CURRENT RESEARCH PROJECTS

2019 – 2020

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
2019 – 2020

Introduction

The Baruch Marine Field Laboratory (BMFL), located on Hobcaw Barony in Georgetown County, has been the center of research activities for scientists and students from the University of South Carolina (USC) and dozens of other institutions since 1969. We conservatively estimate that between senior scientist projects and masters and doctoral studies conducted by graduate students, more than 1,000 grant and institutionally-funded projects have taken place at BMFL. This work has contributed substantially to the more than 2,000 peer-reviewed scientific articles, books, and technical reports that have been published since the Baruch Institute was founded. Independent and multi-disciplinary studies have been conducted by biologists, chemists, geologists, oceanographers, and other specialists who share interests in the structure, function, and condition of coastal environments. Results of research projects are used by educators, coastal resource managers, health and environmental regulators, legislators, and many other individuals and organizations interested in maintaining and improving the condition of estuaries in the face of increasing human activities and changing climate in the coastal zone.

The following annotated list summarizes 89 projects that were underway during the period from July 2019 through December 2020 in the North Inlet and Winyah Bay estuaries by faculty, staff, graduate students, and undergraduates associated with the USC and other institutions. USC is the home institution for 54 of the investigators while over 78 investigators representing 35 other institutions and agencies are carrying out projects through BMFL. Dozens of graduate and undergraduate students assist scientists throughout the year to obtain hands-on training in field methods and to conduct research.

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

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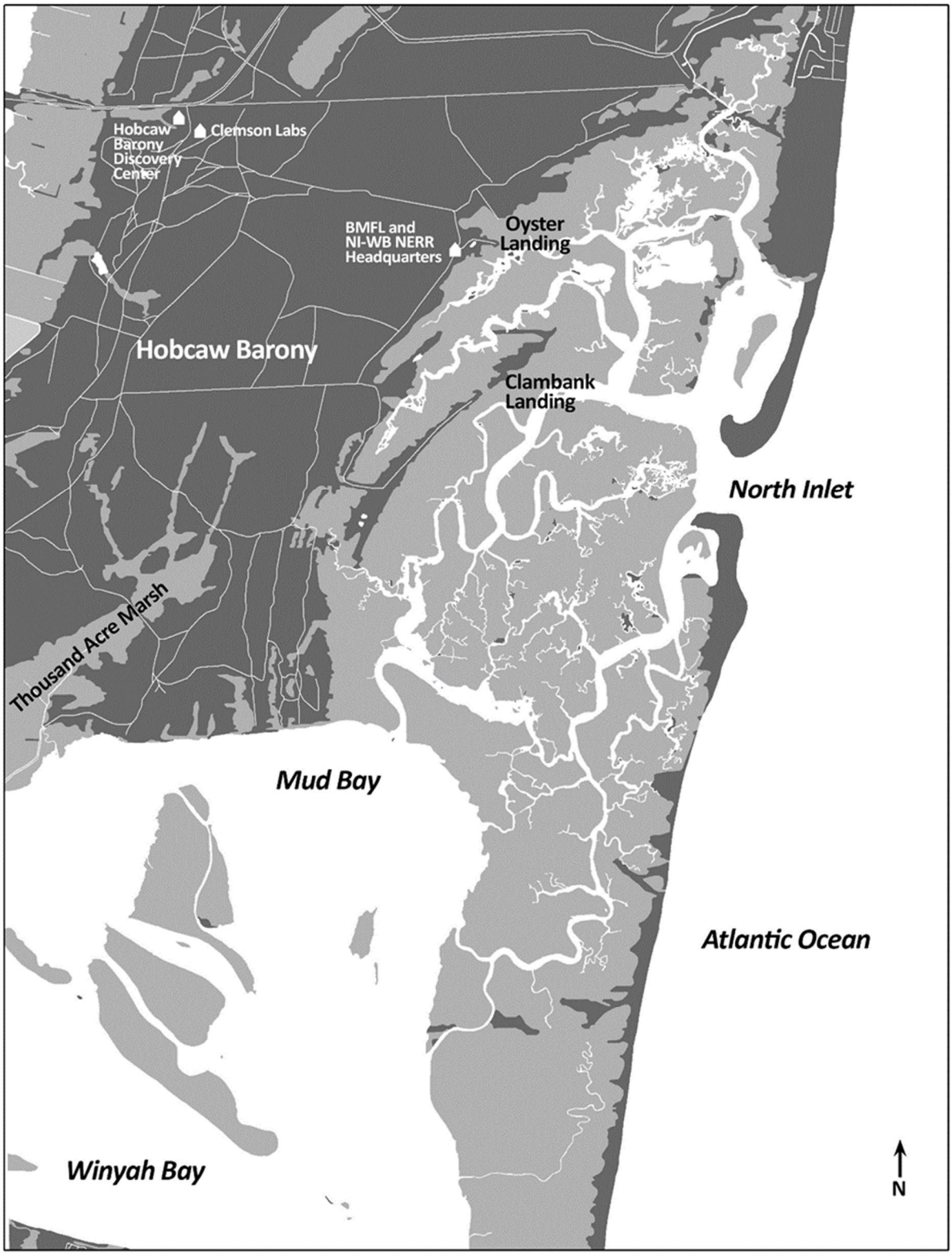

Figure 1: Map of the North Inlet-Winyah Bay estuarine system in Georgetown County, South Carolina.

Fluorescent dissolved organic matter dynamics in the North Inlet estuary

Investigators: Erik M. Smith, J. Baker Stevens, Julie L. Krask

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

There is growing interest in the use of the inherent optical properties of dissolved organic matter (DOM) as proxies for dissolved organic carbon (DOC) concentrations and biogeochemical cycling in coastal ecosystems. This study employs a fluorescent dissolved organic matter (FDOM) optical probe, recently available as part of Xylem/YSI's EXO water quality sonde, to quantify high-frequency DOC dynamics in the North Inlet estuary. Beginning in August of 2012 an EXO equipped with an FDOM probe, together with temperature, salinity, pH, dissolved oxygen, and turbidity probes, has been deployed at the Oyster Landing long-term monitoring station of the North Inlet–Winyah Bay National Estuarine Research Reserve. Initial results have shown that over the majority of FDOM ranges observed to date, FDOM measures can serve as a reliable proxy for DOC concentration once temperature sensitivities and turbidity interferences are accounted for. Ongoing sampling is being conducted to understand the effects of different dissolved organic matter sources on FDOM – DOC relationships as well as the potential issues associated with sample quenching at high FDOM concentrations. This study will allow the temporal dynamics of DOC, the largest pool of organic carbon in marine waters, to be resolved at frequencies not previously possible.

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

Investigator: Rob 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 pattens of distribution and abundance.

Construction of biodegradable floating treatment wetland utilizing wood and bamboo

Investigators: William H.J. Strosnider[1], Travis Tasker[2], Lily Currie[2], Kendra Zaruba[2]

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

The purpose of this research was to develop new designs for floating treatment wetlands (FTWs) that utilize natural and biodegradable materials to support plant growth and improve water quality. In this work, we were able to design biodegradable and durable wood and bamboo floating rafts embedded with coir fiber mats. While the rafts were still floating after 4 weeks and were planted with *Pontederia cordata,* the rafts need to be continually monitored in the future to determine the longevity of the floating mats. The benefits and success of constructing FTWs out of more natural, biodegradable, and ubiquitous materials could reduce the costs of FTWs and allow for more resilient plant and biological communities.

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

Investigators: Bruce W. Pfirrmann, Matthew E. Kimball, Dennis M. 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.

The conservation status of the canebrake rattlesnake (*Crotalus horridus atricaudatus*) at Hobcaw Barony, with identification of key areas for conservation of its herpetofauna

Investigator: Allan L. Markezich

Department of Natural Sciences, Black Hawk College (IL)

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

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

Investigators: Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Green porcelain crab (*Petrolisthes armatus*) larval biology and phenology will be described with field collections. Weekly zooplankton tows will be used to monitor the presence and stages of crab larvae. Larval morphology will be described from field caught specimens. This information will add to the understanding of this invasive (extended geographic range) species' occurrence in the North Inlet estuary. *Petrolisthes armatus* larvae first occurred in biweekly zooplankton collections in the mid-1990s and little is known about the timing, periodicity, and duration of larval production. Modern patterns in larval occurrence can be compared to similar information from archived biweekly collections to evaluate potential changes with temperature and annual salinity trends.

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

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

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

As part of the National Estuarine Research Reserve System (NERRS) System-Wide Monitoring Program (SWMP), water chemistry sampling was initiated in June 1993 to monitor concentrations of suspended solids, total nitrogen, ammonium, nitrate, nitrite, total phosphorus, orthophosphate, and chlorophyll *a* at four locations within the North Inlet–Winyah Bay NERR. Water samples are collected every 20 days with ISCO automated water sampling devices at intervals of 2 hours and 4 minutes over two complete tidal cycles. Sampling and chemical analyses adhere to strict national protocols developed as part of the NERRS System-Wide Monitoring Program. The consistent, long-term collection of water chemistry variables allows for the characterization of short-term variability and detection of long-term change in key water quality parameters. These data also provide critical information for various studies of biological and physical processes in the North Inlet estuary. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control, and then made available via the CDMO website (http://cdmo.baruch.sc.edu). Water chemistry data collected in North Inlet prior to the initiation of the NERRS SWMP sampling (some dating back to 1978) are available via the Baruch website's Data and Publications link (http://www.baruch.sc.edu/water-quality-chemistry-databases).

