Current Research, Monitoring, and Education Projects
2017 – 2018

Introduction

The Baruch Marine Field Laboratory (BMFL) has been the center of research activities for scientists and students from the University of South Carolina 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 2000 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 62 projects currently being conducted at Hobcaw Barony, North Inlet Estuary, and Winyah Bay by staff, graduate students, and faculty associated with the University of South Carolina and other institutions. The University of South Carolina is the home institution for 40 of the investigators while 65 investigators representing 27 other institutions and agencies are carrying out projects at the 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) at Hobcaw Barony, North Inlet Estuary, and Winyah Bay along with a project summary that includes the title, investigators, affiliations, and 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).

Funds for these research projects are provided by a variety of sources, including the National Science Foundation (NSF), Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA) National Estuarine Research Reserve System (NERRS), SC Sea Grant Consortium, US Department of Energy (US DOE), US Department of Defense (DoD), Office of Naval Research (ONR), National Aeronautics and Space Administration (NASA), Slocum-Lunz Foundation, Nemours Wildlife Foundation, South Carolina Independent Colleges and Universities, and the SC Department of Health and Environmental Control (SC DHEC). The Friends of the Institute, an independent organization that supports Baruch Institute activities, also provides assistance and the Belle W. Baruch Foundation provides the long-term stewardship of Hobcaw Barony, maintaining it in a natural state for research and education.

For more information, please contact the individual investigator(s) or Dr. Matthew E. Kimball. Bruce W. Pfirrmann facilitates researcher use of the BMFL and is available for training and assistance. All BMFL staff can be contacted at 843-546-3623. Information can also be obtained from the Institute's website (www.baruch.sc.edu).

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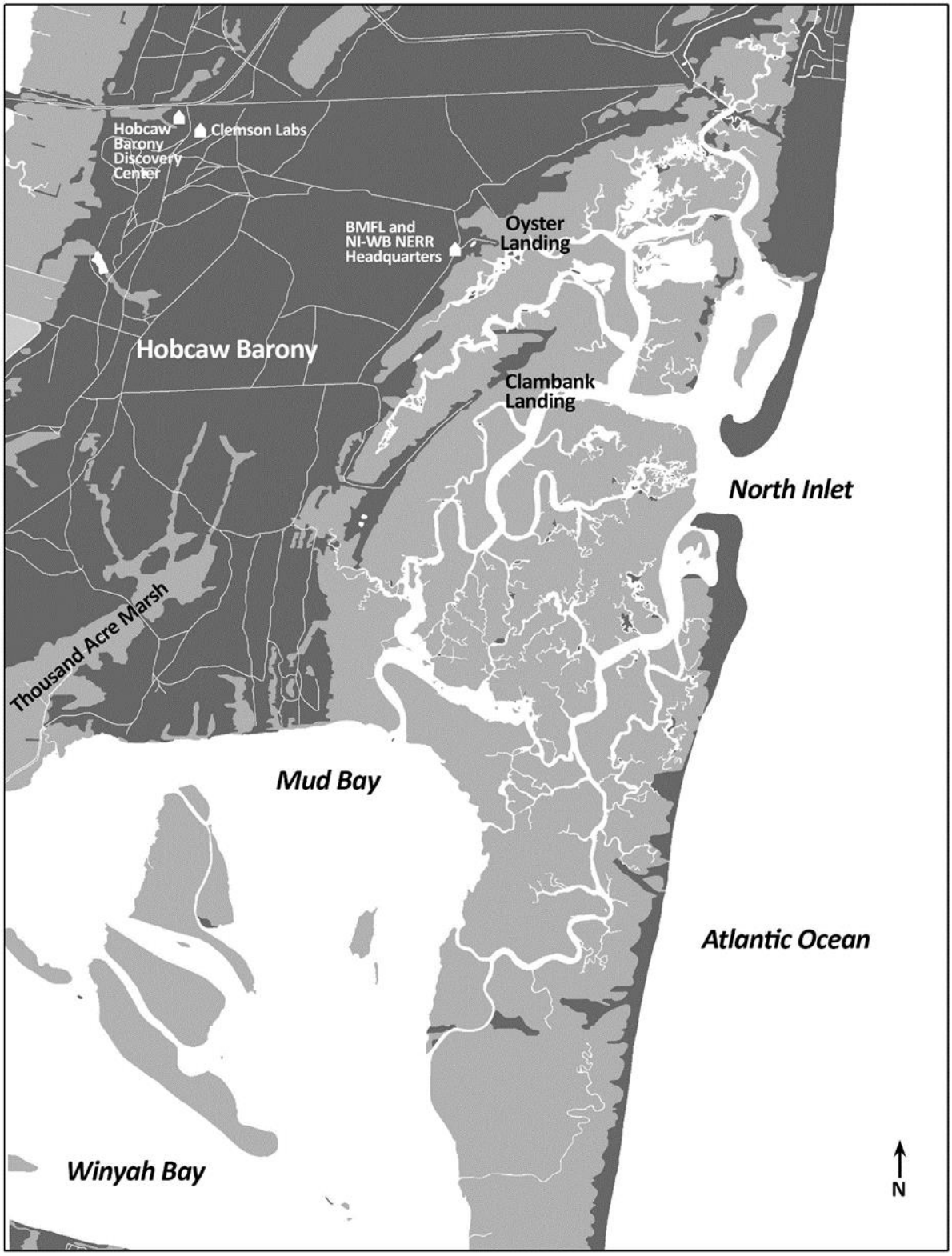
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Fluorescent dissolved organic matter dynamics in the North Inlet estuary

Investigators: Dr. Erik M. Smith, Tracy Buck, and Susan Denham

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.

Ecological role of bottlenose dolphins in North Inlet estuary and adjacent waters

Investigators: Dr. Rob Young and students

Department of Marine Science, Coastal Carolina University (SC)

This long-term project, begun in September 1997, has investigated various questions related to the ecological role of bottlenose dolphins in the North Inlet and Winyah Bay estuaries. As surface-associated apex predators, dolphins are a highly visible indicator species for movements in the prey community and potential system-wide changes. Using photo-ID and focal follow and transect surveys, we have identified long-term resident dolphins in both North Inlet and Winyah Bay estuary. This information is used to model the trophic role of dolphins within the system, to model the potential impact of dolphins upon prey populations, and to examine resident dolphin bioenergetics, social structure, and behavior. Our initial studies have determined that the dozen or so resident dolphins in the North Inlet system consume a significant proportion of the prey fish populations (11-14 metric tons per year) and that 3-7% of the annual primary production in North Inlet estuary is required to support them. Dolphin distribution in North Inlet estuary has been correlated with changing patterns of salinity and prey distribution, and in Winyah Bay it has been correlated with salinity and bottom type. Mothers with young calves apparently favor low current areas, and salt marsh residents swim slower and expend less energy while traveling than coastal dolphins. For future research, we hope to address the genetics and parentage of North Inlet and Winyah Bay dolphins.

