CURRENT RESEARCH PROJECTS

2024

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
2024

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 1,920 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 78 projects that were underway during the period from January through December 2024 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 53 of the investigators while over 96 investigators representing 38 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 are being conducted within the North Inlet and Winyah Bay estuaries.

Contents

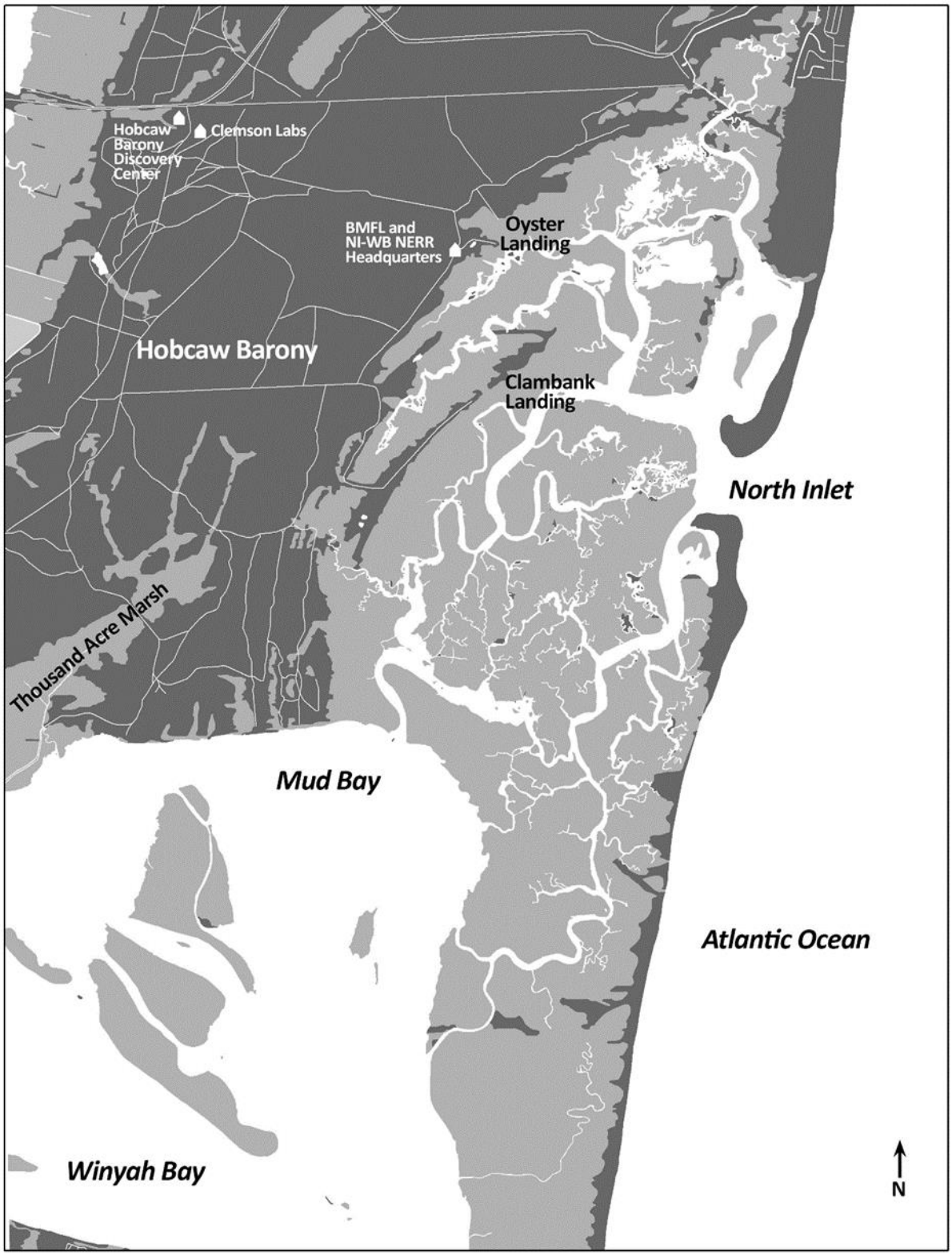

Figure 1: Map of the North Inlet-Winyah Bay estuarine system in Georgetown County, South Carolina.

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

Investigators: Robert Dunn, 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 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.

***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.

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.

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 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 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: Robert Dunn, Julie Krask

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.

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 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 - 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.

