Current Research Projects

2025

A compendium of research conducted through the Baruch Institute in the North Inlet-Winyah Bay estuarine ecosystem

Belle W. Baruch Institute for Marine and Coastal Sciences

University of South Carolina

Current Research Projects
2025

Introduction

The Belle W. Baruch Institute for Marine and Coastal Sciences (Baruch Institute), which is comprised of the Baruch Marine Field Laboratory (BMFL), the North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB-NERR), and the NERRS Centralized Data Management Office (CDMO), is located on Hobcaw Barony in Georgetown County, South Carolina. The Baruch Institute has been the center of research activities for scientists and students from the University of South Carolina (USC) and dozens of other institutions since it was founded in 1969, and we conservatively estimate that more than 1,000 grant- and institutionally funded projects have taken place since. This research has contributed substantially to at least 1,928 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 56 projects that were underway during the period from January through December 2025 at the Baruch Institute by faculty, staff, graduate students, and undergraduates associated with USC and other institutions. USC is the home institution for 52 of the investigators while over 45 investigators representing 19 other institutions and agencies are carrying out projects through the Baruch Institute. 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. Specifically, all studies included here are being conducted on site at the field lab or within the North Inlet-Winyah Bay estuarine ecosystem and watershed.

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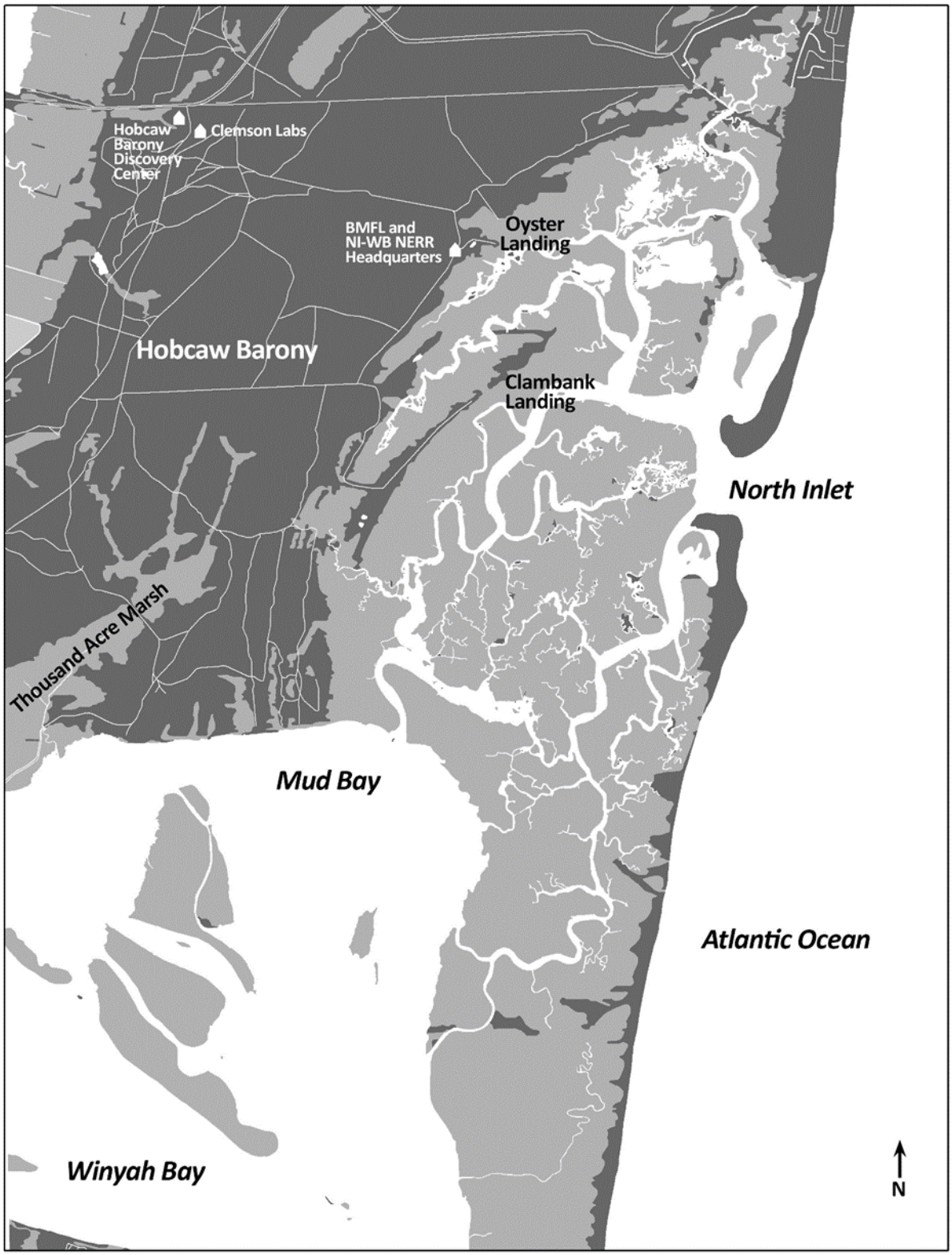

