N.C. COASTAL RESERVE RESEARCH SYMPOSIUM SUMMARY

May 8-9, 2024

NORTH CAROLINA
COASTAL RESERVE &
NATIONAL ESTUARINE
RESEARCH RESERVE

Executive Summary

The N.C. Coastal Reserve and National Estuarine Research Reserve (Reserve) hosted a Research Symposium on May 8 and 9, 2024 in Beaufort for researchers and coastal resource managers to:

- Share and learn about research at the Reserve;
- Learn about the Reserve, available data streams, and funding opportunities;
- Provide thoughts on future research avenues and Reserve management priorities; and
- Network with researchers and coastal managers throughout the N.C. coast.

The event included a field trip to the Rachel Carson Reserve and a poster reception at the N.C. Maritime Museum on May 8 and a full day of presentations and discussions at the NOAA Beaufort Lab on May 9. The 59 meeting participants included research scientists, coastal managers, and graduate students. Poster presenters networked with reception participants to share the results of their work on Reserve sites. The symposium on May 9 included presentations of research occurring on Reserve sites as well as breakout group discussions. The presentations and discussions were organized into the following topics: collaborative science, water quality, coastal and estuarine ecosystem protection, and coastal hazards resilience.

The breakout group discussions identified information gaps, brainstormed project ideas, and formed new partnerships to tackle important research and management needs moving forward.

The outcomes of these discussions will inform the Reserve's National Estuarine Research Reserve System (NERRS) Science Collaborative management needs for future requests for proposals; NERRS Margaret A. Davidson Fellowship management needs for future student research; the next update of the N.C. National Estuarine Research Reserve Management Plan; and the research needs available on the Reserve's website.

See Appendix 1 for the oral presentation abstracts, Appendix 2 for the poster presentation abstracts, and Appendix 3 for symposium attendees.

Symposium Background

The N.C. Coastal Reserve Research Symposium was hosted by the N.C. Coastal Reserve and National Estuarine Research Reserve (Reserve) in Beaufort, North Carolina May 8-9, 2024. Responsible for protecting and managing coastal areas to serve as living laboratories for research and long-term monitoring, the Reserve recognized a need to bring together researchers and coastal managers to learn about work conducted on Reserve sites focused on water quality, coastal and estuarine ecosystem protection, and coastal hazards resilience and to identify gaps, priorities, and opportunities for future work. Researchers and coastal managers from across the N.C. coast were invited to participate (Appendix 3), and Figure 1 shows a breakdown of the attendee backgrounds. The symposium provided an opportunity for researchers and coastal managers to gather and learn about the ongoing work at the Reserve by staff and external researchers. Then, facilitated breakout discussions identified information gaps and brainstormed ways the Reserve and partners could help address emerging research and monitoring needs moving forward. The symposium also provided a forum for students to present their research, network with the research and natural resource management community, and specifically talk with the managers who could use the results from their work. Support for this symposium was provided by the NERRS Science Collaborative Capacity Building Funds and the N.C. Division of Coastal Management.

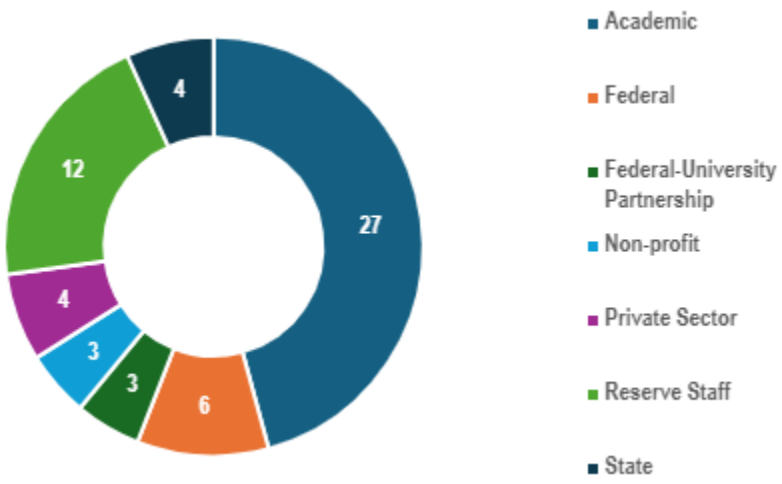

Figure 1. Breakdown of symposium participants by organizational sector

A summary of the topical discussions held to help inform future research, monitoring, stewardship, and collaborative efforts follows.

Summary of Outcomes

The Symposium on May 9 was dedicated to topical presentations from Reserve staff and research partners followed by breakout discussions. The four sessions focused on collaborative science and the three research topical areas defined in the Reserve's 2020-2025 management plan: water quality, coastal and estuarine ecosystem protection, and coastal hazards resilience. The following summarizes the breakout discussions.

Collaborative Science

How to make collaborative science a success

Participants shared their experience with the collaborative science process. Discussions distilled into the following common themes:

- Identify end users at the beginning of the project and involving them from the start leads to success.
- Establish a timeline with key project deadlines and deliverables.
- Define roles for everyone involved and be sure to have a collaborative lead, typically someone with facilitation skills and who is not the project lead.
- Set expectations early, be flexible, and budget time and funding for an iterative process guided by end user needs.
- Facilitate regular communication between the project team and end users.

Identifying the end users is step one of the collaborative science process, and it is prudent to engage them early, with an open mind and ready to ask questions. Involving end users early promotes project buy-in, will help better define the project scope, and allows the incorporation of local expert knowledge. Building trust with end users takes time, and the collaborative process means being adaptable to their needs and the problems they identify. It is helpful to understand how end users prefer to be engaged throughout a project and identifying this in the beginning allows engagement to be factored into the project timeline.

One of the next essential steps in the collaborative process is establishing a project timeline that includes deadlines, communication methods, and defined roles and responsibilities. It is recommended to use a spreadsheet or document to capture and track milestones and responsibilities. This will help in estimating how many hours project team members must devote to the project, which will inform the project budget. Prioritize relevant trainings by including them in timeline and budget, which may include training relevant to the collaborative process, such as facilitation or project management. Ensure funding for the collaborative portion of the project is included in the budget, not just the technical work. Ask the collaborative lead to help with the collaboration budget, and budget time for the iterative process of collaborative science, as the project should be

periodically assessed and adjusted as needed at key points throughout the project. Budget time for relationship building; time to work with end users to understand needs, site selection, and discuss realistic project outcomes, which will help minimize miscommunication and set expectations through regular and appropriate communication with the end users. Remind the project team and end users know that collaborative science takes time, and that flexibility and adaptability are key.

Defining project roles at the beginning of the project is useful for more effective project management. Major roles in collaborative research could include Project Lead, Collaborative Lead, and Technical Lead. Dispersing the responsibilities across these roles helps to reduce the burden of project management, assuming there is effective communication and coordination within the team. While the Project Lead oversees most aspects of the project and the Technical Lead directly manages the research, the Collaborative Lead facilitates the exchange between the project team and end users. Collaborative Leads should be prepared by having conflict management, facilitation, and project management skills as well as relationship building experience. A good Collaborative Lead will ensure that project outputs are appropriate and accessible to end users, thereby fostering a more impactful outcome. It was recommended to also have a generalist on board, who is not necessarily a subject matter expert, to help create a more cohesive project by helping translate the project outcomes to a broader audience and be mindful of end user needs. Furthermore, including a combination of team members from local areas and a larger regional scale will provide different perspectives and enrich the outputs and outcomes.