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

Investigator: Robert Young

Department of Marine Science, Coastal Carolina University (SC)

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

Quantifying microplastics in best management practices for coastal management

Investigators: Louisa Mai[1], Stefanie Whitmire[2], William Strosnider[3]

1 - South Carolina Honors College, University of South Carolina
2 - Baruch Institute for Coastal Ecology and Forest Science, Clemson University (SC)
3 - Baruch Marine Field Laboratory, University of South Carolina

Plastic geotextiles are common elements of shoreline protection best management practices (BMPs). However, may also be a source of microplastics. We conducted a mesocosm experiment to quantify the number of microplastics that may result from the degradation of two common BMP geotextiles: temporary silt fencing and green plastic mesh, both composed primarily of polypropylene. Replicates of each geotextile were partially submerged in seawater in glass aquaria situated on a shaker table within the BMFL greenhouse (to simulate wave action, UV, ambient temperate exposure). Aquaria water samples were collected four times over the 48 day experiment and run through a series of sieves for analysis. Larger plastics were collected off the sieves, and microplastic samples analyzed through visual counting and Agilent 8700 Laser Direct Infrared (LDIR) analysis. Experimental and control treatments contained high concentrations of microplastics (mean range: 1206.9 ± 312 to 859.8 ± 208 MP/L), primarily in the form of clear and blue fibers, likely due to contamination. There were no statistically significant differences among treatments overall; however, there were higher concentrations of green particles in the treatment containing the green mesh geomat and higher concentrations of black particles in the treatment containing the black silt fence, indicating shedding from these geotextile materials. Preliminary LDIR analysis also indicated higher quantities of polypropylene in treatment tanks compared to controls, suggesting these BMP materials are indeed shedding microplastics. This study highlights a need for a reassessment of current BMPs to reduce the microplastic load to our coastal environments.

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).

Ecology of cannonball jellyfish (*Stomolophus meleagris*) in the South Atlantic Bight

Investigators: Joshua Stone, Jasmine Caillier

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 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.

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.

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.

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

Investigators: Joshua Stone[1], Dennis Allen[2], 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.

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.

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.

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

Investigator: Robert Dunn

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

Despite the economic and ecological importance of decapod crabs within estuarine ecosystems, fisheries for blue and stone crabs in South Carolina currently have relatively little management. To better understand the status of crab populations within the waters of North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB NERR), I 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 NIWB NERR, as well as spatial and temporal variation in these parameters. We 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.

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.

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, *Sporobolus 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*.

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

Investigators: Robert Dunn, 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.

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.

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

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

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

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

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.

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 employs 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).

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 30 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.

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 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.

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. Participants will collect and assess samples twice a month. Results will be reported to PMN to be incorporated into larger-scale examinations.

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.

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], Jodi Barnes[5], Savannah Bornheim[6], Bruce Pfirrmann[1]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Georgetown County Public Library, Georgetown, SC
3 - School of the Earth, Ocean, and Environment, University of South Carolina
4 - Baruch Institute for South Carolina Studies, Francis Marion University (SC)
5 - Heritage Trust Program, South Carolina Department of Natural Resources
6 - South Carolina Honors College, University of South Carolina

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.

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 2024 marked the seventh 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 *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.

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

Investigator: Juliana Harding

Department of Marine Science, Coastal Carolina University (SC)

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

Monitoring change in salt marsh vegetation distribution and biomass using UAS-derived multispectral imagery in 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.

The BMFL – University of Dayton ETHOS Service Collaborative

Investigators: William Strosnider[1], Shane White[2], Owen Beer[2], Kelly Bohrer[3], Scott Schneider[3]

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

Beginning in 2021, the Baruch Marine Field Lab (BMFL) established a partnership with the University of Dayton's 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.

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 NSC. The NSC is led by researchers at the University of Michigan, Stanford University, and USC. The CDMO's 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.

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.

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.

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 Unmanned 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.

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

Investigators: Juliana Harding[1], Anna Dietz[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 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.

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, arthropods 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 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 both 2023 and 2024, a diverse range of live fauna were observed interacting with FTWs, including turtles, ducks, shorebirds (e.g., grey heron, little blue heron), 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.