Figure 1: Map of the North Inlet-Winyah Bay estuarine system in Georgetown County, South Carolina.

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

Investigators: Braddock Rhodenhiser, Julie Krask, Mary Margaret Pelton, Ranae Peterson, Erik Smith, Robert Dunn
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 baseline 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.

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

Investigators: Bruce Pfirrmann, Matthew Kimball, Dennis Allen
Baruch Marine Field Laboratory, University of South Carolina

Collections of nekton (fishes, shrimps, and crabs) have been made in the Oyster Landing intertidal creek basin from 1984 to the present. The objective has been to track the composition, abundance, biomass, and length distributions of nekton and determine patterns, trends, and factors influencing changes over seasons, years, and decades. Sampling in the intertidal creek basin has consisted of three different protocols focused on intertidal creek nekton assemblages, with all three sampling sites with a 250 m stretch of the creek. From 1984-2003, this effort was based on biweekly seine hauls from an isolated intertidal creek pool (low tide). In 1996, we started a new time series from the flooded marsh surface (high tide) adjacent to the creek. From 1996-2003, both the low tide seine and high tide enclosure collections were made on the same day and tide. High tide enclosure collections continued through 2011. In 2012 the sample site shifted to an adjacent isolated section of creek at low tide, where from 2012-2018, sampling focused on documenting shifts in the timing, size, and growth of juvenile transient species. Since 2019, our effort expanded to include the entire nekton assemblage occurring in the tidal creek at low tide. The long-term time series is increasingly important as we interpret impacts of global climate change on nekton populations and the shallow water habitats that are essential to their development. The results are used to inform the management of salt marsh-estuaries, watersheds, and fisheries in the southeastern US.

Green porcelain crab density and performance along a latitudinal gradient

Investigator: Jeb Byers
Odum School of Ecology, University of Georgia

Green porcelain crab (*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.

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. To develop such applications, we are 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 oyster (*Crassostrea virginica*). Oysters are collected in the North Inlet estuary 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 the North Inlet and Winyah Bay estuaries

Investigators: Julie Krask, Braddock Rhodenhiser, Mary Margaret Pelton, Ranae Peterson, Erik Smith, Robert Dunn
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 from the Baruch Institute.

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).

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 employs 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 NIWB 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.

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.

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 - Baruch Marine Field Laboratory, 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.

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.

Ecology of cannonball jellyfish sein the South Atlantic Bight

Investigators: Jasmine Caillier, Joshua Stone

Department of Biological Sciences, University of South Carolina

Cannonball jellyfish (*Stomolophus melagris*) are one of the most abundant pelagic species in the coastal zone of the South Atlantic Bight, but much remains unknown about their life history, impacts on the food web, and response to environmental change. To better understand their role in the coastal ecosystem, we are collecting cannonball jellyfish to 1) quantify their gut contents, 2) experimentally measure their feeding rates, 3) quantify the commensal community associated with them, and 4) experimenting on their polyps to determine preferred salinity and temperatures. We will periodically be collecting cannonball jellyfish from the near-shore environment outside of North Inlet estuary and Winyah Bay.

Maintenance and operation of IOOS/SECOORA-priority high-frequency radar sites

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

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Baruch Marine Field Laboratory, 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 Integrated Ocean Observing System (IOOS)/Southeastern Coastal Ocean Observing Regional Association (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.

Long-term measurements of production and physiological ecology of salt marsh cordgrass

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

1 - Department of Biological Sciences, University of South Carolina
2 - Baruch Marine Field Laboratory, 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.