Saltwater intrusion monitoring

Investigators: Alicia M. Wilson[1], William Clendenin[2]

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - South Carolina Department of Natural Resources

Knowledge of the location of the freshwater-saltwater interface in coastal aquifers is critical for managing coastal groundwater resources, for predicting saltwater intrusion, and for calculating groundwater-related chemical exchange between aquifers and the coastal ocean. This project installed permanent wells to monitor salinity and saltwater intrusion in the upper (up to 100 ft depth) aquifers at the North Inlet estuary, as part of the South Carolina Department of Natural Resources long-term coastal monitoring network. Results to date include stratigraphy from the well logs and field observations of hydraulic head and salinity. These field observations also supported the development of a regional groundwater flow model presented by Evans et al. 2020.

Toxicological effects of tire wear particles on fathead minnow (*Pimephales promelas*) and Atlantic killifish (*Fundulus heteroclitus*)

Investigators: Peter van den Hurk[1], Stephanie LaPlaca[2], John Weinstein[3]

1 - Department of Biological Sciences, Clemson University (SC)
2 - Environmental Toxicology Program, Clemson University (SC)
3 - Department of Biology, The Citadel (SC)

Recent studies on the distribution of microplastics in the Charleston Harbor, South Carolina, revealed that a large part of the microplastic particles that are found in the intertidal sediments are tire wear particles. These particles originate from the wear of tire treads on roadways, and wash into the estuary during rain events. The abundance of these particles has raised questions about potential toxicity to aquatic organisms that may ingest these particles. To investigate the potential toxicity of tire wear particles we started a project comparing the effects in both fathead minnow and Atlantic killifish. The fish are exposed to different concentrations of tire wear particles in a 7 day exposure. Earlier experiments in fathead minnow revealed that particles were actually ingested and accumulated in the intestinal tract. At the highest concentration tested (6000 mg/l) we also observed partial mortality in the fathead minnow, which is therefore close to the LC50. To investigate if polynuclear aromatic hydrocarbons were leaching from the particles, bile fluorescence is measured, together with potential induction of cytochrome P450-1A through the EROD assay. In addition, glutathione S-transferase is measured as a general stress parameter. The results of this study will allow a comparison between the two species, with the consideration that Atlantic killifish is an estuarine species that is much more used to being exposed to high particle load in its natural environment than the fathead minnow. The results of the project may be used to support environmental management strategies that reduce particulate matter in road runoff from entering estuarine environments.

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

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

1 - Baruch Institute for Coastal Ecology and Forest Science, Clemson University (SC)
2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Accurate and integrative measures of marsh productivity as well as the sensitivity of marsh production to environmental variability over multiple time-scales are essential to understanding how salt marshes will respond to future environmental and anthropogenic stressors. This study is employing state-of-the-art eddy covariance flux instrumentation (IRGASON, Campbell Scientific) to generate high-frequency (30-minute interval) measurements of terrestrial-atmospheric CO_2 and CH_4 exchange at spatial scales large enough (on the order of 20,000 m^2) to capture landscape-level dynamics. The instrumentation is located with the National Estuarine Research Reserve's existing salt marsh monitoring infrastructure within the Crabhaul Creek marsh of the North Inlet estuary to leverage ongoing data collection of marsh vegetation, surface elevation and tidal inundation, salinity and pore water chemistry, and meteorological data. Results of this study will greatly improve our understanding of marsh sensitivity to environmental variability and change through the development of empirical models relating the integrated response of the salt marsh ecosystem (as gross primary production, ecosystem respiration, and net ecosystem exchange) to environmental variability over temporal scales not previously possible and at spatial scales large enough to integrate landscape-level responses.

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

Investigators: Blaine D. Griffen[1], Matthew E. Kimball[2], Bruce W. Pfirrmann[2]

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

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

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 website (www.northinlet.sc.edu), and the Reserve's Facebook page in addition to local online community event calendars. Program offerings include estuarine and beach ecology activities for all ages, biking and kayaking programs featuring coastal ecology, open houses and research lectures, and research-based citizen science programs. Professional Teacher Development opportunities and field trips for K-12 public, private, and homeschool students are also available, as well as job shadowing and research experiences for middle and high school students. Off-site outreach includes presentations to environmental and civic groups, local festivals, special outreach programs at regional libraries and museums, afterschool programs for local elementary and middle schools, science and environmental fairs, and career days. Partnerships with other local environmental education providers, including the Belle W. Baruch Foundation, ACE Basin 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.

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.

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

Investigators: Joshua P. Stone[1], Dennis M. Allen[2], Nayan Mallick[1], Bruce W. Pfirrmann[2], Matthew E. 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.

Mechanisms for thermal tolerance in an estuarine cnidarian

Investigator: Adam Reitzel

Department of Biological Sciences, University of North Carolina Charlotte

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

Quantifying elevational and latitudinal gradients in marsh snail predation

Investigators: Rebecca Atkins, Craig Osenberg, Daniel Hawkins

Odum School of Ecology, University of Georgia

In southeastern salt marshes, the periwinkle snail (*Littoraria littoraria*) is a dominant grazer, feeding on stalks of smooth cordgrass (*Spartina alternifora*). Previous work has demonstrated that *Littoraria's* effect on *Spartina* depends on the abundance and size structure of its population. *Littoraria* body size and abundance is known to vary across a latitudinal gradient from Florida to Maryland, but we do not know the cause of this variation. *Littoraria* are eaten by mud crabs, blue crabs, birds, and terrapin turtles. However, little is known about the role that these predators play in determining *Littoraria* population size structure and abundance. To gain additional information, "tethering experiments" will be conducted during the summer in the North Inlet estuary as well as other marsh sites from Florida to Maryland.

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

Investigators: Juliana M. Harding[1], Dennis M. 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).

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

Investigator: Jennifer Plunket

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

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

Assessing South Carolina estuaries for contamination affecting fish embryogenesis using the Atlantic silverside (*Menidia menidia*)

Investigator: Shannon Davis

Department of Biological Sciences, University of South Carolina

Estuarine environments are often called the "nurseries of the sea" because of their importance in providing a protected environment for fish, shellfish, and marine mammal reproduction. They also filter contaminants from fresh water sources, which could potentially impact fish embryogenesis. The objective of my proposal is to characterize the Atlantic silverside as a model species for identifying estuarine environments that have reduced embryo viability due to contamination. My hypothesis is that Atlantic silverside embryos collected from contaminated estuaries, such as Murrells Inlet, will have a lower percent viability compared to those collected in protected estuaries such as the North Inlet estuary.

Sediment accretion in North Inlet estuary salt marshes

Investigators: James T. 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.

Benthic bivalves as potential indicator species for ecosystem climate change effects

Investigators: Juliana M. Harding[1], Dennis M. 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.

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

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

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

As part of a National Estuarine Research Reserve (NERR) system-wide initiative, the North Inlet -Winyah Bay NERR is monitoring salt-marsh emergent vegetation with the aim of quantifying variability in salt marsh macrophyte community spatial structure (species composition, relative abundance, and biomass) along elevation gradients, from creek bank to upland edge, in response to changes in tidal height and flooding frequency due to sea level rise. Long-term monitoring is conducted in accordance to established NERRS protocols using a stratified sampling approach of fixed transects and repeated measures within permanent sample plots. This consists of two marsh segments with three fixed transects and 8 sampling plots per transect. Surface Elevation Tables (SETs) have also been established adjacent to the lower and higher elevations of the creek-bank to forest-edge transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in and vegetation and tidal dynamics. Sampling within each permanent plot includes: percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by non-destructive sampling techniques; water table height at low tide; porewater salinity, and nutrient and sulfide concentrations. Elevation data (mm scale vertical resolution) for each plot is determined at biannual intervals to allow for the calculation of duration and frequency of tidal inundation at each plot.

Experimental varying of the marsh platform and macrophyte response

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

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

The objective of this study was to design a simple experiment to investigate how varying the marsh platform in relation to mean sea level would affect macrophyte production, stand dynamics, and biomass allocation patterns of salt marsh plants. One specific goal was to ascertain above ground and below ground allocation patterns and quantify where the bulk of below ground biomass was located in relation to marsh elevation and sea level. The experiments were initiated in 2003. Currently there are three marsh planters ('marsh organs'), each with six treatment platform levels that span the upper half of the tidal range, and six replicates per treatment. In general, the marsh organs are planted in March with salt marsh plugs (currently *Spartina alterniflora*) collected nearby; stem height measurements are obtained monthly as an estimate of standing biomass; and plants are harvested at the end of the growing season, to determine above ground and below ground productivity. In recent years, replicates have been selectively harvested such that we now have an age treatment in addition to the elevation treatment. The frequency of inundation results in significant variation in stand densities and plant heights, and we are observing different biomass allocation patterns with time. These changes in stand densities and macrophyte morphology may have profound effects on the ability of salt marshes to accrete allochthonous sediments and maintain pace with sea-level rise. Furthermore, allocation patterns may ultimately influence net annual primary productivity within salt marshes.

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

Investigator: Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Oyster (*Crassostrea virginia*) population biology sets the foundation for maintenance and persistence of the biogenic habitat as well as the associated trophic communities and ecological services. These dynamics respond to a variety of factors functioning at time scales ranging from days to decades. This research describes basic oyster population parameters including recruitment intensity and periodicity as well as density, demographics, disarticulation rates, Dermo prevalence and intensity, biomass, and reef spatial extent at sentinel sites in the Town, Clambank, Crabhaul, Debidue, and Bly Creek basins. Environmental data will be collected concurrently and integrated with the biological data. The integrated data sets will be examined in the context of available historic data and documented environmental changes across decadal time scales.

