Southeast Tidal Creeks Summit

The Francis Marion Hotel
Charleston, South Carolina

December 5 and 6, 2011

Summit Agenda

Monday, December 5

7:30 Registration and Continental Breakfast (Colonial Ballroom)

8:30 Welcome – *Barbara Doll, North Carolina Sea Grant*

Morning: A Look at Tidal Creek Functions and Impacts – Research Perspectives

Moderator: Barbara Doll, North Carolina Sea Grant

8:45 Tidal creeks: What are they and what ecosystem services do they provide?
Fred Holland (retired) Former Director, Hollings Marine Laboratory, NOAA

9:15 Eutrophication and fecal microbial pollution of tidal creeks
Michael Mallin,Center for Marine Science, UNC Wilmington

9:45 The impact of coastal development on tidal creek ecosystem health
Denise Sanger, S.C. Sea Grant Consortium and Center of Excellence in Oceans and Human Health at the Hollings Marine Laboratory

10:15 Break

10:30 Transport and retention in tidal creeks and surrounding marshes
Jack Blanton, Skidaway Institute of Oceanography

11:00 Forecasting the future of coastal wetlands
James Morris, Belle W Baruch Institute for Marine & Coastal Sciences, University of South Carolina

11:30 Group discussion to identify tidal creeks research gaps
Facilitator: Pam Kylstra, NOAA Coastal Services Center

12:00 **Lunch** (Carolina A Room) - Speaker: The importance of tidal creeks in the lives and livelihoods of coastal communities
Charles Seabrook, author of "The World of the Salt Marsh"

Afternoon: A Look at Tidal Creek Management - Current Focus and Future Needs

Moderator: Gloria Putnam, North Carolina Sea Grant

1:15 Perspectives on state management programs related to tidal creeks
James Gregson, N.C. Department of Environment and Natural Resources, Division of Water Quality; Barbara Neale and David Chestnut, S.C. Department of Health and Environmental Control, Office of Ocean and Coastal Resource Management and Environmental Quality Control, respectively; and Kelly O'Rourke, Georgia Department of Natural Resources, Coastal Management Program

2:00 Federal regulatory programs for protecting and restoring tidal creeks
Pace Wilber, National Marine Fisheries Service, NOAA

2:20 Panel and group discussion to identify information needs for effective future management of tidal creeks
Facilitator: Pam Kylstra, NOAA Coastal Services Center

2:50	Case Study #1: Applying new stormwater management approaches to tidal creeks in Beaufort County, S.C *Dan Ahern, Beaufort County Stormwater Manager*
3:10	Case Study #2: Linking GIS tools with water quality modeling to develop management options for the Lockwoods Folly River in coastal North Carolina *Jason Doll, Moffatt and Nichol*
3:30	**Break**
4:00	Case Study #3: Integrating low impact development in watershed management strategies to reduce bacteria pollution in impaired coastal waters: The grey to blue experience *Phil Prete, Environmental Planner, City of Wilmington*
4:20	Case Study #4: The protection of Chatham County's natural resources: Lessons learned *Jackie Jackson Teel, Savannah Metropolitan Planning Commission*
4:40	Group discussion to identify research and management needs *Facilitator: Pam Kylstra, NOAA Coastal Services Center*
5:00 - 7:00	Poster Exhibit and Reception (Carolina B Room)

Tuesday, December 6

7:30	Continental Breakfast (Colonial Ballroom)

Potential Strategies for Tidal Creeks Research and Management - and Future Directions

Moderator: David Bryant, Georgia Sea Grant

8:00	Watershed, land-use and stormwater influence on tidal creeks *Dan Hitchcock, The Belle W. Baruch Institute of Coastal Ecology, Clemson University*
8:30	Economic incentives for sustainable development in sensitive tidal environments *Warren Kriesel, University of Georgia*
9:00	Strategic restoration designs can maximize ecosystem services in tidal marshes *Mike Burchell, Biological and Agricultural Engineering Dept., NC State University*
9:30	Tampa Bay tidal tributary research and restoration initiatives *Ed Sherwood, Tampa Bay Estuary Program*
10:00	**Break**
10:15	Group discussion on tidal creek restoration *Facilitator: Pam Kylstra, NOAA Coastal Services Center*
10:45	Group discussion on where tidal creek research, management and restoration goes from here (Information to be included in the summit white paper) *Facilitator: Pam Kylstra, NOAA Coastal Services Center*
11:45	Conference wrap-up *Rick Devoe, S.C. Sea Grant Consortium*
12:00	Adjourn

ABSTRACTS AND BIOSKETCHES

Tidal creeks: What are they and what services do they provide to humans?

Fred Holland, Ph.D.
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Abstract: Meandering shallow tidal creeks, and associated intertidal wetlands, are located at the interface of terrestrial, freshwater and marine ecosystems. These complex ecosystems are a dominant feature of Southeastern estuaries composing about 50% of the estuarine area. Tidal creeks have diverse characteristics (e.g., watershed dimensions, geology, hydrology, environmental gradients) that result in complex ecosystems of many shapes, sizes, and ecological characteristics. A continuum of creek types occurs from intertidal headwaters to the coastal ocean. Two major classes of creeks have been identified: upland and salt marsh. Both upland and salt marsh tidal creek ecosystems: (1) provide nursery habitat, refuges and feeding grounds for fish, shellfish, and other wildlife; (2) are repositories for particulate pollutants; (3) have critical roles in material flux; (4) are important transport pathways for dissolved pollutants; (5) provide seafood products; and (6) mitigate storm damage. Increases in runoff into upland creeks from the hardening of coastal watersheds increases non-point source pollution loadings and is the major threat to upland creeks. Restoration and mitigation activities for upland creeks should focus on reducing runoff volume and pollution loadings. A tool for forecasting the impact of coastal development on upland creeks will be described. Salt marsh creeks are the primary hydrologic link between salt marshes and deeper estuarine waters. These creeks are transport pathways for delivering motile organisms and pollutants, including sediments, to marshes on the flooding tides and for delivering marsh productivity and recycled nutrients to deeper waters on ebbing tides. Impediments to tidal flushing, dredge and fill operations and sea level rise are major threats to salt marsh creeks and should be the focus of their restoration activities. The shorelines of tidal creeks are renowned for their natural beauty and are preferred sites for human habitation. Impairment of tidal creeks therefore has the potential to have important cultural and social impacts. A major research need for tidal creek ecosystems is development of a classification framework for tidal creeks that integrates their biogeography, hydrology, and short- and long-term ecological history that is acceptable to scientists, regulators, and planners.