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

Investigators: Joshua Stone[1], Dennis Allen[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.

Atlantic brief squid 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.

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 NIWB 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.

Benthic macrofauna 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 invertebrate 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 describing the current status of macroinfauna will be coupled with historic macroinfaunal sample analyses to 1) quantitatively describe infaunal macrobenthic population metrics (e.g., density, phenology, 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.

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

Investigators: Braddock Rhodenhiser, Julie Krask, Mary Margaret Pelton, Ranae Peterson, Erik Smith, Robert Dunn

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.

Phytoplankton monitoring community science project

Investigators: Jennifer Plunket

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. Participants collect and assess samples twice a month, and results are reported to PMN to be incorporated into larger-scale examinations.

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.

Quantitative descriptions of North Inlet estuary oyster 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 are 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.

Painted bunting 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 (*Passerina ciris*) utilizing the edges of North Inlet estuary marshes as nesting habitat during the breeding season. A point count method is utilized that involves five minutes of listening for calling male buntings at fixed intervals along a prescribed route. Summer 2025 marked the eighth 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 from 2007-2009, thus allowing for comparisons with other studies.

Visual ecology of the green porcelain crab

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 green porcelain crab (*Petrolisthes armatus)*, an invasive crustacean (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.

Oyster drill population dynamics in North Inlet estuary

Investigator: Juliana Harding

Department of Marine Science, Coastal Carolina University (SC)

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

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

Investigator: 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.

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.

Hard clam 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.

Local adaptation of the starlet sea anemone 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 seawater 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, as well as periodic visits throughout the year to collect additional anemones and water samples for off-site experimentation. 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.

Trophic impacts of mummichog in estuarine ecosystems

Investigators: Shannon Powers[1], Jay Pinckney[2]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Department of Biological Sciences, University of South Carolina

The mummichog (*Fundulus heteroclitus*) is a small killifish found along the US Atlantic coastline from New Jersey to northeastern Florida. While their diets have been well studied, little is known regarding the impact of early life stage mummichog on zooplankton and phytoplankton communities within estuarine ecosystems. Understanding how mummichog are influencing the zooplankton grazing community could lead to a better understanding of how top-down grazing may be altering the phytoplankton groups present in estuarine systems. Mummichog eggs will be collected from the North Inlet estuary and brought to Columbia main campus seawater laboratory facilities to spawn. Spawned mummichog of different size classes will be added to active phytoplankton, zooplankton, and micro-heterotrophic communities in a series of feeding experiments. We hypothesize that the presence of mummichog will significantly alter zooplankton and phytoplankton community compositions, and that mummichog will exhibit a feeding selectivity and have differing δ15N ratios at distinctive size classes. This study will provide valuable insight into the role of mummichog as predators exerting top-down control in estuarine ecosystems.

Latitudinal comparison of life-history traits in the eastern mud snail

Investigators: Robert Podolsky

Grice Marine Lab, College of Charleston (SC)

As part of a broad latitudinal study of life-history trait variation in eastern mud snails (*Ilyanassa obsoleta*), I am collecting animals from populations from Florida through Maine and harvesting egg capsules deposited in my laboratory at Grice Marine Lab. Part of this comparison involves local variation among populations in the Charleston estuary, but I am hoping to include a population in central South Carolina from a "cleaner site." The primary goals are to test two sets of life-history predictions about the size and packaging of embryos along the latitudinal gradient: that egg size will increase as a function of latitude, owing to physiological effects of temperature on egg size, and that the number of eggs per capsule will increase as a function of latitude, owing to physiological processes involving greater oxygen depletion and CO_2 generation at lower latitudes.

The benthic microalgal subsidy in the North Inlet estuary

Investigators: James Pinckney[1], Erik Smith[2], Craig Plante[3], Eilea Knotts[1]

1 - Department of Biological Sciences, University of South Carolina
2 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina
3 - Department of Biology, College of Charleston (SC)

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 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. 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. 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.

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

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

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

Estuaries provide important nursery habitat for juvenile transient nekton. Integrated seasonal descriptions of abundance, growth, age, 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 abundance, demographics, age, and standard biological condition indices for spot (*Leiostomus xanthurus*) and white mullet (*Mugil curema*). 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 North Inlet estuary to potentially serve as a reference estuary for EFH evaluations in other locations using these juvenile transient nekton.

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).