Sea turtle nest monitoring on Hobcaw Barony

Investigators: Betsy Brabson[1], Robin Baughn[1], Wendy Allen[2], and other volunteers

1 - DeBordieu Colony (Debidue Beach Coordinators), SC
2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Nesting activity of the threatened loggerhead sea turtle, *Caretta caretta*, on the Hobcaw Barony portion of Debidue Beach has been monitored by trained volunteers, May-October, since 1992. This 2.2 miles of undeveloped beach, owned by the Belle W. Baruch Foundation, provides important nesting habitat for sea turtles and shorebirds. Volunteers walk the beach each morning during the turtle nesting and hatching period, record information on false crawls and nests, and protect nests from predators with screening. Nests laid in areas subject to tidal flooding are carefully relocated to higher areas. Volunteers also inventory nests 72 hours after the major hatch has occurred to determine hatching success of each nest. Inventories, usually conducted in the evening, typically draw large crowds of interested visitors and provide excellent opportunities to educate others about sea turtles. The volunteers are members of the South Carolina United Turtle Enthusiasts (SCUTE), which covers the northern beaches of the state, from Hobcaw Beach to North Myrtle Beach. Debidue Beach (Hobcaw Beach to Pawleys Inlet) typically accounts for 30-50% of all nests in the north coastal region. Reports summarizing nesting activity and success for Debidue Beach and the entire SCUTE region are prepared and submitted to the South Carolina Department of Natural Resources which oversees the volunteer sea turtle program for the state. Data are also entered and available on the www.seaturtle.org website, and include information on a DNA study to track the nesting behavior of individual turtles.

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

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

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

The vascular flora present in three abandoned rice fields of the Winyah Bay estuary at the Belle W. Baruch Institute for Marine and Coastal Sciences, 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 *Phragmites 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.

Fish and crustacean use of marshes and intertidal creeks: Population and community level changes and relationships with weather and climate-driven changes in conditions within the nursery

Investigators: Dr. Matthew E. Kimball, Dr. Dennis M. Allen, and Paul D. Kenny

Baruch Marine Field Laboratory, University of South Carolina

Collections of nekton (fishes, shrimps, and crabs) have been made in the Oyster Landing marsh-creek basin from 1984 to the present. The objective has been to track the composition, abundance, and biomass and length distributions of nekton and determine patterns, trends, and factors influencing changes over seasons, years, and decades. From 1984-2003, this effort was based on biweekly seine hauls from an isolated pool (low tide) in the intertidal creek. 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. These efforts demonstrated that although patterns of occupancy of the intertidal basin by species and life stages within species varied, they were predictable according to tide level and time of year. Large, short-term changes in salinity and temperature affected abundance in the intertidal basin, but familiar patterns were quickly re-established. Recent efforts are focused on documenting long-term shifts in the timing and size of juvenile transient species and their growth rates. Our long-term time series are unique within the Southeast region and are becoming 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 region.

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

Investigators: Dr. George Voulgaris[1] and 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.

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

Investigators: Dr. Erik M. Smith and Susan Denham

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).

Seasonal energetics of the blue crab

Investigators: Dr. Blaine Griffen[1] and Dr. Matthew E. Kimball[2]

1 - Department of Biology, Brigham Young University
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.

Painted Bunting monitoring project

Investigators: Wendy Allen[1], Dr. Jennifer Plunket[1], and citizen science volunteers Bill Brabson, Marlene Konsek, Pete Little, and Sandy Little

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

Painted Buntings (PABUs) are the most colorful of the migratory songbirds that visit the coast of South Carolina. Adult males sport a royal blue head, neon green back, and red breast and rump. PABUs return to the area mid-April, nest in shrubs near marshes, and migrate south in the fall to central and southern Florida, Cuba, and the Yucatan peninsula of Mexico. Surveys conducted since 1966 have demonstrated a decline in PABUs which lead to the establishment of a monitoring project that includes banding at select sites in the southeast and observations made by citizen scientists. This project, Painted Bunting Observation Team or PBOT, is headed up by scientists at UNC Wilmington (www.paintedbuntings.org). The North Inlet-Winyah Bay National Estuarine Research Reserve (NIWB-NERR) served as a PBOT banding site 2007-2012, and has maintained a feeder near the Baruch Marine Field Laboratory (BMFL) since 2007. The NI-WB-NERR established a Painted Bunting monitoring project in summer 2014 to document buntings coming to the feeder. Reserve staff and citizen scientists make timed observations of PABUs and record color band combinations, if present. Citizen scientists continue to work with Reserve staff to monitor PABUs on Hobcaw Barony. The project will contribute to a better understanding of PABU longevity, how long they stay during the nesting season, whether they come back to the same site from year to year, and other aspects of their natural history.

Benthic bivalves as potential indicator species for ecosystem climate change effects

Investigators: Dr. Juliana M. Harding[1] and Dr. 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 ecosystem trophic levels and will enhance existing descriptions and predictions of ecosystem function.

The conservation status of the canebrake rattlesnake at Hobcaw Barony, with identification of key areas for conservation of its herpetofauna

Investigator: Dr. 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.

Interspecific competition among some salt marsh perennials in South Carolina

Investigators: Dr. Richard Stalter[1] and John Baden[2]

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

Salt marsh vegetation in the United States is characterized by distinct zonation of vascular plants. Zonation is less pronounced in brackish versus high salinity marshes. Previous transplant experiments indicated several species could not tolerate conditions in areas where they are not normally found. These experiments, however, failed to differentiate the effects of abiotic and biotic (namely interspecific competition) factors. Controlled, reciprocal transplant manipulations have been performed. Growth and survival were monitored to measure the relative importance of interspecific competition and abiotic factors as determinants of zonation patterns between the salt marsh cord grass, *Spartina alterniflora*, and the black needle rush, *Juncus roemerianus*. *Spartina alterniflora* was able to invade the *J. roemerianus* zone when the latter was removed from land that it originally occupied in the marsh. *Juncus* marginally invaded the *S. alterniflora* zone when the latter was removed. *Juncus* did not transplant well; almost 100 % of the transplanted *J. roemerianus* died even when dug up and replanted in place.