When engaging with end users and communicating about collaborative research it is important to maintain accessibility. Do not use jargon or acronyms and create a variety of ways for end user engagement using multiple platforms for communication (i.e. in-person and virtual meetings). Incorporate regular communication between the scientists, collaborative lead, and end users. Host equitable project meetings, ensure times work for the entire project team, especially the end users. When conducting project outreach, keep it geographically relevant and make sure subject experts are local, this helps deliver the project more effectively. Look to organizations, like the NERRS, to help connect researchers to end users and community needs to create better outcomes. Another idea for creative outreach opportunities is to ask teachers to participate in the research and researchers to participate in the classroom. By helping each other, the project and process becomes truly collaborative and facilitates unique outreach experiences.

Challenges of collaborative science:

The discussion groups identified several common themes regarding the challenges of collaborative science. Poor experiences with collaborative science have resulted from:

- Not working with a Collaborative Lead to create an effective project plan that accounts for the collaborative process;

- Lack of defined roles, end user engagement from the start, and dedicated funding for the collaborative process; and
- Insufficient time or scheduling conflicts that impeded the collaborative process during shorter term projects.

Challenges with collaborative science seem to have evolved from the lack of a dedicated Collaborative Lead to help shape the project plan, including roles, engagement, and budgeting. This may result from the absence of a Collaborative Lead or one who is ill-equipped for the role, or the project team not utilizing a Collaborative Lead effectively. This makes it hard to sustain collaborative groups and end user engagement throughout a project timeline and has proven detrimental to the knowledge exchange with end users, diminishing project outcomes. While a Collaborative Lead can be very helpful, they may not be able to fully mitigate issues groups have with scheduling and the time-consuming nature of the collaborative process when project timelines are short (i.e. less than two years). Other challenges noted were 1) it can also be a challenge to get researchers to think outside of their specialty, to better align their work with the goals of the funding available, and 2) it can be difficult parsing end goals into achievable pieces and conveying realistic expectations to end users. Both challenges have benefited from the use of an engaged Collaborative Lead.

Topical Discussions

Identified Gaps in Reserve Research

Water Quality

Identified research gaps within the Water Quality topic included the following themes:

- Bioaccumulation and abundance of contaminants in the water such as heavy metal pollution, per- and polyfluoroalkyl substances (PFAS), microplastics, and marine debris;
- Better understand connections between water clarity, turbidity, and source detection;
- Upstream monitoring to understand point source pollution, inform land use planning, and the influence of natural areas in mitigating impacts; and
- Higher spatial resolution in water level, salinity, nutrient, and sediment composition monitoring.

In the realm of contaminant research, there is growing demand for how these substances are being transported and the effect they have on ecological communities. Understanding sediment supply dynamics could be very useful in establishing transport vectors for contaminants. Bioaccumulation of mercury and heavy metal pollutants along with other emerging contaminants is a major concern. There is increasing need for more and longer

term PFAS monitoring to understand its effects on marine biology and ecology. Because PFAS is a high-profile topic, this research could be a powerful way to communicate water quality issues on our coasts and great value can be added by using a socioeconomic lens. More research on microplastics and marine debris was also discussed, as these can act as vectors for contaminants and non-native organisms.

More research and monitoring is needed to better understand connections between water clarity, turbidity, and source detection. In understanding how our systems are changing from anthropogenic or climatic changes, there is a need to examine relationships with water clarity or turbidity with temperature. Examining water clarity issues should also pursue linkages in source and seasonality, and whether light attenuation is being impacted by suspended sediment or biological productivity in the water column that may be shifting with climate or land cover change.

There remains a need for higher spatial resolution in water level monitoring, stormwater, and point source impacts within communities surrounding the sounds. For example, researchers shared that high amounts of fecal matter have been observed when testing residential road flood waters after storms. Since flood waters aren't regulated, questions remain about what can be done about the contaminated water that goes into estuaries. More upstream monitoring may help determine types of sources, relations to land use changes, and how Reserve sites and other natural areas may influence downstream transport and mitigate impacts. Along with water level, salinity needs to be assessed at a greater spatial resolution to better understand impacts from sea-level rise (SLR) and saltwater intrusion across the coastline. Nutrient and sediment composition monitoring along estuarine habitat transition areas would also help gauge how the system is responding to water quality changes through time.

Coastal and Estuarine Ecosystem Protection

Identified research gaps within the Coastal and Estuarine Ecosystem Protection topic included the following themes:

- General need for more biological/ecological monitoring;
- Understand ecosystem services values and apply to ecosystem management; and
- Understand impacts of sea-level rise and marsh restoration on ecosystem services.

Universally, discussions mentioned that not enough information is being gathered on the state of coastal and estuarine biology and ecology at Reserve sites and across the coast. Broader coastal health assessments examining Reserve sites at the landscape scale would help identify where and why sites may experience habitat loss/change or places that may become fragmented. A more complete inventory of flora and fauna could be obtained by tapping into a range of methods for biological monitoring (e.g., passive monitoring through acoustic sampling and camera traps, remote sensing and machine learning, etc.) and help monitor the presence and influence of keystone species at the sites. This would allow for quantification of ecosystem change and assessment of SLR impacts on habitat restoration/resilience and ecosystem function (and relation

to the built infrastructure such as sewers and channel deepening). This research would enable the creation of predictive models of habitat changes to inform management and restoration prioritization and could inform restoration suitability modeling to determine what type of conservation activity is appropriate (e.g., living shoreline, thin layer placement). Possible suggested applications include examining oyster mortality, impacts of water quality on wild versus farmed oysters, and the availability of oyster habitat as aquaculture grows in N.C.'s estuaries.

Ecosystem valuations were also a major topic of discussion. More work is needed on how ecosystems should be valued, which would prove helpful in determining management priorities and conveying economic benefits to the public. Better understanding methods for quantifying economic impacts of ecosystem services, including recreational value, as well as the cost of maintaining the habitats and associated services and the limitations of these methods will be important. These data could be used to build ecosystem services-based management frameworks to help inform conservation decisions.

Coastal Hazards Resilience

Identified research gaps within the Coastal Hazards Resilience topic included the following themes:

- Understand chronic and acute hazard events effects on habitats and the resiliency of natural versus modified shorelines; and
- Understand sediment dynamics.