Understanding the drivers of sand dune resistance and resilience

Investigators: Paul Berghuis[1], Floris van Rees[1], Hallie Fischman[2], Joseph Marchionno[2]

1 - Coastal Systems Department, Royal Netherlands Institute for Sea Research
2 - Department of Environmental Engineering Sciences, University of Florida

Our study focuses on the interaction between local abiotic factors (such as storm regimes and nutrient input) and dune-building grasses like *Ammophila brevigulata* and *Uniola paniculata*. These grasses are essential for dune morphology and coastal protection. By examining shoot and patch organization in these grasses across various conditions, we aim to enhance understanding of their ecological dynamics and contributions to nature-based coastal defenses. Fieldwork on Hobcaw Beach in August 2024 consisted of shoot density estimation, sediment and vegetative sampling for biomass and isotopic estimates, and an evaluation of dune morphology and wrack density via drone survey. Our research could provide valuable insights for the management and conservation of dune systems along the US Atlantic coast, particularly in the face of increasing storm frequency and rising sea levels.

Latitudinal comparison of life-history traits in the mud snail *Ilyanassa obsoleta*

Investigators: Robert Podolsky[1], Kora Hansen[2]

1 - Grice Marine Lab, College of Charleston (SC)
2 - Department of Biology, College of Charleston (SC)

As part of a broad latitudinal study of life-history trait variation in mud snails, we are collecting animals from populations from Florida through Maine and harvesting egg capsules in our laboratory at the Grice Marine Lab. Snails from the North Inlet estuary were collected in the summer of 2024 as representatives of a population in central South Carolina from a less developed location. The primary goals of this research were 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.

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).

Exploring the pollination ecology of *Cnidoscolus stimulosus*

Investigators: Kiley Stoj, Eric LoPresti

Department of Biological Sciences, University of South Carolina

Cnidoscolus stimulosus is a native weedy plant found throughout much of South Carolina. This plant produces white flowers that omit scent and offer a nectar reward, indicating nocturnal moth pollination; however, there are reports of other *Cnidoscolus* species attracting diurnal pollinators. Less-effective/less-frequent visitors may still provide important services to plants, and it is estimated that 70% of plants interact with at least one secondary pollinator. However, the extent of secondary pollinator contributions to total reproduction are often overlooked. One aim of this project is to apply exclusion treatments to assess the roles of diurnal and nocturnal insect visitors. Exclusion treatments will be applied by either bagging flowers or placing small cages around the entire plant during the day or night. A second aim of this study is to use *C. stimulosus* as a study system for assessing the impacts of artificial light on pollination success, taking advantage of its distribution along a relative gradient of development on Hobcaw Barony, from along roadways and adjacent to dorms to undeveloped, relatively natural areas. Artificial light has the capacity to modify activity patterns of both diurnal and nocturnal organisms, disrupt movement and migration, and alter the timing of events such as flowering and reproduction. We will apply lighting treatments to plants, comparing pollination success under white LED lights to plants under natural light conditions.

Development of a fully biodegradable floating treatment wetland design

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

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, 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 2024, pickerelweed and common cattail were integrated into geotextiles from both seed and plug forms at the mesocosm scale. 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.

Late Holocene and historic sea-level and land-elevation changes along northern coastal South Carolina

Investigators: Till Hanebuth, Madison Fink

Department of Marine Science, Coastal Carolina University (SC)

There is currently a lack of a continuously measured sea-level records in the northern coastal SC region. The goal of this research is to reconstruct a decadal-scale record of relative sea-level rise in the Waccamaw Neck region over the past two centuries, using a combination of marsh sediment cores, sediment dating, and foraminifera species analysis. Our study site identified within Hobcaw Barony and adjacent to the North Inlet-Winyah Bay NERR (a marsh and creek ridge at the end of Floating Bridge Road), offers the natural, undisturbed conditions necessary to apply our approach and, therefore, create a new source of important data about relative sea-level rise in our region, which is already vulnerable to the impacts of flooding. The data collected will also help us to better compare our geographic area to the wider coastal region when analyzing regionally differentiated rates of vertical land motion

Remote sensing of microphytobenthos

Investigators: Joseph McGuinn[1], Cuizhen Wang[1], Jay Pinckney[2]

1 - Department of Geography, University of South Carolina
2 - Department of Biological Sciences, University of South Carolina