Toxicological effects of tire wear particles on fathead minnow and Atlantic killifish.

Investigators: Dr. Peter van den Hurk[1] Stephanie LaPlaca[2], and Dr. 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, SC, 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.

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

Investigators: Beth Thomas and Hannah Sarver

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 NERR, SC Department of Natural Resources, SC 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.

Saltwater intrusion monitoring

Investigators: Dr. Alicia Wilson[1] and Dr. 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 North Inlet, as part of the South Carolina Department of Natural Resources long-term coastal monitoring network. To date, the stratigraphy from the well logs has been used to support the development of regional groundwater flow models by Ph.D. student Tyler Evans. The models are further constrained by hydraulic head and salinity observations from the wells. Monitoring is ongoing.

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 NERR, SC Sea Grant Consortium, the Coastal Waccamaw Stormwater Education Consortium, the Clemson University Extension Service, and the Carolina Clear Program.

***Littoraria* growth and metabolism as a function of body size across latitudes**

Investigators: Rebecca Atkins, Dr. Craig Osenberg, Daniel Hawkins, and Kathleen Clancy

Odum School of Ecology, University of Georgia

Previous research (in prep) has discussed the variation in marsh periwinkle snail, *Littoraria irrorata*, population size structures and consumer effects across sites spanning approximately 9 degrees of latitude (Florida to Maryland). The objectives of this research in 2017-2018 are to 1) measure *Littoraria* growth rates across a year and 2) quantify both individual feeding and respiration rates in the lab as a function of body size and temperature. Research will be conducted across three sites in Florida, South Carolina and Virginia. Knowledge of *Littoraria* growth, feeding and respiration rates will allow for better understanding of patterns in *Littoraria* population size structure as well as comparison of metabolic traits across populations from multiple marsh sites. This information can then be used to better understand *Littoraria* as both consumers within the marsh and as ectothermic invertebrates responding to environmental conditions. The work underway at Goat Island within the North Inlet–Winyah Bay NERR includes a 1m-squared cage used to monitor the growth of tagged *Littoraria* over 3-month intervals. In addition to a caged plot, *Littoraria* will be collected for use in laboratory based respirometry and feeding experiments.

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

Investigators: Dr. Thomas L. O'Halloran[1] and Dr. 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 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 NERR's existing salt marsh monitoring infrastructure within the Crabhaul Creek marsh of 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.

Mechanisms for thermal tolerance in an estuarine cnidarian

Investigator: Dr. 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. North Inlet–Winyah Bay 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.

Green porcelain crab larval biology and phenology

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

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

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.

Sediment accretion in North Inlet estuary salt marshes

Investigators: Dr. James T. Morris[1] and 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.

Analyzing chromium and copper levels in *Fundulus heteroclitus*

Investigators: Dr. Julia P. Baker, Kristine Golden, and Scarlett Leigh

Division of Business, Mathematics, and Sciences, Columbia College (SC)

In aquatic environments, heavy metals can accumulate from both natural and manmade sources. The fish species *Fundulus heteroclitus* has been used in numerous studies to help assess the status of marine environments. In this study, copper and chromium concentrations in *Fundulus heteroclitus* were assessed on fish from the pristine environment of the North Inlet estuary at Belle W. Baruch Marine Field Lab (BB) and the more polluted water in Georgetown Harbor (GH). *Fundulus heteroclitus* from BB were caught using minnow traps. Fish from the GH proved more difficult to obtain so samples previously caught from this site by Dr. M. Marsh's group at Columbia College were used instead. However, the livers had been removed from these fish raising another research question on the importance of the liver in metal accumulation in *Fundulus heteroclitus*. As a result, the fish were analyzed in two categories: with and without livers. The fish were digested with nitric acid and analyzed by atomic absorption spectroscopy. The BB sample without livers had a copper concentration of 0.15 ± 0.02 ppm and a chromium concentration of 3.7 ± 0.3 ppm. The GH sample without livers gave a copper concentration of 0.167 ± 0.009 ppm and a chromium concentration at 8.2 ± 0.2 ppm. The BB sample with livers had a copper concentration at 0.281 ± 0.006 ppm and a chromium concentration of 5.7 ± 0.3 ppm. These results indicate the liver is an important organ in copper and chromium accumulation in *Fundulus heteroclitus*. Additionally, the GH fish had a considerably higher chromium concentration than those from BB.

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

Investigators: Dr. Dennis M. Allen, Paul D. Kenny, and Dr. Matthew E. Kimball

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 correlated to fluctuations in the physical characteristics of the estuary. Information is collected for more than 50 taxonomic groups and species. Analysis of the 153 μm fraction has indicated a major decrease in the abundance total small mesozooplankton, especially in the numbers of larvae of resident invertebrates, over the past 37 years. The abundance of total large mesozooplankton has not changed as much as the smaller zooplankton, but decreases in larval fishes and some crustacean larvae have been observed. Changes in the timing of larval shrimp and fish production observed for some species may be related to increasing water temperature. Changes in adult fish and invertebrate habitat associated with sea level rise could be altering the production of larvae by resident populations. Variations in the abundances of some taxa are related to changes in salinity with the occurrence of major climatic events such as ENSO (El Niño) and drought. The value of these datasets continues to increase as we formulate and test new hypotheses about impacts of climate change on the structure and function of estuarine systems and on coastal fisheries.

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

Investigators: Dr. Isaure de Buron[1] and Dr. Dennis Kyle[2]

1- Department of Biology, College of Charleston (SC)
2- Department of Global Health, University of South Florida

Blood flukes are pathogenic parasites that infect the cardiovascular system of their fish hosts. Their life cycle uses annelids as intermediate hosts. The objectives of this project are 1) to determine which species of fluke infects seatrout in the North Inlet estuary compared to other South Carolina estuaries and 2) to sample annelids regularly throughout the year in order to unravel the specifics of the life cycles of these particular parasites. This study will also allow us to determine a potential seasonal pattern of infection by the flukes in seatrout and will give us insight into the diversity of blood flukes in the North Inlet estuary.

Experimental varying of the marsh platform and macrophyte response

Investigators: Dr. James T. Morris[1] and 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.

