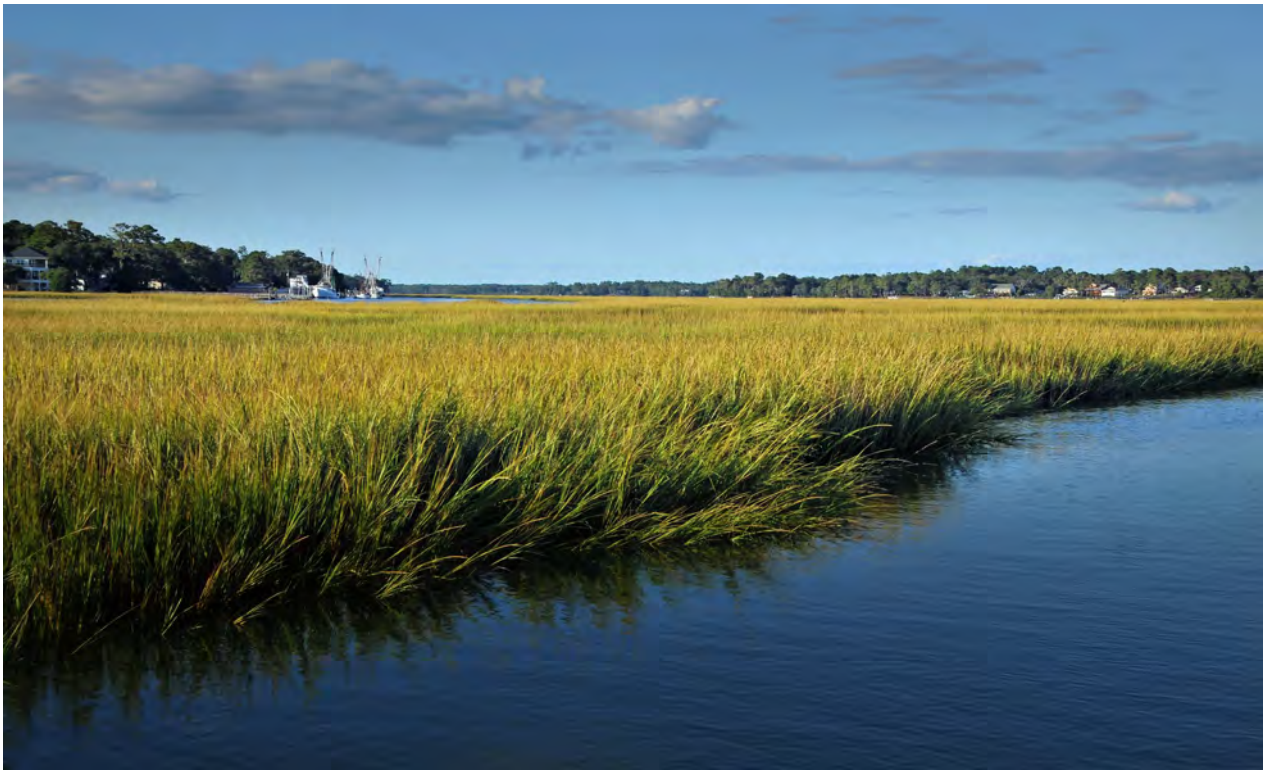
North Carolina Sea Grant Research Symposium:

Investments and Opportunities



April 16, 2014

McKimmon Center

North Carolina State University

Raleigh, NC

North Carolina Sea Grant Investments and Opportunities

North Carolina Sea Grant's leaders and partners are immersed in impacts as they review the program's history and look ahead to its future.

"I have been here more than a year, and each week I am learning more about the strength of the investments the Sea Grant program has made in coastal science over the past four decades," notes Susan White, executive director.

"In business terms, we have a strong brand that is respected across the state. We have an amazing portfolio of research and outreach across a broad range of topics. Our challenge is to build on that success while also providing incentives for innovators to take bold steps."

White cites a multitude of partnerships, including with community leaders, internationally recognized experts, new faculty and resource managers making policy decisions. "They all will be key in helping us identify our path forward," she adds.

Sea Grant's value in North Carolina was cited in the 2013 review of all coastal and marine science programs in the state. Requested by the University of North Carolina system, the study was conducted by a team from the American Association for the Advancement of Science. White has continued to lead a committee looking to increase collaborations in marine sciences across the state.

Sharing Success Stories

As White and a committee of coastal experts from various universities developed plans for a North Carolina Sea Grant Research Symposium, the theme quickly emerged: *Investments and Opportunities*.

"I am excited to see this new collaborative initiative by North Carolina Sea Grant," notes Chris Brown, UNC system vice president for research and graduate education.

"It's increasingly important to engage an array of stakeholders — including researchers, government officials on all levels, business owners and residents — to identify and leverage expertise and resources to address these strategically. Such discussions will move North Carolina coastal and marine research and outreach programming forward to address emerging issues."

The event highlights outcomes from core projects over the past 10 years. Each agenda segment will provide snapshots of results that are being used by resource managers, community leaders and/or property owners.

"The audience is there to participate. Each focus-area discussion could start with how the particular results can be shared with additional partners," notes Jennifer Dorton, symposium coordinator.

"From there, we can move to additional current and emerging problems and potential solutions. These sessions will provide inspiration and focus for future research," she adds.

Moving Forward

John Fear, Sea Grant's deputy director, says the day will show how research projects link seamlessly to the organization's outreach to varied groups.

Fear is especially interested in the graduate students working with expert mentors. "I look for these students to seek out — and at times create — new tools for data gathering and analysis, as well as to find new ways to communicate results. These future leaders reflect generations that grew up with online resources and connections," he explains.

"Also, these days, nearly all research projects are interdisciplinary, because so many tackle problems from many perspectives at the same time."

Presentations from the symposium will be posted online for follow-up discussions.

"We had a difficult time selecting topics just from the core projects, but we will be offering a wonderful spectrum of biological, physical and social sciences, as well as communications studies that traditionally may have been placed in the humanities," White adds.

Future gatherings could focus on minigrants, North Carolina Sea Grant's nationally recognized seed-funding opportunities that often provide proofs of concepts that can be expanded through major grants from other agencies. Other success stories include state and federally funded programs supporting cooperative fisheries research.

Adapted from Coastwatch*, Spring 2014*

Agenda
Wednesday, April 16, 2014

8:00	**Check-in**
8:20 – 8:30	**Welcome** Susan White, Executive Director, North Carolina Sea Grant
8:30 – 8:40	**Opening Remarks** Chris Brown, Vice President for Research and Graduate Education, University of North Carolina System
8:40 – 9:15	**Opening Plenary** Margaret Davidson, Acting Director, National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management
9:20 – 10:30	**Session 1 — Hazard Resilience in Coastal Communities** • Catherine Smith and Donna Kain, East Carolina University • Scott Hippensteel, University of North Carolina Charlotte • Jessica Whitehead, North Carolina Sea Grant
10:30	**Break**
10:40 – 12:00	**Session 2 — Sustainable Coastal Development** • Lisa Campbell, Duke University • Antonio Rodriguez, University of North Carolina - Chapel Hill • Craig Landry, East Carolina University • Huili Hao, East Carolina University
12:00 – 1:30	**Lunch *(provided by NC Sea Grant)* and Poster Session**
1:30 – 2:50	**Session 3 — Safe and Sustainable Seafood Supply** • Jeffrey Buckel, North Carolina State University • David Eggleston, North Carolina State University • Craig Sullivan, North Carolina State University • Scott Baker, North Carolina Sea Grant
2:50	**Break**
3:00 – 4:25	**Session 4 — Healthy Coastal Ecosystems** • Hans Paerl, University of North Carolina - Chapel Hill • Michael Piehler, UNC Chapel Hill/UNC Coastal Studies Institute • Troy Alphin, University of North Carolina Wilmington • Larry Cahoon, University of North Carolina Wilmington
4:25 – 4:40	**Group Discussions**
4:40 – 5:00	**Future Planning**
5:00	**Adjourn**

Opening Session Speakers

Susan N. White
Executive Director, North Carolina Sea Grant and
the Water Resources Research Institute of the University of North Carolina System
Susan White leads two inter-institutional UNC System programs based at NC State University that provide targeted research, outreach, and education projects to address critical water and coastal resource issues in the state and region. Previously, she was the director of the National Oceanic and Atmospheric Administration's Hollings Marine Laboratory in Charleston, S.C. There she provided research vision and organizational management, including strategic planning with the partner agencies and universities. She also served as national research coordinator for NOAA's Estuarine Reserves Division and National Estuarine Research Reserve System.

Chris Brown
Vice President for Research and Graduate Education, University of North Carolina System
Chris Brown promotes research, sponsored programs, and graduate education across the full spectrum of academic disciplines and interdisciplinary activities carried out by UNC's 16 university campuses. He helps advocate for increased levels of external support from federal, state, and private sources and works closely with UNC General Administration staff and campus administration to support a culture of innovation and entrepreneurship, and to develop research and sponsored-program agendas that are supportive of the mission of each. He previously served as associate vice chancellor for research development at NC State, where he was a professor of plant biology.

Margaret Davidson
Acting Director, National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management
Longtime director of the NOAA Coastal Services Center, Margaret A. Davidson joined NOAA in 1996 after 12 years as executive director of the South Carolina Sea Grant Consortium. She served as the acting assistant administrator for NOAA's National Ocean Service from 2000 to 2002 and previously served as special counsel and assistant attorney general for the Louisiana Department of Justice. An attorney active in coastal resource management issues since 1978, she holds a faculty appointment at the University of Charleston and serves on the adjunct faculties of Clemson University and the University of South Carolina. She has served on numerous local, state, and federal committees and has provided leadership for national professional societies. She has focused her professional work on environmentally sustainable aquaculture, mitigation of coastal hazards, and impacts of climate variability on coastal resources.

Presentation Abstracts
Session 1 – Hazard Resilience in Coastal Communities

Reception and Use of Hurricane Risk and Hazard Information

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To assess or to improve hazard resilience in coastal communities, we need to understand risk perceptions and the efficacy of warning communications. Results of the 2008-2011 NOAA-North Carolina Sea Grant supported study "Risk Perceptions and Communication Effectiveness in Coastal Zones" in 20 coastal counties show that residents (sample 1079) as well as businesses/organizations (sample 603) differ in how they 'pull' warning messages to decide on their own response, as well as how they 'push' warning information in social and cultural networks to assist others.

Findings, reports, and selected presentations from this study are accessible at our Risk Communication website (www.ecu.edu/riskcomm). Publications are available from the authors Catherine Smith, Donna Kain and Kenneth Wilson.