Microphytobenthos (MPB) are microscopic primary producers living in sediments exposed to regular sunlight. Typically, MPBs are unicellular eukaryotic algae, and these primary producers are essential to coastal and marsh ecology, greatly influencing carbon and nitrogen cycling processes. MPBs are typically overlooked in coastal ecological health assessments, yet recent advancements in remote sensing have made it easier to assess the distribution and health of MPBs. This project focuses on the marriage of Unmanned Aircraft System (UAS)-acquired multispectral imagery, LIDAR-based elevation data, and soil sample analysis, enabling quantification and analysis of MPB habitats. Spatial analysis of MPB assemblages will provide insight into MPB growth tendencies along an elevation gradient. Soil sample collection and analysis will provide further information and groundtruth remotely sensed data. The comprehensive analysis of mudflat classification, UAV flight, and soil sample analysis to be conducted in this study will shed light on the dynamics of microphytobenthos distribution. Moreover, seeing as MPB distributions can provide valuable insight into overall habitat and marsh health, a remote sensing approach to analyze MPBs will likely prove essential to monitoring this salt marsh ecosystems moving forward.

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. 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.

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

Investigators: Peter Key, James Daugomah, Paul Pennington

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

Long-term ecological monitoring is important to developing fundamental understandings of both biogenic and anthropogenic effects on ecosystem health. This monitoring may provide great insight into natural factors such as disease, pests, and weather (e.g., global climate change, drought, floods, and increased intensity of tropical storms and hurricanes), which may affect populations throughout a geographical region. In addition to population perturbations caused by natural stressors, 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.

Trophic impacts of mummichog *Fundulus heteroclitus* in estuarine ecosystems

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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 the early life stage mummichog on zooplankton and phytoplankton communities within estuarine ecosystems. Understanding how mummichogs 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.

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

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Oyster reefs provide habitat for a diverse and productive community of organisms within estuaries, including Reserves across the NERR System. 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. Therefore, we investigated oyster reef condition and function for fauna across four estuaries at Reserves in North Carolina (NC), South Carolina (NIWB), Georgia (SI), and Florida (GTM) to assess the capacity of four emerging techniques: acoustic imaging, stable isotope analyses, oyster disease assays, and eDNA metabarcoding. Based on the oyster reef characteristics examined, the biophysical structure of fringing intertidal oyster reefs were largely similar within and among all four reserves. Nekton communities differed slightly in species composition, abundance, and size, likely due to the large differences in water temperature between the beginning (~24°C) and end (~15°C) of the field sampling period. Nekton counts from acoustic imaging generally track those from direct capture collections, with acoustic imaging counts ~5X greater than those from direct capture. Stable Isotope Analyses revealed that the primary resource contributing to oyster reef food webs varied, with particulate organic matter (POM) the most important primary resource for reef food webs in NC and GTM, and benthic algae most important in NIWB and SI. Oyster disease assays revealed that Dermo and MSX parasite presence was high at all sites, but infection intensities were generally low. An examination of eDNA metabarcoding for oyster reef communities within and among the four Reserves is ongoing at this time due to challenges experienced with processing the eDNA samples.

Experimental varying of the marsh platform and macrophyte response

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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.

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 continued to explicitly test the efficacy, performance, and economic viability of natural alternatives to plastics in coastal South Carolina. Research conducted in 2024 included mesoscale tests of glass-aggregate-based and biodegradable floating treatment wetlands, economic analysis of glass aggregate floating treatment wetlands, field-scale exposure experiments of natural geotextiles, and multiple efforts to quantify the efficacy of alternative materials as cultch for oyster reef creation and restoration.

Coupled ecological-geomorphological response of coastal wetlands to environmental change

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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 collected LiDAR and multispectral data along with a simultaneous field surveys 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 was 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 was 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.

Guiding successful applications of floating treatment wetlands in brackish coastal ponds

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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 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 in a greenhouse setting to determine those species most suitable for field FTW application. Three 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. Thus far, several workshops focused on how to install and harvest FTWs have been 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. 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.

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

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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.

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.

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

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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 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 ecological significant coastal plain habitats. The NIWB 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.