Soundscapes of the marsh creeks at Baruch: Estuarine animals that make sounds and the pattern of sound production over tidal and diurnal cycles

Investigators: Dr. Joseph J. Luczkovich[1], Dr. Cecilia S. Krahforst[2], Dr. Mark W. Sprague[3], Phillip DeVille[3], Dr. Juliana M. Harding[4], and Dr. Dennis M. Allen[5]

1 - Department of Biology, Institute for Coastal Science and Policy, East Carolina University (NC)
2 - Coastal Resources Management Program, East Carolina University (NC)
3 - Department of Physics, East Carolina University (NC)
4 - Department of Marine Science, Coastal Carolina University (SC)
5 - Baruch Marine Field Laboratory, University of South Carolina

Sound is produced by many marine animals in the course of their daily activities, especially during mating periods, and can be used to understand changes in habitat use, activity patterns, seasonal migrations and other behaviors. We deployed recording hydrophones singly and in arrays with a multi-channel field recorder to record sounds produced by invertebrates, fishes and other animals in marsh creeks near Oyster Landing and Clambank long-term monitoring sites in the North Inlet-Winyah Bay NERR at the Baruch Marine Field Laboratory during May, June, and August 2017. In addition, we identified several unknown sound-producing species using laboratory acoustic and video observations. We identified sound production by five species suspected to be soniferous but previously undocumented to make sound. These include: striped benny, freckled blenny, crested blenny, bighead sea robin, and leopard sea robin. In addition, we recorded sounds from naked gobies, spotted sea trout, Atlantic croaker, silver perch, oyster toadfish, and snapping shrimp. Overall, we recorded soundscapes continuously for over 72 hours and multiple tidal cycles at Oyster Landing and Clambank stations. We are examining the patterns of variation of sound production on these recordings by the species listed above with respect to changes in tide level, diurnal cycles, temperature, dissolved oxygen, and other water quality metrics. Analysis of the recorded sound files is underway using a variety of acoustic and signal processing algorithms. Preliminary conclusions include more sound produced by striped blennies at night than during the day at Oyster Landing and more soniferous species present at Clambank.

Terrestrial response to sea level rise as detected through dendrochronology, geomorphology, and hydrology

Investigators: Dr. Raymond Torres[1] and Dr. Richard Keim[2]

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

We propose to evaluate the rates of salt marsh advance into the terrestrial landscape using dendrochronology. The corresponding tree ring chronology will be used to assess rates of geomorphic change of the terrestrial and intertidal landscapes and the patterns and dynamics of surface and near surface freshwater and salt water flows.

Creating a shared understanding of the specific vulnerabilities of southeastern coastal habitats to climate change impacts

Dr. Jennifer Plunket[1], Michelle La Rocco[1], Dr. Erik M. Smith[1], Hope Sutton[2], and Whitney Jenkins[2]

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

The NI-WB NERR and the North Carolina NERR are collaborating on a project to explore how climate change will affect southeastern salt marshes. We will use the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH) as a framework for answering site-specific questions about how anticipated changes in climate will interact with non-climate stressors (invasive species, nutrients, sedimentation and erosion, and contamination) to impact the future ecological function of salt marshes as habitat. The CCVATCH is a decision support tool that uses an expert elicitation process to incorporate existing information on climate change impacts with knowledge of local conditions. Project participants include local land managers, researchers, and reserve staff, who collaboratively determine the degree of vulnerability of a specific habitat area to defined climate change impacts and stressors, using a facilitated process outlined the CCVATCH Guidance Document. Intertidal salt marsh habitat in North Inlet, Murrells Inlet, and marshes at the four component sites of the North Carolina NERR will each be assessed by local teams. The intent of this process is to highlight opportunities for increasing the resilience of habitats through current or potential management and conservation actions.

Novel inexpensive instrumentation for long term monitoring of water levels and ground movement in salt marshes

Investigators: Dr. Vitalii A. Sheremet[1] and Dr. Erik M. Smith[2]

1 - NOAA Northeast Fisheries Science Center
2 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

An array of six inexpensive tidal gauges and six ground movement detectors is proposed to be deployed at the North Inlet-Winyah Bay National Estuarine Research Reserve. We would like to expand our recent observations at the Waquoit Bay National Estuarine Research Reserve and contrast the effects of different marsh morphology and much larger tidal range. The question is whether the sediment accretion in the marsh is rapid enough to keep up with the sea level rise caused by the climate change. Several Surface Elevation Tables (SET) were established at the Waquoit Bay Reserve and other Reserves to monitor the long term evolution. Recently, we realized that the ground movement caused by tide flooding the marsh needs to be taken into the account. Both the tide gauges and the ground movement detectors are designed by the PI for the project and are based on inexpensive stock Onset Computer Accelerometer Loggers. We propose to make a pilot deployment for a period of 1-2 months in order to record one complete tidal cycle with 1 minute sampling intervals. The observations will allow us to document the propagation of tides within the reserve and corresponding expansion of the top surface of the marsh. The ultimate goal is to develop an observation protocol that could be applied throughout the whole National Estuarine Research Reserve System.

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

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

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 through fall 2018. 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).

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

Investigator: Dr. Juliana M. Harding

Department of Marine Science, Coastal Carolina University (SC)

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

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

Investigators: Dr. Denise Sanger[1], Dr. Andrew Tweel[1], Sharleen Johnson[1], Dr. Robert F. Van Dolah[1], and David E. Chestnut[2]

1 - South Carolina Department of Natural Resources
2 - South Carolina Department of Health and Environmental Control

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 the summer 2017, over 780 sites have been sampled statewide, with 9 located in the North Inlet estuary and an additional 34 stations located in the adjacent Winyah Bay.

Linkages between intertidal creek geomorphology and nekton use determined from Terrestrial Laser Scanning

Investigators: Alex Gorr[1], Dr. Scott White[1], Dr. Matthew E. Kimball[2], Dr. Dennis M. Allen[2], and Kyle Houser[2]

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

Previous work in 1997-1999 examining nekton use in 8 intertidal creek tributaries of Clambank Creek revealed variations in geomorphology (e.g., depth, bank steepness, etc.) correlated to abundance of resident and transient nekton. The nature of these patterns suggests nekton actively select creeks with preferred geomorphic characteristics, which has implications for essential fish habitat, conservation, and restoration efforts. To examine the stability of the intertidal creek geomorphology and the consistency of nekton habitat preferences, the geomorphology of these same 8 intertidal creeks was measured again 15 or more years later. Geomorphological characteristics originally measured in 1997 using traditional surveying techniques were re-measured in 2016 using terrestrial laser scanning, and seasonally starting in early 2017 to allow comparison of small seasonal changes within creeks and large, decadal changes among creeks. The goal of this study is to determine if and how much the geomorphology of these creeks has changed over the years.