About the Speakers:
Catherine F. Smith is Emerita Professor of English/Technical and Professional Communication, East Carolina University. She is the author of Writing Public Policy: A Practical Guide to Communicating in the Policymaking Process, 4th edition forthcoming 2015 (Oxford University Press). She was principal investigator (with co-PIs Donna J. Kain and Kenneth Wilson) of the 2008-2011 NOAA-Sea Grant North Carolina study of hurricane risk and hazard communications. Results of that study are presented at this symposium. Additionally, she was co-investigator (with principal investigators Kenneth Galluppi, Jessica Losego, and Burrell Montz) of the 2009-2011 NOAA-NWS-RENCI (UNC) studies of the use of National Weather Service products and services for decision-making by North Carolina emergency managers, hospital and school administrators, utility companies, and other support functions during winter and tropical storm emergencies. Since retiring from ECU in 2012, she focuses on public affairs and environmental interests. She contributes public comments in federal rule-making, participates in local government as a concerned citizen, and writes funding applications for community groups in Orange County, North Carolina, and Centre County, Pennsylvania. She lives primarily on an old farm (http://chicorylane.com) where she is active in wildlife habitat preservation, conservation ecology, native plant inventory, historical land-use research, and public environmental education.

Donna Kain is an Associate Professor of Rhetoric, Writing, and Professional Communication in the English Department of East Carolina University. She teaches courses including technical communication, writing for business and industry, and risk communication. Her research includes risk communication and natural hazards including severe weather and sea level rise and related public policies, visual information, and new media. Related positions have included Director of Outreach and Communication for the ECU Renaissance Computing Institute (RENCI) Engagement Center and affiliate faculty in the Center for Natural Hazard Research and the Center for Sustainable Tourism at ECU. Kain is currently the Editor of Technical Communication Quarterly, the journal of the Association of Teachers of Technical Writing.

Paleotempestology of Onslow Bay, North Carolina

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As coastal populations continue to grow, and as recent Gulf Coast and New England hurricanes dramatically demonstrated, there is a need for better understanding of storm frequency. The paucity of historical records for hurricane landfalls along the southern Atlantic coast limits their use as a predictive tool. Whereas historical records of hurricanes along the Atlantic coast are limited to the past 300 years, and reliable instrumental records extend back only half that length of time, proxy records taken from coastal sedimentary archives offer the potential to extend this record several thousand years, offering better statistical constraints on hurricane prediction. Paleotempestology is the study of ancient hurricanes. Two primary proxies have been the most studied during the last decade: sedimentary criteria and microfossils. During hurricanes, sand and microfossils are eroded from shallow marine environments and deposited by storm surge across backbarrier marshes. Eventually these sand layers are reburied by the marsh and may be preserved for millennia in the backbarrier strata.

In this North Carolina Sea Grant-funded study, Hippensteel used a microfossil-based proxy — displaced marine foraminifers — to investigate a 1,500-year paleostorm record of Onslow Bay, North Carolina. He also compared marsh sediments and foraminifers pre- and post-Hurricane *Irene*, which made landfall in Onslow Bay on August 27, 2011. He found fewer hurricanes archived in the 1,500 years of backbarrier marsh deposits than have made landfall in Onslow Bay since 1950. This absence of preserved hurricane deposits, as well as the lack of a definitive signature from Hurricane Irene, suggests caution in respect to the sensitivity of sedimentological or micropaleontological proxies in paleotempestology studies. He concludes that, at best, only direct strikes from intense storms are being preserved. It is likely Hurricane Irene's landfall will not be detectable in the future in the marginal-marine sediments from this region.

To share findings with other geologists, climatologists, and the general public, the research team submitted manuscripts to high-impact journals with different audiences. One was published in December 2013 as the cover article for *GSA Today*[1], the highest circulation journal in all of the earth sciences. The findings were presented at the Geological Society of America's annual meeting in Charlotte, North Carolina. A second manuscript is in press with the *Journal of Coastal Research*[2],

[1]Hippensteel, S., Eastin, M., and Garcia, W. 2013. The geologic legacy of Hurricane Irene: Implications for the fidelity of the paleo-storm record. *GSA Today*, v. 23, n. 10, p. 4-10.
[2]Hippensteel, S.P., and Garcia, W.J., (in press), Micropaleontological evidence of prehistoric hurricane strikes from southeastern North Carolina, *Journal of Coastal Research*

About the Speaker: Scott P. Hippensteel is an Associate Professor of Earth Sciences at the University of North Carolina Charlotte where he teaches environmental geology, paleontology, and coastal geology. He graduated from the University of Delaware in 2000 with a Ph.D. in Geology. His research interests include using microfossils to solve environmental problems, such as quantifying Late-Holocene sea-level rise and documenting ancient hurricane strikes along the Atlantic coast. The research he most enjoys involves Civil War geoarchaeology and the Confederate submarine *H.L. Hunley*, where his micropaleontological analysis provided new insights into both the sinking and sediment infilling history of the boat and the eventual fate of the crew.

Preparing Plymouth, North Carolina for Future Flood Risks

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Co-Authors: Gloria Putnam, North Carolina Sea Grant and Michele Covi, Old Dominion University/Virginia Sea Grant

North Carolina's coastal communities are already exposed to weather and climate hazards like flooding and hurricanes. This exposure may increase as rainfall becomes more variable and sea levels rise. Simultaneously, many communities are becoming more sensitive to damage from these hazards as critical infrastructure ages and economies change. In 2010, the Town of Plymouth, North Carolina, asked for North Carolina Sea Grant's assistance to begin exploring how changing environmental conditions may impact their community, with a particular focus on the town's already aging infrastructure. With funding from NOAA Sea Grant and the NOAA Sectoral Applications Research Program, North Carolina Sea Grant coordinated the plan of work with the town manager and mayor, as well as East Carolina University's Renaissance Computing Institute (RENCI) and the Social and Environmental Research Institute (SERI), to conduct interviews and a participatory adaptation assessment using the Vulnerability, Consequences, and Adaptation Scenarios (VCAPS) process (Putnam et al 2012). Interviews with 18 local leaders were conducted in 2010 to identify their concerns about how a changing environment may impact Plymouth and to identify areas that are currently prone to flooding from stormwater runoff or rising water levels on the Roanoke. In 2011, town leaders worked with the research team to implement the VCAPS process, allowing them to further explore their concerns and identify strategies with regards to how localized flooding could impact the town's stormwater and wastewater collection and treatment systems.

During the interview, local leaders reported noticing changes in shoreline erosion, localized flooding, stormwater management, drainage systems, saltwater intrusion to the river, drought, sea level rise, weather patterns, groundwater quantity and quality, river flow, wetlands and marshes, and other infrastructure (roads, buildings, and water and sewer facilities). Primary issues of concern centered on addressing current and future challenges associated with the wastewater treatment plant collection system, reducing localized flooding, improving the local economy, protecting and utilizing local natural resources, and providing amenities for and retaining youth within the community.

The team used the VCAPS process to further examine stormwater management and impacts to wastewater infrastructure further. Using a process rooted in the causal structure of hazards, during a VCAPS exercise a group of local decision-makers convenes for a facilitated discussion about a management issue. In real time, the facilitation team captures this discussion in a diagram that reflects the group's collective expertise on the stressors, consequences, and possible solutions. Through the VCAPS process, Plymouth leaders were able to identify many of the outcomes of the town's increased flooding risks and some general strategies to address them. Consequences of concern included fish kills, worsening inflow and infiltration, and flooded sewer pump stations and treatment facilities. However, many of the adaptation options identified depend on Plymouth's ability to get future grant funding to repair and move vulnerable infrastructure. The conditions of such grant funding often limit its use for preventive measures that build resilience. This lack of funding continues to provide Plymouth with barriers to implementing adaptive measures that reduce flood vulnerability.

Putnam, G., J. Whitehead, J. Thigpen, M. Covi, and S. Tuler, 2012. Facing the Future in Plymouth, NC: Preparing for Increased Flooding Risks. North Carolina Sea Grant Publication # UNC-SG-12-05. http://www.ncseagrant.org/images/stories/ncsg_pdf/documents/products/reports/facing_the_future_in_plymouth_nc_12-05.pdf

About the Speaker: Jessica Whitehead is the Coastal Communities Hazards Adaptation Specialist for North Carolina Sea Grant. Previously, she worked in North Carolina and South Carolina as the regional climate extension specialist for the South Carolina Sea Grant Consortium, North Carolina Sea Grant, and Carolina's Integrated Sciences and Assessments program at the University of South Carolina. She assists coastal users with integrating information about coastal hazards into their decision-making processes. Her work ranges from giving talks on coastal weather and climate hazards to community groups to working with scientists to develop decision-support tools for weather and climate hazards risk and adaptation. Whitehead holds a Ph.D. in Geography from Pennsylvania State University, where her dissertation focused on building scenarios of small drinking water utilities' capacities to adapt to climate change. She also holds a master's in Meteorology from Pennsylvania State University and a bachelor's in Physics from the College of Charleston.

Presentation Abstracts
Session 2 – Sustainable Coastal Development

Change in Coastal Communities: Perspectives from Down East

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From 2008-2010, a group of researchers at Duke University conducted research to better understand the perspectives of residents and landowners in Down East, Carteret County, North Carolina, on changing economies, cultures, and environments. Data were collected through door-to-door and mail surveys, in-depth interviews that were also used in a documentary film, and county tax records. Results were discussed at a series of community meetings, with a focus on identifying possible responses by communities to both perceived problems and possibilities. Although results are interesting for what they illustrate about areas of common and different concern among respondents (see Boucquey et al. 2012; Campbell et al. 2009; Voices of Down East at http://communityvoicemethod.org/change-in-coastal-communities/), in this presentation, we highlight how the project and its results have been translated into a number of other projects and initiatives designed to improve the economic, environmental, and social well-being of communities Down East, as well as on Ocracoke and Hatteras islands.

Boucquey, N., L.M. Campbell, G. Cumming, Z.A. Meletis, C. Norwood, and J. Stoll, 2012. Interpreting Amenities, Envisioning the Future: Common Ground and Conflict in North Carolina's Rural Coastal Communities. *Geojournal* 77: 83-101.

Campbell, L.M., N. Boucquey, G. Cumming, C. Norwood, Z. Meletis, and J. Stoll. (2009) Summary of Survey Results: Change in Coastal Communities: Perspectives from Down East. Retrieved from http://www.ml.duke.edu/coastalcommunities/Survey%20Results,%20Coastal%20Communities.pdf

About the Speaker: Lisa Campbell's research focuses on policies and projects designed to reconcile resource conservation with socio-economic development. She studies the process of policy-making, the transition from policy to practice, and the impacts of (and responses to) implementation at the local level. At the policy-making stage, she examines how the interaction of science and other values, and how negotiations between stakeholders (local people, bilateral agencies, NGOs, and 'experts') inform the process. Specific policies include participatory development, community-based conservation, sustainable use, and ecotourism. A major research focus of her work has been on marine turtle conservation policy, and its implementation in Latin America and the Caribbean. More recently, she has studied rural change in communities in eastern North Carolina and works with community partners to envision and implement responses to such change.