Development of a fully biodegradable floating treatment wetland design

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

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Department of Biological Sciences, University of South Carolina
3 - Department of Plant and Environmental Science, Clemson University (SC)
4 - Shoreline Restoration Group, Charleston, SC

The purpose of this research is to develop new designs for floating treatment wetlands (FTWs) that use natural and biodegradable materials to support plant growth, improve water quality, and provide habitat for various terrestrial and aquatic taxa. 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 2024, pickerelweed and common cattail were integrated into geotextiles from both seed and plug forms at the mesocosm scale. In 2025, a more robust FTW design was tested alongside three new plant species (golden canna lily [*Canna flaccida*], maidencane [*Panicum hemitomon*], and tussock sedge [*Carex stricta*]). These FTWs were buoyant and supported ample plant growth, solidifying this design as a viable option for field-scale applications. 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.

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]

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

Trophic diversity is a critical component of functional diversity, underpinning ecosystem resilience and stability. 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 were 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.

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 - Baruch Marine Field Laboratory, 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 goal was to ascertain above- 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.

Characterizing dissolved organic matter optical properties in blackwater ecosystems to support management and protection of blackwater rivers and streams

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

1 - North Inlet-Winyah Bay National Estuarine Research Reserve, University of South Carolina
2 - Bureau of Water, South Carolina Department of Environmental Services

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 Environmental Services (SCDES) has initiated a pilot effort to develop a formal definition of blackwater that would then support development of appropriate water quality criteria for these ecologically significant coastal plain habitats. The NIWB NERR is working with SCDES 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 estuary 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.

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

Investigators: Matthew Costa[1], Jennifer Bowen[1], Randall Hughes[1], Anne Giblin[2], James Morris[3], Karen Sundberg[4]

1 - Marine Science Center, Northeastern University (MA)
2 - The Ecosystems Center, Marine Biological Laboratory (MA)
3 - Department of Biological Sciences, University of South Carolina
4 - Baruch Marine Field Laboratory, University of South Carolina

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 conducted paired plot-level nutrient enrichment experiments at Plum Island LTER, MA and at the North Inlet estuary wherein nitrate and ammonium was added at a range of concentrations for two years. We measured 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 performed marsh organ experiments at both locations, where N form was 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

Investigators: Gavin Gleasman[1], Scott DeWolf[2]

1 - Department of Geological Sciences, Salem State University (MA)
2 - Department of Environmental Engineering and Earth Sciences, Clemson University (SC)

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 were deployed in No Man's Friend Creek and used to identify 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.

Dynamics of estuarine optical properties and phytoplankton communities in the Winyah Bay estuary

Investigators: Camille Michaud, Jay Pinckney, Tammi Richardson
Department of Biological Sciences, University of South Carolina

Estuarine systems present complex light environments due to large amounts of colored dissolved organic matter (CDOM) and turbidity that absorb and scatter light, respectively. Optical properties influence phytoplankton communities because their photosynthetic efficiency depends greatly on light availability. This study examined the optical properties of the Winyah Bay estuary in South Carolina using mixing diagrams and related these factors to phytoplankton biomass and community composition across the salinity gradient. Results showed that the behavior of optical properties and their relationship to chlorophyll-a changed under various environmental conditions. Notably, CDOM and chlorophyll-a showed different correlations, positive or negative, based on river discharge and wind direction. Additionally, the phytoplankton community showed a gradient along the estuary with diatoms highly associated with marine, low-CDOM waters whereas cryptophytes and green algae were associated with fresher, high-CDOM waters. These results have implications for remote sensing of phytoplankton biomass as algorithms should not rely on fixed CDOM correction factors to estimate biomass across varying environmental conditions in estuarine waters. Overall, these findings improve understanding of how optical properties fluctuate in estuaries and how environmental changes influence phytoplankton, which are foundational species in the estuarine food web.