Major discussion involved the need for more mapping, modeling, and monitoring to understand how Reserve sites have changed and will change in the decades to come. There was a strong push for a combination of mapping and modeling with more informed parameterization to assess geomorphic and ecological impact and recovery of coastal habitats from acute events (e.g., storms) and contributions from slower chronic events (e.g., sea-level rise). This could include more finite flooding/inundation mapping across Reserve sites and pursuit of a more detailed examination of wetlands, submerged aquatic vegetation, and living shorelines to track habitat migration. Modeling efforts could consider adaptation strategies for coastal habitats, alternative treatments for resilience, like habitat coupling. Reserve sites could provide an opportunity to test the efficacy of alternative or novel strategies for shoreline protection and habitat restoration. Discussion further noted the need to understand hazard impacts on community resilience around Reserve sites.

Another common theme was the role of sediment dynamics in coastal resilience. It was recommended to use models to study and manage sediment budgets around Reserve sites and to work to keep sediment within the system. There was a recognition to better understand the impacts of beach nourishment on coastal ecosystems and adjacent geomorphology, especially given the increasing emphasis on beneficial use of dredge sediments. Specific questions include how do sediment dynamics influence suitable habitat, how does thin layer deposition help or harm the system, and how does disturbance of the microbial community impact the system. Research could help inform

the decisions and timing of management-based decisions (i.e., if, when, and where to place sediment on Reserve sites).

Improving Utility of Reserve Sites for Research and Management

Water Quality

The following themes emerged from discussion groups about how Reserve sites could be better leveraged to enhance water quality research and management:

- Expand the current water quality data collection to Northern Reserve sites, increasing the spatial and temporal resolution of long-term salinity and water-level data in the region;
- Explore community science, mobile monitoring, remote sensing, and cameras at stations to enhance/expand data collection, and artificial intelligence and partnerships to expand analyses; and
- Need for a centralized water quality database/dashboard for coastal waters.

There was much discussion about expanding capacity for water quality data collection and analysis. However, it was acknowledged that additional funding would be needed to provide adequate support for current and necessary additional staff to expand monitoring. Interest primarily focused on expanding the water quality and weather monitoring of the NERRS System-Wide Monitoring Program (SWMP) to other locations, such as the Reserve's northern sites. Additional suggestions included: adding a camera at the water quality stations to collect stills of the conditions to provide more contextual information for water quality events that show up in the data; exploring larger scale or more mobile water quality monitoring platforms such as remote sensing, FerryMon, the Argo program, and water quality meters with georeferenced collections; and employing community science models to gather data. For example, Dr. Jesse Jarvis at UNC Wilmington has explored some do-it-yourself water clarity sensors. Greater spatial coverage in water quality data would provide opportunities to better examine drivers and impacts with land use change and socioeconomic lenses and evaluate long-term variability and short-term change in waters at Reserve sites.

In addition to more data collection, the groups emphasized that more data analysis and synthesis of existing data would be helpful. In this way, the Reserve could help alert the research community to what changes are happening that could influence their own research questions. Additional capacity and funding would be needed to conduct analyses in-house at the Reserve; alternatives were proposed including the use of artificial intelligence to interpret water quality trends and the use of students and university classes to analyze the data.

The community as whole is interested in increased data accessibility. A common suggestion was to consider creating a centralized water quality dashboard, like N.C. OneMap, and training portal. A dashboard could include project contact information to connect the data collectors with the data users. This could make it easier for users and the public to know where data are collected, by whom, and how to find these data. Such a product could also help enhance education and outreach through web maps and other visual learning products. Dashboards require significant investment in creation, data consolidation and formatting, and up-keep in partnership with data providers; at present, this is beyond the capacity of the Reserve. Nonetheless, it was suggested that the Reserve increase accessibility to its data and resources by promoting existing Reserve water quality data available from the Centralized Data Management Office (CDMO) and training modules on standardized data collection to help inform methodologies used by others to promote comparability across water quality datasets including SWMP.

Coastal and Estuarine Ecosystem Protection

The following themes emerged from discussion groups about how Reserve sites could be better utilized to advance coastal and estuarine protection research and management:

- Update Reserve site habitat maps and species inventories, and access to updated fine scale imagery;
- Identify priority areas within sites that need to be protected; and
- Utilize new monitoring technologies to better understand species dynamics and marsh surface change, leveraging existing research platforms and monitoring programs.

As with the research gaps, the participants broadly acknowledged the utility of updated Reserve habitat maps, species inventories, and fine scale imagery. This includes surveys of submerged aquatic vegetation, potentially combining remote sensing techniques with on-the-ground methods. These data are invaluable for quantifying change and informing management decision frameworks (e.g., Resist-Accept-Direct [RAD]) to inform and analyze action vs. non-action. These data could be used to create and update vulnerability maps to identify management priorities for specific locations and species, and to better consider how Reserve sites fit within the watershed landscape and at regional scales.

Novel ways to collect data were also discussed across the groups. The use of eDNA is growing, and it provides an easy and fast way to glimpse the distribution and relative abundance of species in a system. Using acoustic telemetry attached to water quality stations was also suggested to understand what tagged species are using Reserve sites. There were also discussions about expanding current forms of monitoring to capture marsh elevation changes and sedimentation rates using more Surface Elevation Tables (SETs) and marker (feldspar) beds. Leveraging existing research platforms and monitoring

programs was identified as a way to opportunistically or passively collect data when additional resources and capacity may be limited.

Coastal Hazards Resilience

The following themes emerged from discussion groups about how Reserve sites could be better utilized to advance coastal hazards resilience research and management. These themes are similar to those also identified for coastal and estuarine ecosystem protection:

- Establish baseline data for habitats, elevation, and biodiversity and long-term time series for all sites;
- Conduct suitability studies to prioritize vulnerable areas for restoration or intervention;
- Consider higher spatial and temporal resolution data including wave data, water flow, groundwater salinity, sedimentation, and habitat change, particularly at and adjacent to vulnerable and modified sites; and
- Develop communication materials about resilience research and projects to inform audiences about their benefits and lessons learned.

Following the coastal and estuarine ecosystem protection topic, group discussions emphasized the utility of having more mapping and monitoring data to support the research community's exploration of coastal hazards resilience. One of the primary needs identified was baseline data including habitat extents, elevation, and biodiversity for all 10 Reserve sites and further establishing long-term time series. A high-resolution time series across the site geographies will help measure and model recovery from disturbance events like storms across habitats and the ecological gradient of N.C.'s coast. The inclusion of these baseline data in suitability studies will help prioritize vulnerable areas for restoration or intervention as part of resilience efforts.

In addition to the baseline monitoring, there were calls for incorporating higher spatial and temporal resolutions of other data types as possible. This included groundwater salinity monitoring, wave data, water flow, and sedimentation across the landscape, with particular emphasis on focusing data collection efforts around areas of concern or restoration sites. Sedimentation rate studies were recommended on the back sides on islands in tidal creeks, and to better understand how ocean overwash sediment affects marshes and the hydrology dynamics between rivers and marshes. Along these lines, the inclusion of real-time data during storm events would be highly informative. For example, the University of Florida puts out temporary weather stations with additional sensors to better understand what happens during storm events.

Finally, there was an identified need to quantify and communicate the benefits provided by resilience projects and lessons learned. Thoughtful development of education and outreach materials on resilience projects and research will be highly useful for informing

the public, coastal managers, local communities, and conservation groups on the benefits and challenges of this work.