Examining the Geospatial Linkage between Modern Erosional Hotspots and Holocene Progradation and the Implications for Predicting Future Shoreline Positions along the Outer Banks, North Carolina

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Co-Authors: Greg Rudolph, Carteret County Shore Protection Office, and Christopher Freeman, Geodynamics, LLC

This research project was aimed at examining possible linkages between along-shore variability in barrier-island evolution over millennial time scales, the locations of underlying paleochannels that intersect barriers and variability in shoreline retreat rates over decadal time scales. The study area was Bogue Banks, the southernmost barrier of the Outer Banks island chain. The island contains areas of high-elevation beach ridges, large island widths, and stratigraphy consistent with regressive barrier islands. These regressive-island segments are separated by a broad and narrow section of the island devoid of any transgressive or regressive morphologic elements. The analyses of seismic data from the inner continental shelf reveal paleo-channels intersect the wider sections of the island, while the narrow central part of the island occupies an inter-fluvial area. Reworking of fluvial sediment from paleo-channels was an important sediment source for the barrier during regression. Transects of cores, seismic data, ground-penetrating radar data, and radiocarbon and OSL dates show that prior to ~1500 cal yr. BP the central narrow section of the island was wide and regressive similar to adjacent areas. Back-barrier erosion of the central part of the barrier primarily caused island narrowing as a result of increased storminess, which occurred around the Medieval Warm Period (~1100 cal yr. BP). The presence of historical inlets along the narrow central section of the island indicates Bogue Banks may be nearing a critical width threshold and will subsequently transition to a transgressive barrier. Maps from the study were used by managers and coastal engineering firms to locate nearshore sand resources.

Proxies, such as changes in beach profiles and shoreline positions, are commonly used in management and research for estimating changes in subaerial beach volume; however, the accuracy of these proxies across increasing time scales and complex morphologies is unclear. Management decisions and research results may be adversely influenced by inaccurate depictions of beach volume change that were based on a proxy that is not well suited to that particular beach morphology or time frame of interest. This study assessed the impacts of morphologic variations, associated with beach cusps and nourishment material, on volume change estimates from profiles and shoreline change at 0.5 to 3.5 year time periods. Results indicate that profiles spaced ≥ 150 m apart and the shoreline-change proxy will likely estimate volume change inaccurately over periods ≤ 1 year at beaches that are consistently eroding or accreting and contain cusps. However, over longer time periods (1–3.5 years), estimates of volume change from both proxies improved at those types of beaches. Results from these studies were communicated to decision makers by publishing in peer-reviewed journals, giving public stakeholder presentations, and most importantly, having a beach manager and coastal-engineering business owner directly involved with the project.

About the Speaker: Antonio Rodriguez grew up in Connecticut playing and working on Long Island Sound, and those experiences inspired his interest in coastal geology. He graduated from Hamilton College (Clinton, NY) in 1994 with a bachelor's degree in geology and Rice University in May 1999 with a Ph.D. in geology and geophysics. He stayed at Rice for the next year as a Postdoctoral Research Associate (from May 1999 to January 2000) and as a Lecturer (from January to July 2000). In August

2000, he accepted a job at the University of Alabama, Department of Geological Sciences as an Assistant Professor. There, he pursued research mainly looking at the evolution of estuaries in response to changes in sea level and climate over the last 9,000 years across the northern Gulf of Mexico. He left the University of Alabama in August, 2005 as a College of Arts and Sciences Leadership Board Faculty Fellow, and the George Lindahl Fellow. He is currently an Associate Professor at the University of North Carolina at Chapel Hill's Institute of Marine Sciences and Department of Marine Sciences. While his research emphasis is still on estuarine evolution, most of his work now takes place in the middle Atlantic coast. He also collaborates with many of his colleagues at UNC-CH examining anthropogenic and climate impacts on the ecogeomorphology of marsh, oyster-reef, and beach environments.

Economic Values of Coastal Erosion Management

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Co-Author: John C. Whitehead, Appalachian State University

North Carolina currently faces many problems related to the management of its beaches. Problems stemming from coastal erosion, storms, and sea-level rise are exacerbated by development along the coast and, especially, by development at the water's edge. Potential solutions include shoreline hardening, beach replenishment and coastal retreat. The project employs a survey of North Carolina households to estimate the benefits and costs of beach erosion management alternatives. The survey gathers data on use (and non-use) of North Carolina's coastal beaches, perceptions of coastal resource quality, and knowledge of coastal processes. We collect information on recreational visitation under current and hypothetical future conditions in order to assess the effects of coastal erosion and erosion management policies on tourism in the coastal zone. We use contingent valuation to assess households' willingness to pay for different approaches to shoreline erosion management. Our survey design also permits assessment of the economic costs of negative environmental impacts.

We contracted with Online Sampling Solutions, Inc. to access an eRewards online panel of 1,005 North Carolina households, receiving a 61% response rate. Comparing our descriptive statistics to data from the U.S. Census, we find our sample is comparable in terms of gender and household size, but our respondents tend to be slightly more educated and wealthier than the average North Carolina household. Our results indicate that shoreline retreat receives a larger proportion of support (71.3% indicating 'support' or 'highly support' on a 5-point Likert scale) relative to beach nourishemtn (67.2% support) and shoreline armoring (58.1%). We estimate recreation demand regression models in order to assess the effects of travel costs, management regimes, beach width, and environmental impacts on the intensity of visitation. Projected visitation is roughly the same (about 3 trips per year) under beach replenishment, but increases (by approximately 0.5 trips on average) under shoreline retreat management approach. The shoreline-armoring scenario reduced average trips to 2.25 per year. Negative environmental impacts reduce the number of trips for each scenario: to about 2 trips per year under beach nourishment, 1.75 trips per year under shoreline armoring, and 2.5 trips per year under shoreline retreat. Annual consumer surplus (the net value that visitors accrue over-and-above the expenditures they incur with visiting) is around $450 per household per year. Consumer surplus is roughly the same under beach nourishment, somewhat

larger under shoreline retreat ($560 per household per year), and smallest under shoreline armoring ($344 per household per year).

Turning to the contingent valuation data, we assessed North Carolina household willingness to pay for coastal erosion control using a simulated referendum, where the payment vehicle was an increase in state income taxes (coupled with an additional property tax assessment on beach houses). The average household was willing to pay an additional $18.84 for beach replenishment (only $8.77 if it entials negative environmental effects), $9.20 for shoreline armoring ($6.40 with negative environmental effects), and $23.41 for shoreline retreat ($17.88 with negative environmental effects).

About the Speaker: Craig Landry received bachelor's and master's degrees in Environmental Economics and Natural Resource Management from the University of Georgia in 1996 and 1998, respectively. He earned a Ph.D. in Natural Resource Economics from The University of Maryland, College Park in 2004. His research has been funded by the National Science Foundation, Bureau of Ocean Energy Management, National Oceanic & Atmospheric Administration, the North Carolina Energy Center, and North Carolina Sea Grant. External grant projects have focused on determinants of disaster migration and preference for rebuilding New Orleans in the wake of Hurricane Katrina, the impacts of coastal wind farms on recreation and tourism, economic impacts and value of the North Carolina for-hire recreational fishing fleet, individual risk perceptions and behavior in the context of tropical storms, and economic values for coastal erosion management. Landry has served as an Ad Hoc scientific peer reviewer on over 130 scholarly papers and research proposals and is current Associate Editor for Marine Resource Economics, The Natural Hazards Review, Ag & Applied Economics, and Journal of Ocean & Coastal Economics. Landry has over 30 peer-reviewed publications on various topics including individual decision-making in the context of natural hazards risk, recreation demand, econometrics of non-market valuation, hedonic property price models, community hazard mitigation, and experimental analysis of individual charitable giving. His current research projects include an analysis of amenity and structural capitalization in coastal property rental and sales markets, assessing individual preferences for multi-hazard insurance coverage, understanding the relationship between beach quality and coastal property values, and assessing economic costs of beach erosion management.

Tourism Impacts and Second Home Development in Coastal Counties (Brunswick, Currituck and Pender): A Sustainable Approach

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Co-Author: Patrick Long, East Carolina University

The coastal tourism economy and coastal tourism products are based upon a fragile environment, a declining water-based culture, and a history of suffering from neglect. As more and more people come to the coastal area for economic and recreational opportunities, stakeholders have come to realize the importance of managing growth while protecting social, environmental and economic resources and values. A clear understanding of the level of support for sustainable tourism development is a critical step for effective planning and management. Population growth and second home development in the past two

decades have accelerated demand for natural resources, land-use change management, coastal housing and service provision. Issues associated with economic trends and population migration, such as second home development, investment in community infrastructure, and services for second-home owners and tourists, have created additional pressure for coastal resource management.

The goal of our research was to improve the ability of coastal communities to plan more effectively for long-term sustainable development in tourism and create information on which they can ultimately balance "profit with preservation". This research provided information to stakeholders regarding the attitudes of homeowners, both full time residents and second-home owners, of the impacts of tourism and second home development, identified the importance of sustainable actions to the county's long-term economic health, as well as determined the manner and extent that climate impacts resident and second home properties and recreational decisions. It was also undertaken to explore research questions that contribute to the broader understanding of how communities, rich in natural amenities, might adjust to the many changes and pressures brought about by tourism and second home development.

Written reports were prepared for all stakeholder groups who advised the study, and followed up with face-to-face presentations to each county planner, Tourism Development Authority director, and Convention and Visitor Bureau director. The reports and PowerPoint presentation on the findings of this research have also been made available on the Center for Sustainability website (http: www.sustainabletourism.org). In order to understand how local decision-makers use information provided by this study in their planning decisions, we conducted a follow-up study that assessed municipal and county planning staff opinions about how their respective planning board might use the study findings. Eight out of the 13 interview participants responded that their board would like to use the study. This study has since advised us in three current master's theses, one on climate and weather effects on tourism business decision-making in coastal counties, one on the effects of maritime history on coastal county tourism development, and one investigating the investment value of the second homes in coastal North Carolina. To date, we have affected scholarship in the topic area of sustainable tourism in coastal destinations through 12 conference presentations and three journal articles and others in progress.

Hao, Huili, Patrick Long and Scott Curtis (2012). "Attitudes of Property Owners to Climate Change Considerations and Their Effects on Future Property Values in Coastal Communities". Journal of Risk Analysis and Crisis Response, Vol. 2 (4), pp 285-291.

Patrick Long and Huili Hao (2012) "Property Owners Attitudes of the Effects of Tourism and Second Home Development on the Future Economic Stability in Coastal Counties". Research Papers of the Transit Chair in Tourism, Special Edition, Montreal, Canada.

Hao, Huili and Patrick Long (2012). "Assessing Place Attachment Among Permanent and Second Home Property Owners In a Tourism Dependent Coastal County." Travel and Tourism Research Association 43rd International Annual Conference Proceedings.