The nursery value of salt marsh intertidal creeks for juvenile white shrimp

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As juveniles, white shrimp (*Penaeus setiferus*) occupy a suite of interconnected habitats within the estuarine mosaic before migrating offshore as adults. In the southeastern US, intertidal creeks make up a substantial proportion of available habitat within the estuarine mosaic. However, it is unclear if individual intertidal creeks differ in their value (level of support) for juvenile white shrimp. Further, it is unclear which morphological and physical attributes of creeks may have the most influence on shrimp habitat use and support. Therefore, we examined the distribution, abundance, and growth of juvenile white shrimp using salt marsh intertidal creeks during their period of estuarine residency. From June to December 2024, we collected juvenile shrimp biweekly in six intertidal creeks in the North Inlet estuary using seines, cast nets, and kick nets. During each biweekly sampling event at each creek one bag seine haul was conducted in the isolated creek pool near the creek mouth to collect all nekton species present, then additional cast net and kick net hauls were conducted to collect up to 100 individual white shrimp. All nekton species were identified and counted, and the length of up to 30 individuals of each species was measured (in mm). Individual white shrimp were measured for length (TL, RCL, CL) and weight (g). Results will provide important habitat-specific estimates of the value of intertidal creeks for white shrimp, and likely also provide insights that may apply to other estuarine fishes and invertebrates.

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 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.

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

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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.

Adapting salt marsh vulnerability assessment methodologies to southeastern salt marshes

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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 (NIWB) 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 Aircraft 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.

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, Julie Krask

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.

Dissolved organic matter concentrations and optical properties of canopy throughfall in forested wetlands of the Southeastern Coastal Plain

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Forested wetlands (swamps) produce and export large amounts of colored dissolved organic matter (CDOM), giving their surface waters the characteristic "blackwater" appearance. Much of this CDOM is thought to originate from decaying plant litter and soils. Previous work in upland forests suggests, however, that rainwater can accumulate high concentrations of CDOM as it passes through the tree canopy. The objective of this study is to collect preliminary data on colored dissolved organic matter (CDOM) concentrations and optical characteristics (as a proxy for CDOM chemical characteristics and degree of color per unit carbon) produced by canopy throughfall from dominant forested wetland tree species, in comparison to typical upland forest tree species, common to the Southeastern Coastal Plain. Throughfall will be collected in 4 different forest stand types on Hobcaw Barony, each of which is dominated by a single tree species: bald cypress (*Taxodium distichum*); water tupelo (*Nyssa aquatica*); loblolly pine (*Pinus taeda*); and laurel oak (*Quercus laurifolia*). CDOM concentrations in throughfall will be evaluated among canopy stand types and in comparison to rainfall CDOM concentrations to assess the degree to which forest canopy type (forested wetland vs. upland; broadleaf vs. coniferous) impacts CDOM production and optical characteristics contributing to the formation of “blackwater.” While CDOM production from forest canopies has been previously assessed in temperate upland habitats, this will be the first study to examine the role of throughfall in CDOM production in forested wetlands and will provide initial information on whether models relating land cover to CDOM export need to account for forest community types.

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], Mary Margaret Pelton[3]

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Understanding the impacts of 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 juvenile blue catfish in Winyah Bay and its tributaries using a trawl during 2023, and in 2024 processed over 400 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 full guts 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.

Examining wooden stakes as an alternative to shell cultch for oyster harvest and habitat provisioning for estuarine nekton

Investigators: Mariah Livernois[1], Briar Ownby-Connolly[1], Lexi Watson[2], Joshua Robinson[3], William Strosnider[1]

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Oyster reefs provide numerous ecosystem services, including shoreline protection, water filtration, and habitat for many species of fish and invertebrates. Oysters require hard substrate to attach to as larvae, after which they are able to grow and provide structured habitat for associated fauna. In South Carolina, commercial oyster harvesters are required to replant shell cultch to replenish oyster populations, but shell is a limited resource that can be difficult to obtain. Commercial permit holders are therefore allowed to use alternative substrates, including wood stakes which are readily colonized by oysters. In addition to serving as substrate, these stakes may provide similar ecosystem services as natural oyster reefs. The goal of this study was to document metrics of oyster growth on wood stakes planted in 2022 at a commercial harvest site (Swinton Creek, Sullivans Island, SC). Two years post-deployment (July to September 2024), oyster density and individual shell height measurements were collected from upright wood stakes and the adjacent natural reef. These metrics will allow shellfish managers to quantitatively assess current regulations guiding the use of wood stakes on harvest sites. Furthermore, a modest assessment of nekton communities inhabiting wood stakes and natural reefs occurred via biweekly sampling with fyke nets. Nekton community composition and relative abundance will be compared between colonized stakes and natural oyster reefs to explore the utility of wood stakes as a habitat restoration tool.