Appendix 1: Oral Presentation Abstracts

Amanda Williard, UNC Wilmington
Physiological ecology of the estuarine diamond-backed terrapin

Co-Authors/Collaborators: Brett Wilson, Jasmine Pierre
Abstract: The diamond-backed terrapin is the only temperate turtle species that exclusively inhabits estuarine environments and is a species of conservation concern throughout its range. My students and I conduct studies to investigate the morphological, behavioral and physiological features that contribute to the terrapin's ability to thrive in highly dynamic estuarine habitats. We are particularly interested in the strategies used by terrapins to maintain salt and water balance in their bodies and how alterations in salinity and temperature may affect energy allocation and behavioral patterns in terrapins. We also conduct studies to assess the health status of terrapins at multiple sites in the lower Cape Fear region in relation to various anthropogenic threats, such as interactions with fishing gear and the presence of chemical contaminants (PFAS). An understanding of the environmental factors that affect terrapin physiology and energy allocation may provide us with insight into how terrapins and other estuarine organisms may respond to the effects of climate change and sea level rise on coastal habitats.

Presenter Bio: Amanda Williard is a Professor in Department of Biology and Marine Biology at UNC Wilmington. Her research falls under the broad umbrella of conservation physiology. My students and I assess how environmental and anthropogenic factors affect the physiological status of marine and estuarine turtles, with a focus on metabolism and energetics. Our most recent collaborations with NCCR scientists include an investigation of the impacts of incidental capture in crab pots on diamond-backed terrapins and assessments of the efficacy of novel bycatch reduction technology.

Andrea Hawkes, UNC Wilmington
A review of observations and modeling of erosion and recovery of a coupled barrier island beach-dune system, Masonboro Island, NC

Co-Authors/Collaborators: Joe Long
Abstract: The geomorphic and ecological vulnerability of barrier islands is influenced by the way they respond to oceanographic and anthropogenic forcing over a broad range of temporal and spatial scales. Integrated models, based on in-situ field observation (weather, grain size, etc), capable of simulating these processes are increasingly necessary to understand barrier island trajectories under future conditions and to aid in management decisions by evaluating the impact of potential restoration activities. While there are numerical models capable of simulating some of the dominant barrier processes, the role of beach berm evolution is rarely included despite the important function of berms in sustaining beaches, enabling dune growth via Aeolian transport, and mitigating backshore and dune erosion during storm events. This is primarily due to a lack of available data that resolves details of beach profile evolution and characteristics (grain-size) at necessary temporal scales (e.g., seasonal, post-storm recovery, etc.) to test and develop models,

especially considering the inherent difficulty of including these intra-annual processes into decadal scale models of barrier island evolution. Here we provide a review a unique and growing dataset of environmental forcings, barrier island topographic changes, and sediment grain-size characteristics on Masonboro Island. We also use the dataset to develop and test a model for barrier island evolution and quantify the role of storms, moderate wave conditions, and wind-driven transport in dictating coastal change on various timescales.

Presenter Bio: Professor, Earth and Ocean Sciences Department, Sea Level Research Lab, UNCW. Hawkes is a coastal geologist that reconstructs coastal hazards over varying temporal and spatial scales (relative sea level, earthquakes, tsunamis, hurricanes). Her and colleagues, Joe Long (UNCW), Dave Wells (UNCW ops), Liz Pinnix (NCNERR), and Chris LaClair (COMRP), have been working on Masonboro Island for the past ~6 years to fly quarterly drone imagery, upkeep two real-time weather stations and offshore wave buoys and sample two cross-shore sediment/elevation transects with the goal of providing data and models to help with island management.

April Blakeslee, East Carolina University
Parasites as Biodiversity Surrogates in Oyster Reef Restoration

Co-Authors/Collaborators: Rachel Gittman, Chris Moore, Grace Loonam
Abstract: Parasites have been identified as key bioindicators of myriad conservation related questions, including serving as surrogate taxa for community biodiversity following oyster reef restoration. Here, we discuss the importance of including parasites in investigations of community biodiversity as well as their utility in demonstrating temporal changes in community assembly, species composition, and taxa diversity following oyster reef restoration. We provide examples from the Rachel Carson Reserve for how parasites can inform biodiversity assessments following the addition of novel habitat.

Byron Toothman, N.C. Coastal Reserve & NERR
The NERRS System-Wide Monitoring Program

Abstract: A brief overview of the NERRS System Wide Monitoring Program (SWMP). I'll discuss environmental monitoring programs as well as how to acquire and a number of ways in which the data are currently being used.

Presenter Bio: Research Biologist with the NC Coastal Reserve & NERR and PhD Candidate, UNC-Wilmington. Byron has been helping run the System-Wide Monitoring Program efforts for the NC NERR since 2008.

Celso Castro-Bolinaga, North Carolina State University
Improved Understanding of Sediment Dynamics for the Rachel Carson Reserve

Co-Authors/Collaborators: Swarna Chowdhury; Evelynn Wilcox; Grace Massey; Paula Gillikin; Justin Ridge; Whitney Jenkins; Steven G. Hall; Nina Stark

Abstract: This presentation will provide an overview of an ongoing NERRS Science Collaborative project that is focused on generating an improved understanding of sediment dynamics at and around the Rachel Carson Reserve. Specifically, this presentation will show results of a multifaceted field effort that was conducted to characterize flow and sediment conditions at and around the Reserve, as well as provide a sneak peek on the construction of a two-dimensional (2D) hydro-morphodynamic numerical model that is being developed for the Reserve's staff. Ultimately, it is envisioned that results of the NERRS Science Collaborative project will generate: an improved understanding of how the interaction between extreme storm events, river systems, and coastal processes impact sediment dynamics at and around the Reserve; refined decision making and management for engineering practices at the Beaufort Inlet; and an improved understanding of the impact of sediment dynamics on the vulnerability of coastal habitats and infrastructure for informing effective resilience planning.

Presenter Bio: Celso Castro-Bolinaga is an assistant professor in the Biological and Agricultural Engineering Department at NC State University. He is the PI of the Environmental Sediment Mechanics Research Group, which primarily focuses on studying phenomena related to the dynamics of water and sediment in a range of aquatic environments that include streams, rivers, and estuaries. He has collaborated with staff at the Rachel Carson Reserve since 2018, working on projects that range from understanding local changes in sediment composition and erodibility caused by the presence of oyster reefs to simulating large-scale sediment dynamics at and around the Reserve.