About the Speaker: Huili Hao is on faculty at the Center for Sustainability: Tourism, Natural Resources and the Built Environment, East Carolina University. Her research interests include the impacts of second home and tourism development, sustainability, community sense of place, and sustainable brownfield redevelopment. Hao is also interested in applying Geographic Information Science and spatial techniques to her research projects.

Presentation Abstracts
Session 3 – Safe and Sustainable Seafood Supply

Estimation of Mortality and Selectivity of Red Drum with High Rates of Catch and Release

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Red drum *Sciaenops ocellatus* support commercial and recreational fisheries in North Carolina, but the stock was overfished in the 1980s. Stock status is difficult to assess in red drum because of migration to ocean waters, prohibited harvest of older fish, and relative importance of catch and release. Prior assessments relied on landings data and lacked information on selectivity of caught-and-released fish. Furthermore, natural mortality rates were indirectly estimated with no empirical information. We conducted a conventional and telemetry tag study and analyzed historical tagging data from the N.C. Division of Marine Fisheries to estimate fishing mortality, natural mortality, selectivity, and movement patterns. We found that regulation changes were successful in having a dramatic reduction in fishing mortality. Selectivity of harvested fish was generally dome-shaped and shifted toward larger, older fish in response to regulation changes. Selectivity of caught-and-released red drum was highest on the youngest and smallest fish in the 1980s and 1990s, but increased on larger, legal-sized fish in the 2000s. Within a year, there was a strong seasonal pattern to monthly fishing mortality rate estimates from both conventional and telemetry tags. Highest fishing mortality occurred in fall months and lowest levels occurred during winter. Although monthly fishing mortality values were similar in pattern and magnitude between conventional tagging and telemetry, information on fishing mortality in the combined conventional and telemetry tag model came primarily from conventional tags. The estimated natural mortality rate in the combined model was low and based primarily upon the telemetry approach. Tag return locations confirmed the assumption of a separate northern stock of red drum. Findings from our work were relied upon heavily in the 2009 coastwide stock assessment of red drum and patterns in fishing mortality and spatial patterns in movement can be used for spatial and temporal management.

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About the Speaker: Jeff Buckel is currently a Professor in the Department of Applied Ecology at NC State University. His laboratory uses a combination of traditional and novel field and analytical approaches to address research questions related to the assessment of finfish populations and their habitat. Current projects include: estimating fishing and natural mortality in spotted seatrout, weakfish, and southern flounder; assessing habitat impacts on fish movement and demographic rates in tidal and non-tidal creeks; identifying important predator-prey linkages in North Carolina estuaries; and estimating discard mortality and gear selectivity in reef fishes. Buckel serves on the N.C. Marine Fisheries Commission's finfish advisory committee and the South Atlantic Fisheries Management Council's science and statistical committee.

Metapopulation Dynamics Guides Oyster Restoration in Pamlico Sound

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Co-Authors: Brandon Puckett, North Carolina State University; Rick Luettich, University of North Carolina – Chapel Hill Institute for Marine Science; and Amy Haase, Ray Mroch, Katie Pierson, Rodney Guajardo, and Jason Peters of North Carolina State University

Concepts such as (i) metapopulation and source/sink dynamics, (ii) marine protected areas (MPAs) and (iii) functional equivalency are powerful tools for guiding habitat restoration and conservation in marine systems. Metapopulations consist of spatially separated sub-populations that are often connected by larval dispersal or animal movement. Some "source" sub-populations may contribute disproportionately to the overall metapopulation and some "sink" sub-populations may only persist due to immigration from sources. No-take, marine protected areas often preserve the size-at-age structure of populations, which can enhance reproductive output and subsequent spillover of larvae to downstream fished populations. Restored habitats are often assessed in terms of whether or not their demographic rates, as well as ecosystem functions and services, are equivalent to natural habitats or populations. We applied these concepts to a large-scale oyster restoration program in Pamlico Sound being conducted by the N.C. Division of Marine Fisheries (NC DMF).

NC DMF constructed 10 no-take broodstock reserves in Pamlico Sound with the main goal being to establish a self-sustaining network that would also provide spillover of larvae to fished oyster populations. We applied a complementary suite of field measurements and experiments, as well as modeling tools, to determine that: (i) demographic rates (e.g., density, growth, survival, fecundity) of oysters in restored reefs was equal to or greater than natural reefs that have been protected in other estuaries such as Chesapeake Bay, (ii) certain reserves serve as population sources, (iii) the network of

reserves, however, was not self-sustaining, yet oyster densities increased nearly 400% at 8 of 10 reserves over 4 years, (iv) the network of reserves is likely supplemented by larval supply from fished oyster reefs, (v) the optimal locations for future oyster restoration are in the NE and SW portions of Pamlico Sound, and (vi) restored oyster reefs harbored more unique species of finfish than unstructured bottom, thereby enhancing the overall diversity of estuarine fish assemblages.

This study provides (i) information on how best to manage, restore and conserve an ecologically and economically important species, and (ii) a blueprint for creating a network of sustainable reserves that subsequently support oyster harvest through larval subsidies to harvested areas. This information has been applied by NC DMF and the U.S Army Corps of Engineers in (i) siting additional oyster reserves, (ii) planning the location of future reserves, and (iii) considering substrate materials for restoration. Future work will provide an estimate of the role of fished sub-tidal and inter-tidal reefs to the overall larval pool that is sustaining oyster populations in reserves, as well as examine how to combine oyster restoration practices (reserves and cultch-planting) to increase oyster metapopulation growth rate in Pamlico Sound. The research framework in this study can be applied to restoration and conservation of a broad range of marine species and habitats.

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Dunn, R., D. Eggleston, N. Lindquist. (in review). Cliona boring sponge preferentially infests oyster shells over alternate reef substrates, but does not affect early-life demographic rates of eastern oyster (Crassostrea virginica). Estuaries and Coasts.

Puckett, B. and D. Eggleston. (in review). Metapopulation dynamics and the design of a marine reserve network. Ecological Applications.

About the Speaker: David Eggleston is a marine ecologist with an interest in testing ecological theory in marine systems in a manner that can be applied to the management and conservation of species, habitats, and ecosystems. He has applied (i) predator prey theory to better understand the impact of predatory crabs on their bivalve prey, (ii) optimization models to predict ontogenetic habitat shifts in coral reef fish, (iii) metapopulation and source/sink theory to guide oyster restoration and understand population connectivity of deep-sea benthic communities, and (iv) soundscape ecology to understand the role of sound on larval biology, as well as sound diversity as an indicator of habitat quality. He also pioneered work on the grow-out of blue crabs in freshwater systems for aquaculture. Eggleston earned his bachelor's degree in biology from Old Dominion University, master's and Ph.D. degrees in marine science from The College of William and Mary, and was a post-doctoral research scholar at the College of Ocean and Fishery

Sciences, University of Washington. His has published more than 100 peer-reviewed research articles, logged over 3,000 hours as a scientific research scuba diver, and has trained over 35 graduate students and post-doctoral scholars. Eggleston is a National Science Foundation Early Career Awardee, a member of the North Carolina Academy of Outstanding Teachers, Outstanding Extension Service Awardee at NC State University, and serves on the advisory boards for local, regional, national and international organizations and research teams. He is currently a Professor of Marine Science in the Department of Marine, Earth & Atmospheric Sciences at NC State University. He also serves as Director of NC State University's marine laboratory in Morehead City, known as the Center for Marine Sciences and Technology, or CMAST.

Hybrid Striped Bass Farming: Sea Grant Fosters a New Aquaculture Industry for North Carolina and the Nation

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In the late 1980s, North Carolina Sea Grant supported evaluations of hybrid striped bass (HSB), a cross between striped bass (SB) and white bass (WB), as a potentially profitable cultivar on farms in eastern North Carolina. The fish were initially produced by Lee Brothers, a young farmer from Aurora, in a couple of 3-acre ponds dug on row-crop land. For the project, Brothers partnered with Ron Hodson, a highly experienced aquaculturist working at Sea Grant, and the next year Craig Sullivan joined the team after being hired by the NC State University Zoology Department as a fish reproduction expert. Over the next 25 years, this team and other Sea Grant researchers addressed most challenges faced by the nascent industry, as HSB production grew into a major form of fish farming in North Carolina, eventually rivaling rainbow trout production in North Carolina and spreading nationwide. Advances were made in engineering, water quality management, veterinary medicine, fish nutrition, and reproductive physiology. This presentation focuses on mastery of the reproductive biology of HSB and its parents.

In the early days, most HSB were produced from female SB, but farmers had limited access to females mature enough to reproduce because capturing fish from the spawning grounds was prohibited. Sullivan and Hodson developed a special hormone implant that made it possible to reproduce the less mature females available from commercial pound nets downstream. They went on to pioneer reproduction of fish adapted to or reared in captivity for several years. Detailed characterizations of the reproductive cycles of the species were undertaken, including discovery of major hormones and proteins controlling maturation. The new knowledge yielded clinical measures of maturity that empowered the researchers to identify environmental conditions under which the fish could be reproduced most successfully. All the while, the NCSU scientists obtained wild fish from most known natural stocks and interbred them, founding genetically diverse broodstocks that have been domesticated and subjected to intense selection over many generations. Domesticated NCSU SB are more than twice the size of wild fish of the same age. These animals are foundation stock for the National Program for Genetic Improvement and Selective Breeding

for the Hybrid Striped Bass Industry, a unique consortium of government and university scientists and fish farmers that the NCSU researchers were instrumental in founding.

Recent efforts in HSB breeding have been directed at accelerating gains from selective breeding of its parent species through application of state-of-the-art methods in molecular genetics, such as DNA marker-assisted selection. The striped bass is now one of a handful of species belonging to the National Aquaculture Genome Project. Its genome has been mapped using a certain type of DNA (microsatellite) marker, and a preliminary assembly of the complete sequence of the SB genome is under construction.

North Carolina Sea Grant provided key support for all of these developments in HSB farming and the HSB story epitomizes the Sea Grant focus on basic research that transits into societally important applications, which are extended to stakeholders and the general public.

About the Author: Craig Sullivan is widely regarded as the premier scientific expert on reproduction and selective breeding of the striped bass and its relatives (genus *Moronidae*), having developed most of the procedures employed to domesticate and breed these species in captivity. He established at North Carolina State University the foundation stocks of the U.S. National Program of Genetic Improvement and Selective Breeding for the Hybrid Striped Bass Industry (National Breeding Program), and he selectively bred these stocks for over 30 years at NC State's Pamlico Aquaculture Field Laboratory. Sullivan is founder and coordinator of the Striped Bass National Breeding Program, and he has served since its inception as the Striped Bass Species Representative to the U.S. National Aquaculture Genome Project. He is recognized internationally as a leading researcher in the scientific fields of fish reproductive physiology and breeding in aquaculture, having authored over 170 scientific publications in leading peer-reviewed journals of these disciplines. For these achievements, he was named William Neal Reynolds Distinguished Professor of Biology at North Carolina State University in 2005 and was elected as a Fellow of the American Association of the Advancement of Science (AAAS) in 2010. These honors recognized him for excellence in research, scientific outreach to the aquaculture industry, and education. Sullivan retired from the NC State faculty in 2013 and is presently President and CEO of Carolina AquaGyn, a contract research and consulting company operating in the general field of fish reproductive biology with emphases on physiology, genomics, genetics and selective breeding, including assisted reproduction technologies. He is presently continuing his 30 years of Sea Grant research in a project on black sea bass in South Carolina.