About the Speaker: Fred Holland is a retired ecologist who was formerly the Director of the NOAA's Hollings Marine Laboratory (HML) and the Center of Excellence for Oceans and Human Health at the HML. He also was the Director of the Marine Resources Research Institute of the South Carolina Department of Natural Resources and served as Vice President with Versar Inc, an environmental consulting firm in the Wasington D.C./Baltimore, MD area. Dr. Holland has a B.S. degree from The Citadel and MS (Biological Sciences) and Ph.D. (Marine Science) from the University of South Carolina. He has spent his career studying the impact of human activities on estuarine ecosystems and the services they provide humans. For the past 15 years he has focused his research on defining the linkages between land use in coastal watersheds and the quality of the marine environment and human well-being.

Eutrophication and Fecal Microbial Pollution of Tidal Creeks

Michael A. Mallin, Ph.D.
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Abstract: Continental-draining tidal creeks can be mesohaline on average and drain into larger estuaries and sounds, or fresh-to-oligohaline and drain into rivers and riverine estuaries. These types of tidal creeks are highly subject to anthropogenic loading of nutrients and fecal microbes. Documented sources of nutrients include sewage spills and leaks, septic system leachate, and urban, suburban and agricultural fertilizer runoff. Upper areas of anthropogenically influenced tidal creeks tend to have elevated nitrate concentrations while lower, high-salinity areas are nitrogen depauperate. As such, phytoplankton growth in lower creeks is nitrogen limited while growth in upper creeks may be limited by either nitrogen or phosphorus, or even by light. Upper creeks can host large algal blooms, and toxic species have appeared in some circumstances. Tidal creeks are subject to hypoxia, the sources of which can be natural as well as anthropogenic. Anthropogenically, concentrations of the nutrient-response variable chlorophyll *a* have been statistically correlated with both biochemical oxygen demand (BOD) and sediment oxygen demand in tidal creeks; thus nutrient loading is one driver of hypoxia. Additionally, BOD5 and especially BOD20 concentrations in tidal creek waters have been correlated with rainfall, indicating there are runoff sources of BOD-inducing materials. Tidal creeks are also subject to fecal microbial pollution from sewage spills and leaks, septic leachate, and stormwater-driven runoff of domestic animals and urban wildlife. Such pollution is strongly correlated with the degree of watershed urban development. Upper (1st order) tidal creeks are especially subject to fecal pollution and can be considered sentinels for larger pollution problems. Microbial pollution is particularly problematic to humans due to tidal creek usage as shellfishing areas and places for human recreational contact. Finally, tidal canals are ubiquitous, human-designed features of the estuarine landscape that are highly subject to pollution resulting in algal blooms, severe hypoxia, fish kills, and microbial and chemical pollution. Due to their abundance and susceptibility to human impacts, yet connections with natural ecosystems, their role in estuarine ecology bears more investigation.

About the Speaker: Michael A. Mallin is Research Professor at the University of North Carolina Wilmington Center for Marine Science. He has served as Research Director of the New Hanover County Tidal Creeks Program, the Wilmington Watershed Program, and the Lower Cape Fear River Program. His research interests include landscape impacts on water pollution, eutrophication, major storm impacts on water quality, assessing sources of nutrient and fecal pollution, and studying the efficacy of land mitigation of runoff pollution. He is an elected Fellow of the American Association for the Advancement of Science, an Aldo Leopold Leadership Fellow, and has served as President of the Southeastern Estuarine Research Society.

The Impact of Coastal Development on Tidal Creek Ecosystem Health

Denise Sanger, Ph.D.
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Abstract: In the Southeast, watersheds that form tidal creeks are among the most rapidly developing in the nation. Tidal creeks form the primary hydrologic link between estuaries and land-based activities and, as such, reflect the impacts of coastal development earlier than larger coastal water bodies. Nonpoint source pollution (e.g., stormwater runoff) increases with development through carrying sediments, chemicals, bacteria, viruses, and other pollutants into tidal creeks and salt marshes and degrading water quality. Research throughout the Southeast has found linkages between surrounding watershed land use (e.g., impervious cover) and the ecological condition (i.e., physical-chemical and biological) of headwater tidal creeks. A conceptual model identifying adverse changes at the physical-chemical, biological and societal responses will be discussed. In general, adverse impacts on the physical and chemical environment (e.g., water quality indicators such as indicator bacteria for sewage pollution or sediment chemical contamination) occur when impervious cover levels in the watershed reach 10-20%. Ecological characteristics respond and are generally impaired when impervious cover levels exceed 20-30%. Estimates of impervious cover levels defining where human uses are impaired are currently being determined, but it appears that shellfish bed closures and the flooding vulnerability of headwater regions become a concern when impervious cover values exceed 10-30%. The synthesized research presented will be of value in addressing local, regional and national needs for understanding multiple stressor (anthropogenic and human impacts) effects upon estuarine ecosystems and response trends in ecosystem condition with changing coastal impacts (i.e., development, climate change). This information can be used to forecast the impacts of changing land-use patterns on tidal creek environmental quality, as well as associated human health and well-being. Tidal creeks are the appropriate scale to assess the impacts of land-use change in the watershed, as well as providing appropriate scale for making land-use decisions.