Mapping spatial and temporal variations in groundwater salinity along a salt marsh creek basin

Investigators: Albert Asare[1,2], Alicia Wilson[1], Riliwan (Dami) Abioye[1]
1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Geological Engineering Department, Kwame Nkrumah University of Science and Technology (Ghana)

Groundwater salinity is an important control on salt marsh ecological productivity and plant zonation, and groundwater salinity also influences the composition of submarine groundwater discharge (SGD) to tidal creeks. This project uses electrical resistivity to (1) map along-creek variations in groundwater salinity, which have been widely overlooked by studies that typically focus on transects perpendicular to the creek and (2) investigate temporal variability in the supply of fresh groundwater entering the marsh from the upland. North Inlet estuary, and specifically Crabhaul Creek, is ideal for this work because of prior stratigraphic, geophysical, groundwater and carbon studies. The project contributes to broader work regarding the ecohydrology of salt marshes; plant zonation and variability in the high marsh; salt marsh migration; salt marsh carbon budgets; and the expansion of groundwater studies of salt marshes from 2-D transects to 3-D systems.

Latitudinal analysis of environmental drivers of common reed invasion in US coastal wetlands over the past 20 years

Investigators: Yuyang Wang, Emily Bernhardt, Justin Wright
Department of Biology, Duke University (NC)

The invasion of common reed (*Phragmites australis*) in North American coastal wetlands threatened native vegetation and disrupted ecosystem processes. To better understand its spread, this study examined environmental drivers of *Phragmites* invasion across 11 salt marshes along the US east coast over 20 years. Using remote sensing and field data (collected in summer 2025), we assessed how slope, temperature, salinity, and nutrient availability influenced invasion dynamics at regional and site levels. This is the first multi-site study along a latitudinal gradient focused on *Phragmites* front dynamics, offering insights for managing coastal wetlands under climate change. Results will inform conservation practices by identifying conditions that promote or constrain *Phragmites* expansion, helping land managers at Hobcaw Barony and elsewhere prioritize mitigation efforts.

South Carolina Seismic Network Station BELLE on Hobcaw Barony

Investigators: Philip Crotwell, Dan Frost
School of the Earth, Ocean, and Environment, University of South Carolina

The South Carolina Seismic Network operates a dozen seismic stations across South Carolina for background monitoring of earthquakes for the USGS. There was a lack of coverage in the northeastern corner of the state and so we installed a new station, BELLE, at BMFL to improve spatial coverage. The seismometer records ground motion and transmits it in real time to USC and to our partner organizations at USGS and is archived for use by researchers. BELLE improves the ability to accurately locate earthquakes within the state, especially in the northeastern portion. All data collected is available without restriction to researchers in near real time via the Earthscope Data Management Center. Earthquake locations are distributed by the USGS in partnership with the Center for Earthquake Research and Information (CERI) at the University of Memphis.

Quantifying and characterizing microplastics in North Inlet and Winyah Bay estuaries

Investigators: Emily Contract, Tammi Richardson
Department of Biological Sciences, University of South Carolina

Microplastics (1 μm to 5 mm) accumulate in the bodies of marine organisms and negatively impact their health. Microplastics have also been linked to birth defects, endocrine disruption, and cancer in humans. This study quantified, characterized, and compared microplastics in a protected estuary (North Inlet estuary) and an estuary impacted by anthropogenic activities (Winyah Bay estuary). Water samples were taken from three sites in each estuary from February 2025 to December 2025. The samples were digested and filtered, then examined visually for microplastics. Plastic particles were extracted and analyzed by Raman microscopy to obtain polymer content. Results indicated a significant difference in plastic concentration between the North Inlet and Winyah Bay estuaries ($p = 0.03$) and in composition ($p = 0.006$). Fibers were the most abundant plastic type in both estuaries ($p < 0.001$). There was a significant interaction between sampling month and site, each site had different seasonal patterns in microplastic type. A significant interaction was also found when analyzing polymer and season, with polyethylene, polyester, and polypropylene showing distinct seasonality ($p < 0.05$). These results show that microplastic type depends on seasonal use patterns of specific sites, and that overall polymer abundances shift seasonally. It is essential to investigate the presence of microplastics in estuaries to understand their impacts on both environmental and human health. This research will advance our understanding of microplastic contamination in South Carolina estuaries, especially how concentrations vary across temporal and spatial scales.