Adding Value to the North Carolina Seafood Industry through Use of Collaborative Partnerships

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Commercial fishing is an integral part of North Carolina's heritage and coastal economy, contributing $122M in total economic impacts and more than 3,500 jobs in 2012. Historically, the state's fishermen satisfied a strong demand along the East Coast for fresh, seasonal seafood. Since 1995, less expensive imports have taken a significant market share from domestic processors. Operational costs, regulation, and particularly the rise in seafood imports have further stressed the fishing industry. As such, many

businesses have struggled to remain profitable. Product safety and local food movements, however, are impelling people to buy more domestic seafood — and directly from fishermen when possible. To adapt to this change, local seafood businesses must become consumer-focused. Companies must discern consumer needs and product trends to compete in the new global economy. Over the last decade, North Carolina Sea Grant has initiated positive change within the seafood industry by working collaboratively with a diverse array of partners to source and deliver objective information. This presentation will focus on the impacts and outcomes of three projects that were positively enhanced by Sea Grant involvement: (1) development of the first Community Support Fishery program, (2) development and delivery of direct marketing technical training to shrimp fishermen in North Carolina and beyond, and (3) development of individual county and state umbrella "Local Catch" community organizations.

About the Speaker: Scott Baker has been a fisheries specialist with North Carolina Sea Grant since 2003. In his position, Baker helps the commercial and recreational fishing communities understand and apply the latest in fisheries management, research and technology. Some of his latest activities have included pilot testing electronic monitoring and reporting approaches for recreational and commercial fisheries, providing technical training to shrimp fishermen in the Gulf and South Atlantic as part of federal trade adjustment assistance program and organizing the Third Annual North Carolina Catch Summit in February 2014 in Southport. Current activities include developing a webinar series to replace the N.C. Marine Recreational Fisheries Forum, partnering with N.C. Division of Marine Fisheries to educate commercial fishermen about fisheries observing, and reviewing what seems to be an endless number of research proposals from state and federal fisheries research programs. Originally from Washington, N.C., Baker holds a master's in oceanography and coastal sciences from Louisiana State University and a bachelor's in biology from the University of North Carolina at Chapel Hill. Prior to joining Sea Grant, Baker worked as a research associate at Louisiana State University and as a biological science technician for NOAA Fisheries in Panama City, Fla.

Presentation Abstracts
Session 4 – Healthy Coastal Ecosystems

Assessing Human and Climatically Driven Changes of North Carolina Estuarine Water and Habitat Quality: Management and Decision-Support Applications

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Nutrient over-enrichment and resultant eutrophication is a pervasive problem in the estuaries comprising the United States' second largest estuarine system, the Albemarle-Pamlico Estuarine System (APES). These microtidal, poorly flushed estuaries are highly efficient in transforming nutrients into primary (phytoplankton) and secondary (i.e., shellfish and finfish) production, sustaining highly valued fisheries resources. There is a fine line, however, between adequate fertility and nutrient over-fertilization that leads to harmful algal blooms, hypoxia, and fish kills. Compounding this problem is climatic variability and change, including an increase in tropical Atlantic cyclones and record droughts, which modulates eutrophication by influencing the delivery, retention, and cycling of nutrients. Our North Carolina Sea Grant-supported projects focused on improving our understanding of the interactive roles of human nutrient enrichment and freshwater discharge in the eutrophication dynamics of the APES with a focus on the Neuse River, a primary tributary estuary. A long-term UNC-CH and North Carolina Department of Environment and Natural Resources (NC DENR) collaborative monitoring program, ModMon (www.unc.edu/ims/neuse/modmon/), and a novel, ferry-based autonomous monitoring program, FerryMon (www.ferrymon.org), served as platforms for investigating the causes, consequences, and controls of eutrophication.

Nutrient addition bioassays identified nitrogen (N) as the key nutrient mediating eutrophication in the Neuse River Estuary. This information was used to develop a U.S. Environmental Protection Agency (EPA) and NC DENR mandated Total Maximum Daily Load (TMDL) for N, the nutrient management tool aimed at reducing algal biomass and improving water-quality conditions in the NRE. Using pigments as measures of algal biomass (i.e. chlorophyll a for total algal biomass), our intensive, collaborative monitoring programs allow the State (NC DENR) to better assess when and where "acceptable" levels of algal biomass are exceeded. Pigment-based indicators developed for identifying and quantifying algal groups forming harmful blooms are now used for early detection and quantification of blooms throughout the NRE and Pamlico Sound, providing a means for the State, EPA, and NOAA to link nutrient inputs and climatic events to bloom formation and establish links between such blooms and fish kills. This provides managers with tools to more effectively develop long-term, nutrient-management strategies aimed at mitigating eutrophication. Pigment-based indicators have also been used for calibrating aircraft and satellite-based remotely sensed imagery of the Albemarle-Pamlico Sound System and nearby coastal waters, enabling State (NC DENR) and federal agencies (NASA, EPA, NOAA) to "scale up" quantification of algal biomass and detection of blooms at larger ecosystem and regional levels.

These projects have: 1) clarified the linkage between human and climatic drivers and eutrophication in this ecologically/economically important system, and 2) provided indicators and supported platforms to better assess conditions and trends in water and habitat quality for developing adaptive nutrient management strategies in a more climatically extreme world.

About the Author: Hans W. Paerl is Kenan Professor of Marine and Environmental Sciences at the University of North Carolina – Chapel Hill's Institute of Marine Sciences. His research addresses microbially mediated nutrient cycling and primary production dynamics, environmental controls and management of harmful algal blooms, and assessing effects of human and climatic alterations of water quality and sustainability of inland and coastal waters. He has published over 250 peer-reviewed articles and book chapters on these subjects. He received the 2003 G. Evelyn Hutchinson Award from the Association of the Sciences of Limnology and Oceanography, and the 2001 Odum Award from the Coastal and Estuarine Research Federation for addressing the causes, consequences and controls of eutrophication in aquatic ecosystems.

Ecosystem Engineers Contribute to Maintaining Water Quality in Coastal Ecosystems

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Controlling eutrophication and improving estuarine water quality are priorities for many government and non-government organizations. An agreed upon solution is to control loading of nutrients (particularly nitrogen), thus reducing excesses in phytoplankton production. Restoration of estuarine ecosystem engineers, such as marsh grass, oysters and sea grass, could potentially ameliorate eutrophication by removing or retaining nutrients. The goal of this project was to determine if ecosystem engineers increase nitrogen removal and contribute to enhancing levels of water quality. We were especially interested in understanding how ecosystem engineers alter estuarine nitrogen cycling.

This research involved a combination of field measurements, laboratory experiments, and mesocosm manipulations to determine whether and how ecosystem engineers enhance water quality in eastern North Carolina estuaries. Initial field observations assessed the mechanisms by which oysters, sea grass and marsh grass modify biogeochemical exchanges between the sediment and water column through regeneration and removal of nutrients. In mesocosm experiments, nutrient concentrations were manipulated to determine how variation in nutrient availability alters ecosystem engineer-mediated nitrogen cycling. Additional field experiments were conducted on one ecosystem engineer, the eastern oyster, to determine the contribution of oyster structure and biotic activity to modification of nitrogen cycling, and to assess the role that landscape position plays in determining oyster impacts on nitrogen cycling.

We found that salt marshes, oyster reefs and seagrass beds all had elevated levels of denitrification relative to unstructured subtidal and intertidal flat habitats. Oyster reefs had among the highest rates of

denitrification. Manipulative experiments found oyster reef structure alone enhanced denitrification, but that maximum enhancement of denitrification occurred when both the structure and biotic process of filtration were present. Landscape was found to affect the degree to which oyster reefs modified denitrification. Reefs on flats away from other structured habitats resulted in the largest increase in denitrification.

Our improved understanding of the interactions between biogeochemistry and ecosystem engineers has informed efforts to model the interactions between estuarine habitats and water quality. Additionally, this information has been conveyed to government and non-government organizations conducting estuarine restoration with water-quality improvement goals.

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Higgins, C.B., C.R. Tobias, M.F. Piehler, A.R. Smyth, R. Dame, K. Stephenson, B.B. Brown. 2013. Impact of aquacultured oyster biodeposition on sediment N_2 production in Chesapeake Bay. Marine Ecology Progress Series 473:7-27.

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Grabowski, J.H., R.D. Brumbaugh, R. Conrad, A.G. Keeler, J. Opaluch, C.H. Peterson, M.F. Piehler, S.P. Powers, A.R. Smyth. 2012. Economic valuation of ecosystem services provided by oyster reefs. Bioscience 62: 900-909.

Piehler, M.F. and A.R. Smyth. 2011. Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. Ecosphere 2(1):art12.

About the Speaker: Michael Piehler was born and raised in Pittsburgh, Pennsylvania,where through the collapse of the steel industry in the 1980s, he experienced first-hand the complex relationship between human activities and aquatic ecosystems. After completing his undergraduate degree in biology, he worked as an environmental consultant in Washington, D.C. Following that, he received a master's of science degree in public health and a Ph.D. in environmental sciences and engineering from UNC Chapel Hill. He holds a dual appointment as an Associate Professor at the UNC-Chapel Hill Institute of Marine Sciences in Morehead City, N.C. and as Head of the Program in Estuarine Ecology and Human Health at the UNC Coastal Studies Institute in Wanchese, N. C. Additionally, he is Director of Graduate Studies for the Curriculum for the Environment and Ecology at UNC-Chapel Hill. His research focuses on material transport and processing at the coastal land-water interface. He has conducted work on a broad range of microbial systems, including benthic microalgae, epiphytic microalgae, phytoplankton, benthic bacteria and bacterioplankton. His research is funded by the National Science Foundation, the U.S. Environmental Protection Agency, the National Oceanographic and Atmospheric Administration, the Strategic Environmental Research and Development Program and North Carolina Sea Grant. Piehler serves on scientific advisory panels for governments, nongovernment organizations and industry.

