide valuable insights into the contribution of BMA to total system NPP and how the magnitude and distribution of BMA NPP may change with sea-level rise.

Development of a fully biodegradable floating treatment wetland design

Investigators: William Strosnider[1], Levi McKercher[2], Sarah White[3], Zach Snipes[4]

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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, improve water quality, provide suitable habitat for various terrestrial and aquatic taxa, and improve stormwater pond aesthetic. Past efforts in 2021 and 2022 focused on the design and construction of wood and bamboo floating rafts embedded with coir fiber and planted using pickerelweed (*Pontederia cordata*). In 2023, these efforts were expanded, and the focus, shifted towards growing common cattail (*Typha latifolia*) within geotextiles of varying composition and density in the BMFL seawater laboratory greenhouse. The anticipated benefits of constructing FTWs out of more natural, biodegradable materials include reduction of FTW costs, minimization of unintended risks following FTW application (e.g., microplastic pollution, ecological trap formation), and maximization of ecosystem service provision.

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

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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 2023, we conducted manipulative laboratory experiments with brown and white shrimp together to simulate their period of overlap in these shallow intertidal estuarine habitats. For this overlap experiment, we created three treatments which varied in both density and relative abundance of each species. A medium density treatment (25 m^{-2}) included brown and white shrimp in equal proportion (n = 1 individual of each), while two high density treatments (37.5 m^{-2}) were made up of either twice as many brown as white shrimp or twice as many white as brown shrimp (n = 1 for one species and n = 2 for the other). Tailfin clipping was used to identify individuals of the same species in high density treatments. When placed into multi-species treatments, mortality was generally low and growth rates (length or mass) did not vary as a function of density or species composition. 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 ecologically and economically important shrimp species during their estuarine residency.

Tidal creek nekton, zooplankton, and benthic infaunal communities across three southeastern NERRs

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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 (*Penaeus setiferus*) and brown (*Penaeus aztecus*) shrimp, constitute the bulk of commercial shrimp landings along the southeast US 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 conduct field sampling for nekton, zooplankton, and benthic infauna to characterize creek-level, estuary-level, and regional variation in tidal creek communities. These efforts leverage NERR System Wide Monitoring Program environmental data and infrastructure. In the North Inlet estuary in 2023, we collected 72 otter trawl samples, 72 benthic cores, and 40 zooplankton samples distributed across 4 sites over the 6 month period from April - September.

NERR Wetlands to Water Levels: Effects of sea level on the spatial dynamics of salt marshes in the North Inlet estuary

Investigators: Erik Smith, Robert Dunn, J. Baker Stevens, Julie Krask, Brittany Morse

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 NI-WB 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 7-9 sampling plots per transect. Surface Elevation Tables (SETs) have also been established adjacent to the lower and higher elevations of the creek-bank to forest-edge transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in and vegetation and tidal dynamics. Sampling within each permanent plot includes: percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by non-destructive sampling techniques; water table height at low tide; porewater salinity, and nutrient and sulfide concentrations. Soil organic content and bulk density adjacent to each plot were determined in 2008 and re-sampled in 2020. 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. In addition, biweekly drone flights for remotely sensed images of each marsh segment have been conducted since 2021.

Site- and species-specific metal concentrations, mobility, and bioavailability in sediment, flora, and fauna of a southeastern United States salt marsh

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

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The salt marshes of the mid-Atlantic United States often exhibit geochemical behavior that varies significantly from other estuaries around the world, but our understanding of metal mobility and bioavailability remains incomplete for these systems. We sampled abiotic (water and sediment) and native biotic (three halophyte and two bivalve species) compartments of North Inlet estuary and salt marsh to understand the site- and species-specific metal concentrations, fractionation, and bioavailability for 16 metals and metalloids, including two naturally occurring radionuclides. Location on the marsh platform greatly influenced metal concentrations in sediment and metal bioaccumulation in halophytes, with sites above the mean high-water mark (i.e., high marsh zone) having lower concentrations in sediment but plants exhibiting greater biota sediment accumulation factors (BSAFs). Transition metal concentrations in the sediment were an average of 6× higher in the low marsh zone compared to the high marsh zone and heavy metals were on average 2× higher. Tissue- and species-specific preferential accumulation in bivalves provide opportunities for tailored biomonitoring programs.

Characterizing dissolved organic matter (DOM) optical properties in blackwater ecosystems to inform development of waterbody classification, condition assessment, and protection of blackwater rivers and streams

Investigators: Erik Smith[1], Julie Krask[1], David Chestnut[2], Justin Lewandowski[2]

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Tidal forested wetlands represent the upper reaches of estuaries in the Southeastern United States. Their waters are usually referred to as “blackwater” due to their very clear but darkly stained (tea-colored) character. It has long been recognized that blackwater streams with significant forested wetland drainage have very different water quality and biogeochemical characteristics from piedmont and mountain streams, yet no formal definition of blackwater exists with respect to state waterbody classification standards. The South Carolina Department of Health and Environmental Control (SCDHEC) has initiated a pilot effort to develop a formal definition of blackwater that would then support development of appropriate water quality criteria for these ecological significant coastal plain habitats. The NI-WB NERR is working with SCDHEC to characterize dissolved organic matter (DOM) concentrations and inherent optical properties (as UV-Visible absorption characteristics) from samples collected across a range of blackwater to non-blackwater waters throughout the state, as well as from targeted sites along the Black River, which has some of the most intact forested wetlands in the Winyah Bay watershed. The intended outcomes of this effort are to: 1) produce numeric metrics based on DOM concentrations and optical properties that can inform development of a quantitative definition of “blackwater” for the purpose of waterbody classification; and 2) relate these metrics to watershed and water quality conditions to ultimately support development of appropriate water quality criteria for these waterbodies.