Katherine Anarde, North Carolina State University
Tracking beach state changes daily at Masonboro Island Reserve

Abstract: The subaerial beach, from the shoreward extent of runup to the dune, is an essential buffer protecting human development and coastal habitats from hydrodynamic forces. This region, however, can vary significantly over individual storms to decadal time scales. Researchers often categorize the process of beach evolution as storm-induced severe erosion events and subsequent reformation to equilibrium. Due to the lack of long-term and high temporal frequency field observations, the comprehension of complex geomorphic responses that transpire over short periods of time is limited. In this project, two pole-mounted cameras were placed on Masonboro Island Reserve, NC and collected images on an automated schedule. Images are processed multiple times a day with an increase of collection during storm events. We use Agisoft's Metashape application to perform stereo-reconstruction of images into topographic maps. GCPs (Ground Control Points) placed within the cameras' field of view are surveyed using real-time-kinematics GPS and used as references to build dense point clouds which are further processed into DEMs (Digital Elevation Models) as seen in Figure 1. Stereo reconstruction techniques can vary based on system setup, site-specific topography and desired results. This presentation will discuss the workflow and methods used to process raw imagery into three-dimensional surface maps of a semi-variable subaerial beach face. The DEMs produced will be compared to LiDAR (Light Detecting and Ranging) data to develop the most efficient and accurate procedure. Stereo reconstruction is still a relatively new method of data collection; therefore sensitivity testing is crucial for developing a standard system of operations.

Presenter Bio: Dr. Katherine Anarde is an Assistant Professor in the Environmental, Water Resources, and Coastal Engineering Group at North Carolina State University. Anarde received a B.A. in Geology from the University of Colorado at Boulder in 2011. She then worked as an environmental consultant before returning for a Ph.D. in Civil and Environmental Engineering at Rice University. Prior to joining NC State in 2021, she was a Postdoctoral Researcher in the Coastal Environmental Change Lab at the University of North Carolina at Chapel Hill. She is a coastal engineer and geomorphologist that combines observational and numerical approaches to investigate coastal hazards.

Heather McGuire, Chowan University
A Bird in the Hand: Breeding Ecology of the Prothonotary Warbler in Northeastern North Carolina

Co-Authors/Collaborators: James Dame, Skadi Kylander
Abstract: Chowan University (CU) is a small, liberal arts, minority serving institution in northeastern North Carolina. The CU Department of Biology collaborates with the NC Coastal Reserve and National Estuarine Research Reserve System to promote undergraduate research and provide opportunities for students to gain field experience. This presentation will focus on the department's Prothonotary Warbler research (Kitty Hawk Woods) but will also briefly describe other ongoing projects – marsh response to sea level rise (Currituck Banks), SAV community composition (Currituck Banks), and biodiversity monitoring of inner dune ponds (Kitty Hawk Woods).

Madison Lytle, UNC Wilmington
Effects of cold temperature stress and water clarity on Halodule wrightii persistence

Co-Authors/Collaborators: Jessie Jarvis
Abstract: North Carolina (NC) is a transition zone between temperate and tropical seagrass bioregions. Seagrasses in Nc declined at rate of 1.5% per year between 2007 and 2013, potentially due to reduced light availability and temperature stress. Tropical species *H. wrightii* experiences cold stress when water temperatures are < 20ºC. It is unknown how prolonged periods of cold thermal stress (≥ 2 weeks) will impact the persistence of *H. wrightii* if light conditions also deteriorate. In Jan 2023 the stress response of *H. wrightii* to cold temperatures and reduced light was accessed in situ over 4 weeks. Light levels were manipulated to ambient, 11% and 22% of surface irradiance and shoot density and C:N were collected weekly. Belowground biomass had a response with water depth where deep (≥2m MLW) treatments had greater belowground biomass than shallow (≤ 2m MLW) treatments. This could possibly be due to differences in water temperature between the two treatments.

Presenter Bio: PhD Candidate, Coastal Plant Ecology Lab, UNC-Wilmington. Dissertation theme is spatiotemporal methods to monitor and manage seagrasses. Recipient of the 2022 NC Coastal Fellowship to study effects of water clarity on seagrasses at the Rachel Carson Reserve.

Matthew Godfrey
Collaborative research between NCWRC & NC Coastal Reserves

Co-Authors/Collaborators: Coastal Wildlife Diversity biologists at NCWRC
Abstract: Staff at NC WRC and NCCR have a rich history of collaborating on various research and monitoring projects involving coastal wildlife. This presentation will highlight a few current projects that are focused on birds and turtles.

Presenter Bio: Sea turtle biologist with NC Wildlife Resources Commission since 2002. Works closely with N.C. Coastal Reserve staff/volunteers on sea turtle nest monitoring and protection and/or sea turtle stranding response on Currituck Banks Reserve, Rachel Carson Reserve, Permuda Island Reserve, Masonboro Island Reserve, Zeke's Island Reserve, and Bird Island Reserve.

Taylor Reid Mattioli, UNC Wilmington
Bridging the Research-Action Gap: a "How-To Guide" for Conducting Marsh Organ Experiments

Co-Authors/Collaborators: Stacy B. Endriss, Devon Eulie, Joe Long, Gabrielle Pinto
Abstract: Marsh organs, structures designed to raise potted plants to different elevations to represent sea level rise predictions in real time, present a promising avenue for understanding how coastal environments will respond to global change. Experiments using marsh organs can inform critical coastal management decisions aimed at building long-term ecological and community resilience. However, despite the vast potential of marsh organ experiments, they remain largely underutilized. Here, we aim to increase the accessibility of marsh organs by creating reproducible guidelines that can be adapted to address diverse ecological questions across dynamic coastal environments. Specifically, we conduct a systematic literature review to synthesize common themes in current marsh organ studies and identify practices used to implement marsh organs. Further, we utilize a local case study to evaluate these methods and inform recommendations for future studies. To this end, we provide (i) recommended practices for evaluating potential marsh organ sites, (ii) methods and resources to increase transparency and accessibility of marsh organ construction and installation, and (iii) structural guidance for utilizing marsh organs in high-energy coastal systems. We recommend that future studies using marsh organs clearly report site evaluation methods, building materials, construction methods, and installation methods. To facilitate this reporting, we provide a template for reporting methods, a structural blueprint for an adaptable marsh organ design, and a site-suitability model for determining optimal marsh organ placement. We believe these guidelines and resources will enhance the quality, interpretability, and repeatability of future marsh organ studies, and thus help bridge the gap between research and action in this emerging field that has so much unrealized potential to assist in addressing current management needs.

Presenter Bio: Taylor Reid Mattioli is a Master's student in Environmental Studies at UNCW, where she is leading a Marsh Organ experiment in the Endriss and the CES Lab to understand the effects of salinity, sea level rise, and management techniques on Phragmites australis in coastal North

Carolina. This experiment has only been possible through collaboration with NERRS, and highlights Taylor's passion for invasive plant control, problem solving, and practical environmental conservation and conducting research that informs coastal land management decisions.

Appendix 2: Poster Presentation Abstracts

This is a summary of the research abstracts presented at the Poster Reception at the N.C. Maritime Museum on May 8 from 5:30-7:30pm.