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

Investigator: Dr. 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.

Goby and blenny movements, fidelity, and habitat use

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

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 Gobies (*Gobiosoma bosc*), Crested Blenny (*Hypleurochilus geminatus*), Feather Blenny (*Hypsoblennius hentz*), Freckled Blenny (*Hypsoblennius ionthas*), and Striped Blenny (*Chasmodes bosquianus*) in Crabhaul Creek, North Inlet estuary are being examined. Artificial nesting substrates and passive integrated transponder (PIT) tags have been and will continue to be used to describe movement and fidelity patterns of these resident fishes. Regular surveys and recaptures of tagged fishes will provide information on site fidelity and home range as well as demographics and habitat use patterns of resident fish populations.

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 and Dr. Erik M. Smith

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

As part of a NERRS 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 20 sampling plots per transect. Surface Elevation Tables (SETs) have also been established adjacent to the lower and higher elevations of the creek-bank to forest-edge transects in each marsh region to determine changes in marsh surface elevation associated with long-term changes in and vegetation and tidal dynamics. Sampling within each permanent plot includes: percent cover for each species or cover category; species' shoot/stem density; species' maximum canopy height; species' aboveground biomass by non-destructive sampling techniques; water table height at low tide; porewater salinity, and nutrient and sulfide concentrations. Soil organic content and bulk density adjacent to each plot were determined in 2008. 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.

Impacts of crab burrow on exchanges of inorganic and organic carbon across the interface of water column and sediments in salt marshes

Investigators: Dr. Kai Xiao[1], Dr. Alicia Wilson[2], Dr. Erik Smith[3], and Dr. Susan Lang[2]

1 - School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen, China
2 - School of the Earth, Ocean, and Environment, University of South Carolina
3 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina

Crab burrows are a common feature in coastal wetlands. Crab burrows can play an important role as preferential flow conduits for enhancing pore water-surface water interaction and subsurface transports. However, the effect mechanism is not fully understood. We hypothesize that the crab burrow will enhance the exchange of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) between the overlying water and sediment porewater. To verify the above hypothesis, two kinds of field observations will be used to quantitatively estimate the crab burrow effect. The first set will come from a volume of the marsh with the dimensions of 1 (width) × 1 (length) × 1 (depth) m3. Detailed monitoring of water pressure, temperature and salinity using high-precision transducers and groundwater sampling using tension and push-point samplers will be conducted within the crab burrows and the ambient sediment matrix. The other observations will come from a 2-D transect from the upland to the Crab Haul Creek Basin, where the existing NERR Monitoring Network wells are available. Radon (222Rn) and radium isotopes (224, 226Ra) will be measured along the transect to determine the groundwater discharge. The surface water flux through the creek will also be measured by an ADCP installed in the bottom of the Crab Haul Creek. The samples of DIC and DOC will be sampled from the above models, including the creek water, inland groundwater, porewater in the sediment matrix and crab burrows.

Shorebird monitoring in the North Inlet estuary

Investigators: Wendy Allen[1], Dr. Jennifer Plunket[1], Paul D. Kenny[2], and citizen scientist volunteer Emma Boyer

1 - North Inlet–Winyah Bay National Estuarine Research Reserve, University of South Carolina
2 - Baruch Marine Field Laboratory, University of South Carolina

Shorebirds (Aves: Charadriiformes), are a diverse group of birds including plovers, sandpipers, curlews and oystercatchers. Of the more than 50 different species that occur in North America, more than half are considered a species of concern or "highly imperiled" due to declining numbers. A shorebird monitoring effort was initiated in the spring of 2016 to assess populations of shorebirds in the North Inlet estuary, primarily during migration periods, March – June and July – October. Shorebird surveys in the North Inlet estuary are conducted biweekly during these periods by boat and land near high tide. A new survey site along Clambank Causeway was added in spring 2018 and is covered all by land. Species are identified and counted and 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 compliment winter shorebird surveys that are conducted each year. 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: Dr. James T. Morris[1] and 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.

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

Investigators: Dr. Dwayne E. Porter[1,2], Melissa Ide[3], and Jeremy Cothran[1]

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 - Baruch Marine Field Laboratory, University of South Carolina

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 USC's 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.

Evaluating intertidal oyster reef restoration success

Investigators: Dr. Keith Walters, Thomas Funk, and students

Department of Marine Science, Coastal Carolina University (SC)

A series of oyster reefs, shell-filled mesh bags, were created within inlets (Hog, Murrells, and North) and swash tidal creeks (Whitepoint, Singleton, and Withers) to evaluate the success of reef restoration efforts. In the North Inlet estuary, reefs were created within Bly Creek in June 2014 and, along with coincident natural reefs, have been the focus of graduate and undergraduate researchers and CCU classes (e.g., Marine Ecology). The following data were or continue to be collected to evaluate constructed reef development and assess the ability of inlet and swash constructed and natural reefs to attract and support important fishery species: (1) yearly oyster spat recruitment; (2) numbers, sizes, and distribution of oysters on constructed and natural reefs; (3) numbers and species richness of resident and transient nekton associated with reefs; (4) short-term predation on reef-resident bivalve and decapod fauna. Although oyster recruitment onto reefs is similar, preliminary results suggest inlet oysters survive better as juveniles and live longer as adults compared to swash creek populations. Nekton seasonally captured during high tides within baited minnow traps, pull traps, and gill nets indicate constructed reefs are colonized quickly. Survival of tethered bivalve and decapod individuals within mudflat and constructed and natural reefs documented initial differences in structural complexity and the role of complexity in the survival of reef-resident taxa. The ongoing studies are providing valuable experiences for students, identifying demographic differences that influence reef development, and demonstrating the value of reef restoration efforts to intertidal resident and transient taxa.