About the Speaker: Denise Sanger is the S.C. Sea Grant Consortium's Assistant Director for Research and Planning. She obtained her Doctorate in Marine Science in 1998 from the University of South Carolina and her Bachelor of Arts degree in Marine Biology in 1993 from the University of California, Santa Cruz. Her current research emphasis involves evaluating the impacts of development on tidal creek and salt marsh ecosystems including examining water quality, sediment contamination, biological quality, and human health and welfare in association with Center of Excellence in Oceans and Human Health at Hollings Marine Laboratory, NOAA.

Transport and Retention in Tidal Creeks and Surrounding Marshes

Jack Blanton, Ph.D.
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Co-authors*:* Alfred Garrett (Savannah River National Laboratory, Aiken SC), Julie Amft (SkIO) and Trent Moore (SkIO)

Abstract*:* The complex morphology of tidal creeks and surrounding marshes significantly distorts tidal currents, thereby impacting the transport of sediments and conservative tracers. Creek currents typically have surge-like characteristics that are caused by pressure gradients formed by delays in the propagation of the tidal wave through the marsh area. High friction in the marsh impedes the transport of conservative tracers between the creeks and marshes, leading to a decrease in the ability to flush material out of the marshes. Recent studies have indicated a two-phase flushing of conservative tracers out of marsh areas. The first is related to the flooding of the marsh surface by rising tides with a relatively short residence time. The second phase begins several tidal cycles later and has a lower flushing rate, resulting in an increase of residence time. While speculative, this delayed phase is consistent with the percolation of the tracer through the marsh sediments and out into the surrounding creek, a subterranean component of the overall circulation regime that retards flushing. This hypothetical two-phase circulation of material between marsh and creek requires new and well-designed studies in order to validate its significance. We will demonstrate the insight offered by a three-dimensional numerical simulation of the exchange of a tracer between a complex of connected creeks and surrounding marsh.

About the Speaker: Blanton graduated in civil engineering at the University of Florida in 1962 and obtained a Ph.D. degree in physical oceanography at Oregon State University in 1968. Since 1976, he has been a faculty member at Skidaway Institute of Oceanography in Savannah GA and currently holds the position of Professor Emeritus. He has lead research programs on the cross-shelf transport of material originating in coastal waters and in estuarine and tidal creek circulation. He also lectures in coastal physical oceanography.

Forecasting the Future of Coastal Wetlands

James T Morris, Ph.D.
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Abstract: The current distribution of coastal wetlands is the product of 4,000 years of near static sea level. The rise in sea level that we see today began several centuries ago and is accelerating. Evidence will be presented that some coastal wetlands are not keep up with sea level or cannot keep up with projected rates of sea level rise (SLR). Vegetated salt marshes survive only at relative elevations that are approximately above mean sea level (MSL) and below the elevation of local mean high water. Salt marsh plants help to stabilize the elevations of salt marshes within this range, even as MSL rises. However, the stable elevation will decrease as the rate of SLR increases, and there is a tipping point beyond which

marshes are unable to maintain their relative elevation. The remaining lifetime or survival time of a wetland varies among estuaries depending on a variety of factors, including concentration of suspended sediment, tide range, and current elevation. I will present a simple model that accounts for these factors and predicts survival time, and present a rapid assessment technique for evaluating marsh stability based on an analysis of LiDAR data. The talk will conclude with a discussion of future research needs.

About the Speaker: Dr. James Morris is the Director of the Belle Baruch Institute for Marine and Coastal Sciences, the Class of '32 Distinguished Professor of Marine Studies at the University of South Carolina, and a AAAS Fellow. His academic background includes degrees in environmental sciences, (B.A., Univ. Virginia), biology (M.A., Yale) and forestry and environmental studies (Ph.D., Yale). He was a postdoctoral fellow at the Marine Biological Laboratory, Woods Hole before taking a faculty position at the University of South Carolina in 1981. He has served as a Program Officer for the National Science Foundation and a visiting professor at Aarhus University, Denmark. Morris has authored more than 80 peer-reviewed publications and is regarded as an expert on the effects of sea level rise on coastal wetlands. He has served on numerous committees and panels, including the National Science Foundation, the Irish National Science Foundation, the National Research Council, and the IndoFlux committee of India.

Pam Kylstra
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Pam is a program development specialist with the NOAA Coastal Services Center where she also serves as the Center's Sea Grant Liaison. She assists with the instructional design of Center products, develops training programs, and provides facilitation services for the coastal resource management community, including Sea Grant, National Estuarine Research Reserves (NERR), and other federal, state, and local agencies and organizations.

Pam holds a master of science in marine resource management from Oregon State University's College of Atmospheric and Oceanic Sciences and a bachelor of science in zoology from North Carolina State University. She also has completed certification courses in training design, facilitation, and mediation.

The Importance of Tidal Creeks in the Lives and Livelihoods of Coastal Communities

Charles Seabrook
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Abstract: Thanks to years of detailed and dedicated scientific scrutiny of tidal creeks, we now have a thorough understanding of the waterways' ecological importance, such as nursery areas for numerous marine species. My presentation will focus on the cultural aspect of tidal creeks and how entire communities of people have relied on them for sustenance, livelihood and recreation. In essence, tidal

creeks represent a way of life for countless individuals and communities along the southeastern U.S. Atlantic coast. Most notable of these are the Gullah-Geechee people, whose daily lives have revolved around tidal creeks and salt marshes for centuries. Yet, despite the importance of tidal creeks, many of them have become impaired because of urban sprawl, weak enforcement of anti-pollution laws and other human factors. I will give examples of some of these problems from my forthcoming book. I wrote the book to help the general public understand the ecological importance of tidal creeks and salt marshes -- and the environmental and cultural upheavals that ensue when they become impaired.