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

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

1 - South Carolina Department of Natural Resources
2 - South Carolina Department of Health and Environmental Control
3 - NCCOS Charleston Laboratory, National Oceanic and Atmospheric Administration (SC)

The South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) have been conducting an ongoing comprehensive collaborative coastal monitoring program (South Carolina Estuarine and Coastal Assessment Program; SCECAP) since 1999. The goal of SCECAP is to annually monitor the condition of the state's estuarine habitats and associated biological resources. SCECAP integrates measures of water and sediment quality with multiple measures of biological condition at a large number of sites throughout the state's coastal zone. It also expands historical monitoring activities that have primarily focused on open water habitats (e.g., bays, sounds, tidal rivers) to include an assessment of conditions in tidal creeks, which serve as important nursery habitat for many species. The SCECAP program, combined with the other cooperating programs, provides a number of benefits including 1) the ability to identify areas of estuarine habitat that are impaired or degraded with respect to a suite of sensitive biological, chemical, and physical measures; 2) a cost-effective standardized protocol that is used by both SCDNR and SCDHEC that is consistent with protocols used in other US coastal states, thus allowing better regional prioritization of stressors and impacts; 3) more comprehensive periodic reports on the condition of water quality and habitat condition throughout the state's coastal zone than could be accomplished by the individual programs alone. As of August 2020, over 870 sites have been sampled statewide, with 12 located in the North Inlet estuary and an additional 37 sites located in the adjacent Winyah Bay.

Goby and blenny movements, fidelity, and habitat use

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

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

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

Tracking gravid female movements of diamondback terrapins (*Malaclemys terrapin*) in the North Inlet estuary

Investigators: Danielle Capella, Scott Parker

Department of Biology, Coastal Carolina University (SC)

The purpose of this research is to quantify large-scale and small-scale movement patterns and habitat use of diamondback terrapins during the summer activity season. Specifically, we aim to determine if movement and habitat of gravid females differs from males and non-gravid females. This information will help inform future diamondback terrapin conservation efforts.

Shorebird monitoring in the North Inlet estuary

Investigators: Jennifer Plunket[1], Wendy Allen[2], Emma Boyer[2]

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

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

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

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

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

Salt marsh grass (*Spartina alterniflora*) dominates the intertidal marsh in North Inlet estuary. Regular measurements of grass density and height allow for estimates of growth and primary production rates in both control and fertilized plots. Abiotic conditions that are measured include pore water salinity, phosphate, ammonium, sulfide, and iron concentrations to provide insights into factors that affect production. Large monthly and interannual variations in the amount of organic material produced by the cordgrass are related to such factors as sea level and precipitation patterns. This time series was initiated in 1986.

Characterization of oyster cement

Investigators: Jonathan Wilker[1], Paul D. Kenny[2]

1 - Department of Chemistry, Purdue University (IN)
2 - Baruch Marine Field Laboratory, University of South Carolina

Marine species such as mussels, barnacles, and oysters produce adhesive and cement materials for affixing themselves to surfaces. The strong bonding, wet adhesion capabilities, and biological origin of these materials indicate promise for developing new biomedical materials such as surgical glues and dental cements. In an effort to develop such applications, we are beginning by characterizing adhesive materials produced by marine organisms. Prior studies have determined some of the key chemical reactions and bonding motifs used by mussels for production of their adhesive. For the current project, our main objective is to characterize the chemistry within the cement of the Eastern or Atlantic oyster (*Crassostrea virginica*). Oysters are collected near the Baruch Marine Field Laboratory and then grown in laboratory aquaria. Chemical methodologies are used to analyze the cement, including wet chemistry and spectroscopic techniques. Insights gained will provide both fundamental understanding of how a marine biological material functions as well as providing insights for the design of new biomedical adhesives.

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

Investigators: Dwayne E. Porter[1,2], Melissa Ide[3], Jeremy Cothran[2], Julia Britton[3], Tracy Buck[3]

1 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
2 - Arnold School of Public Health, University of South Carolina
3 - Centralized Data Management Office, National Estuarine Research Reserve, University of South Carolina

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

Co-evolution of weapons, armor, vision, and behavior in snapping shrimp

Investigators: Daniel I. Speiser, Alexandra C. N. Kingston

Department of Biological Sciences, University of South Carolina

Complex traits evolve in organismal contexts in which their functions are often linked to the functions of other traits. Thus, traits do not evolve in isolation: changes to any trait are likely to have functional and evolutionary consequences for others. We are using snapping shrimp (Decapoda: Alpheidae), including *Alpheus heterochaelis* from the North Inlet estuary, to investigate how the functions of physiological and behavioral traits co-evolve. Snapping shrimp generate shock waves with their cavitation-producing snapping claws. They use these shock waves to stun or kill other animals. Along with their deadly claws, snapping shrimp have a number of other unique traits. These include an extension of the carapace, termed the orbital hood, that may protect their heads from shock waves. Some species of snapping shrimp have orbital hoods that cover their eyes, suggesting these animals may have impaired vision. To compensate for their vision being impaired, it has been proposed that snapping shrimp engage in behavioral associations with other species, such as goby fish, that help them avoid predators. Our project tests how the functions of the cavitation-producing claws, orbital hoods, visual systems, and behavioral partnerships of snapping shrimp have co-evolved by: 1) examining the relationship between the power of the cavitation-producing claws of snapping shrimp and the protective qualities of their orbital hoods; 2) testing how the protective properties of the orbital hoods of snapping shrimp relate to how well their visual systems perform; and 3) asking if the visual abilities of snapping shrimp influence their shelter-seeking behaviors and whether they engage in behavioral partnerships with other species.

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

Investigators: Peter Key, James Daugomah, Blaine West

Center for Coastal Environmental Health and Biomolecular Research, 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. Long-term monitoring may provide great insight into natural factors such as disease, pests, and weather (e.g., global climate change, drought, floods, and increased intensity of tropical storms and hurricanes), which may affect populations throughout a geographical region. In addition to population perturbations caused by natural stressors, is the complexity of differentiating anthropogenic effects of chemical and biological contaminants in aquatic ecosystems from natural background effects. There is a clear need to develop accurate ecological forecasts using long-term ecological data sets. Long-term ecological monitoring data thus can be used not only to ascertain effects of natural and anthropogenic stressors, but also when properly used in conjunction with GIS and advanced modeling techniques may enhance predictive capabilities. The grass shrimp (*Palaemonetes pugio*) is the dominant motile macrobenthic invertebrate in tidal creek systems of the southeastern United States and is an important prey item for higher trophic levels. The Oyster Landing site within the North Inlet estuary is maintained as a long-term reference site for comparison to estuarine sites with other land uses.

The National Estuarine Research Reserve System Centralized Data Management Office

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

1 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
2 - Arnold School of Public Health, University of South Carolina
3 - Centralized Data Management Office, National Estuarine Research Reserve, University of South Carolina

NOAA's National Estuarine Research Reserve System (NERRS) acknowledges the importance of both long-term environmental monitoring programs and data and information dissemination through the support of the NERRS System-Wide Monitoring Program (SWMP). The goal of the SWMP is to "identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purpose of contributing to effective national, regional and site specific coastal zone management." This comprehensive program consists of three phased components: estuarine water quality monitoring (phase I), biodiversity monitoring (phase II), and land-use and habitat change analysis (phase III). The Centralized Data Management Office (CDMO) was established in support of the System-Wide Monitoring Program involving 29 sites around the US and Puerto Rico. The purpose of the CDMO, housed at the North Inlet–Winyah Bay NERR, is the management of the infrastructure and data protocol to support the assimilation and exchange of data, metadata, and information within the framework of NERRS sites, coastal zone management programs, and other education, monitoring and research programs.

Analyzing the seasonal change of heavy metal sediment content in Winyah Bay estuary tidal marshes

Investigators: Isabel Fangman, Jennifer Hawk

Department of Biology, Chemistry, and Physics, Converse College (SC)

Wetland areas are an extremely vital part of the environment and serve a variety of functions including filtering out pollutants in the water system and providing food sources for humans. Heavy metals can enter the food chain through the wetlands and accumulate in toxic levels in the plants and animals that live there. To help monitor the human influenced stress-levels of heavy metals in the environment, the Environmental Protection Agency (EPA) established the Heavy Metal Index. The goal of this study is to measure the heavy metal content in sediment in tidal marshes of the Winyah Bay estuary on the Hobcaw Barony property in Georgetown, SC. This study will help establish a baseline for the heavy metal content in this area. Sediment samples will be collected from the marshlands and analyzed using Atomic Absorption Spectrometry. The levels of chromium (Cr), lead (Pb), iron (Fe), nickel (Ni), copper (Cu), and cobalt (Co) will be studied over the course of three seasons, specifically spring, summer, and fall, to determine if and how those levels change over the course of the year.

Determining age structure of juvenile tarpon (*Megalops atlanticus*) in nursery habitats in South Carolina estuaries

Investigators: Garrett M. Elmo[1,2], Justin McNabb[1], Matthew E. Kimball[2], Derek P. Crane[1]

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

Recruitment of early life stage tarpon to coastal nursery areas in this region typically peaks during the summer months, and tarpon rear in a variety of marsh habitats that range widely in water quality (e.g., salinity, dissolved oxygen) and physical (e.g., substrate, depth) characteristics. Size differences between juvenile tarpon in natural marsh habitats compared to marsh impoundments (about 2.5 times bigger on average) were documented in fall of 2016 and 2019 in the North Inlet-Winyah Bay estuarine system. These size differences occurred despite larval tarpon recruiting to both habitats around the same time (June). While these size differences may be due to factors such as habitat quality and varying growth rates, discerning the age structure of early life stage tarpon populations in these habitats is a critical first step for understanding recruitment and habitat use patterns, and ultimately determining the underlying mechanisms for such observed size differences. We will estimate the age of juvenile tarpon from natural marsh habitats and marsh impoundments using extracted sagittal otoliths. Prior to processing otoliths for age estimation, dried otoliths will be weighed, as earlier work indicated that otolith weight was positively correlated with age for juvenile tarpon. After weighing, otoliths will be mounted in epoxy and cut into transverse sections containing the core. Sections will then be mounted to a glass slide and polished until daily growth increments are visible. Otoliths will be viewed using a zoom stereo microscope and associated software, and daily increments will be counted and used to determine potential age differences between habitats.