The effects of inhibited carbonic anhydrase on the phytoplankton communities in coastal waters

Investigators: Eilea Knotts[1] and Dr. James L. Pinckney[2]

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

Carbon concentrating mechanisms (CCMs) are used by phytoplankton in order to concentrate dissolved inorganic carbon (DIC) within their cells. These adaptions were evolved to enhance uptake of DIC at present surface water concentrations. However, mechanisms, such as the carbonic anhydrase enzyme (CA), are active, energy-consuming processes that may become redundant in the future due to increased concentrations of CO_2 in surface waters. In order to gain a better understanding of the carbonic anhydrase enzyme, recent studies have investigated the CA enzyme through the use of inhibitors: acetazolamide (AZ) and ethoxyzolamide (EZ). Most of our knowledge is based on individual cultures or oligotrophic water samples. However, there are few studies that look at the mechanism's effects on estuarine phytoplankton communities and none have measured the *in situ* effects on community composition. Using bioassays of natural phytoplankton communities, our research will explore how community composition is altered when the competitive advantage of the CA enzyme is reduced. These changes will be monitored with measurements of chlorophyll *a* fluorescence, cell abundances, microscopy, photopigments, nutrients, and the inhibitors: AZ and EZ. This study will provide a better understanding of how the CA enzyme impacts the composition of phytoplankton communities in coastal waters.

The National Estuarine Research Reserve System Centralized Data Management Office

Investigators: Dr. Dwayne E. Porter[1,2], Melissa Ide[3], Jennifer Kessee[3], Amber Knowles[3], Brooks Folk[3], Lee Shutt[3], Dan Ramage[2], and William H. Jefferson[1]

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 - Baruch Marine Field Laboratory, 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 (CZM) programs, and other education, monitoring and research programs.

Characterization of oyster cement

Investigators: Dr. Jonathan Wilker[1] and 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.

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

Investigators: Dr. Peter Key, James Daugomah, and Blaine West

NOAA Center for Coastal Environmental Health and Biomolecular Research, Charleston, 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 North Inlet estuary is maintained as a long-term reference site for comparison to estuarine sites with other land uses.

Co-evolution of complex traits associated with key innovation: Armor and vision in the snapping shrimp *Alpheus heterochaelis*

Investigators: Dr. Alexandra C. N. Kingston and Dr. Daniel I. Speiser

Department of Biological Sciences, University of South Carolina

Snapping shrimp are a morphologically diverse and speciose group of crustaceans in which the evolution of a key morphological innovation, the snapping claw, is accompanied by the evolution of sophisticated armor. This armor, called an orbital hood, partially or totally conceals the eyes of snapping shrimp to protect them from the explosive collapse of cavitation bubbles produced by their snapping claws. The morphology of the orbital hood has led to the long-standing hypothesis that snapping shrimp are blind, even though they have well-developed eyes. To study the co-evolution of complex traits associated with the origin of key innovation, we have examined the transmittance of orbital hoods and tested visual function in the snapping shrimp, *Alpheus heterochaelis*. We found that orbital hoods (n = 40) are 80-90% transmissive to incident light, suggesting that enough light passes through the orbital hood to support vision. Using electroretinography (ERG), we discovered that the visual system is functional and is maximally sensitive to middle wavelength light (500nm; n = 13). We will continue to investigate the relationships between the weapon, armor, and visual system by exploring (1) pressure generation by the snapping claw and the effect of snapping on the orbital hoods during conspecific interactions, and (2) the functionality of the visual system through behavioral experiments. The presence of protective armor in an animal with such a powerful weapon provides opportunities to examine relationships between these and other complex traits, and the evolutionary trade-offs that result from such specialized morphological traits.

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

Investigators: Dr. Erik M. Smith and Tracy Buck

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

As part of the NERRS 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 waters, and provides base-line data critical 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. Data can be accessed via the CDMO website (http://cdmo.baruch.sc.edu/).

Effect of wrack accumulation on salt marsh vegetation, Baruch Institute, Georgetown County, South Carolina

Investigators: Dr. Richard Stalter[1], A. Jung[1], A. Starosta[1], John Baden[2], and M. D. Byer[3]

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2 - US Army Corps of Engineers, NC, Retired
3 - Division of Natural Resources, Gateway National Recreation Area, National Park Service, Staten Island, NY

In March 2004, four arrays in different types of salt marsh vegetation were covered with 15-20 cm of wrack secured in place, in an attempt to duplicate the natural deposition of wrack on the marsh by tides and storms, and to quantify and extend anecdotal observations and the results of previous studies. A control plot in each array was left uncovered; another plot was covered with only 2-3 cm. The wrack was removed from one plot in each array at one, two, four and seven month intervals. One month of wrack coverage appeared to have little effect on either density or standing crop, recorded seven months after initial covering, of the principal marsh species. Above ground parts of these species, with the exception of *Spartina patens* and *Borrichia frutescens*, appeared to be killed or extremely inhibited after two months, but not as much as the 15-20 cm wrack mat treatment. We continue to assess survival of wrack impacted plants and monitor recruitment and growth in specific wrack impacted zones.

Evaluating the feasibility and utility of high-resolution acoustic imaging technology to examine nekton movement and behavior in estuarine habitats

Investigators: Dr. Matthew E. Kimball[1], Dr. Dennis M. Allen[1], and Shay Rule[2]

1 - Baruch Marine Field Laboratory, University of South Carolina
2 - Rogers Fellow in Environmental Science, Cornell College (IA)

Nekton use of the mosaic of habitats within estuaries is largely species-specific and varies according to biological and physical factors. Habitat function and nekton use patterns are largely understood from studies employing direct capture sampling techniques in these varied estuarine habitats to document species composition, abundance, and timing. Recent advances in high-resolution acoustic imaging now allow for examination of these traditional metrics such as abundance and size of fishes, but also permit examination of fish movement and behavior, which are often difficult to study in turbid estuarine waters, without disturbance to the habitat or animals. We plan to use high-resolution acoustic imaging (i.e., ARIS) to examine fish behavior in multiple salt marsh habitats to 1) determine the limitations and feasibility of using the ARIS for in situ behavioral ecology studies and 2) discern the utility and accuracy of software (i.e., ARISFish) for examining collected imaging data and extracting quantifiable metrics. In addition to observing nekton in creeks, pools, and around oyster reefs, we will conduct experiments to groundtruth acoustic imaging observations (e.g., nekton size) and develop procedures to analyze imaging data from both horizontal and vertical viewfields.

Estimating above ground biomass utilizing Planet multispectral satellite data

Investigators: Gwen Miller[1] and Dr. James T. Morris[2]

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

Conducting field work to analyze landscape scale above ground biomass within the North Inlet-Winyah Bay National Estuarine Research Reserve (North Inlet) is infeasible due to the extent of the salt marsh and access difficulty. Estimates of above ground biomass is important for better understanding marsh productivity and modeling how a salt marsh may respond with sea-level rise. Furthermore, a landscape scale map of above ground biomass within North Inlet will highlight regions within the marsh with higher or lower biomass. Publically available satellite data such as data available through Landsat, have a large spatial resolution (30 meters), which smooths out spatial variability. A private company, Planet, offers us free 3 meter resolution multispectral through Planet's education and research program. We will collect above ground biomass samples at various locations within the North Inlet and use Planet's spectral data to create a model between above ground biomass and satellite data. Using the calibrated model, we will develop a map of above ground biomass within the entire salt marsh dominated by *Spartina alterniflora*.