Success in Oyster Reef Restoration: Population and Ecosystem Measures

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Declining oyster populations — and the interrelated impact of poor water quality, habitat loss and reduction in ecosystem services — has raised oyster restoration along the Atlantic coastal states to a national issue. Oysters once supported a major fishery in the Mid-Atlantic and Southeast, and oyster reefs were critical ecosystem components providing habitat for juvenile finfish, crabs and shrimp as well as influencing local water quality and biogeochemical cycling. However, oysters have undergone significant declines over the past 5 decades, with oysters in the Chesapeake Bay region less than 1% of their former abundance and parts of Pamlico Sound having only 5 to 10% of former levels. Although the extent of decline varies along the North Carolina coast, oysters are clearly a fishery and habitat of concern along the entire coast. There are multiple causes for this decline that have been highlighted in a number of studies, workshops and congressional hearings, including impacted water quality, siltation and increased suspended solids, disease, and overfishing.

Over the past 2+ decade there have been numerous efforts to restore oyster reefs for habitat, fishery, support of other fisheries and filtration functions. In particular, private conservations groups and state agencies have been engaged in shell planting and introduction of seed oysters in both subtidal and intertidal habitats. Unfortunately, the short-term nature of restoration-monitoring efforts is in direct contradiction to the goal of establishing stable long term functioning oyster habitats. Therefore management and restoration groups (both industry and citizen based) need a set of reliable metrics that can be used to assess both the oyster habitat in general, and oysters themselves, that will give a more accurate indication of restoration success. This need has been underscored by state and regional workshops on oyster restoration success that emphasize the need to follow restoration efforts over a longer period, applying standardized sampling protocols to restored oyster reefs and control areas in order to examine aspects of oyster population and ecosystem success.

Here, we have applied a series of metrics to restoration sites of varying ages to identify those metrics that lend themselves to identification of long-term success. Some methods provide clear indication of reef development and oyster health with minimal effort while other metrics are conditional or may only provide a portion of the information needed. The development of a unified set of "success" criteria is key to the future of restoration efforts in North Carolina and other states with goals directed at enhancing the ecosystem function of oyster populations.

About the Speaker: Troy Alphin currently serves as Senior Research Associate with the University of North Carolina Wilmington in the Department of Biology and Marine Biology and the Center for Marine Science. He is a benthic ecologist and shellfish biologist, who has worked on issues related to trophic dynamics and ecosystem function of oysters. His research has focused on issues related to estuarine, beach, nearshore and offshore systems on the Atlantic coast of the United States and the Gulf of Mexico since 1991. Specific investigations include issues related to ecosystem health, beach renourishment and borrow-site impacts, dredging impacts in estuarine systems and beach functionality, as well as evaluation of erosion control structures and living shorelines. He served as a member of the Shellfish Advisory Committee to the N.C. Division of Marine Fisheries from 1999 to 2012, as well as serving on Fisheries

Management Plan committees for oysters, clams and bay scallops. He has served on the Board of Directors for the East Coast Shellfish Research Institute since 2009 and as the Vice-President from 2010 to 2011. He has published over 50 peer-reviewed scientific articles and presented or co-authored more than 95 presentations at national and international scientific meetings.

Key Parameters for Assessing Beach Functionality

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Beach nourishment is the preferred option for mitigating ocean shoreline retreat in North Carolina. As demand for nourishment rises, assessment of biological impacts in coastal ecosystems becomes more important. This project examined the beach and surf zone as an ecosystem, sampling the near shore food chain across seasons at nourished and unnourished sites and at sites immediately before and after nourishment in New Hanover County, the most heavily urbanized coastal county in North Carolina.

Nourishment impacts varied with time and trophic level. Microflora (surf zone phytoplankton and beach microalgae) and small fauna (surf zone zooplankton and beach meiofauna) responded to nourishment, but only briefly. Benthic macrofauna were much more variable and taxon-specific in their responses to seasonality and nourishment, which is conducted in winter and early spring. Surf zone fishes responded to the disturbance of nourishment activity in terms of species composition (with more transient species associated with disturbed locations) and lower body fat densities, implying lower feeding success, although overall numbers of fishes were not affected.

The overall view emerging from this study and others is that the nearshore ecosystem is a productive and biologically important link between coastal ocean and estuarine ecosystems. The surf zone supports high primary and secondary productivity, which in turn provides important food resources for higher trophic levels, including commercially and recreationally important fishes. In particular, juvenile fishes recruiting from offshore spawning to the near shore environment find a food-rich refuge from predation that allows them easy longshore access to inlets and estuarine nursery habitats. Evaluation of human impacts on beaches and inlets should therefore consider the connectivity of coastal, nearshore and estuarine ecosystems.

Publications

Kahn, A.E., and L.B. Cahoon. 2013. Phytoplankton productivity in the surf zone of sandy beaches estimated by simultaneous *in situ* ^{14}C incubations and Fast Repetition Rate Fluorometry. Estuaries and Coasts 35:1393–1400.

M.S. Thesis

Kelly Jo Stull, "Zooplankton abundance in the surf zone of renourished beaches in southeastern North Carolina," M.S., 2011.

About the Speaker: Lawrence Cahoon is currently Professor of Biology and Marine Biology at UNC Wilmington, where he joined the faculty in 1982. He received his Bachelor of Science in biology (summa cum laude) at Washington & Lee University in 1975, and his Ph.D. in zoology at Duke University in 1981. He had a postdoctoral fellowship at Mountain Lake Biological Station with the University of Virginia, was a Temporary Instructor at Duke University, and has taught biological oceanography at Duke University Marine Laboratory. Cahoon currently teaches an undergraduate course in limnology (the study of freshwater ecosystems), a graduate course in biological oceanography, and a doctoral seminar in oceanography and environmental science at UNCW. He has served as a member of the North Carolina Marine Science Council and the North Carolina Ocean Affairs Council, as Chair of the North Carolina Ocean Resources Task Force, as Vice-President and President of the North Carolina Academy of Science, and as member of the Ocean Policy Advisory Committee for the North Carolina Division of Coastal Management and a legislative study subcommittee on Offshore Energy Exploration. His research interests include coastal biological oceanography, particularly the ecology of the sediment-water interface and ocean beaches; the effects of nutrient loading and grazing in estuarine and freshwater environments; environmental aspects of concentrated animal production; and a wide variety of water-quality issues.

Poster Viewing List

1. **The Use of Norm Curves to Investigate Acceptability of Resource Condition and Recreational Use Levels**
   Mary E. Allen and David K. Loomis, East Carolina University

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The Use of Norm Curves to Investigate Acceptability of Resource Condition and Recreational Use Levels

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Coastal ecosystems offer a variety of important ecosystem services including tourism, recreation, and aesthetic and cultural value. Ecosystem services are the benefits people derive from the environment, reflecting social values, goals, and desires. However, production of these services also involves trade-offs between environmental and social objectives. One way of understanding the attributes people value in ecosystems and the associated trade-offs is from a normative perspective. Research was conducted on recreational visitors to Buck Island Reef National Monument between March and August 2013. As concern for coral reef conditions persist, perspectives from the park visitors were needed in order for managers to have a complete understanding of current coral reef conditions. Normative theory was used to investigate visitors' views on acceptable levels of resource conditions and use. Norm curves were constructed to reveal critical information on coral reef conditions and resource use by illustrating when 'acceptable' becomes 'unacceptable'. Results indicate that park visitors accept seeing no more than 25% coral bleaching, 25% algal cover, or underwater visibility no less than 20 ft. They also have standards for appropriate numbers of snorkelers, divers, and boats in one area at one time. This information can help identify the ecosystem attributes that people value, as well as the potential trade-offs between services. If used in conjunction with ecological data, decision-makers can have a more complete picture of what specifically needs to be addressed.

North Carolina Coastal Atlas: Transforming Information to Empower Decisions

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East Carolina University is collaborating with the North Carolina Division of Coastal Management, North Carolina Sea Grant and other partners to develop the North Carolina Coastal Atlas (www.nccoastalatlas.org), an online mapping and investigation system that provides both static and interactive maps and related data for exploration and analysis. The Atlas combines physical, ecological and human-use data to support education, management and decision-making. We are developing the atlas to incorporate user objectives and review user experience iteratively. A needs assessment of coastal planners, managers and other potential users revealed a desire for thematic maps in the areas of ecosystem health, biological resources, shoreline change and hazards such as flooding and storm surge. Multiple datasets are now available including estuarine shorelines and associated structures, submerged aquatic vegetation, wetlands extent, and FEMA designated flood risk areas. A unique partnership with East Carolina University's Joyner Library makes scholarly research discoverable using geo-referencing. This

presentation will highlight thematic maps, demonstrating use cases for planners in high flood risk coastal communities and the identification of protected-resource areas, such as wetlands, for waterfront property owners interested in obtaining development permits. Future capabilities of the atlas include decision-support tools and public-engagement programs that have the potential to help make coastal and estuarine research more accessible and relevant to managers and the public.

Improving Outreach of Information on Contamination in Self-Caught Fish

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Recreational fishing is popular and fish is a good source of health benefits, yet self-caught fish may be a source of contaminants. Each state issues consumption advisories, some statewide and some specific to water bodies, and each state manages marine fish and shellfish through catch limits, size limits and closed areas. An open-ended intercept survey of coastal anglers in North Carolina revealed extensive knowledge of catch restrictions, but minimal knowledge of the effects of contaminants on health, little concern for contaminants in their catch, and a misguided faith that the government would post warnings at every water body at risk for contaminants. This project is intended to encourage collaboration between fishery management agencies and public health agencies, and to outline an effective outreach framework.

Monitoring Water Quality in Falls Lake Using High Spatial Resolution Satellite Imagery

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An important resource for any city is a reliable source of clean drinking water. Falls Lake provides a drinking water reservoir for Raleigh and flood control and recreational opportunities for communities surrounding the lake. Despite these vital functions, the water quality of Falls Lake has been problematic for some time with the upper reaches of the lake listed as 303(d) impaired waters. Phytoplankton blooms, high suspended sediment loads and other impairments are potential hazards to both the drinking-water supply and human health. Rapid population growth in the communities surrounding the lake make the monitoring of water quality in Falls Lake increasingly difficult and important. A water body the size of Falls Lake is difficult to adequately monitor using traditional boat- or mooring-based sampling strategies. One solution is to use high spatial resolution satellite imagery. In collaboration with the Center for Applied Aquatic Ecology at NC State University, Global Earth Observation and Data Analysis Center at National Cheng Kung University and the National Space Program Office of Taiwan a program was instituted to integrate remotely sensed images and a suite of water-quality measurements taken from small boats. The goal of this joint effort is to produce maps of important water-quality parameters for the

entirety of Falls Lake at a given time. These synoptic snapshots of the health of Falls Lake can provide a valuable tool for managers at both the state and local levels. The preliminary results of this work are presented here.