Andrew McMains, East Carolina University
Investigating the Impacts of Dredging on Coastal Inlet Habitat Function Using Acoustic Imaging

Co-Authors/Collaborators: Chris Taylor, James Morley
Abstract: Despite the accepted importance of coastal inlets as foraging habitat and as critical movement corridors between estuaries and the littoral ocean, these areas remain understudied. Along with their ecological function, inlets play an important role in coastal economies. Deep draft shipping channels must be maintained through inlets to allow the passage of commercial shipping vessels, requiring consistent dredging. Historically, inlet dredging has been restricted to winter months to mitigate the impacts on larvae and nekton. While it would be desirable to allow the dredging of port serving inlets year-round, the ecological tradeoffs of that strategy are unknown. We utilized a Before, After, Control, Impact experimental design to investigate the impacts of inlet dredging on fish abundance and habitat utilization in Beaufort Inlet, NC in the summer and fall of 2022. Random stratified sampling was conducted using an acoustic imaging sonar to determine the relative abundances and trophic guilds of fish in the inlet area. Overall, we saw low fish densities in the inlet and large temporal variations in abundances; peak abundances in Beaufort Inlet occurred in late August. Our data will provide important information to managers regarding the impacts of dredging on inlet use by fish as well as the duration of the disturbance. Additionally, this work will provide a baseline understanding of the seasonal trends in inlet utilization and will support future work identifying the drivers of large-scale inlet ingress and egress events.

Presenter Bio: PhD student studying fisheries ecology. Specific research interests revolve around identifying range of anthropogenic impacts on fish habitat use using and array of acoustic techniques. NERRS involved research includes using split beam sonar and acoustic imaging to look at the impacts of dredging on inlet habitat use in Beaufort Inlet and the adjacent estuary.

Antonio Rodriguez, UNC-Chapel Hill
Accelerating sea-level rise promotes rapid oyster reef accretion

Co-Authors/Collaborators: Justin T. Ridge, Molly C. Bost, Naomi Nice, Eve R. Eisemann, Yasamin Sharifi, Joshua Himmelstein, and F. Joel Fodrie
Abstract: Intertidal oyster reefs are increasingly being promoted as effective natural breakwaters to protect coastal infrastructure from storm waves and as carbon burial sites to mitigate greenhouse gas emissions. Their function as carbon sinks and breakwaters is often supported by information extracted from living oyster populations and assessment over short periods; however, both services depend on accretion, which operates over decadal to century time scales. Sea-level rise is accelerating globally and a reef's provision of wave attenuation and carbon burial into the future is predicated on its growth. Here we show that the rate of sea-level rise drives oyster reef vertical accretion and carbon burial. We found that when sea-level rise began to continuously accelerate

after 1800 CE to the modern rate of ~3.5 mm y-1, reef vertical accretion rates were an average of three times greater than the previous 18 centuries when sea level was rising 0.9 mm y-1. Oysters modulate carbon burial because the flux of shell to the subsurface was directly related to the flux of organic matter; however, none of the 25 reefs sampled ever functioned as net carbon sinks because CO2 is emitted during shell formation. Our results suggest that as sea-level rise continues to accelerate, oyster reef vertical growth will rapidly respond, shell production and burial will increase more than organic matter, and there will likely be ecosystem-service tradeoffs with reefs becoming even larger sources of CO2 but more effective at damping waves.

Brett Wilson, UNC Wilmington
Diamond-backed terrapin bycatch reduction in the North Carolina commercial Blue crab fishery

Co-Authors/Collaborators: Amanda Southwood Williard, Joe Facendola (NC Division of Marine Fisheries) Abstract: The commercial blue crab (Callinectes sapidus) harvest represents one of the most valuable fisheries in North Carolina and is a significant economic driver for coastal communities. The estuarine diamond-backed terrapin (Malaclemys terrapin) is listed as a Species of Special Concern by the North Carolina Wildlife Resources Commission, and a report submitted by the Scientific Council on Amphibians and Reptiles concluded that incidental bycatch in crab pots is the most serious threat to terrapins in North Carolina and throughout their range. Efforts to reduce bycatch by installing bycatch reduction devices (BRDs) to funnel openings on crab pots have been met with strong resistance due to perceived reductions in blue crab catch. In 2020, the North Carolina Division of Marine Fisheries (NCDMF) designated Diamond-backed Terrapin Management Areas (DTMAs) at Masonboro Island and Bald Head Island, within which the use of NCDMF-approved BRDs is required. While this regulatory measure was taken, the NCDMF acknowledged the need to explore alternative gear modifications that exclude terrapins while minimizing impacts to target species catch and therefore more accepted within the industry. The primary goal of our study was to test the efficacy of novel, industry proposed gear modifications that narrow the funnel entry without the need to install a BRD, referred to as the narrow funnel design (NFD) and reinforced funnel design (RFD), at excluding terrapins and assess impacts to blue crab catch.

Presenter Bio: Graduate student in the Comparative, Integrative, and Marine Biology Program at UNC Wilmington. Dissertation research focused around Diamond-backed terrapin bycatch reduction and management in the North Carolina commercial blue crab fishery, using a combination of fishing gear development and testing, population genetics, and spatial analysis of crab pot distribution. Actively collaborating with crabbers fishing within the Masonboro Island Reserve and Zeke's Island Reserve

Dan Rittschof, Duke University Marine Lab
Sympatric Speciation in Blue Crabs

Co-Authors/Collaborators: Megan Moran, Zack Darnell, Gary Dickenson
Abstract: Blue crabs release larvae at mouths of estuaries and in the coastal ocean. Larvae spend 40 to 60 days developing into the last larval stage and return to estuaries. Female crabs undergo a

terminal molt to maturity and mate 1 to several times over a few days until their seminal receptacles are full. Crabs mature their ovaries and then migrate to the mouths of estuaries and coastal ocean where they release 3 to 7 clutches of embryos about 64,000,000 larvae. We provide molecular biology evidence on a mitochondrial enzyme that suggests Blue crab genotypes sort by salinity with high salinity crabs being different than low salinity crabs. Because the crab fishery removes intermediate genotypes, development of two species from one species may be accelerated.

Grace Loonam, East Carolina University
Biodiversity and habitat complexity as indicators of community assembly following oyster reef restoration

Co-Authors/Collaborators: Rachel Gittman, Ulises Mendoza, Chris Moore, Emory Wellman, April Blakeslee
Abstract: While anthropogenic ecological degradation has posed significant challenges on a global scale, human-induced changes to habitats and communities provide opportunities to not only investigate the resilience and recovery of communities following disturbance, but also how they assemble and shift over time. Habitat restoration offers a way to study these changes while also providing a mechanism for restoring lost ecosystem function and services following human disturbance. Two restoration approaches were implemented in 2018 in the Rachel Carson Reserve in Beaufort, North Carolina: a traditional shell bag approach, and a novel biodegradable substrate, OysterCatcherTM. My project compares these approaches to each other and with nearby natural reefs to examine measures of habitat complexity and community composition five years post-restoration. I use established protocols to characterize habitat complexity including oyster reef parameters (live oyster densities, oyster sizes, reef dimensions). Community succession and diversity are assessed using passive samplers that recruit reef-resident organisms and their parasites. I also use the trematode parasites of eastern mud snails (Ilyanassa obsoleta) as surrogates of biodiversity, as parasite diversity is often an 271 indicator of trophic structure and complexity. This work will illustrate the applicability of restoration as a tool for studying ecological succession.