Benthic microalgal biofilm characterisation and activity in the North Inlet-Winyah Bay National Estuarine Research Reserve (NI-WB NERR)

Investigators: Dr. Graham J.C. Underwood[1] and Dr. James L. Pinckney[2]

1 - School of Biological Sciences, University of Essex, Colchester, Essex, England
2 - Belle W. Baruch Institute of Coastal and Marine Sciences, University of South Carolina

Coastal sediments are important sites of organic carbon generation, cycling and accumulation. In vegetated sediment, macrophyte biomass and detritus is a major contributor to the organic carbon pool, but unvegetated sediments also produce and store carbon. A key group of primary producers on such sediments are benthic microalgae that form biofilms and microbial mats on the surface of sediments. A feature of sediment biofilms is the mucilaginous matrix (consisting mainly of polysaccharides) that provides structural integrity. Carbohydrates are an important component of the blue carbon in unvegetated sediment, and the microalgal component is a significant element in determining the concentrations of total and colloidal (labile) carbohydrates. We will determine the interrelationships between sediment microphytobenthic biomass (Chl a, total, colloidal carbohydrate, species composition) across a range of sediment types (sands, silts,muds) and nutrient conditions within the NI-WB-NERR, taking advantage of the gradient of pristine (low nutrient) and higher anthropogenic impact sites, and to relate this to total sediment organic content. In addition, we will conduct some short term perturbation × response measures of biofilms and nutrient and DOC exchanges under different conditions (outdoor mesocosms). The exact design will depend on availability and quality of biofilms present.

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

Investigator: Dr. 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. Hard clam age structure, growth rates and sex ratios continue to 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.

Examination of potential juvenile tarpon overwintering habitat in the North Inlet estuary

Investigators: Dr. Matthew E. Kimball, Dr. Dennis M. Allen, and volunteers

Baruch Marine Field Laboratory, University of South Carolina

Juvenile tarpon occur in small, shallow, and often tidally restricted environments in and around estuaries (e.g., ditches, pools or ponds, and impoundments) during summer and fall. Based on laboratory low temperature tolerance experiments, juvenile tarpon that do not emigrate in late fall likely do not survive the winter in most estuarine habitats where temperatures drop below their lethal limit (~10-13° C). However, tarpon have been observed during winter months in a thermally stratified pond with little tidal influence, as well as artificially warmed inshore habitats (e.g., discharge canal from power plant). To examine the overwinter potential of thermally unique estuarine habitats, we have monitored the survival and growth of juvenile tarpon in a pond along the upland edge of the North Inlet estuary since 2016. Juvenile tarpon (~100 - 500 mm SL) have been consistently observed in this pond and preliminary temperature data suggests that it may provide suitable overwinter habitat. Throughout the year, juvenile tarpon are collected using hook-and-line, tagged with a 12-mm Passive Integrated Transponder (PIT) tag, and released back into the pond. Both pond surface and bottom water temperatures are measured continuously during winter months (December through March). Combined, information on tarpon habitat use garnered through observations of tagged individuals along with winter water temperature records will provide a better understanding of tarpon survival in potential overwinter habitat in this region.

Development of models for phytoplankton-nutrient responses in support of numeric nutrient criteria for estuarine water quality

Investigators: Dr. James L. Pinckney[1], Dr. Erik M. Smith[2], and Krystyn Kibler[3]

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

The primary objective of the proposed research is to develop and test a family of empirical mathematical models to quantify the responses of the total phytoplankton community as well as phytoplankton groups to increases or reductions in total N loading. Models will be constructed for a range of N loading scenarios under both high and low light exposure conditions. These models will be invaluable for developing and validating numeric nutrient criteria for Winyah Bay and North Inlet Estuary and provide a "proof of concept" for determining criteria in other estuarine systems. Phytoplankton-nutrient response curves will be constructed using natural phytoplankton communities collected in North Inlet Estuary and Winyah Bay, SC. Surface water (0.5 m depth) will be obtained seasonally over 2 years from each location. The N treatment for the bioassays will consist of a range of concentrations (1 - 100 µmol N l^{-1} in increments of 10 µmol N l^{-1}) and will be composed of an equimolar mixture of NO_3^-, NH_4^+, and urea ($CO(NH_2)_2$) to simulate the types of N compounds likely available in the estuary. Data from the bioassays will be used to derive an empirical numerical relationship between N loading and phytoplankton community biomass (as chl *a*) responses. The empirical models we will develop can be directly used by SC DHEC to evaluate numeric nutrient criteria for these systems under a variety of N addition/reduction scenarios.

Satellite observations of marsh dieback events and potential environmental influences along coastal SC, 2000-2017

Investigators: Dr. Cuizhen (Susan) Wang and Dr. Jean T. Ellis

Department of Geography, University of South Carolina

Using the North Inlet as one of the experimental sites, this study aims to identify the marsh dieback events and recovery pathways in SC via a series of NASA satellite observations since 2000. South Carolina has over 340,000 acres of salt marshes that support 96% of the state's commercial seafood and shellfish catch. Since 2000, studies have reported multiple dieback events in the U.S. Southeast. Investigations of marsh dieback in SC, however, have been limited. The most pristine along the east coast, the SC marshes and dieback-recovery pathways deserve critical research. Satellite images provide a long-term, continuous way to identify the thinning and dead marsh patches. Supported by the NASA EPSCoR program, this study will address the following objectives to: 1) classify marsh dieback patches through Landsat (TM, ETM+, OLI) image series; and 2) identify initial indicators of stressors by exploring the environmental anomalies during the events from NASA satellite products (MODIS; TRMM-GPM; Aquarius-SMAP). The expected outcomes of this project include an inventory of dieback events and potential stressors in SC. When future funding opportunities are available, these results will help us explore how these environmental stressors impact marsh healthiness, and how marsh habitats sustain under natural and anthropogenic impacts along coastal SC.

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

Investigators: Dr. Erik M. Smith and Tracy Buck

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.