About the Speaker: Charles Seabrook, a native of John's Island, S.C., was an award-winning science and environmental writer for 34 years with the *Atlanta Journal-Constitution* before his retirement in 2005. He continues to write a popular weekly nature column called "Wild Georgia" for the newspaper on a contractual basis. His newspaper series about Georgia's mining industry won the Investigative Reporters and Editors "Best Story of the Year" award in 1994 and was the basis for his first book. In 2001, the state of Georgia gave him the R. L. "Rock" Howard Award, its highest conservation award. His second book, *Cumberland Island: Strong Women, Wild Horses* was published in 2002. His third book is scheduled for publication in April 2012 by the University of Georgia Press. It is titled *The World of the Salt Marsh: Appreciating and Protecting the Tidal Marshes of the Southeast Atlantic Coast*.

North Carolina Department of Environment and Natural Resources – Perspective on State Level Tidal Creek Management Programs

Jim Gregson
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Abstract: Several NCDENR programs share in the responsibility for managing tidal creeks. This presentation will focus on two of those agencies, the Division of Water Quality and the Division of Costal Management. The Division of Water Quality is responsible for the protection and enhancement of the state's surface and ground water for the citizens of North Carolina and future generations. The Division of Coastal Management is charged with protecting NC coastal resources through an integrated program of planning, permitting, education and research. Three NCDENR projects/programs will be briefly discussed: (1) the use of a collaborative TMDL process for managing non-point sources of fecal coliform bacteria in shellfish waters; (2) the N.C. Coastal Stormwater Program; and (3) understanding the effects of coastal development through the N.C. Estuarine Shoreline Mapping Project.

About the Speaker: Jim Gregson works as the Regional Water Quality Supervisor for the N.C. Division of Water Quality, Surface Water Protection Section, in the Wilmington Regional Office. In this capacity he oversees all aspects of the Surface Water Program with the mission of protecting and enhancing the surface waters of the state. Program areas include: NPDES and Coastal Stormwater permitting and compliance, NPDES wastewater treatment permitting and compliance, Statewide Ambient Network Monitoring Program, Aquatic Toxicity Program, and 401 Water Quality Certification and Isolated Wetland/Water Permitting Program. Prior, he served as the Director of the N. C. Division of Coastal Management from 2007-2011.

South Carolina Department of Health and Environmental Control, Environmental Quality Control – Perspective on State Level Tidal Creek Management Programs

David Chestnut

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David Chestnut is a Senior Scientist with the South Carolina Department of Health and Environmental Control, Bureau of Water, where he has worked since 1985. He received a B. S. in Biology from Northern Illinois University in 1980, graduating cum laude, and a M.S. in Biology from the University of South Carolina in 1983. His primary responsibilities at SCDHEC include the design and oversight of the statewide Ambient Surface Water Monitoring Program and the assessment of water quality data to support Clean Water Act reporting requirements (§305(b) and §303(d) reports) and other SCDHEC internal needs. Mr. Chestnut is currently a member of the National Water Quality Monitoring Council, a subgroup of the federal Advisory Committee on Water Information, representing the southeastern U.S.

Georgia Department of Natural Resources – Perspective on State Level Tidal Creek Management Programs

Kelly O'Rourke

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Abstract: The Coastal Resources Division of the Georgia Department of Natural Resources is the state agency entrusted to manage Georgia's coastal marshes, beaches, waters, and fisheries for the benefit of present and future generations. The Division's service area extends from the inland reach of tidal waters to three miles offshore – an area that includes approximately 1,000 square miles in size. The Division is composed of two sections, Ecological Services and Marine Fisheries, with separate but complementary functions.

The Marine Fisheries Section provides information to manage Georgia's diverse coastal fisheries through programs such as scientific marine organism and habitat surveys, seafood harvest information collection, saltwater game-fish record program, construction and maintenance of boating and fishing access sites, EFH assessment, restoration and enhancement, and recreational angler surveys. The Ecological Services Section administers the Georgia Coastal Management Program in coordination with NOAA, permits structures and activities in coastal marshlands and along the shorelines, conducts compliance enforcement, coordinates acquisition of sensitive and unique coastal habitats, administers the Coastal Incentive Grant Program, provides technical assistance and outreach to local governments, provides federal consistency review, and conducts water quality monitoring through the shellfish and beach programs.

This presentation will review the most recent projects and program developments as they relate to tidal creek monitoring, research, enhancement, restoration and overall management.

About the Speaker: Kelly O'Rourke works as a Coastal Resources Specialist with the Georgia Coastal Management Program (GCMP), housed at the Coastal Resources Division of the Georgia Department of Natural Resources. She provides technical assistance to local governments, developers, and the general public by offering expertise on coastal issues, assisting with the Program's coastal incentive grants, clarifying regulatory requirements and identifying agency contacts. She provides assistance within the program by researching policy and rule development, participating in marsh dieback monitoring, and other tasks as needed. Her specialty area focuses on sustainable and green growth practices as well as promoting the use of low impact development techniques for stormwater management in the coastal region. Recently she worked on developing several demonstration projects showcasing native landscaping practices, rainwater harvesting techniques, rain gardens and bioswales.