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

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

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

In 2013 we initiated a second study of salt marsh vegetation along an elevation gradient beginning with the most flood tolerant taxon, *Sporobolus alterniflora* and ending with the least flood tolerant taxon, *S. pumilus* was covered with 15-25 cm of wrack, duplicating the natural deposition of wrack on the marsh by tides and storms. Contiguous controls were left uncovered. Generally 6 months were needed for the wrack to decompose and be carried away from the arrays by tides. During this time the buried vegetation was killed. We have monitored the time it takes for the pre-existing vegetation to invade and cover the bare soil where the original vegetation was killed. Generally it takes between 2 and 3 years for the original marsh taxa to invade and cover the wrack impacted sites. By 3 years the salt marsh vegetation on the wrack impacted sites is indistinguishable from the contiguous controls. We have observed that the least flood tolerant taxon, S. *pumilus* has been gradually replaced by more flood tolerant *Borrichia frutescens*, at arrays covered with wrack in an earlier study initiated in 2004. Salt marsh vegetation exists along very narrow elevation gradients. Thus saltmarsh vegetation distribution is an excellent indicator of sea level rise. Gradual sea level rise (3.6mm/year) at this site between 2004 and 2020 accounts for *S. pumilus* being replaced by the more flood tolerant *B. frutescens*.

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

Investigators: Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

Hard clam (*Mercenaria mercenaria*) populations play an ecological and structural role within tidal creek habitats. The population biology and dynamics of hard clams are being quantitatively examined in North Inlet estuary tidal creeks 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.

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

Investigators: Robert P. Dunn, J. Baker Stevens, Julie L. Krask, Tracy Buck

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

As part of the NERR System-Wide Monitoring Program, the physical characteristics of the water in four tidal creeks of the North Inlet -Winyah Bay NERR have been monitored using YSI data loggers since 1994. A new, fifth site in the mainstem of Winyah Bay was added in 2016. These data loggers are deployed at 0.5 m above the sediment surface and record water depth, temperature, salinity, pH, dissolved oxygen, and turbidity at 15 min intervals throughout the year. The site in Winyah Bay has data loggers deployed in both surface and bottom waters to account for the vertical stratification that exists in this location. The instruments are calibrated and deployed according to strict NERRS protocols. The consistent, long-term collection of this physical data allows for the characterization of short-term variability and long-term change in North Inlet and Winyah Bay estuary waters, and provides base-line data critical for various studies of biological and physical processes in these estuaries. Data, along with detailed metadata, are sent to the NERRS Centralized Data Management Office (CDMO) for quality assurance and quality control. Data can be accessed via the CDMO website (http://cdmo.baruch.sc.edu/).

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

Investigators: Kelly Gibson, Sarah Shealy

Department of Biology and Geology, University of South Carolina Aiken

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

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

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

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

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

Heart development and molecular characterization of the teleost *Megalops atlanticus*

Investigators: Haley A. Davies[1], Matthew E. Kimball[2], Aaron J. Adams[3], Frank L. Conlon[1]

1 - Integrative Program for Biological & Genome Sciences, University of North Carolina Chapel Hill School of Medicine
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Bonefish & Tarpon Trust (FL)

The tarpon (*Megalops atlanticus*), a bony, ray-finned fish in the teleost subclass, is a prized game-fish that has been poorly studied. Teleosts comprise the largest subclass of the Actinopterygii class and include 96% of extant fish species. Tarpon fishing for sport is a tourism industry that generates millions of dollars every year for the economies of Central American countries including Costa Rica, Belize, and Panama. In collaboration with the Bonefish and Tarpon Trust and the University of South Carolina Baruch Marine Field Laboratory, our lab has acquired samples to begin characterization studies on this species. Tarpon are one of very few fish to have an obligatory requirement to breathe atmospheric oxygen for at least some portion of its lifespan. We aim to elucidate the mechanisms underlying the intricacies of the co-development of the heart and swim bladder from an evolutionary perspective by characterizing this non-model organism. As the characterization of non-model organisms becomes more feasible with the decreasing costs of sequencing, supplemental comparisons between these non-model organisms with traditional model systems become more possible. Here, as we begin to study tarpon, we describe the general anatomy with whole-mount skeletal visualization and histology. In addition, we performed the first whole tarpon RNAseq paired with de novo transcriptome assembly as well as preliminary proteomic profiling. Preliminary transcriptome assembly revealed transcripts with sequence homology to known cardiac master regulators, such as Tbx5, Gata4, and Nkx2-5. Future directions will investigate more specific aspects of the cardiac and respiratory functions of tarpon.

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

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

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 of 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).

Geographic distribution of gelatinous zooplankton in the North Inlet-Winyah Bay estuarine system

Investigators: Joshua P. Stone[1], Imani Haley[2]

1 - Department of Biological Sciences, University of South Carolina
2 - College of Education, University of South Carolina

The North Inlet-Winyah Bay estuarine system is a dynamic system with short retention times and strong currents. In order to determine the distribution of gelatinous zooplankton within the system, we sampled throughout the North Inlet estuary and parts of Winyah Bay over three weeks in June of 2019. We used surface and epi-benthic zooplankton net tows to collect zooplankton samples that will be analyzed and counted over the fall of 2019 for gelatinous zooplankton abundance. The samples were taken across transects from the mouth of the estuary to the heads of the tidal creeks as well as a mid-estuary location across a full tidal cycle. These data will be used to determine the environmental conditions most favorable to gelatinous zooplankton, as well as the total abundance of gelatinous zooplankton throughout the estuarine system

Petrolisthes armatus density and performance along a latitudinal gradient

Investigator: Jeb Byers

Odum School of Ecology, University of Georgia

Petrolisthes armatus is an invasive tropical crab that has spread throughout the southeastern US in the past decades. Its northern distribution seems to have remained close to the North Inlet estuary for many years, perhaps because the crab is limited by low winter temperatures. We have been latitudinally sampling the crab for the past 2 years to establish information on its distribution and abundance, and also to collect crabs for genetic analyses. In particular we wish to examine whether there is any genetic differentiation in the crab within its invasive range. As the northernmost end point in our latitudinal sampling, the North Inlet estuary is an important spot to include in our analyses.

Investigation into the occurrence of juvenile common snook (*Centropomus undecimalis*), a subtropical estuarine sport fish, in saltmarshes beyond their established range

Investigators: Philip W. Stevens[1], Matthew E. Kimball[2], Garrett M. Elmo[2,3], Kyle L. Williams[4], Jared L. Ritch[1], Derek P. Crane[3]

1 - Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Department of Biology, Coastal Carolina University (SC)
4 - Tequesta Field Laboratory, Florida Fish and Wildlife Conservation Commission

Given recent trends of warming water temperatures and shifting fish distributions, detecting range expansion is important for resource management and planning. The subtropical common snook (*Centropomus undecimalis*; hereafter referred to as snook) is an estuarine species that historically extended from the tropics to southern portions of Florida and Texas, but this range has been expanding for the past decade. We collected juvenile snook (n = 16; size range = 96–210 mm standard length [SL]) in saltmarshes of South Carolina, which is well outside their usual range but not unprecedented. Growth rates of juvenile snook in South Carolina (0.72 mm SL da−1) were similar to those reported for Florida during a cold period, but faster than rates reported for Florida during a recent period of mild winters (0.49 mm SL da−1). Based on collection and estimated hatch dates, and supported by winter water temperature records, juvenile snook overwintered for at least 1 year allowing them to grow to sizes that are typical for emigration from nursery habitats to open estuarine shorelines. Continued work is needed to determine whether there is potential for ongoing range expansion of snook to the region, and a strategy is proposed to focus on future research.

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

Investigator: Patrick Duff

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

Close examination of modern shallow marine deposits can also help us better understand similar ancient deposits, including their internal structure and relationship to other passive margin deposits. A series of Ground Penetrating Radar (GPR) lines, along with vibracore, and a UAS drone survey will be acquired near the Baruch Marine Field Laboratory on Hobcaw Barony, as one field site within the coastal plain of South Carolina to investigate the internal structure and stratigraphy of a variety of a recent shoreface deposit, as well as to serve as an experiment in the application of GPR to sedimentological and stratigraphic research.