Spatial and temporal analysis of blue catfish, *Ictalurus furcatus*, gut contents in a southeastern estuary

Investigators: Robert Dunn[1], Rebecca Clyburn[2,3], Matthew Kimball[3], Bruce Pfirrmann[3], Liam Batchelder[2,3]

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Understanding the impacts of the blue catfish invasion on the trophic structure of estuarine systems is crucial for formulating management strategies for this species. Previous work from the Chesapeake Bay revealed ontogenetic diet shifts from omnivory in small catfish to piscivory in larger catfish and diet variation with salinity and season. In this study, we examined the hypotheses that smaller juvenile blue catfish would be more omnivorous and that their diets would have a high proportion of blue crabs, *Callinectes sapidus* and penaeid shrimp. We collected fish at multiple sites within Winyah Bay and its tributaries using a trawl during the spring and summer of 2023, and processed a total of 130 stomachs with fish ranging in size from 45 to 250 mm total length. Juvenile blue catfish exhibited an ontogenetic diet shift, with smaller fish having a higher proportion of guts full and guts with detritus than larger juvenile blue catfish. Both *Callinectes* spp. and *Penaeus* spp. were found to occur in < 2% of stomachs. Conversely, amphipods and unidentified arthropods were far more frequently encountered. These results support the ontogenetic diet shift theory, suggesting that juvenile crabs and shrimp are only a significant part of the diet of larger blue catfish in estuaries.

Adapting salt marsh vulnerability assessment methodologies to southeastern salt marshes

Investigators: Denise Sanger[1], Pamela Marcum[2], Erik Smith[3]

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With roughly one third of the Southeast's estuarine salt marsh acreage, South Carolina faces an escalating concern at local and state levels over marsh vulnerability due to rising sea levels. The ACE Basin and North Inlet-Winyah Bay (NI-WB) NERRs received a 2021 Science Collaborative capacity building funds to develop a community of interested managers, regulators, and scientists and identify appropriate methods to assess salt marsh health in South Carolina. As part of this effort, questions emerged that centered around identifying appropriate vulnerability metrics and thresholds to assess vulnerability to impacts from increasing rates of sea level rise as a first step for restoration strategies. While a variety of marsh vulnerability metrics have been developed nationally, their direct applicability to Southeastern marshes remains a knowledge gap, potentially due to the region's sparse vegetation densities. However, several of the known metrics can be derived from remotely sensed data. Conveniently, another Science Collaborative-funded project, Drone the SWMP, expanded remote sensing capabilities in the Southeast by establishing Unmanned Aerial Systems (UAS)-based data collection, which has provided the necessary tools and processing methodologies to successfully utilize UAS within the South Carolina reserves. Building on these prior efforts, this team will assess existing marsh vulnerability metrics at multiple spatial scales at the two South Carolina reserves. Responding to a critical need of local managers, the main output will be an outline of available local marsh vulnerability methodologies, their current applicability and limitations with respect to marsh management and restoration needs, and potential improvements.

Linking land use types to runoff characteristics and concentrations of pollutants in Murrells Inlet estuary, South Carolina, USA

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The expansion of urban land use along the coast can reduce water quality by introducing a plethora of pollutants and pathogens. Increases in contaminants can negatively impact the health of the inhabitants, strain local economies, and diminish an area's aesthetic. It is hypothesized that the pollutant concentrations associated with stormwater runoff increase with urban density and varies with the timing and magnitude of rainfall. Here, we examine the relationship between fecal coliform, nitrogen, and phosphorous concentrations in stormwater runoff within Murrells Inlet, SC. Arc GIS Pro and NOAA C-CAP land cover data was combined with USA SURGO soil hydrology data to quantify land use type and change, soil type, and other runoff characteristics over the past 20 years. Results demonstrate that Murrells Inlet has experienced an 11.5% average growth in urban land use from 1996-2016, with some sites undergoing upwards of 41% growth, concentrated in the northern section of the Murrells Inlet watershed. Approximately 43% of the land use is associated with impervious surfaces, but ranges from low to high density development across the different sub-watersheds. These results provide the basis for conducting water quality (nutrients and fecal coliform) measurements throughout the summer of 2023 at 8 discrete sub-watersheds of varying land use types. Understanding the influence of development on water quality in Murrells Inlet enables mitigation of estuary contamination via more effective implementation of best management practices.

Understanding microalgal biofilm contributions to sediment "blue carbon" in contrasting salt marsh habitats in the US and Europe

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Coastal sediments are important sites of organic carbon generation, cycling and accumulation. Stored organic carbon in marine sediments (blue carbon) is part of the global carbon budget, but there is real uncertainty in the size of this number. Are coastal sediments sinks for organic carbon and can they therefore help offset human CO^2 emissions? There are key knowledge gaps surrounding coastal carbon stores, with salt marshes and mudflats identified as sites of high biological activity, but where we lack full understanding on the modes of carbon cycling and storage. In this project we measured the distribution and relationships between algal biofilms and their organic carbon components in a range of salt marsh and intertidal unvegetated sediments, and derived relationships between these. The aim was to determine the relationships between sediment microphytobenthic biomass (Chl a, total, colloidal carbohydrate, species composition) across a range of sediment types within US east coastal salt marshes, namely the North Inlet estuary in South Carolina. This was successfully completed, with field work in February and March 2023. We compared our different relationships with other published models, finding that some of the published models would over-estimate sediment organic carbon content by +60 to +70%. Using Near Infrared (NIR) Spectroscopy, we have found two different spectral signals in these sediments. One is closely related to algal biofilm content, while the other probably reflects more recalcitrant detrital material. These are important findings to understand the contribution of algal photosynthesis and primary production to coastal blue carbon stores.

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