Federal Regulatory Programs for Protecting and Restoring Tidal Creeks

Pace Wilber, Ph.D.
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Co-Authors: Jaclyn Daly, Melanie Harris, Howard Schnabolk, Melissa Strickland, Lisa Vandiver, NOAA Fisheries Service

Abstract: Tidal creeks and adjoining salt marshes provide important ecosystem services, including fishery production, water quality improvement, flood protection, and human health services. In recognition of this role, tidal creeks are protected under the Clean Water Act, Fish and Wildlife Coordination Act, and Magnuson-Stevens Fishery Conservation and Management Act. The effectiveness of these federal authorities varies and inversely correlates with population growth and development. The effectiveness of these federal efforts also strongly and directly correlates with the strength of parallel programs administered by state agencies. While proposals to directly impact tidal creeks (e.g., point source discharges, dredging and filling) are relatively easy to identify and address within existing regulatory frameworks, indirect impacts (e.g., non-point-source runoff, reduced tidal prism, and impacts that cascade into a creek from outside areas) are more difficult to forecast and address. This presentation will review the roles of federal resources agencies in the protection and restoration of tidal creeks and provide case studies that illustrate the public interest balancing test that provides the basis for decision making by federal and state regulatory programs.

About the Speaker: Pace Wilber leads the Habitat Conservation Division's Atlantic Branch for the NOAA Fisheries Service, Southeastern Region. Each year the Atlantic Branch examines approximately 1000 proposals for projects that would impact wetlands within North Carolina, South Carolina, Georgia, the Atlantic coast of Florida, and the U.S. Caribbean. In collaboration with other NOAA offices, including the NOAA Fisheries Office of Habitat Conservation and Southeast Fisheries Science Center, NOAA Restoration Center, and NOAA's National Centers for Coastal and Ocean Science, a strategic approach for protecting, conserving and restoring tidal creeks is being developed.

Applying New Stormwater Management Approaches to Tidal Creeks in Beaufort County

Dan Ahern, P.E.
Beaufort County Stormwater Utility, 102 Industrial Village Road, Bld #3, Beaufort, SC 29906, dahern@bcgov.net

Abstract: Beaufort County is proud of its tidal water resources and efforts to protect them through water quality control. Water quality controls in its best management practices (BMP) manual adopted in 1998 seemed to be working as the county saw a 30 percent increase in population without any additional water quality impairments. This changed in 2009 when the state restricted shellfish harvesting in a section of the May River. Investigations suggested that stormwater runoff volume, rather than water quality, was contributing to increasing fecal coliform bacteria levels. This led to a two-step volume control effort that addresses future impacts of new stormwater runoff volume. This presentation will show how standards in a federal law dealing with new federal construction were adopted for new developments and then for on-lot construction for a large universe of un-built lots in older developments. Modifications to the BMP manual translated the rainfall event runoff volume standards to "equivalent" impervious surface that allowed control of volume to be reflected in water quality controls. A web based program was developed to select on-lot control practices.

About the Speaker: Dan Ahern has been the Manager of the Beaufort County Stormwater Utility since 2007. The Utility has over 30 personnel addressing stormwater issues in the county and supporting efforts in four municipalities in the county. He is a professional engineer in Georgia and South Carolina with degrees in Civil and Environmental engineering. He has over 40 years of previous experience with consultants, US EPA, US Army, and now Beaufort County. When not focused on stormwater, he participates in triathlons, masters swimming, flying, and trying to sail faster than the tide.

Linking GIS Tools with Water Quality Modeling to Develop Management Options for the Lockwoods Folly River in Coastal North Carolina

Jason C. Doll, CPSWQ
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Abstract: Brunswick County, North Carolina is the 29th fastest growing county in the United States, and much of that growth is focused around the County's fragile coastal and estuarine resources. The coastal watershed of Lockwoods Folly River servs as an example of the impacts of rapid coastal development. In 1980, 16% of the estuary was closed to shellfish harvesting, whereas now approximately 55% is closed. The estuary was listed as impaired by USEPA due to the loss of the ability to harvest that resource because of increasing pathogen loads from on-site septic systems and increasing stormwater runoff. Brunswick County and the North Carolina Coastal Federation organized and convened a Roundtable of local citizens, developers and community leaders to develop a slate of recommendations to protect and restore Lockwoods Folly. Concurrently, the NC Ecosystem Enhancement Program selected the watershed for development of a local watershed plan. Shortly after initiation, the two groups combined their efforts to avoid duplication, pool resources, and achieve a greater impact. Mr Doll lead the

consulting team that provided both technical support for the watershed planning effort, and a strong scientific basis for the Roundtable Recommendations. The consulting team developed an integrated GIS – PLOAD watershed modeling framework to examine nutrient, sediment and fecal coliform loads under both existing and future land-use conditions. The modeling analysis predicted a four-fold increase in pathogen loading under future conditions under existing land-use plans and management scenarios. The Roundtable advanced a set of strategies including the implementation of low impact development (LID) methods, stream and wetland restoration, targeted preservation and stormwater BMP retrofits to reduce and prevent further degradation of Lockwoods Folly. Through simulation of "what if" management scenarios, the model predicted significant pollutant load reductions from some of the Roundtable Strategies, but clearly illustrated that no one approach alone would achieve the desired reductions. Rather, an aggressive and comprehensive pursuit of all the strategies would be required to prevent further degradation of Lockwoods Folly and restore some shellfishing opportunities. The Roundtable and the Coastal Federation, with the support of the consulting team, further leveraged the ongoing watershed planning efforts to successfully apply for a Clean Water Act Section 319 Grant to support development of a TMDL for the estuary. The TMDL analyisis used the existing GIS-PLOAD framework, in conjunction with a Tidal Prisms model to predict repsonses in the estuary to watershed pollutant load changes in order to arrive at the final TMDL. The watershed plan and subsequent TMDL are currently undergoing implemention.