Spatial and temporal variation in salt marsh crab communities

Investigator: Robert P. Dunn

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

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

Conservation of diamondback terrapin (*Malaclemys terrapin*) nesting sites in the North Inlet estuary: Using predator vocalization to deter raccoon (*Procyon lotor*) nest predation

Investigators: Colleen Naeger[1], Scott Parker[2]

1 - Department of Coastal and Marine Systems Science, Coastal Carolina University (SC)
2 - Department of Biology, Coastal Carolina University (SC)

Diamondback terrapins experience nest predation from foraging raccoons. The purpose of this study is to determine if predator vocalizations deter raccoons from foraging on diamondback terrapin eggs. The hypothesis is that vocalizations from potential raccoon predators will deter raccoon foraging on diamondback terrapin nests. This study will randomly assign predator, non-predator and no vocalization treatments to a series of nest sites. GEN2 GC350 Programmable Call Machines will project vocalizations (domestic dog barks), while Moultrie® M-880 trail cameras will observe and quantify raccoon foraging behaviors. Expected outcomes are that predator vocalizations will deter raccoon foraging and conserve critical diamondback terrapin nest habitats

The effects of climate change on *Littoraria irrorata* and *Ilyanassa obsoleta* distribution and movement

Investigators: Samantha McClain and Students Engaged in Aquatic Sciences (SEAS)

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

Two types of marsh snail, the marsh periwinkle (*Littoraria irrorata*) and the eastern mud snail (*Ilyanassa obsoleta*), are common to the North Inlet estuary. Data will be collected concerning their size, distribution, and movement throughout tidal cycles. Using environmental data collected by the NI-WB NERR over several years, the effects of climate change, including water and air temperature, on each species of snail will be revealed and will be used to indicate how climate change is effecting the greater marsh ecosystem. Additionally, this project will provide experience in field research and oceanography for the members of the University of South Carolina undergraduate program Students Engaged in Aquatic Sciences (SEAS).

Developing a behavioral bioindicator of habitat health for coastal salt marshes

Investigator: Blaine D. Griffen

Department of Biology, Brigham Young University (UT)

The goal of this study is to compare herding behavior of sand fiddler crabs across marshes with varying levels of human disturbance to determine whether changes in crab behavior can be predictably used as an indicator of marsh health. At 25-30 marsh sites along the coast between Georgetown and Myrtle Beach that experience varying levels of human disturbance, we will measure herding behavior using a simple experiment where a predatory attack is simulated by an individual walking towards a herd. Experiments will be video recorded and later analyzed. In addition, at each site we will assess the level of human disturbance (e.g., distance to roads, infrastructure, amount of foot and road traffic, etc.).

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

Investigators: Robert P. Dunn, J. Baker Stevens, Tracy Buck, Julie L. Krask

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

As part of the North Inlet -Winyah Bay National Estuarine Research Reserve (NERR), a fully functional meteorological station (National Weather Service installation) is located on the Oyster Landing pier in the North Inlet estuary. Wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation are recorded at 15-minute intervals. Data are telemetered via the NOAA GOES satellite system to the NERR Central Data Management Office, and made available in near real time (http://cdmo.baruch.sc.edu). For most parameters, records have been collected for more than 20 years. Long-term, continuous weather records provide data for determining the effects of climatology on the various biological and physical processes being studied in the North Inlet estuary.

The implications of geographic location and intraspecific size variation on *Littoraria irrorata* personality types

Investigators: Christina Salerno, Stephanie Kamel

Department of Biology and Marine Biology, University of North Carolina Wilmington

One of the most abundant and commonly studied invertebrates in southeastern US salt marshes is the marsh periwinkle (*Littoraria irrorata*). Previous research has determined that individual *L. irrorata* exhibit distinct personality types that are consistent over time. This proposed research will further investigate the presence of personality types and examine the effects of snail size, geographic location, refugia presence, and predator presence on individual personality types of *L. irrorata* from four states using a series of experiments. Intraspecific variation of *L. irrorata* personality types can have many ecological implications including predator-prey interactions, community compositions, population stability, and overall marsh health.

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

Investigators: Richard Stalter[1], Joseph Rachlin[2], John Baden[3]

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

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

Juvenile white shrimp (*Litopenaeus setiferus*) can be effectively implanted with passive integrated transponder tags

Investigators: Robert P. Dunn[1] Bruce W. Pfirrmann[2], Matthew E. Kimball[2], Alyssa Chorney[3]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina
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3 - Biological Sciences, Arizona State University

Connectivity among estuarine habitats can influence nekton vital rates, and studying these processes requires the ability to track individuals effectively. Passive integrated transponder (PIT) tags have been used to evaluate movement of juvenile fishes in estuaries, yet this technique remains untested for penaeid shrimp. We evaluated survival, growth, and feeding behavior of juvenile white shrimp (*Litopenaeus setiferus*), an ecologically and economically important penaeid species along the US Atlantic and Gulf coasts, implanted with 8-mm PIT tags. Daily survival and tag retention observations and weekly length and weight measurements were made of tagged individuals (n = 18) kept in individual seawater tanks for 28 days, and compared with similarly housed untagged (control) individuals (n = 18). After four weeks, tagged and control shrimp were offered varying densities of a common estuarine prey item, grass shrimp (*Palaemonetes* spp.), in feeding trials. Tagged white shrimp exhibited 100% tag retention and an estimated probability of survival after 28 d that was not different from control shrimp (0.81 and 0.94, respectively). We found no evidence of a relationship between tagging treatment or initial shrimp size on the probability of survival. Tagged shrimp demonstrated positive growth (increase in total length and weight) at rates similar to control shrimp, and both tagged and control shrimp consumed grass shrimp (*Palaemonetes* spp.) at low but similar rates. Our results suggest PIT tag technology represents an effective tool to study the movement and vital rates of juvenile white shrimp during their estuarine residence.

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

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

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3 - Baruch Marine Field Laboratory, University of South Carolina

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

Assessment of leptocephali and juvenile recruitment of three sympatric species, the Atlantic tarpon (*Megalops atlanticus*) and ladyfish (*Elops saurus*; *Elops smithi*), along the South Carolina coast

Investigators: Garrett M. Elmo[1,2], Derek P. Crane[1], Matthew E. Kimball[2]

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

Estuarine arrival of larval fishes plays an important role in the development and growth of individuals and year classes of fish. Investigating larval recruitment and the factors that affect recruitment (e.g., water quality, climate, and currents) is essential to understanding the early life histories of Atlantic tarpon (*Megalops atlanticus*) and ladyfish (*Elops saurus; Elops smithi*). To investigate the timing of recruitment for these species we sampled three locations in South Carolina (North Inlet estuary, Yawkey, and Kiawah Island), May through November 2019, and sampled one location in South Carolina (North Inlet estuary), April through November 2020. High marsh pools and managed impoundments were sampled using a modified plankton net and a cast net to sample the early life stages of these fishes. Analysis of variance was used to determine if size at arrival, duration of arrival, and densities differed among species and study sites. Distribution of catches was plotted across sites and time to visualize arrival patterns of the three species.

Overwinter survival, age, and growth of juvenile tarpon (*Megalops atlanticus*) in a shallow, tidally restricted upland pond

Investigators: Marvin M. Mace III[1], Matthew E. Kimball[1], Garrett M. Elmo[1,2], Derek P. Crane[2]

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

Early life stage tarpon (*Megalops atlanticus*) have been collected in the western Atlantic Ocean north of Florida where it has been assumed that individuals migrate from estuarine areas at the onset of winter because water temperature during winter is too low for survival. However, there is anecdotal evidence of juvenile tarpon present during winter in this region. We conducted a tag-recapture study to examine potential overwinter survival in a tidally-restricted, upland pond in coastal South Carolina where tarpon have been observed during winter months. We also estimated the age structure of tarpon in this location to determine if age-0 fish were temporarily using this pond or if there were older individuals present, indicating the pond may be occupied for extended periods of time. We recaptured 29 of the 95 individuals tagged and released during January 2016 through October 2018. Of those 29 recaptured individuals, 13 survived one winter and two tarpon. Estimated ages for 36 individuals ranged from 0 to 3 years (n = 10, 20, 5, 1, respectively). To our knowledge this is the northernmost documented overwintering of juvenile tarpon. Determining the extent of this type of habitat in the region and examining the population dynamics of tarpon in these locations could ultimately help determine how this region contributes to the productivity of adult tarpon populations.

Finding the genetic basis of developmental evolution using a marine polychaete.

Investigator: Christina Zakas

Genetics Program, North Carolina State University

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

South Carolina BioDiscovery Biofouling Project

Investigators: Beth Thomas, Hayley Fournier

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

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

Juvenile tarpon (*Megalops atlanticus*) use of natural and managed marsh habitats in coastal South Carolina

Investigators: Garrett M. Elmo[1], Derek P. Crane[1], Matthew E. Kimball[2], Erin Hosto[3]

1 - Department of Biology, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Cornell College (IA)

We investigated juvenile tarpon (*Megalops atlanticus*) use of natural and managed habitats in coastal South Carolina by monitoring recruitment during July – November 2019 in the North Inlet estuary, Kiawah Island, and Tom Yawkey Wildlife Center Heritage Preserve. One-hundred and two juvenile tarpon (36 – 333 mm standard length) were observed during July – November. Tarpon from natural marsh pools (North Inlet estuary; mean ± SD = 65.4 ± 20.2 mm) were smaller than those from managed impoundments (Kiawah Island and Yawkey Preserve; 253.9 ± 41.6 mm), with no overlap in size across habitats throughout the study duration. Mean tarpon length was relatively constant throughout the study in marsh pools (65 mm SL), but mean tarpon length increased from 180 mm SL in August to 289 mm SL in October in managed impoundments. Peak catch-per-unit-effort occurred during August (marsh pools) into September (managed impoundments) across habitat types, and then declined as water temperatures decreased at the end of October into November. The absence of size overlap between habitats and increasing size of tarpon over time in marsh impoundments compared to the minimal change in length over time observed for marsh pools suggests (1) tarpon are transient in marsh pools early in life, (2) tarpon do not enter impoundments until reaching a certain size, (3) small juvenile tarpon are cryptic in impoundments and larger juvenile tarpon are more susceptible to capture in those habitats, or (4) a combination of (1), (2), and (3).