Georgette Tso, East Carolina University
Wave transformation across natural and restored oyster reefs

Co-Authors/Collaborators: Rachel Gittman, Siddharth Narayan, Hannah Sirianni, Megan Geesin
Abstract: Oyster reefs offer coastal protection benefits by reducing incoming waves and stabilizing coastal sediments. As offshore waves propagate towards coastlines, intertidal oyster reefs act to reflect and dissipate waves through depth-induced wave breaking and bottom friction, reducing wave heights before they reach the shore. Wave attenuation by oyster reefs is critical to the stabilization of coastal sediments, yet the degree of wave attenuation provided by natural and restored oyster reefs has not been quantified. Wave gauges were deployed across natural and restored oyster reefs in Middle Marsh and Back Sound to capture wave transformation processes and to quantify wave attenuation benefits.

Joel Fodrie, UNC-Chapel Hill (on behalf of Lillian Doll, Nadya Gutierrez, and Heather Bruck)
Weathering the storm: are restored oyster reefs insensitive or vulnerable to tropical cyclones?

Abstract: Resilience to intense weather is an essential quality of successfully restored habitat, including constructed oyster reefs. Factors that drive the long-term lifespan of restored oyster reefs, including physical stressors from extreme environmental events, are unclear. We used fetch, the distance over which wind travels over open water, as a proxy for constructed oyster reef vulnerability to physical damage from storms. We measured fetch in four cardinal and four ordinal directions from reefs constructed between 1997 and 2016, and compared those values to historical (1997 - 2021) and present-day (April 2024) reef status (present or absent). Reefs present as of April 2024 had >50% lower fetch values than those that were absent. Lower fetch values likely correlate with lower physical stressors during storms (i.e., wind, current, or wave energy). The historical track of reef conditions suggests there are threshold dynamics at play, where only large storms (i.e., Florence) triggered reef loss. Though the conditions that promote resilient, long-lasting oyster reefs need further investigation, the information collected here suggests that fetch should be considered when determining reef construction locations.

Presenter Bio: Professor, Estuarine Ecology Lab, UNC-CH Institute of Marine Sciences. Our lab's activities in and around the Rachel Carson Reserve date back to 1998, and span projects related to oyster reef restoration, living shorelines, seagrass community ecology, and nursery habitat dynamics via long-term juvenile fish surveys (2010-present, monthly)

Kalena Walker, UNC Wilmington
Characterizing inter- and intra-annual grain size trends on Masonboro Island, NC

Abstract: Barrier islands are coastal features that provide wildlife habitat, recreation opportunities, and protection from storm surge and wave action for adjacent communities. Barrier islands are also particularly dynamic and responsive to changes in the environment and require informed management practices for coastal resiliency. An important component of informed management practices is the utilization of probabilistic models, which often use a default grain size for a given barrier island system. However, studies have suggested that grain size has a significant impact on sediment dynamics that control barrier island morphology and by incorporating real-world grain size measurements, modelers can improve their accuracy and performance. There remains a need to analyze sediment grain size on barrier islands with high spatiotemporal resolution to inform the use of grain size as a model parameter. This study aims to characterize the grain size distribution of Masonboro Island, North Carolina at varied spatio-temporal resolution to capture the range in grain size variability. In 2018, a north and south transect was established, each consisting of five surface sampling stations placed from the foreshore to backbarrier, and an aerial sediment trap array installed at the crest of the foredune. Surface and aerial sediment samples were collected seasonally as well as before and after storms, then analyzed for grain size from 2018–2024. By examining the grain size trends on Masonboro Island, I aim to elucidate the role grain size may play in the geomorphology of the island over short (i.e., days to weeks) and long (i.e., seasons to years) timespans. A better understanding of the variability in sediment grain size on a barrier island will

inform coastal management and allow coastal communities to better prepare for coastal related challenges like storms, rising sea levels, and resource management.

Presenter Bio: MS Geoscience Student in Earth and Ocean Sciences at UNCW. Kalena is currently working on characterizing the grain size characteristics of surface and aeolian transported sediments on Masonboro Island over varying spatial and temporal scales.

Kate Goodenough, Larid Research and Conservation, and Lindsay Addison, Audubon NC
GPS telemetry reveals important foraging dynamics for American Oystercatcher pairs nesting in variable habitats

Abstract: Approximately 400 pairs of American Oystercatchers (Haematopus palliatus) (AMOY) nest in North Carolina, with the majority nesting on natural marsh islands and barrier island beaches (36% and 45%, respectively), while others nest on dredged-material islands (19%). In some regions, these nonbarrier island breeding locations have up to 17.6 times more breeding pairs per kilometer than barrier beach habitat, yet we know little about how AMOY use these landscapes. For this project, we used GPS telemetry to identify associated foraging areas for AMOY nesting in each of these landscapes. We deployed a total of 30 GPS dataloggers on nesting AMOY during the 2019 and 2021-2023 breeding seasons. Our preliminary results suggest that space use by AMOY varies spatially and temporally depending upon nesting habitat. All monitored AMOY foraged nocturnally throughout the night from dusk to dawn (2200-0400). Very little foraging overlap occurred, suggesting AMOY might have foraging territories in addition to nesting territories. Last, foraging distances were smaller for pairs with nesting territories that had adjacent foraging grounds compared to locations without, which has important implications for AMOY conservation and management.

Presenter Bios: Lindsay is a coastal biologist, Audubon North Carolina, and manages Audubon's coast islands and sanctuaries program which manages and monitors 40% of the state's nesting coastal waterbirds and collaborates on conservation-related research. She sits on the American Oystercatcher Working Group's steering committee and coordinates oystercatcher banding statewide. For over a decade, Audubon has been a partner of the Coastal Reserve System, supporting bird monitoring efforts at Masonboro Island and Rachel Carson Reserves. Kate is a movement ecologist whose research is focused on life history strategies of coastal nesting bird species. She has been involved in shorebird management and conservation related research since 2004. She has over 12 years of experience working with telemetry projects and over 18 years of experience working on avian movement projects.

Mackenzie Douglas, UNC-Chapel Hill Outer Banks Field Site
An Analysis of Community Values and Vegetation Changes in Buxton Woods

Co-Authors/Collaborators: Lindsay Dubbs, '21 & '22 UNC-Chapel Hill Institute for the Environment
Abstract: This research poster presents findings from a study conducted in 2021 and 2022 involving stakeholders from Buxton Woods, aiming to understand shifts in the ecology and perceptions of change within the area. Through the analysis of 11 interviews, 26 key concepts were identified

which were then utilized in the Conceptual Content Cognitive Mapping (3CM) method. This method, involving physical ranking and grouping of terms, yielded many insights. Notably, participants highlighted positive connections to natural systems, particularly emphasizing resource access and recreational activities like hunting and trail use. Concerns about Buxton Woods were less frequently mentioned but were highly ranked. The Carolina Vegetation Survey (CVS) method was employed to understand the natural systems in Buxton Woods. By employing the CVS method, current vegetation structure and composition were assessed and compared to a similar study conducted in 1988, revealing shifts in species variation and stem cover density. The study underscores the importance of community engagement and ongoing monitoring to ensure the resilience and sustainable management of protected ecosystems like Buxton Woods amidst natural and anthropogenic changes.