About the Speaker: Mr. Doll is originally from one of the most remote areas of the northeastern North Carolina Coast. He attended North Carolina State University where he graduated with a B.S. in Fisheries and Wildlife Science in 1987. After a stint with non-profit environmental groups, he worked six years as a water quality modeler with the North Carolina Division of Water Quality. Now, with the addition of 13 years in private consulting, Mr. Doll has an 18 year track record using modeling tools and GIS in the assessment and management of point and non-point sources of pollution in the context of watersheds and whole river basins. He is currently a Senior Scientist and Project Manager with Moffatt & Nichol in Raleigh. He is a Certified Professional in Storm Water Quality and is certified in Low Impact Development by N.C. State University.

Integrating Low Impact Development in Watershed Management Strategies to Reduce Bacteria Pollution in Impaired Coastal Waters: The Grey to Blue Experience

Phil Prete
City of Wilmington, 305 Chestnut Street, 3rd Floor, Wilmington, NC 28401,
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Abstract: Water quality in coastal North Carolina is often impaired by bacteria pollution that limits the use of the waters for harvest of shellfish and recreational swimming. Public health standards for shellfish harvest and swimming require almost pristine water quality. Conventional methods used to concentrate and treat stormwater have consistently failed to achieve the water-quality standards required by the federal Clean Water Act.

Through an EPA Section 319 grant, the City of Wilmington, the North Carolina Coastal Federation, UNC Wilmington and Town of Wrightsville Beach have worked together to develop an innovative coastal watershed restoration plan for Wilmington's Bradley and Hewletts Creeks. The plan focuses on the transport of bacterial pollutants rather than the removal of the bacteria by finding opportunities to reduce the volume of runoff and tracking progress toward meeting specified volume reduction goals. This project will serve as a model for establishing restoration strategies and volume reduction goals as a surrogate measure to track improvement of other impaired coastal waters.

Key strategies of the plan include finding opportunities for retrofits for stormwater runoff reduction on city streets, capital improvement projects and city owned properties and schools, outreach and education for property owners on disconnecting impervious surfaces, and promoting low impact development for new development. Presenters will discuss the collaborative process, share the targeted volume reduction approach and review the specific watershed strategies that will address fecal coliform bacteria pollution.

About the Speaker: Before arriving at Wilmington eight years ago, Phillip Prete was the Environmental Planner for the Town of Carrboro, worked in environmental program enforcement for state agencies in North Carolina and Texas, and was an environmental consultant. He conducted research on water quality and fisheries impacts related to oil field production practices, industrial discharges, and hydroelectric dams. Phil has an M.S. in Ecology from North Texas State University and an M.S.P.H. in Environmental Science and Engineering from the University of North Carolina at Chapel Hill. He was first certified as a Registered Environmental Professional in 1992 by the National Registry of Environmental Professionals.

The Protection of Chatham County's Natural Resources: Lessons Learned

Jackie Jackson Teel, LEED-AP BC & D
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Abstract: The *Coastal Stormwater Supplement (CSS) to the Georgia Stormwater Management Manual* completed and released in 2009 provides Georgia's coastal communities with comprehensive guidance on an integrated, green infrastructure-based approach to natural resource protection, stormwater management and site design. All of the 8 municipalities within Chatham County's boundaries are currently in the process of adopting the CSS' recommendations into their stormwater ordinances and development processes.

Ms. Teel is currently researching and working with local scientists and planners on preparing Chatham County for any climate change issues that may need to be addressed in the next 50 years. Through update of the Chatham County- Savannah's Comprehensive Plan and finalization of the Unified Zoning Ordinance, policy documents will be implemented to assist in the coastal region's protection of its natural resources in addition to defining Chatham County's next steps in preparing for climate adaptation.

About the Speaker: Jackie Jackson Teel is a native of Savannah, Georgia and has worked for the Chatham County – Savannah Metropolitan Planning Commission (MPC) as the Natural Resources

Administrator and Environmental Planner for 8 years. She actively plays a role in working with 8 local jurisdictions in Chatham County by overseeing the stormwater NPDES and water conservation programs for these areas. Ms. Teel was a co-author and project manager for the *Coastal Stormwater Supplement (CSS) to the Georgia Stormwater Management Manual* which was recognized by the Georgia Environmental Protection Division's Director and the Department of Natural Resources Board. She has also been awarded the Virginia Brown Memorial Award for Civic Engagement from the League of Women Voters for her work in starting the Chatham County Resources Protection Commission (RPC). She came to the MPC via Fort Stewart / Hunter Army Airfield where, as a Biologist, she managed the drinking water, wastewater and air quality environmental compliance programs for both Fort Stewart and Hunter Army Airfield for 6 years. Jackie is a Leadership in Energy and Environmental Design (LEED) Accredited Professional focusing on Building Construction and Design, a member of the American Planning Association (APA), American Water Works Association (AWWA), American Society of Civil Engineers (ASCE), United States Green Building Council (USGBC) and a licensed water and wastewater operator in the State of Georgia.

Watershed, Land-Use, and Stormwater Influence on Tidal Creeks

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Abstract: An increasing coastal population requires land-use change to support the demand. Growth and management strategies must guide this change in order to not only protect natural resources but also build resilient communities. Potential impacts due to landscape modification, specifically the conversion of forests to residential and commercial development, could lead to irretrievable natural resource impairment with respect to water quality and fisheries. Improperly managed stormwater is a primary pollution source for coastal watersheds and in receiving tidal creeks, while volume reduction has been the typical control strategy, historically using retention and detention ponds. Beyond ponds, progressive management strategies include natural resource-based planning guidelines, by way of green infrastructure inventory, as well as stormwater control measures such as rainwater harvesting techniques and landscape features such as rain gardens and constructed wetlands. The implementation of land-use practices that mimic natural coastal water budgets and ecological processes can reduce impacts from developing landscapes. Yet coastal hydrology is complex and typified by flat topography and shallow groundwater, limiting the potential for conveyance and infiltration, respectively. Furthermore, any combination of effective sustainable land-use strategies, whether in developed or developing areas, require consideration of varying spatial and temporal scales: at the watershed level, in developed neighborhoods and urban centers, and in rural communities or preserved tracts of land - all with respect to management decisions and practices. Complex watershed and landscape elements extend beyond and occur between geopolitical boundaries; therefore, holistic decision-making must consider these intricate resource elements within and between their differing levels of scale. This presentation will focus on issues related to land-use change

in upland coastal watersheds, with specific emphasis on sustainable strategies, solutions, and tools for protecting natural resources and coastal communities.