Keystone chemicals: Identifying general and universal molecules of fear

Investigators: Marc Weissburg[1], Lee Smee[2], Julia Kubanek[1], Benjamin Belgrad[2]

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Many prey species adjust their behavior and morphology in the presence of predators to avoid being consumed which can affect numerous community-wide interactions. In aquatic environments, prey often rely on waterborne chemical cues to recognize predators. Although numerous prey species are consumed by the same types of predators, it is unknown the extent chemical cues are unique for specific predator-prey combinations or if some compounds are universally recognized as “molecules of fear” by species. Here, we perform a series of bioassays on two important prey species that share common predators, but have different responses to these predators. While eastern oysters (*Crassostrea virginica*) will change their morphology and increase their shell strength in the presence of predators, mud crabs (*Panopeus herbstii*) alter their behavior and become less active. Bioassays involve extracting urine from common predators, including other crab species and fish that were fed either oysters or mud crabs, and creating several cue mixtures unique to each predator species - diet combination. These mixtures are then regularly applied to cultures of our prey species to cause changes in their morphology and behavior. Compounds within these mixtures are identified through NMR spectroscopy and mass spectrometry-based metabolomics and correlated to the strength of the prey species' response to that mixture. By using metabolomics this work is expected to identify a number of waterborne cues where other approaches have historically failed, and advance our understanding of the chemical nature of a wide range of ecological interactions.

Blood parasites in squamates in the southeastern United States: diversity and genetic structure

Investigators: Vince Connors[1], Viki Majlathova[2], Igor Majlath[2], Isaure de Buron[3], Eric McElroy[3]

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2 - Institute of Biology and Ecology, Pavol Jozef Šafárik University in Košice, Slovak Republic
3 - Department of Biology, College of Charleston (SC)

This project focuses on the blood parasites of squamates (lizards and snakes) and their potential transmission to mammalian hosts, including humans, via ticks. The goal is to identify and outline the diversity of host blood parasites and ticks that infect squamates in the southeastern USA using molecular and morphological analysis. Squamates will be hand captured and released after tick and blood samples are obtained.

Diets of juvenile tarpon (*Megalops atlanticus*) from South Carolina estuaries

Investigators: Justin McNabb[1], Derek P. Crane[1], Matthew E. Kimball[2], Juliana M. Harding[3]

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

Atlantic tarpon (*Megalops atlanticus*) are a saltwater fish found in nearshore and estuarine subtropical and tropical waters along the US Atlantic coast, often along the South Carolina coast during summer months. Juvenile tarpon inhabit the managed impoundments and natural high marsh pools within South Carolina, and we investigated their diets within these habitats. Our research focused on tarpon within the North Inlet-Winyah Bay estuarine ecosystem to try to better understand the possible ontogenetic shifts in diets of age-0 tarpon during their typical period of residency in these estuaries. We examined stomach contents of 385 tarpon collected August-November 2015, 2016, and 2019. Comparisons across tarpon size classes indicated that variability in prey size increased with fish length and that tarpon transition to piscivory early in life.

Response to COVID-19 field research and education disruptions: Creating virtual field experiences in coastal and estuarine science

Investigators: Robert J. Hougham[1], William H.J. Strosnider[2], Katherine D. Ryker[3], Damon P. Gannon[4], Zoe Goodrow[1], Emily G. Baumann[3], Bruce W. Pfirrmann[2], J. Kyle Houser[2], Matthew E. Kimball[2]

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3 - School of the Earth, Ocean, and Environment, University of South Carolina
4 - University of Georgia Marine Institute

The pandemic has dramatically impacted the educational landscape in the United States and globally, radically limiting enriching educational experiences for undergraduates and high school students. There is a pressing need to develop educational content and experiences that not only mitigate the loss of in-person learning, but also outdoor, field-based learning. Field stations are uniquely pressed with not only serving as laboratories, but also educational venues that need to fully consider both the research as well as the educational front when they reopen their doors to a world changed by COVID-19 as recently noted in Science. We are addressing this problem by bringing accessible, engaging, and rigorous science experiences to learners virtually by developing a suite of estuarine field experiences polished for distance-delivery in undergraduate programs that use marine field laboratories from New York to Texas. These experiences will consist of 10 modules, each focusing on a particular estuarine ecology topic and feature research projects, datasets, prompts, and worksheets to support science learning. The modules will also be modified for delivery to high school students as virtual modules usable by outdoor education centers and schools. It is critical to address this educational shortfall rapidly as the COVID-19 limitation of field experiences will persist through summer and fall of 2020, and likely through the spring and summer of 2021, de-coupling a cohort of future scientists and stewards from critical educational engagement.

Salt marsh seasons phenology monitoring - community science project

Investigator: Jennifer Plunket

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

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

Listen In: Acoustic monitoring of estuarine communities facing ecosystem change

Investigators: Matthew E. Kimball[1], Robert P. Dunn[1,2], Eric W. Montie[3]

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Passive acoustics (hydrophones) are effective for monitoring underwater soundscapes across a range of biological complexity (shrimp, fish, mammals), while active acoustics (sonar) can noninvasively quantify patterns of organismal abundance, distribution, and behavior across complementary spatial and temporal scales. By combining acoustic data with traditional environmental monitoring, scientists and managers can identify key habitats for protection and measure how ecological communities respond to environmental changes (e.g., storm events, coastal development, eutrophication) in a cost-effective and low-impact manner. This project will bring together academic leaders in bioacoustics, estuarine ecology, and fisheries ecology with managers and staff from three NERRs that "book-end" the entire southeastern coast of the United States. Our goal is to develop the framework for a new acoustic monitoring program that can be integrated within long-term monitoring (e.g., SWMP), targeted research (e.g., hurricane impacts), stewardship (e.g., protected area designations) and education programs (e.g., TOTE) of NERRs throughout the region. This framework holds great potential to address priority management needs of regional NERRs associated with climate change, water quality, and habitat restoration. The project will also engage state fishery managers in each region as end-users to ensure the designed framework informs their efforts to manage coastal habitats, species, and fishery resources.

The physiological limits and response of *Doriopsilla pharpa* to rapid changes in temperature and salinity in specimens from the North Inlet estuary, SC

Investigators: Brittany DeArmitt[1], James L. Pinckney[2], Juliana M. Harding[3]

1 - School of Earth, Ocean, and Environment, University of South Carolina
2 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina
3 - Department of Marine Science, Coastal Carolina University (SC)

With climate change altering environmental conditions, specifically increasing sea surface temperatures and decreasing salinities, it is essential to understand how organisms and ecosystems will react. This project will look at the physiological limits and the response of *Doriopsilla pharpa*, or the lemon drop sea slug, to rapid changes in temperature and salinity. *D. pharpa* specimens and specimens of their food source, *Cliona celata* (sulfur-burrowing sponge) will be collected in the fall of 2020 and the spring of 2021 from the North Inlet Estuary, SC, primarily near Clambank Landing. The specimens will be brought back to the University of South Carolina wet lab where they will be exposed, along with their lab offspring, to a range of salinities and temperatures that include values above and below the estuary's range for 72 hours. The length, wet weight, biovolume and for those that perish, the dry weight of the nudibranchs will be measured to evaluate growth. The respiration rate and Q10 level will be measured so that the physiological stress of the organism in the treatment conditions can be evaluated. The percent survival will be also be evaluated. It is expected that *Doriopsilla pharpa* will have a wide, concave curved relationship with increasing temperatures and with decreasing salinities that will include an optimal range for growth, respiration rates, and survival. This research will help to predict how *D. pharpa* will react to the predicted climate change temperatures and salinities and if it will be possible for them to survive as a species.

Detection and characterization of *Vibrio* spp. from the environment

Investigators: Karlen E Correa Velez, Ryan Leighton

Arnold School of Public Health, University of South Carolina

Our research at the Baruch Marine Field Lab has as the main goal isolate *Vibrio* strains from an environmental water sample. An ISCO 6700 sampler will be set up in the Oyster Landing Dock to collect water samples each 15min for a period of 24hrs. The water samples for the high and low tide periods will be combined and used to isolate *Vibrio* strains. The isolated strain will be expose to different temperatures and salinities to assess how climate-linked environmental factors can affect the *Vibrio* growth. The research aims to better understand the influence of environmental changes on the *Vibrio* spp. abundance and distribution.

Long-term patterns in juvenile brown (*Farfantapenaeus aztecus*) and white (*Litopenaeus setiferus*) shrimp occurrence, phenology, and growth in a warm-temperate estuary

Investigators: Kaitlin Glover[1], Matthew E. Kimball[2], Bruce W. Pfirrmann[2], Marvin M. Mace III[2]

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For nearly 40 years, biweekly (every two weeks) nekton collections have been made within the North Inlet estuary, a warm-temperature, salt marsh-dominated estuary in South Carolina. Though methods and locations have varied slightly over time, this near continuous, still-ongoing, 38-year record provides a unique opportunity to investigate long-term patterns in juvenile nekton habitat use, occurrence, and growth in association with environmental conditions. Here, we combine data from three discrete but related seine collections from the same intertidal creek basin to evaluate patterns in occurrence, phenology, and growth of brown (*Farfantapenaeus aztecus*) and white (*Litopenaeus setiferus*) shrimp. The goal of this project is to examine long-term brown and white shrimp population demographics and growth in estuarine nursery habitats. Specifically, we used the 35-year long-term record (1984-2018) of juvenile brown and white shrimp abundance and length from the Oyster Landing intertidal creek basin to examine changes in juvenile shrimp phenology, abundance, size, and growth both seasonally and annually. In addition, we also take preliminary steps to evaluate the association between any observed patterns in these shrimp populations with environmental conditions (e.g., water temperature and salinity fluctuations, storm events, etc.) observed throughout the 35-year study period. This avenue of research will help us better understand the function of this important estuarine nursery habitat for brown and white shrimp, as well as other similar transient estuarine fishes and invertebrates in this region as well as other estuaries throughout the US Atlantic and Gulf coasts.