Feeding ecology and prey selectivity of ichthyoplankton in the North Inlet- Winyah Bay estuarine system

Investigators: Maya Skirka, Madison Tovar, Joshua Stone
Department of Biological Sciences, University of South Carolina

Estuarine ecosystems act as critical nursery habitat for a multitude of marine fish species, yet early factors of survival, such as feeding ecology are poorly understood. The goal of this study is to provide critical insights of dietary composition, prey selectivity, and digestion rates of ichthyoplankton (larval and early stage juvenile fish) in the North Inlet- Winyah Bay estuarine system. Larval fish were sampled weekly at two locations with contrasting environmental conditions, Clambank Landing (high-salinity), and Hagley Landing (tidal freshwater). Larval fish gut contents were dissected and identified to assess dietary composition, and prey preference was quantified through comparing the proportion of each prey in the gut to its relative abundance. These analyses will provide valuable insights into the feeding strategies, trophic interactions, and change in prey selection under differing environmental conditions.

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

Investigators: Erik Smith, Braddock Rhodenhiser, Julie Krask, Mary Margaret Pelton, Ranae Peterson, Robert Dunn
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 NIWB 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 with 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.

Effect of seed traits on harvester ant foraging decisions

Investigators: Eric LoPresti, Maddie DiMarco, Lena Kadau, Kiley Stoj
Department of Biological Sciences, University of South Carolina

Most plants do not survive to germinate; instead, they are either killed by environmental stress, pathogens, or granivores. Which seeds do survive is not random, but rather those with traits which defend against these factors are selected for. We are specifically interested in how seed mucilage defends seeds against granivory across species and under different conditions. Harvester ants (*Pogonomyrmex* spp.) are important granivores in many dryland habitats of North America, including dry, sandy pine forests found on Hobcaw Barony. We provided ant nests with seeds of two species with differing traits, and determined the relative removal rate over one hour. By testing across many nests and seed species (with varying traits), this allows us to determine effects of trait on removal rate. This project will yield greater understanding of how seed traits (not just adult plant traits, like defensive chemistry of phenology) contribute to survival and persistence of plant populations, as well as potential solutions for seed predation in agriculture.

Coastal development effects on estuarine benthic microalgal communities

Investigators: Henry Guy[1], James Pinckney[2]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
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As key drivers of neritic primary productivity, benthic microalgae (BMA) play essential roles in biogeochemical cycling and estuarine food webs. When considered alongside their shallow, restricted habitats, BMA contribute disproportionately to global carbon fixation. However, the extent of human impact on BMA communities is largely unknown. This study aimed to quantify anthropogenic forcing through specific abiotic drivers of benthic microalgal success. BMA biomass, community composition, porewater nutrients, and sediment composition were measured within two South Carolina estuaries. North Inlet and Murrells Inlet estuaries share similar geographic and morphological characteristics but differ significantly in terms of watershed population. Dissolved phosphate, nitrate, and ammonium were measured spectrophotometrically. Grain size distributions were collected using standard sorting methods. BMA biomass was quantified fluorometrically, and community composition was determined using a Flowcam and EcoTaxa. Murrells Inlet estuary sites had distinct BMA communities and lower biomass, possibly due to anthropogenic forcings that led to larger grain assemblages and higher phosphate concentrations. Understanding the anthropogenic drivers of BMA structure and distribution provides key insights into the potential abiotic regulation of spatio-temporal patterns of BMA in estuarine intertidal sediments.

Quantifying in-situ weathering of biodegradable geotextiles for improved coastal zone applications

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Plastics dominate the current material choices available in coastal environments for erosion control, shoreline stabilization, and water quality protection. These materials are generally effective at securing sediment, slowing erosion, or arresting oyster shell movement for reef restoration. However, their degradation, which begins immediately upon environmental installation, releases microplastics that are harmful to the environment and human health. Natural fiber geotextiles (e.g., coir, jute) have been slowly increasing in usage as non-plastic biodegradable alternatives for multiple use cases (e.g., oyster bags, shore stabilization geotextiles). However, quantitative testing of how these materials degrade under environmental exposure is lacking, an issue that extends critically to the unique stressors of the coastal zone, where information is needed to guide how practitioners may most effectively expand their use. To address this concern, a suite of non-plastic geotextiles (i.e., coir and jute or different mesh sizes and weights as well as BESE biopolymer) and fastener rope (i.e., cotton, jute, coir, sisal, BESE) were exposed to the harsh environmental conditions of first-order tidal creeks in the marine-dominated North Inlet estuary. Over time, sacrificial samples were taken for laboratory materials testing to determine the percent elongation at break, ultimate tensile strength, toughness, and elastic modulus for each. Results are revealing the durability of these materials and will be applied to guide future applications of various non-plastic fiber alternatives in the harsh estuarine environment.