Presenter Bio: Environmental studies graduate with a bachelor's degree from UNC-Chapel Hill. With a passion for understanding and preserving natural ecosystems, Mackenzie has engaged in research projects focused on community involvement and environmental change assessment, specifically in the Buxton Woods. Currently working as a Middle School science teacher in rural Appalachia, Mackenzie seeks to drive scientific knowledge and understanding whilst encouraging student-led action for the sustainable management of ecosystems in response to evolving environmental challenges.

Megan Geesin, East Carolina University
Evaluating the influence of a biodegradable oyster breakwater on local ecosystems and geomorphology

Co-Authors/Collaborators: Hannah Sirianni, Georgette Tso, Rachel Gittman
Abstract: Salt marshes are highly productive systems that provide a variety of ecosystem services including shoreline stabilization, water purification, carbon sequestration, and nursery habitat to important fisheries species and wildlife. A variety of human impacts including climate change, coastal development, and pollution threaten salt marshes. A common method of protecting salt marshes from sea level rise and storm surges involves installing fringing oyster reefs. Because oyster reefs can attenuate waves, they are able to reduce shoreline erosion and accrete sediments allowing salt marshes to expand seaward.

Presenter Bio: Ph.D. candidate, Integrated Coastal Studies, East Carolina University. Megan’s research focuses on investigating the influence of different living shoreline structures on their surrounding habitats and faunal communities through the use of in situ methods and remote sensing techniques. As a member of Dr. Rachel Gittman’s lab, she has assisted with data collection and processing at living shoreline sites constructed in 2020 along Taylors Creek in the Rachel Carson Reserve.

Ray Danner, Althouse and Meade, Inc. & UNC Wilmington
Synthesizing Motus Data Across the NERRS For Research, Education, and Conservation

Co-Authors/Collaborators: Marae L. West, Evangelyn Buckland, Lori Davis

Abstract: Over half of the NERRs have Motus wildlife tracking stations, which provide new information on the presence and movements of animals. Given the NERRS' increasing number of Motus stations, growth of the resulting databases, and interest in these data from within and outside of the NERRs, there is an opportunity to develop a collaborative community and supporting infrastructure within the NERRS. Objectives: 1) Create a website that displays Motus data from across the NERRS, which would support research, education, and conservation. The website will show locations of towers, numbers of species detected, example species detected, and connections among sites. 2) Develop freely available educational resources related to Motus data from the NERRS. Including: i) an online dashboard intended for students in grades 6–12 that could be used individually or in a directed lesson in the classroom, ii) digital and printable resources for visitors to the NERR sites, and iii) social media content. 3) Develop inperson educational experiences at NCNERR by attaching Motus transmitters to painted buntings at Reserve sites. 4) Facilitate construction of Motus systems at approximately four priority locations. 5) Promote communication and collaboration among the NERRS staff to ensure that shared values and goals are met.

Presenter Bio: Ray Danner has expertise in coastal bird ecology, including marsh and beach-nesting birds, population biology, assessments of current and future habitat availability, assessment of human disturbance, breeding biology, radio telemetry, and thermal biology. He is a Senior Research Scientist at Althouse and Meade, Inc. and an Associate Professor in the Department of Biology and Marine Biology at UNCW. He and colleagues are leading a current NERRS Science Collaborative Project with the NCNERR and other NERRs across the country that is helping build the NERRS' capacity to use the Motus radio telemetry network. His current and former students conduct research at NCNERR sites, with a current project led by Juan Zuluaga focusing on thermal biology of birds at Bird Island, and previous projects on marsh sparrows and beach-nesting birds.

Appendix 3: Symposium Attendees

This is a list of participants who attended the symposium.

First Name	Last Name	Affiliation
Abby	Williams	N.C. Coastal Reserve & National Estuarine Research Reserve (NCNERR)
Amanda	Williard	University of North Carolina Wilmington (UNCW)
Andrea	Hawkes	UNCW
Andrew	McMains	East Carolina University Coastal Studies Institute
Antonio	Rodriguez	University of North Carolina at Chapel Hill (UNC-CH)
April	Blakeslee	East Carolina University (ECU)
Brandon	Puckett	National Oceanic Atmospheric Administration (NOAA)
Brett	Wilson	UNCW
Byron	Toothman	NCNERR
Chris	Ellis	NOAA Office for Coastal Management
Claire	Rapp	North Carolina Coastal Federation
Dan	Bowling	NC State / NC NERR MAD Fellow
Elizabeth	Pinnix	NCNERR
Erica	Seiden	NOAA Office for Coastal Management
Erik	Alnes	NCNERR
Eve	Eisemann	UNC-CH Institute of Marine Sciences (IMS)
Georgette	Tso	ECU
Grace	Loonam	ECU
Heather	Wells	NCNERR
Heather	McGuire	Chowan University
Jacob	Boyd	NC Coastal Federation
Jenny	Davis	NOAA
Jillian	Daly	NCNERR
Joe	Long	UNCW
John	Fear	Sea Grant - WRRI
Juliet	Wong	Duke University Marine Lab
Justin	Ridge	NCNERR
Kalena	Walker	UNCW
Kate	Goodenough	Larid Research and Conservation
Katherine	Anarde	North Carolina State University (NCSU)
Leanne	Poussard	NOAA NCCOS
Lindsay	Dubbs	UNC-CH Institute for the Environment Outer Banks Field Site and the Coastal Studies Institute (ECU)
Lora	Eddy	The Nature Conservancy
Lori	Davis	NCNERR
Mackenzie	Douglas	UNC-CH Institute for the Environment - OBX Field Site

Madison	Lytle	UNCW
Mariko	Polk	North Carolina Sea Grant
Matthew	Godfrey	NC Wildlife Resources Commission
Megan	Geesin	ECU
Michelle	Brodeur	NC Division of Marine Fisheries
Miriam	Sutton	Science by the Sea
Morgan	Penrose	NCNERR
Nathan	Hall	UNC-CH, Earth Marine and Environmental Sciences, Institute of Marine Sciences
Niels	Lindquist	UNC IMS
Paige	Siegel	ECU
Paula	Gillikin	NCNERR
Raymond	Danner	Althouse and Meade, Inc.
Rebecca	Ellin	NCNERR
Risper	Nyairo	Davidson College
Sarah	Spiegler	NC Sea Grant
Stacy	Endriss	UNCW
Stephanie	Robinson	Lynker on contract with NOAA OCM
Stephanie	Kelly	Earth Matters Planning & Design
Susan	Cohen	UNC-CH
Taylor	Mattioli	UNCW
Wayne	Hall	Division of Coastal Management
Whitney	Jenkins	NCNERR
Yasamin	Sharifi	UNC
Yener	Ulus	Davidson College