Influence of urea and temperature on cyanobacteria in a stormwater detention pond

Investigators: Halley Carruthers[1], James L. Pinckney[2]

1 - School of Earth, Ocean, and Environment, University of South Carolina
2 - Belle W. Baruch Institute of Coastal and Marine Science, University of South Carolina

The primary goals of this study are to analyze changes in community composition and quantify photosynthetic efficiency (PE) of phytoplankton from summer to fall in response to urea $CO(NH_2)_2$, and changes in temperature. These effects will be tested using nutrient addition bioassays under a 72 hr incubation conducted every 14-days. Measurements will be made on water samples taken from an SDP located in Murrells Inlet, SC, to assess nutrient concentrations, photopigment concentrations, and photosynthetic efficiency. Similar studies have looked at the long-term changes in phytoplankton composition, along with only studying cultured organisms. However, this study will be looking at the effects of nutrients and temperature on natural communities, and on a smaller time scale. We are expecting a positive correlation between cyanobacteria growth with temperature and for growth to be the highest under urea nutrient conditions. We are also expecting to see the highest PE measurements under the urea and urea + phosphorus & silica treatment groups relative to the control.

Localization of soniferous fish using a sparse hydrophone array and conventional steered response power method

Investigators: Phillip M. Deville[1], Mark W. Sprague[1], John Kenney[1], Gregory Lapicki[1], Joseph Luczkovich[2]

1 - Department of Physics, East Carolina University (NC)
2 - Department of Biology, East Carolina University (NC)

A sparse seven-channel hydrophone array was deployed in intertidal marsh creeks located within the North-Inlet-Winyah-Bay Nature Reserve at Baruch Marine Field Laboratory in Hobcaw Barony, Georgetown, South Carolina, USA for the purpose of localizing the sounds produced by local fish and invertebrates. A conventional approach to localize sound sources was used, consisting of a delay-and-sum beamforming algorithm known as steered response power (SRP) applied to the seven-channel array data during post-processing. This was accomplished by delaying the signal recorded by each channel and combining the signals to “listen" to sounds propagating through the array from candidate source locations. The power of the combined signal was maximized, yielding a likely location for the source position. Two-dimensional localization of the soniferous fishes is possible, with a reasonable degree of robustness to noise and aliasing effects of spatial under-sampling. Accuracy is limited due to field measurements and the number of sound producers in the area.

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

Investigators: Annamaria Deitz[1], Juliana M. Harding[1], Matthew E. Kimball[2], Bruce W. Pfirrmann[2]

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

Estuaries provide important nursery habitat for juvenile transient nekton. Integrated seasonal descriptions of abundance, growth, age, and energy flow are required for a comprehensive assessment of organism-habitat interactions. These interactions aid in establishing a baseline for ecosystem-based management, Essential Fish Habitat (EFH), in particular. Biweekly juvenile transient fish collections from Oyster Landing Creek are being used to quantitatively evaluate seasonal trends in abundance, demographics, age, and standard biological condition indices. *Leiostomus xanthurus* (spot), *Mugil cephalus* (striped mullet), and *M. curema* (white mullet) 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 North Inlet estuary to potentially serve as a reference estuary for EFH evaluations in other locations using these juvenile transient nekton.

Examining potential inhibitory effects of swamp water DOM additions on phytoplankton growth in North Inlet estuary, SC

Investigators: Adriana Webb[1], James L. Pinckney[2], Annie Bourbonnais[1]

1 - School of Earth, Ocean, and Environment, University of South Carolina
2 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

The primary goal of this project is to investigate possible inhibitory effects of swamp water dissolved organic matter (DOM) on the growth on phytoplankton communities in the North Inlet estuary, SC. The objective is to measure the response of the phytoplankton community composition to DOM and ammonium additions at monthly intervals during spring 2021, using phytoplankton samples collected from Oyster Landing. To accomplish this, three different treatment additions to phytoplankton samples, as well as a control, will be measured over the course of 72 hours. These treatment additions include swamp water DOM, an ammonium solution, and swamp water DOM plus the ammonium solution. Use of these treatments will provide insight on if swamp water DOM contains inhibitory elements or not based on the outcome of the DOM plus ammonium samples. This project is significant because with the rise of global temperatures, rainfall along the US East Coast is expected to increase significantly in the coming decades. This will lead to increased terrestrial runoff and, consequentially, rises in DOM additions to coastal waters. There is still much unknown about how these DOM increases are affecting phytoplankton; therefore, this project will provide insight on if the growth of phytoplankton is indeed stunted. In this experiment, it is expected that the ammonium treated samples will experience phytoplankton growth over the 72-hour incubation, but that the DOM and the ammonium plus DOM treated samples will see no significant growth.

Anthropogenic alterations of nitrogen loading induce phosphorus limitation of estuarine phytoplankton

Investigators: Sarah Humphrey[1], James L. Pinckney[2], Erik M. Smith[3]

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

The purpose of this research is to determine the effects of nitrogen loading inducing phosphorus limitation on phytoplankton in two different estuaries, Murrells Inlet and North Inlet. Murrells Inlet is an estuarine system approximately 14 miles south of Myrtle Beach, South Carolina, an urbanized and highly developed tourist destination. The North Inlet estuary is a protected research reserve in Georgetown, South Carolina, and not surrounded by development like Murrells Inlet. Phytoplankton in these systems are historically limited by the available nitrogen in these waters, and by manipulation of typical Redfield ratios, it is possible to induce phosphorus limitation for these phytoplankton. It is crucial to understand how phytoplankton from a much more developed and urbanized area respond to induced phosphorus limitation compared to those of the North Inlet estuary, a much more natural system. This research could lead to future understanding of how the estuarine system could change if urbanization and tourism increased in Georgetown surrounding the North Inlet estuary.

Elucidating the mechanisms of dissolved oxygen impairment in the Waccamaw River, SC

Investigators: Curtis Szewczyk[1], Erik M. Smith[2], Claudia Benitez-Nelson[1]

1 - School of Earth, Ocean, and Environment, University of South Carolina
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The occurrence of low dissolved oxygen (DO) is a widespread concern for aquatic systems, especially within coastal zones. The blackwater, carbon-rich Waccamaw River, is an example of a body plagued with annual DO impairment during summers. The goal of this research is to investigate how increasing temperatures and nutrient loading can impact the rate at which microbial respiration consumes DO, thus further exacerbating DO impairment in these waters. Additionally, the potential for sites of varying organic matter (OM) lability to vary in their sensitivity to these proposed mechanisms of DO impairment will be explored. Sample collection will occur within the Waccamaw River, nearby forested wetlands (mostly terrestrial, refractory OM), and stormwater detention ponds (mostly aquatic, labile OM) to explore any quality-sensitivity relationship in the OM pools. Samples will be incubated for 5-days across different temperature and nutrient addition treatments and DO will be tracked over this incubation period. Findings from this work will inform stormwater managers and scientists concerned with DO impairment, and with ongoing climate change leading to higher temperatures and more extreme precipitation events, this information may prove vital. We expect that warming will lead to higher rates of DO consumption across sites, but those characterized by more refractory organic matter will show higher sensitivity, using Q10 temperature coefficient measurements. Additionally, nutrient loading to our carbon-rich systems may support higher rates of respiration. Overall, this research will be insightful for the understanding of DO impairment in coastal regions and its potential mechanisms.

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

Investigators: Juliana M. 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. Brief squid biology, demographics, age structure, and growth rates are being quantitatively examined in North Inlet estuary within and across years. Squid biological measurements are being 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.

Zooplankton community structure and grazing within stormwater detention ponds near North Inlet estuary, SC

Investigators: Kristen Laccetti[1], James L. Pinckney[2]

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Stormwater detention ponds (SDPs) on the coast of South Carolina have become increasingly prevalent as the area experiences rapid urbanization. SDPs are man-made reservoirs of standing water that were first implemented to provide stormwater storage to control runoff and enhance stormwater quality to minimize pollution inputs into receiving waters. Zooplankton have been well documented in trophic interactions through grazing experiments with phytoplankton in many ecosystems, including ponds. Zooplankton can act as a top down control on phytoplankton through grazing, possibly preventing or reducing HABs. In addition to this, zooplankton act as a good water quality indicator due to their quick response times. Biological and chemical features of an aquatic system, such as food availability and salinity, have a large effect on zooplankton community composition in certain environments. This proposal aims to determine the seasonal variability in zooplankton community composition and grazing rates at 14-day intervals in one SDP located in Murrells Inlet, SC. Zooplankton and phytoplankton interactions in stormwater detention ponds are an essential component for understanding community dynamics in SDPs.

Quantifying the impacts of recreational harvest on mobile oyster reef fauna

Investigator: Robert P. Dunn

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

In September 2020, a pilot study was initiated to investigate the effects of fishery harvest ('oyster picking') on mobile oyster reef fauna. At three oyster reef locations within North Inlet estuary which span a range of fishery harvest, I have deployed oyster shell baskets buried into the reef matrix. Shell baskets are made of the bottom of a plastic basket which hold loose, weathered oyster shells, and shell baskets are left in the field for ~4 weeks and then swapped. Mobile fauna that inhabit oyster reefs colonize the shells and sediment that accumulate within the basket. After 4 weeks in the field, these organisms are sieved from the shells and mud. These initial deployments will provide baseline with the goal of expanding this reef monitoring program as time and resources allow. Ultimately, this project will contribute to the implementation of ecosystem-based management via enhanced understanding of the effects of a culturally important recreational fishery on target and non-target ecosystem components.