Exploring biodegradable materials for intertidal oyster restoration with shell substrate

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Along US Atlantic coastlines, reefs built by the eastern oyster (*Crassostrea virginica*) provide important ecosystem services such as shoreline protection and habitat provisioning, but anthropogenic pressures have resulted in severe degradation of these keystone biogenic habitats. Reef restoration efforts often rely on synthetic materials like plastic mesh bags and metal cages, which are relatively inexpensive and can be long-lasting but introduce environmental concerns. For restoration efforts using shell (typically bagged in plastic mesh), we developed a protocol to create bags from coir geotextile and deployed test plots in intertidal habitats in the North Inlet estuary. While preliminary, our results indicate that these more sustainable material options are viable for oyster management and restoration in the southeastern US and invite future research into appropriate use cases.

Identifying patterns of co-occurrence and growth of two ubiquitous species of grass shrimp in multiple estuarine habitats

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Grass shrimp (*Palaemon* spp.) are a highly abundant component of estuarine communities and serve as important links in estuarine food webs by acting as detritivores, opportunistic consumers, and common prey for higher order consumers. While it is possible to differentiate the two most abundant species (*P. pugio* and *P. vulgaris*) from external morphology, the small size of diagnostic characteristics and sheer abundance of these species in ongoing collections like the Oyster Landing biweekly juvenile nekton seine survey have prevented researchers from regularly identifying these organisms to the species level. The objectives of this study were to 1) determine the ratio of *P. vulgaris* to *P. pugio* in various habitat types (oyster reef, intertidal creek pools, saltmarsh edges) by leveraging ongoing sampling efforts and to 2) determine the stability of this ratio and the growth rates of both species in a continuously inundated habitat (Oyster Landing dock) throughout the year. Up to 100 grass shrimp were retained from the Oyster Landing seine, lift nets, and fyke net sampling in the summer of 2025 and 100 grass shrimp were collected from Clambank Landing dock (June - July 2025) and Oyster Landing dock (June 2025 - July 2026) using dip nets. All individuals were identified to species and measured for rostrum-telson length. Sampling will continue until July 2026 and these data will be used to calculate the ratio of each species in each habitat type, as well as the growth of both species throughout the year, to examine habitat and seasonal differences for these grass shrimp species.

Epiphyte dynamics on salt marsh cordgrass: Implications for salt marsh productivity

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Salt marshes are highly productive ecosystems where epiphytic microalgal communities contribute to primary production, nutrient cycling, and food web dynamics. In the North Inlet estuary, salt marsh cordgrass (*Spartina alterniflora*) dominates the intertidal zone and serves as a primary substrate for epiphytic colonization. These communities, composed of diatoms, cyanobacteria, green algae, fungi, and heterotrophic bacteria, form biofilms on their substrates and experience periodic submersion during the tidal cycle. During high tides, epiphytes are almost completely submerged, allowing nutrient uptake and the recruitment of other microalgal species, whereas during low tides, they are exposed to desiccation. This study measures net primary production (NPP) of epiphytic communities on *Spartina* under subaerial and submerged conditions and evaluates non-destructive alternative substrates (wooden dowels, PVC pipe, and plastic straws) as sampling mimics. Chlorophyll *a* is used as a proxy for biomass to compare epiphytic growth with and without *Spartina* influence. We hypothesized that submerged conditions will support higher NPP due to consistent inundation and nutrient availability. Among the mimics, we expect wooden dowels to effectively support epiphytic growth due to their porous, hydrophilic surfaces. This research provides insight into epiphytic community dynamics, their contribution to ecosystem productivity, and a long-term methodology for monitoring epiphytic microalgal communities.

Estuarine nekton use of salt marsh habitats at high tide

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Estuaries are composed of a mosaic of interconnected habitats that serve numerous roles for members of the diverse nekton communities found in the southeastern US. At high tide, habitats that are isolated from one another at low tide become interconnected and allow for movement of animals between proximate habitat types. Understanding the role that each of these habitat types serves in supporting nekton is an important part of understanding the importance of estuaries as essential habitats in the southeastern US. The objectives of this study were to quantify differences in the use of estuarine habitats (saltmarsh edge, shallow intertidal, and subtidal channel) by nekton when these habitats are connected at high tide, and to identify what conditions (temperature, salinity, dissolved oxygen, depth, structural complexity) may contribute to observed differences in nekton community composition, density, distribution, and growth. Nekton were collected monthly April - October 2025 in sections of Old Man Creek and Town Creek using otter trawls, cast nets, and bottomless lift nets. The structure of saltmarsh edge (canopy height, shoot density, elevation) and adjacent oyster reef (rugosity, cluster height, % cover) at each lift net site was quantified in October 2025 following the completion of nekton sampling.