About the Speaker: Dr. Dan Hitchcock is an Assistant Professor in the School of Agriculture, Forest, and Environmental Sciences (SAFES) at Clemson University. He is stationed at Baruch Institute of Coastal Ecology and Forest Science in Georgetown, SC. He is also a licensed civil engineer in South Carolina. His areas of expertise include forest and urban hydrology, water quality, and ecological design from both a research and education standpoint. Using ecological engineering principles for natural resource preservation and restoration, Dan is investigating ecological design and green infrastructure solutions to coastal environmental and water resource impacts from land conversion and urbanization. The mission of the Clemson – Baruch Institute is to advance sustainable coastal environments through science.

Economic Incentives for Sustainable Development in Sensitive Tidal Environments

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Abstract: Since the 1980s, environmental advocates have promoted low-impact, or green growth, designs. Benefits from more open space include the visual appeal, recreational uses, improved tree cover and reduced pollution from storm runoff. However, the land that is used for open space comes at the expense of land that developers can sell as residential parcels. The wide-spread adoption of green growth designs cannot happen unless the typical developer has good reasons. This research investigates whether home buyers display preferences for low-impact designs, and therefore provide market-based incentives for wide adoption of the designs. It was within this context that we analyzed the residential property market in each of three non-neighboring coastal US counties of which one was metropolitan, another suburban and the other rural. Here, the sale prices of properties were explained in a linear regression, where the independent variables described the property's characteristics including environmental variables of interest. Comparing results between the counties, we found that while the estimated coefficients were quite similar across the three models, the metropolitan county displayed the strongest response of prices to the open space, impervious surface and proximity to marshland variables, and the weakest (but still positive) response was in the rural county. A series of property price simulations for the three counties indicated that homebuyers' preferences for low impact characteristics overcame their dislike of small lot sizes, such that developers could earn more revenue if they adopted low-impact design characteristics. These results agree with those from a previous study in a suburban Maryland county. However, this study is the first to show that the trade-off between open space and lot sizes also holds up in coastal areas where nature was already providing open space in the form of saltwater marshes, tidal rivers and other water features. This is important because the marshland ecosystem is quite sensitive to pollution from stormwater runoff.

About the Speaker: Warren Kriesel is originally from Northern Virginia, he was a Peace Corps Volunteer, and he received his Ph.D. from the Ohio State University. His teaching and research has

focused on the links between communities' economic well-being and their natural resource and environmental base. His latest research explores how local coastal economies are impacted by natural hazards and residential development designs. Please don't ask him about macroeconomics and the recession. He does not fully understand the field and doubts that anybody else does.

Strategic Restoration Designs Can Maximize Ecosystem Services in Tidal Marshes

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Co-Authors: Francois Birgand, Steve Broome, Kris Bass, Randall Etheridge, Yo-Jin Shiau, and Robert Evans - NC State University; Ken W. Krauss - U.S. Geological Service - National Wetlands Research Center

Abstract: A partnership that included NC State University, the NC Coastal Federation, and the NC Ecosystem Enhancement Program resulted in the design and construction of 14 ha (35 acre) of tidal marsh and over 1500 m (5000 ft) of tidal stream on a prior converted wetland in eastern NC. This restoration was strategically located between existing drained agricultural land and the North River, designated by divisions in the NC Department of Environment and Natural Resources as a shellfishing and primary fishery nursery area. Following construction, research at the site was initiated to evaluate the stability of the design and the ecosystem services provided by the marsh and tidal stream. Two studies are currently on-going at the site to determine the impact the tidal stream and marsh has on nitrogen retention and carbon sequestration. This presentation will show research methods and initial results, and explore the potential benefits strategic restoration planning can have on enhancing the ecosystem services tidal marsh systems provide.

About the Speaker: Michael R. Burchell II, Ph.D. is an Assistant Professor and Extension Specialist in the Department of Biological and Agricultural Engineering at North Carolina State University. He currently is involved in research and extension in the areas of wetland restoration, riparian buffers, constructed wetlands, and innovative methods for stormwater treatment. One of his program goals is to improve design and implementation techniques to maximize the ecosystem services restoration projects can provide.

Tampa Bay Tidal Tributary Research & Restoration Initiatives

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Co-authors: Holly Greening, Lindsay Cross, TBEP

Abstract: Tidal tributaries within the Tampa Bay estuary encompass a collection of system types including coastal and riverine creeks with and without direct freshwater input, dredged inlets, and other "backwaters." Relative to other larger riverine systems, the ecological condition and function of the >100 small tidal tributaries flowing into the bay was not well understood. In 2006, the Tampa Bay Estuary Program embarked on a collaborative research project to assess the importance of these systems to estuarine processes. Water and sediment quality, benthos, and nekton species were found to be variable across the 9 small tidal tributaries studied. Landscape development intensity along the tributary corridors was associated with water and sediment quality degradation. Position of the tributaries along the estuarine gradient appeared to influence the variability in observed ecology, and seasonal shifts in benthic microalgae production played an important role in nutrient pathways to higher trophic levels. Common snook (*Centropomus undecimalis*), an economically-important fisheries species, were significantly more abundant in these tributaries than adjacent habitats.