Phytoplankton monitoring - community science project

Investigators: Jennifer Plunket, Maeve Snyder

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

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

Mosquitoes of the Carolinas

Investigator: Brian Byrd

School of Health Sciences, Western Carolina University (NC)

The overall project seeks to monitor the presence of native and invasive mosquito species in NC and SC. Particular focus is on the spread of traditionally southern species that may be moving north and the presence of invasive mosquito species. Hobcaw Barony represents an ideal collection and monitoring site with more than 20 known mosquito species obtained by the principal investigator during previous collections. The mixed land use and land classifications at Hobcaw provide reliable locations for the collection of salt marsh, permanent and semi-permanent freshwater wetland mosquito species. Mosquito specimens will be obtained by larval sampling, aspiration, and light traps.

Validity of daily and annual age estimation and back-calculation methods for early life stages of a subtropical-tropical species, the Atlantic tarpon (*Megalops atlanticus*)

Investigators: Garrett M. Elmo[1,2], Derek P. Crane[1], Matthew E. Kimball[2], Philip W. Stevens[3], Kyle L. Williams[4]

1 - Department of Biology, Coastal Carolina University (SC)
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission
4 - Tequesta Field Laboratory, Florida Fish and Wildlife Conservation Commission

Understanding early life history processes (e.g., growth) for fishes is critical because they can affect other life history characteristics (i.e., age at reproduction, migration). Additionally, habitats used by young fishes are often the target of conservation and restoration efforts and growth has been proposed as a metric for evaluating the quality of habitats. Accurate estimates of growth rely on the validation of aging and back-calculation methods, which in turn allow for informed fisheries management decisions. We used oxytetracycline to chemically mark juvenile tarpon (*Megalops atlanticus*) for an annual increment validation study, a controlled back-calculation validation study, and a controlled daily increment periodicity study. Oxytetracycline marks were realized on all the otoliths of recaptured tarpon (n = 22), prior to a newly formed annulus, validating true age and that one annulus is deposited yearly. However, annuli in scales were more easily identified by readers, thus leading to more accurate and precise estimates of age from scales (100% accuracy of age estimates for age-1 fish) compared to otoliths (88% accuracy). Marginal increment analyses indicated that tarpon annuli are deposited in the spring (March-April) on juvenile tarpon scales and otoliths. Back-calculated lengths from otoliths were significantly different compared to measured lengths, and bias of length estimates differed between months. Daily increment estimates from otoliths were relatively accurate during September but not during October, leading to mean error of 21 d (37% error) across the 56-d study period. Results from this study highlight the importance of validating age estimates for juvenile fishes, particularly for subtropical and tropical species that have protracted spawning seasons.

Research to operationalize the use of UAS in wetland monitoring in support of the NOS/NERRS science mission

Investigators: Erik M. Smith[1], Jenny Davis[2], Brandon Puckett[3], Justin Ridge[4]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina
2 - Beaufort Laboratory, National Centers for Coastal Ocean Science, NOAA (NC)
3 - North Carolina National Estuarine Research Reserve
4 - Duke Marine Laboratory, Duke University (NC)

A core mission of NOAA's National Ocean Service includes stewardship of sensitive coastal habitats like those of the National Estuarine Research Reserve System (NERRS). To fulfill this mission, the NERRS has made substantial investments in monitoring tidal wetlands for change detection. To date this has largely involved labor-intensive ground-based sampling conducted at relatively course temporal and spatial scales. The current project is a coordinated effort among the National Ocean Service's National Centers for Coastal Ocean Science (NCCOS), NERRS, and Duke University to develop protocols for the collection of high-resolution wetland monitoring data based on imagery acquired by Unoccupied Aerial Systems (UAS), which can complement and expand current national monitoring efforts. Project goals include assessing the efficacy of UAS-based imagery for estimating common monitoring parameters (e.g., percent cover), delineating boundaries/ecotones, generating digital elevation models, and estimating vegetative biomass. UAS image collection and field sampling for the North Inlet - Winyah Bay NERR component of the work will leverage the Reserve's long-term marsh monitoring efforts in the Crab Haul Creek basin of the North Inlet estuary. The work involves a systematic analysis of the impacts of image collection practices and data processing techniques on the accuracy of image-based products. This effort will result in the production of standardized protocols and best practices for the incorporation of UAS in wetland monitoring in the NERRS and beyond. Anticipated outcomes include expansion of technical UAS capacity within NOS/NERRS and improved ability to detect and quantify change in wetland habitats.

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

Investigators: Xuefeng Peng[1], Bruce W. Pfirrmann[2], William H.J. Strosnider[2], James L. Pinckney[3]

1 - School of Earth, Ocean, and Environment, University of South Carolina
2 - Baruch Marine Field Laboratory, University of South Carolina
3 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

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

Variability in sediment organic matter concentrations along a tidal inundation gradient in Crabhaul Creek, North Inlet estuary.

Investigators: Erik M. Smith[1], Claudia Benitez-Nelson[2], Heather Kish[2], Brittany Morse[1]

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina
2 - School of Earth, Ocean, and Environment, University of South Carolina

Salt marshes are known to bury and store substantial amounts of organic carbon and thus play a critical role in global carbon cycling and the sequestration of atmospheric CO_2. The degree to which marsh sediment organic carbon concentrations vary over small spatial scales within individual marshes, and how this may be changing over time as a result of increasing sea level rise rates, remains poorly known. To address this knowledge gap, small-scale spatial variability in sediment organic carbon concentrations is being quantified along gradients of tidal inundation and marsh vegetation community composition from creek bank to upland forest edge. This project is leveraging the NERR's long-term monitoring infrastructure in the Crab Haul Creek basin of the North Inlet estuary. Triplicate sediment cores were collected adjacent to the 53 permanent NERR monitoring plots in summer of 2020 and sectioned at 0-10, 10-20 and 20-30 cm depth intervals. Sediment samples are being analyzed for bulk density, organic carbon, total nitrogen and phosphorus, percent organic matter, and sediment grain size. Sampling in 2020 for sediment bulk density, organic carbon and grain size analysis repeats identical efforts conducted in the summer of 2010. Comparisons between years will allow an assessment of potential change over a decade of increasing tidal inundation along the marsh elevation gradient. Results of this study will improve understanding of variability in marsh carbon storage, the factors that influence this variability, and potentially how this is changing over short-term increases in sea level. This information is essential for informing strategic initiatives involving the value of marshes in carbon emission reduction scenarios.

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

Investigators: Juliana M. 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.

Painted bunting (*Passerina ciris*) breeding survey

Investigators: Jennifer Plunket[1], Wendy Allen[2], Bill Brabson[2], and Marlene Konsek[2]

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

The project goal is to estimate of 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 2019 marked the second year of this survey. The plan is to continue this breeding bird survey of painted buntings each year so that changes in numbers can be detected for this species of high concern in South Carolina. The point count methodology is consistent with North American Breeding Bird Surveys and a population assessment of painted buntings conducted in the southeast, 2007-2009, thus allowing for comparisons with other studies.

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

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

1 - School of the Earth, Ocean, and Environment, University of South Carolina
2 - Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

The objective of this study is to remotely monitor the ocean surface currents and waves in Long Bay using two high frequency (HF) radar stations. Scientists from the University of South Carolina operate and maintain two US IOOS/SECOORA identified priority WERA system radar sites (Georgetown, SC and Fort Caswell, NC). One station is located on Hobcaw Barony (33°21'19.60"N, 79° 9'12.56"W) and the other station is located at Caswell Beach, NC (33°53’25.18”N, 78° 1'40.64"W). Each station remotely measures the surface ocean currents up to 120 miles offshore and when combined, create maps of temporal and spatial distribution of waves and currents over the entire Long Bay area. Data from these sites are sent to SECOORA and National High Frequency Radar Network for integration, display, and dissemination.

Experimental tests of post-release habitat selection by hatchery-reared juvenile red drum

Investigators: Bruce W. Pfirrmann[1], Robert P. Dunn[2], Matthew E. Kimball[1], Erin M. Levesque[3], Caitlin O'Brien[4]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina
3 - Waddell Mariculture Center, South Carolina Department of Natural Resources
4 - University of North Carolina Chapel Hill

Habitat restoration and stock enhancement programs are crucial pillars of sustainable fisheries management, yet the intersection between these efforts remains an open question for many habitats and finfish fisheries. We investigated the habitat preferences of a hatchery-reared finfish red drum (*Sciaenops ocellatus*) across habitat gradients commonly found within estuarine seascapes using experimental mesocosms. Juvenile (fingerling, ~ 40 mm) red drum were sourced from the South Carolina Department of Natural Resources (SCDNR) Waddell Mariculture Center in Bluffton, SC, and held in the Baruch Marine Field Laboratory's flow-through seawater system. In a series of three experiments, we presented newly released red drum with a choice between 1) *Spartina alterniflora* salt marsh vegetation and high relief oyster shell, 2) *S. alterniflora* and high relief oyster shell in the presence of a common estuarine predator (blue crab), and 3) *S. alterniflora* and low relief oyster shell in the presence of a predator. Red drum selected for high-relief oyster shell over *S. alterniflora* in both the presence and absence of a predator, yet did not significantly select for either for low-relief oyster shell or *S. alterniflora*. These results suggest that the presence of high relief oyster shell, representative of a healthy restored or natural oyster reef, may enhance the initial post-release survival or growth of hatchery-reared red drum. Our findings could improve ongoing stock enhancement efforts in South Carolina by informing the selection of release sites in estuarine seascapes.

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