Comparison of Fish and Invertebrate Assemblages Among Variably Altered Tidal Creeks in a Coastal Landscape

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Anthropogenic alterations to saltmarsh watersheds along the U.S. South Atlantic coast can impact the production of common resident taxa. We deployed a 1 m^2 throw trap monthly in summers 2012 and 2013 in the vegetated portions of five variably altered saltmarsh creeks in coastal North Carolina to compare the density of resident macrofauna: the mummichog Fundulus heteroclitus, mosquitofish Gambusia holbrooki, sheepshead minnow Cyprinodon variegatus, and grass shrimp Palaemonetes spp. For each species, the relationship between density and a combination of biotic and abiotic variables was examined using poission-distributed generalized linear models (GLMs). Model parsimony was evaluated using Akaike Information Criteria (AIC). The GLM that best fit the data (lowest AIC score) for each species included creek as an explanatory variable. Salinity, depth, and percent coverage of Spartina alterniflora were additional factors that explained patterns of faunal density. Percent imperviousness also explained patterns of density, but the direction of the effect was dependent on species. Results of this study emphasize the importance of imperviousness and vegetative cover in affecting the density of resident species inhabiting saltmarsh creeks along the U.S. South Atlantic coastline.

Experimental Analysis of Cold Tolerance in Spotted Seatrout

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In the U.S., cold fronts can expose fish in relatively shallow temperate estuarine ecosystems to rapid drops in temperature. Without thermal refugia, acute cold stress can lead to episodic mass mortality. Populations existing near the northern extent of a species' latitudinal range, such as spotted seatrout (Cynoscion nebulosus) in North Carolina, are particularly vulnerable to lethal winter conditions. Only anecdotal information on cold tolerance exists for spotted seatrout, limiting our understanding of a likely important source of natural mortality for this species. In this study, we applied two different methods for controlled exposure of spotted seatrout to dynamic decreases in water temperature, in order to determine cold tolerance as affected by temperature severity and salinity. Critical thermal minimum (CTMin) methodology was used to determine stressful but sublethal low temperatures, defined as the temperature at which fish lost equilibrium, across two representative overwinter salinity treatments. The CTMin of 2.3 °C at high salinity was significantly lower than that of 3.4 °C at low salinity ($p < 0.001$). Chronic lethal methodology was adapted to examine the effects of prolonged exposure to three temperatures representing a range of winter severity on spotted seatrout survival. Temperature had a significant effect on 10-day survival; no survival at 3 °C, moderate survival at 5 °C, and high survival at 7 °C. Patterns in survival were similar across high- and low-salinity treatments. Given the propensity of spotted seatrout to

overwinter in shallow lower salinity environments, some benefit must outweigh the higher risk of acute cold stress found in these habitats.

First Step in Understanding Striped Bass Maternal Contribution: Larval Otolith Formation and Growth

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Otolith studies have become more prevalent in recent years as use has expanded from only aging to examination of migration patterns and fidelity to natal habitats. The otolith of Striped Bass, Morone saxatilis (Walbaum; 1792), is used for all of these purposes, yet its formation and early development have not been documented. We were able to identify the timing and formation of the three otolith pairs during late egg stage, yolk-sac larvae, and post yolk-sac larvae. The sagittal otoliths were first to appear, forming shortly before hatch and were observed growing larger throughout the larval stage. The lapilli otoliths formed within the first 24 hours post hatch. The asterisci otoliths were difficult to locate, but seemed to form between 4 and 15 days post hatch. At hatch the sagittal otoliths appear circular, and by 5 days post hatch seem to gain some dimensionality. At 15 days post hatch the sagittal otolith began to elongate along the anterior/ posterior axis. This knowledge of the when the otoliths form will affect any microchemical analysis done in in the first year of life, especially as the asterisci otoliths form around first feeding, and should be taken into account when choosing an otolith for analysis.

Impact of Endocrine Disrupting Compounds on Sex Determination and Development in the Blue crab, *Callinectes sapidus*

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Over the past two decades a large body of work has established a clear link between endocrine disrupting compounds (EDCs) and deleterious physiological impacts on aquatic organisms. EDCs act at low concentrations, and originate from a variety of sources, including urban or agricultural runoff (e.g., pesticides) and components of treated wastewater effluent. Endocrine disruption in crustaceans is of particular concern to North Carolina considering the importance of the blue crab fishery. The Division of Marine Fisheries issued a draft report in November 2011 that emphasizes the need for research on endocrine disruption in blue crabs. Although the USGS has conducted preliminary analyses of EDCs in North Carolina watersheds that detected a wide array of pharmaceuticals and pesticides, to date the biological impacts of EDCs in North Carolina blue crab populations have yet to be assessed. Initial sampling surveys were conducted from spring through fall in 2013 to assess potential impacts on populations of blue crabs. A preliminary analysis of morphological endpoints from 4 different sampling regions shows a size disparity of high significance (ANOVA) between the control site (Santee River, SC)

and the putatively most polluted site (Cape Fear River, NC). Furthermore, ecdysteroid (molting hormone) concentrations in hemolymph differ among collection sites. Sites will be sampled again in 2014, and molecular analysis of vitellogenin (egg yolk protein) and insulin-like androgenic gland hormone (masculinizing hormone), is currently being conducted. Additionally, chemical analysis on suite of common EDCs is being performed on eggs and embryos from each site.

Effects of Mixed Alternative Protein Sources and Meat and Bone Meal Protein Substitution for Menhaden Fish Meal Protein on Growth Performance, Body Composition, and Digestibility of Juvenile Red Porgy, *Pagrus pagrus*

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In order for finfish mariculture to become a sustainable and profitable industry, effective protein sources other than fishmeal (FM) need to be identified for each species. This study tested meat and bone meal (MBM) as well as a mixture of three different alternative protein sources (MPS), including poultry by-product meal, corn gluten meal, and soybean meal, as a substitute for FM in the diet of hatchery raised juvenile red porgy (RP). Eight iso-nitrogenous (50% CP) and isolipidic (11%) diets were formulated where the control diet 1 contained 60% FM. Diets 2, 3, 4 and 5 had increasing levels of the MPS (25, 50, 75, and 100%), and diets 6, 7, and 8 had increasing levels of MBM (20, 40, and 60%) in replacement of FM as the protein source. Crystalline L-methionine, L-lysine, arginine, taurine and leucine were added to all diets, and iso-leucine and threonine were also added to diets 6, 7, and 8 to simulate the calculated values of these amino acids found in the control diet 1. Diets were fed twice daily to triplicate groups of juvenile RP (mean initial weight = 12.5 g) to apparent satiation for 8 wks. Fish were held in 75-L rectangular tanks (12 fish per tank) using a recirculating seawater (34 g/L) system maintained at 22 °C. To measure apparent protein digestibility, chromic oxide (0.5%) was added to the diets once the feeding trials ended, and fecal samples were collected for 7 d for analysis.

Utilizing Water Chemistry in the Albemarle Sound/Roanoke River Management Areas to Establish Natal Origin and Movement of Juvenile Striped Bass (*Morone saxatilis*)

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Striped bass (Morone saxatilis) is an important anadromous species that provides valuable ecological and economic benefits to North Carolina. This fishery accounts for over 45 million dollars in revenue from commercial and recreational activities within the Albemarle Sound Management Area (ASMA) and the Roanoke River Management Area (RRMA) (NCDMF 2011). The strategic habitat areas of striped bass

continue to be a topic of interest to researchers, fisheries managers, and recreational and commercial fishermen. The fundamental basis of otolith microchemistry (a technique used to characterize movement and natal origin in fish) is reliant on knowing the spatial and temporal variation of water chemistry. Surface water chemistry can be used to discriminate between different water bodies because typically each system has different types and abundance of elements (Elsdon and Gillanders 2003c; Dorval et al. 2007). This research examines dissolved elemental concentrations in water samples. Water samples will identify whether watersheds have elemental signatures, and if so determine the trace elements that make each of these river systems unique. Previous research has shown that the ASMA/RRMA has stable patterns of water chemistry over time and temporal variations have been relatively short (Mohan 2009; Zapf 2012). However, collecting water samples over several seasons and years is essential to verify stable conditions. Assessing trace elements in water chemistry will determine spatial and temporal variability in the ASMA/RRMA.

Plankton Assemblages as Sentinels for Ecosystem Change within Estuarine Food Webs

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Bogue Sound can be considered an ideal case study for North Carolina's estuarine environments that experience multiple stressors both long- and short-term, from eutrophication to change in global climate parameters (e.g., temperature and carbon chemistry). These stressors impact abundance and species composition in phytoplankton and zooplankton and thereby energy flux to higher trophic levels such as shellfish, crab or fish. For instance, excess nutrients can drive shifts from diverse algal assemblages to dominance by few or even single species as seen during Harmful Algal Blooms (HAB). Latter may disrupt food webs or lead to lowoxygen conditions when excess biomass accumulates. A better predictive understanding of how environmental perturbation can lead to plankton regime shifts and effect ecosystem resources requires knowledge of plankton dynamics over spatial and temporal scales. Presented here is a one-year time-series of phyto- and zooplankton dynamics at two study locations within Bogue Sound. Preliminary analyses of weekly data show that Bogue Sound is characterized by high-biomass events dominated by diatoms that include Pseudo-nitzschia spp, a microalgae capable of producing domoic acid (cause of Amnesic Shellfish Poisoning). Here, we discuss observed trends in plankton abundance and species composition, examined together with pertinent physiochemical parameters (temperature, salinity, dissolved oxygen, inorganic nutrients).

Modeling Overwash on a Barrier Island: Land Cover Implementation

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Communities and businesses on barrier islands are extremely vulnerable to landform changes brought on by extreme events such as hurricanes. State-of-the-art morphological models with high predictive capabilities are essential to predict landform response to storms; understand the risks; and make informed decisions. One effort to improve the predictive capabilities of morphologic models is to consider the influence of land cover such as vegetation and pavement. Land cover becomes especially important in modeling cases with overwash since the water flow directly interacts with the features landward of the dune crest. To study this phenomenon a location at US Fish and Wildlife Pea Island National Wildlife Refuge (PINWR) on the Outer Banks of North Carolina was selected where overwash has occurred multiple times. Hurricane Isabel (2003) and Hurricane Sandy (2012) both created overwash fans at the selected location spreading sand approximately 150m and 130m landward of NC 12. Thirty-six cross-shore profiles were extracted from pre-storm lidars and modeled using eXtreme Beach behaviour (XBeach). The simulations were carried out in 1D mode given its widespread use due to the significantly lower computational requirements. XBeach was implemented in two frameworks, first; all the profiles were represented as sand, and in second; land cover was incorporated to profiles as concrete/pavement, vegetation and sand. The results of the simulations were compared to post-storm field measurements focusing on the landward extent of the washover fan and the average depth of deposition. Results indicate that the incorporation of land cover has improved the prediction capability of the model.