Considering floating treatment wetlands as fish habitats using estuarine mesocosms

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Floating treatment wetlands (FTWs) are an innovative, nature-based approach to improve water quality in manmade or natural aquatic systems; However, they may also provide shelter and/or habitat for aquatic organisms such as fish. The purpose of this research was to quantify fish associations with unvegetated and vegetated FTWs deployed in 110-L simulated estuarine mesocosms. Both a model fish species, mummichog (*Fundulus heteroclitus*), and a plant species, saltmarsh hay (*Spartina patens*), were used in experimental trials. Using high-definition video surveillance, we observed whether mummichog occupied or avoided FTW root systems over eight, 6-h long trials. Results indicated that mummichog associated with both unvegetated and vegetated FTWs, but they showed a stronger preference for vegetated FTWs which indicates the value of robust root systems in successful FTW designs. FTWs may attract fish when applied to coastal stormwater ponds, and incorporating foundational native plants is likely to maximize potential habitat value. Quantitative studies, such as this, are critical in determining FTW habitat potential, especially because habitat value is often assumed by FTW retailers and throughout the literature.

Investigating the drivers of change in oyster reefs along latitudinal, salinity, temperature, and tidal inundation gradients

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The eastern oyster (*Crassostrea virginica*) plays a critical role in maintaining the health of coastal ecosystems by providing habitat, water filtration, and erosion control. To better understand the factors that influence oyster reef health and function across various environmental gradients, the Marine Global Earth Observatory (MarineGEO) is conducting a large-scale, multi-site study in partnership with a network of Federal agencies, NGOs, and universities. This study, led by the MarineGEO Oyster Working Group, focuses on investigating the drivers of change in oyster reefs along latitudinal, salinity, temperature, and tidal inundation gradients. Researchers at BMFL participated as project partners by deploying standardized "Bio Boxes" in three locations around the North Inlet estuary during the summer of 2025. Bio boxes equipped with water temperature loggers and spat settling sticks were buried in intertidal oyster reefs (n = 3) in June and filled with living oysters and shell hash characteristic of that reef's structure. In August, the bio boxes were retrieved, oysters were counted, measured, and weighed, and the associated fauna were identified, counted, and preserved. Data were shared with the MarineGEO Oyster Working Group for a regional analysis which will compare findings from the North Inlet estuary to those from other estuaries along the US Atlantic and Gulf coasts.

Influence of stake material and density on intertidal oyster enhancement in a subtropical estuary

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Over 85% of natural oyster reefs have been lost globally, prompting widespread restoration efforts to recover the critical ecosystem services they provide, such as shoreline stabilization and habitat provisioning. Common restoration methods often use recycled oyster shell, either loose or in plastic mesh bags, as substrate for larval oyster settlement. However, lack of shell availability and growing concerns over plastic pollution in coastal and marine environments have driven interest in biodegradable alternative substrates. In the southeastern US, alternative substrates have been used by commercial oyster harvesters for decades, including wood and bamboo stakes placed in various configurations to foster intertidal oyster recruitment and growth. However, no studies have tested the effects of material type and spatial design on oyster enhancement success. This study is evaluating the effectiveness of wood and bamboo stakes deployed at three spacing densities (6, 12, and 18 inches apart) for oyster enhancement and restoration. Across 24 experimental plots, created in March 2025 and located along Crabhaul Creek within the North Inlet estuary, biofouling community development and oyster recruitment (density) and growth (shell height) are being quantified for two years to assess material and density effects. Additionally, the habitat value of wood stakes in each density is being measured through monitoring associated nekton communities over time compared to adjacent natural oyster reefs. Finally, drone surveys are being conducted to assess potential effects of staking density and material on landward saltmarsh habitat. Findings from this study aim to provide actionable insights for shellfish managers and restoration practitioners, identifying optimal materials and spatial designs to maximize oyster recruitment, growth, and ecosystem service enhancement.

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