American alligator movement ecology in coastal South Carolina

Dr. Thomas R. Rainwater[1], Abigail J. Lawson[2], and Dr. Patrick G.R. Jodice[3]

1 - Baruch Institute of Coastal Ecology and Forest Science, Clemson University (SC)
2 - Department of Forestry and Environmental Conservation, Clemson University (SC)
3 - U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Department of Forestry and Environmental Conservation, Clemson University (SC)

Effective wildlife management necessitates a working knowledge of demography and habitat requirements. In South Carolina (SC), the American alligator (*Alligator mississippiensis*) is managed as a renewable natural resource, through public and private lands harvest programs. To date, SC's monitoring program for alligators has primarily focused on an estimation of the total number of animals in the state-wide population but has not incorporated efforts to identify underlying mechanisms that may drive variation in realized or observed abundance patterns (e.g., habitat selection, associated movement patterns). In 2015, we initiated a movement ecology study of adult male alligators in coastal SC and deployed GPS transmitters on animals in the Santee Delta and ACE Basin regions of the state. During our tracking efforts, we observed some alligators move significant distances over short periods. One animal captured and tagged at the Tom Yawkey Wildlife Center routinely crossed Winyah Bay and spent considerable time on the southern end of the Hobcaw Barony (HB) property, highlighting both extensive movement as well as the potential importance of habitats in the HB/North Inlet area for coastal alligators. In 2017, we tagged an adult male alligator at HB and have tracked its movements for the last year. Results indicate this animal uses multiple freshwater and estuarine habitats on HB, complementing data from other alligators tracked in coastal SC. We now aim to investigate how alligators select and utilize these different habitat types (e.g., foraging, breeding, nesting, overwintering) using a combination of GPS telemetry, trail cameras, and stable isotope analysis.

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

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

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

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 recently (2016) documented 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.

Painted Bunting breeding survey

Investigators: Wendy Allen, Dr. Jennifer Plunket, and citizen scientist volunteers Bill Brabson and Marlene Konsek

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

The project goal is to estimate of the number of Painted Buntings utilizing the edges of the North Inlet marsh as nesting habitat during the breeding season. A point count method will be utilized that involves 5 minutes of listening for calling male buntings at fixed intervals along a prescribed route. 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.

Satellite observations of marsh dieback events and spatial assessment of environmental influences

Investigators: Huixan Li and Dr. Cuizhen (Susan) Wang

Department of Geography, University of South Carolina

The primary goal of this research is to detect the marsh dieback events from the long-term satellite observations (since 2000) and to examine the potential influencing factors by investigating the spatial and temporal relationships between marsh diebacks and satellite-observed environmental anomalies. To achieve this goal, the following objectives will be addressed: 1)Map the current distributions of primary marsh species from recent Landsat images in the two NERRs; 2)Identify the dieback patches in marshes from Landsat (TM, ETM+, OLI) image series in 2000-present that experienced apparent greenness reduction, indicating marsh dieback events; 3)Explore the relationships between these dieback events and environmental anomalies from NASA satellite products (MODIS; TRMM-GPM; Aquarius-SMAP) and in-situ water quality data records, which are primary indicators of environmental influences;4)Perform comparison analysis of marsh dieback events between the two study sites (natural vs. land development) to examine the anthropogenic impacts on marsh dynamics on SC coasts.

Relating nonpoint source BOD loading to land-use and stormwater management practices in coastal South Carolina

Investigators: Dr. Erik M. Smith[1], Dr. Claudia Benitez-Nelson[2], and Kelly McCabe[2]

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

The presence of a sufficient concentration of dissolved oxygen (DO) is a fundamental requirement necessary to sustain aquatic life. The occurrence of low DO is the number one cause of impairment with respect to the ability of waters to support aquatic life use in South Carolina's coastal zone, representing 48% of all EPA Section §303(d) listings for Aquatic Life Use impairment in the eight coastal counties. Maintaining sufficient DO requires managing anthropogenic discharges of oxygen demanding substances. The operational measure of oxygen demanding substances is the determination of five-day Biochemical Oxygen Demand (BOD). While BOD loading from point sources is relatively straight-forward, the role of nonpoint sources in contributing BOD loading to coastal waters remains a significant information gap. The overall goal of this research is thus to develop a predictive understanding of how land-use and specific stormwater management conveyances and structural control structures impact variations in the magnitude of nonpoint source BOD. This will be accomplished by analyzing BOD on samples collected from 1) first-order catchments that represent the range of land cover and land use found in this region, from largely natural (including both forested uplands and wetlands) to high density urban development; and 2) the outfalls of common stormwater management practices (detention ponds, constructed wetlands, etc.). Water samples analyzed for BOD will also be subject to a suite of carbon, nitrogen and phosphorus analyses. Anticipated results will contribute to both improved stormwater management and Total Maximum Daily Load (TMDL) development for coastal waters impacted by low DO.

Diet of terrestrial-mammalian carnivores that have access to marine-aquatic resources compared to terrestrial upland habitats in coastal South Carolina

Investigators: Amanda L. Wilson[1], Dr. David Jachowski[1], Dr. Ernie Wiggers[2], Dr. Michael Childress[3], Dr. Patrick Gerard[4], and Dr. Lisette Waits[5]

1 - Department of Forestry and Environmental Conservation, Clemson University (SC)
2 - Nemours Wildlife Foundation, Yemassee, SC
3 - Department of Biological Sciences, Clemson University (SC)
4 - Department of Mathematical Sciences, Clemson University (SC)
5 - Department of Fish and Wildlife Sciences, University of Idaho

Coastal ecotones, where marine aquatic and terrestrial habitats interact, have been shown to be productive systems where allochthonous input subsidize terrestrial mammalian predators. Research involving the diets of predators along the Atlantic coast is sparse, yet important because it allows for a fuller understanding of community dynamics, and function and position of animals within a food web. The objectives of this study are to compare diets of predators that have access to coastal ecotones to upland areas in order to (1) assess how the diet of each predator using coastal areas (e.g. impoundments) is influenced by allochthonous inputs, (2) document any seasonal variation in its use, and (3) compare dietary breadth and overlap among predators that could inform community ecology of sympatric predators' dynamics and structure. By conducting scat surveys across the coastal plain of South Carolina, this study will compare the diets of those predators, via scat, using microscopic and macroscopic identification of prey items from reference collections. Further, this study will use molecular genetic techniques to confirm predator species identification since rates of misclassification using field morphometric identification of scat is high. This research will contribute to a gap of basic ecological knowledge of how predators utilize these coastal ecotones and will inform land managers and property owners of how predators interact with those species for which properties are predominantly managed.

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