Economic Value and Impact of Visitation to Cape Hatteras National Seashore: Addressing Onsite Sampling

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We examine recreation demand, travel costs, and visitor expenditure patterns for Cape Hatteras National Seashore (CHNS) on the Outer Banks, North Carolina. CHNS is one of the largest protected barrier islands on the East Coast, comprised of nearly 30,000 acres along 140 miles of shoreline. The island system is unique, consisting of primarily thin barrier islands, dunes, and mud flats, backed by a large and shallow back-barrier estuary; CHNS is remote, accessible only by ferry or a single stretch of road running along the chain of islands. Data were collected at various beaches along CHNS in 2001-2002. We estimate count data demand models, controlling for endogenous stratification stemming from the on-site sampling. We present corrected estimates of economic value and extend the analysis of avidity bias to

examine the impact of on-site sampling on economic expenditure analysis. Our hypothesis is that expenditure estimates will be downward biased (reflecting lower spending patterns of more avid users that live closer to CNHS), which would give rise to underestimates of economic impact. The estimated net benefit of a day at CHNS is estimated at $75.89/household and $17.21/individual (2002 USD).

Effects of Sea-Level Rise on Coastal Freshwater Wetland Animals

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In light of rising salinity levels in coastal freshwater ecosystems, we have designed a series of experiments that will investigate how the physiological mechanisms that maintain osmotic balance during each stage of the anuran life cycle interact with, associate with, and influence tolerance to brackish conditions, biological interactions (e.g., parasitic, mutualistic, predator/prey, competition), phenotypic plasticity (e.g., larval morphology, behavioral traits, life history traits), and community organization. We plan to utilize these data to create predictive risk maps to forecast species distributions according to present and future environmental conditions and recommend management and intervention strategies to prevent amphibian losses along the coast of North Carolina.

Seasonal and Size-Specific Variation of Total Mercury Content in Large Pelagic Fishes Off North Carolina

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The large pelagic fish community in the U.S. South Atlantic supports valuable commercial and recreational fishing industries in several states. Some members of this community, including blue marlin and wahoo, have previously been found to contain mercury levels sufficient to impact reproduction and survival as well as pose a potential health risk to consumers. However, most regional consumption advisories are based on studies with small sample sizes of fish collected outside of state waters which may not be representative of fish landed by North Carolina anglers. The objectives of our study were to estimate the mercury concentrations in tissues of several large pelagic fish species in state waters and assess seasonal and size-specific variation in mercury concentration. Fish were collected through fishing tournaments and cooperation with charter captains from North and South Carolina. A sample of muscle tissue was dried and homogenized using mortar and pestle then the mercury concentration was estimated using a Tri-Cell Direct Mercury Analyzer (model DMA-80) and values converted to wet weight mercury concentration. Mercury concentrations exceeding the FDA action level of 1.0 ppm were observed in wahoo, blackfin tuna, and blue marlin, with all mercury concentrations for dolphinfish and yellowfin tuna falling below. Mercury concentration increased with increasing fork length and trophic level for all species. Seasonal differences were observed for blackfin tuna, with highest mean mercury concentration during the spring. Trends in mercury concentration from this study support those reported previously for the southeastern U.S. and will help to inform regional advisories from the FDA.

The Influence of Landscape Setting and Duration of Inundation on Oyster Reef Growth

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Physicochemical boundaries and optimal conditions characterizing the response of coastal foundation species to sea-level rise must be defined to accurately predict sustainability. Using 15-year-old experimental oyster reefs in Middle Marsh, Back Sound, we examine the effects of varying inundation levels and landscape settings on vertical reef growth and oyster density, two proxies of productivity that determine the ability of reefs to maintain their position relative to sea level. These reefs were constructed adjacent to sandflat and saltmarsh habitats over a subtidal-to-intertidal depth gradient. Reefs surrounded by sandflats are defined by a strong parabolic growth pattern in relation to duration of aerial exposure. We find an abrupt switch from reef accretion to reef deterioration occurring at a critical exposure duration of 10%, an optimal reef growth zone (30-40% exposure) defined by the highest vertical accretion rates (~ 2 cm/yr), and a growth ceiling near mean sea level (~55% exposure) where exposure stress becomes too high to support additional vertical growth. We also discover a landscape-specific response in reef growth as reefs adjacent to salt marshes exhibit a negative relationship between vertical accretion and aerial exposure. Considering impacts from rising sea level and associated changes to tidal regimes, we present a model that predicts sandflat reef productivity for any inundation condition. Based on our model and future predictions of accelerating sea-level rise, shallow, sandflat reefs will subsist in the euhaline waters of North Carolina, while oyster reefs below the critical exposure depth will perish.

Alewife *Alosa pseudoharengus* Population Changes in Lake Mattamuskeet are Related to Water Control Structures

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The alewife population at Lake Mattamuskeet has been in decline since the early 1990s. This research documented changes in the population level after a redesign of the water control structures, which provide access to spawning grounds at Lake Mattamuskeet. Tyus in 1970 and 1971 estimated 150,000 to 200,000 alewife were entering the lake each spring. Wall (1997, 1998) determined that the population was nearly wiped out after a new steel flapgate design installed in 1989 caused high water velocities preventing good lake access by fish. After new flapgates of the original design were installed in 2001, the 2001 alewife spawning run was estimated at 8,424 alewife (Godwin and Rulifson 2002). Sampling from the 2003 spawning season yielded a population estimate of 38,689 alewife. It is clear that the new flapgates installed in 2001 had immediate success in passing alewives to Lake spawning grounds. This study may help other fishery managers in the proper design and implementation of water-control structures in habitats similar to Lake Mattamuskeet.

Climate Change Risk Perception among Adolescents

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Though many climate literacy efforts attempt to communicate climate change as a risk, these strategies may be ineffective because, among adults, worldview rather than scientific understanding largely drives climate-change risk perceptions. Further, increased science literacy may polarize worldview-driven perceptions, making some climate literacy efforts counterproductive among skeptics. Because worldviews are still forming in the teenage years, adolescents may represent a more receptive audience. This study examined how worldview and climate-change knowledge related to acceptance of anthropogenic global warming (AGW) and in turn, climate-change risk perception among middle school students in North Carolina, USA (n = 387). We found respondents with individualistic worldviews were 16.1 percentage points less likely to accept AGW than communitarian respondents at median knowledge levels, mirroring findings in similar studies among adults. The interaction between knowledge and worldview, however, was opposite from previous studies among adults, because increased climate-change knowledge was positively related to acceptance of AGW among both groups, and had a stronger positive relationship among individualists. Though individualists were 24.1 percentage points less likely to accept AGW than communitarians at low levels (bottom decile) of climate-change knowledge, there was no statistical difference in acceptance levels between individualists and communitarians at high levels of knowledge (top decile). Non-whites and females also demonstrated higher levels of AGW acceptance and climate-change risk perception, respectively. Thus, education efforts specific to climate change may counteract divisions based on worldviews among adolescents, versus polarize them as among adults.

Integrating Eukaryotic and Prokaryotic Plankton Community Transcriptomics into an Ecological Network Analysis of the Neuse River Estuary

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Eutrophication of estuarine and coastal systems can often result in harmful algal blooms (HABs), hypoxia and fish kills. Non-point sources of pollution in the Neuse River Estuary (NRE) watershed have been increasing as the area has experienced steady growth in agriculture, industry and urbanization. Efforts to reduce nutrient inputs of phosphorus have had positive results; however, similar efforts for nitrogen input reduction have not been as successful. Necessary to the effective management of this ecosystem are the identification of the abiotic and biotic components of the system and subsequent understanding of the relationships of those components. The aim of this project is to provide insight into bloom dynamics, causes, and effects, and to provide new molecular tools that may aid in forecasting HABs. We seek to build ecological relationships between the plankton communities incorporating transcriptomic (analysis of RNA sequences) data from eukaryotic phytoplankton, cyanobacteria, and heterotrophic bacteria. The

utilization of next-generation sequencing technologies will provide high resolution of biotic components of this ecosystem. These data will be contextualized with environmental data routinely collected by the ModMon monitoring program in the NRE, such as chlorophyll a, particulate organic matter, primary productivity and dissolved organic and inorganic nutrients. The coupling of these data, with an emphasis on nitrogen cycling, will elucidate important ecological networks that can then be used to guide best management practices to promote healthy ecosystems. The models, approaches, and tools produced by this study could be expandable to other coastal and estuarine systems.

Evaluating Proxy Methods for Estimating Subaerial Beach Volume Change

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Proxies, such as changes in beach profiles and shoreline positions, are commonly used for measuring changes in subaerial beach volume; however, the accuracy of these proxies at representing the true volume change is unclear. Volume change associated with along-beach variations in morphology may not be captured well by changes in profiles, while volume change associated with across-beach variations in morphology may not be captured well by shoreline changes. This study assesses the impacts of variations in morphology associated with beach cusps and nourishment material on volume change measurements from profiles and shoreline change at varying time periods. Results indicate that it is unlikely cross-beach transects spaced ≥150 m apart will accurately measure volume change over both short- and longer-time frames at beaches with cusps, on the border of a nourishment area, and where high temporal variability in shoreline position exists. Changes in beach profiles accurately measure volume change over longer (~3.5 year) time scales at beaches with consistent magnitudes and directions of change. The shoreline change proxy works best at beaches with low temporal variability in shoreline position, at beaches where there are no significant morphologic changes to the backshore, and at beaches with ramp-like morphologies, which often exists after nourishment material is graded. Topographic data collection using LIDAR methods is essential at beaches where volume change oscillates between erosion and accretion on both short and long time scales because the magnitude of small-scale changes in beach volume will always be similar to the long-term net volume change.

Visitor Use and Impact Monitoring at North Carolina National Estuarine Research Reserve Sites

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Coastal protected areas offer myriad ecosystem services, including biodiversity conservation, natural disaster alleviation, and recreation and tourism opportunities. The N.C. Coastal Reserve and National Estuarine Research Reserve (NCCR-NCNERR) program protects unique coastal environments along the North Carolina seaboard for education, long-term research and compatible recreation. However, ecological processes and anthropogenic pressures threaten the sites and play an important role in their management. Many sites receive high levels of visitation, with increases closely related to the rapidly growing population along the coast. High levels of visitation can further degrade resource conditions and health of these coastal ecosystems. Despite the managerial relevance of visitor use and related impact

information, data are often scarce and a common limitation to proactive management. Meetings with managers of NCCR-NCNERR sites during a workshop hosted by the NCCR-NCNERR program and NOAA in 2012 identified salient visitor use issues for study and began an ongoing partnership to collect managerial relevant data. Specifically, this partnership strives to facilitate proactive management by collecting timely visitor use and impact-monitoring data and engaging the public and local communities in monitoring. Three main issues (i.e., compliance with dog-leash regulations, visitor interactions with feral horses, proliferation of visitor-created trails and campsites) were selected for study at two NCNERR sites. Volunteers were recruited from the local community, provided with a training workshop, and began collecting data in 2013. This poster will highlight data collection methods for all indicators, lessons learned from 2013 and a discussion of future plans.

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