Effect of acclimatization at different latitudes on the visual and metabolic physiology of the Atlantic marsh fiddler crab (*Minuca pugnax*)

Investigators: Rebecca LeBlanc, Jonathan Cohen

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Many biological processes change predictably with latitude due to acclimatization, the process of individuals adapting to their environment, to local temperature conditions. For example, metabolic capacity of specific populations often upregulates in response to chronic exposure to colder temperatures. We propose to investigate how acclimatization at varying latitudes can influence two temperature-dependent physiological processes, visual speed and metabolic rate ($\dot{M}O_2$), using the Atlantic marsh fiddler crab (*Minuca pugnax*), a highly vision-reliant crab species abundant in salt marshes along the US Atlantic coast. $\dot{M}O_2$ increases with temperature, as does critical flicker fusion frequency (cFFF), the maximum speed an animal's eyes can detect flash series. Using animals from three separate populations along a latitudinal gradient (Rhode Island, Delaware, and South Carolina), we will examine visual speed and metabolic rate of the marsh fiddler through use of electroretinography and oxygen consumption experiments. We hypothesis Rhode Island crabs will have upregulated metabolic capacity and exhibit higher visual speeds at colder temperatures relative to Delaware and South Carolina crabs. Although they are closely connected processes, temperature-dependence has only been heavily researched on its implication to metabolism, not vision. This study will provide insights into physiological adaptations of *M. pugnax* to different latitudes and how warming chronic conditions due to climate change could downregulate their biological processes towards worse performance under acutely colder conditions.

Performance and degradation of plastic-free geotextiles along the tidal exposure gradient in a warm-temperate salt marsh estuary

Investigators: Mariah Livernois[1], Bruce Pfirrmann[1], William Strosnider[1], Briar Ownby-Connolly[1], Levi McKercher[1], Robert Lowe[2], Evan Smyjunas[2], Molly Savage[2], Loring Leitzel[2], Scott Schneider[3], Rashawna Huntley[4], Owen Beer[5], Shane White[5], Kayla Thompson[6]

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Synthetic geotextiles (plastics) are commonly used in coastal environments for erosion control, shoreline stabilization, and water quality protection. Natural fiber geotextiles have increased in popularity as biodegradable alternatives, particularly in fields of shoreline and oyster restoration, yet a quantitative understanding of how these materials degrade when used in estuarine environments is lacking. To address this gap, we deployed experimental panels containing seven different biodegradable materials (including coir, jute, and a proprietary biopolymer) at three sites (intertidal creeks) in the North Inlet estuary beginning in August 2024. At each site, replicate panels were positioned along a tidal inundation gradient (marsh surface, intertidal creek bank, intertidal creek bed) and exposed to ambient conditions. Replicate swatches from each treatment (site x tide level) were collected at regular intervals beginning 3 weeks post-deployment and ending 4 months post-deployment (December 2024). Upon collection, swatches were dried, packaged, and shipped to the University of Dayton for mechanical testing, surface electron microscope imaging, and chemical analysis. We anticipate our results will help delineate the ideal conditions for use of each material in coastal development and habitat restoration applications, and will inform future studies employing plastic-free geotextile materials in estuarine environments.

Investigating microplastic distribution, abundance, and composition in the surface waters of two South Carolina estuaries

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Urbanization may increase the accumulation of microplastics in estuarine systems. We examined microplastic distribution and abundance within two estuaries along South Carolina's Grand Strand differing in their degree of urbanization (Murrells Inlet and North Inlet estuaries. We collected water samples at 5 different sites within each system in the summer of 2024, and quantified microplastic abundance and composition using an Agilent LDIR 8700 (capable of detecting microplastics from 20-500 μm). Mean microplastic abundance was greater in Murrells Inlet estuary (231 ± 64.77 MP/m^3) compared to North Inlet estuary (195± 78.21 MP/m^3), but this difference was not statistically significant. The most abundant particle type in both estuaries was rubber; abundance of rubber particles was not statistically different between systems. Within each estuary, tire wear particles were more abundant adjacent to boat ramps compared to other sites. Despite overall similarities in microplastic abundance between the two estuaries, Murrells Inlet samples contained significantly higher amounts of polytetrafluoroethylene (PTFE) and polyethylene terephthalate (PET) compared to samples from North Inlet estuary. Our results point to a need for local mitigation and prevention efforts in order to reduce the load of microplastics into estuarine environments.

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 2024, 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.

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. 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.

Author Index

K (cont.)

L

M

O-P

O-P (cont.)

R

S

T-V

W-Z