Preliminary management actions developed from the results of this initial study included: 1) maintaining connectivity between open bay waters, tidal rivers, and smaller, tidal tributaries to allow fish movement, water flow and nutrient flux between systems; 2) reducing "flashiness" of water flow to tidal tributaries to promote natural flow patterns and foster the productivity of fish food sources within these systems; 3) tracking the condition of additional tidal tributaries to further assess their uniqueness; and 4) improving public education and stewardship of tidal tributaries by promoting the importance of these systems as key habitats to important estuarine fish species. Based on these recommendations, local partners are currently investigating the feasibility and implications of removing salinity barriers as a restoration option for Tampa Bay tidal tributaries. The culmination of this work will be pilot restoration projects that include the removal/modification of salinity barriers within tidal tributaries that flow into Old Tampa Bay in order to improve their estuarine ecological function.

About the Speaker: Ed Sherwood is Program Scientist at the Tampa Bay Estuary Program. Mr. Sherwood received his B.S. degree in Marine Biology from the University of West Florida in 1999 and his M.S. degree in Marine Fisheries Ecology from the University of Florida in 2003. He has worked previously as a marine fisheries researcher with the Florida Fish and Wildlife Conservation Commission and an environmental projects manager with the Environmental Protection Commission of Hillsborough County. As Program Scientist with the Tampa Bay Estuary Program, he is responsible for the technical assessment and analysis of the program's projects to protect, restore, and sustain the Bay's ecosystems. His roles include grant proposal preparation, estuarine monitoring design, implementation and interpretation, database quality control, environmental impacts review, and statistical and geo-statistical analysis. He has worked on a number of research projects within the Tampa Bay watershed focused on estuarine water quality and fisheries resources. His current interests involve the ecological restoration of Tampa Bay tidal tributaries.

Poster Abstracts

Southeast Coastal Monitoring Using the Student Friendly Basic Observation Buoy (BOB)

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ABSTRACT: The Basic Observation Buoy (BOB) is a scaled down, relatively inexpensive buoy made of PVC that can be assembled and deployed by students and volunteer groups. The buoy is designed to serve as a platform for a suite of sensors that continuously measure parameters like temperature, pH, dissolved oxygen, and salinity levels in protected waterways, tidal creeks and estuaries. Doug Levin designed BOB, while working at NOAA's Chesapeake Bay Office in 2008. Due to the user friendly nature of BOB, the Center for Ocean Sciences Education Excellence Southeast (COSEE SE) and Southeast Coastal Ocean Observing Regional Association (SECOORA) have adopted BOB as an outreach and education project. It has supported its growth and implementation in student monitoring programs through a series of three workshops whose participants are researchers, educators, and non-profit water related leaders over the last few years. In the southeast, high school groups in South Carolina and North Carolina, undergraduate and graduate students in North Carolina and Florida, and an informal science center in Florida have constructed and deployed BOBs. Partnerships between university scientists, local schools, and informal science centers strengthen coastal monitoring coverage, benefiting both the observing community and research programs of participating scientists as well as engage students and community members in the nature of science through data collection. Students learn first hand about environmental issues like the importance of water quality in our coastal ecosystems and the importance and role of technology in scientific research all while contributing data from their watershed. The data collected by BOB can be uploaded to the BOB Data Portal System, which is housed at UNCW and supported by SECOORA. These monitoring relationships often develop into community networks that positively affect all involved. One such relationship began in 2010 between Kennesaw State University, Hilton Head Preparatory School, and the Coastal Discovery Museum, where students began monitoring a local tidal creek in South Carolina using BOB. BOBs have been effective in addressing broader impacts of scientists by connecting them with students and citizens within the local community.

Tidal Migratory Fishes, Shrimps, and Crabs: Behavior, Geomorphological Determinants of Habitat Use in Tidal Creek Basins, and Recommendations for Management

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ABSTRACT: Tidal marsh ecosystems can be described as complex mosaics of individual intertidal drainage basins. Each basin consists of an intertidal creek and a surrounding area of marsh and mudflats that, on average high tides, flood and drain through the same creek. Intertidal Creek Basins (ICBs) provide fishes, shrimps, and crabs (nekton) with critical habitat for foraging, reproducing, and avoiding predators. Research in North Inlet estuary has demonstrated that:

1. Nekton use (based on number or biomass per m^2 or m^3) of neighboring ICBs can vary by a factor of 10, and these spatial differences persist between seasons and years.
2. Differences in nekton use can largely be explained by differences in the geomorphology of the ICBs.
3. Geomorphological features that matter most are ones that maximize higher benthic prey densities and provide favorable nekton foraging conditions.
4. Resident and young transient species of fishes have high fidelity for individual creeks.
5. Nekton partition limited space, access time, and food resources in ICBs through variations in the timing and depth of movements over the tidal cycle.
6. In the processes of digging for food (bioturbation) and excreting nutrients, nekton contribute to the maintenance and productivity of the nursery habitat.
7. Changes in the patterns and extent nekton use of an ICB over the past 25 years may be related to climate change and variability.

Understanding both the behavior of tidal migratory nekton and how physical features of intertidal creeks and marshes affect their abundance, diversity, and productivity is critical to decisions regarding upland runoff, dredging, and marsh restoration. Specific recommendations for preserving or constructing salt marsh creeks include favoring creeks with: relatively shallow mean depth, sloped rather than steep banks, and wide mouths relative to the volume of the creek.

Multidisciplinary Tidal Creek Dynamics Study: Mapping, Monitoring and Modeling in Groves Creek, GA

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ABSTRACT: A multidisciplinary tidal creek experiment, which includes mapping, monitoring and modeling all aspects of the physical environment in a saltmarsh tidal creek network, is being carried out in Groves Creek, located adjacent to the Skidaway Institute of Oceanography, in Savannah, GA. Early work in this marsh has shown that coastal salt marshes absorb, retain and then slowly release contaminants as creeks deliver and remove tidal waters.

The focus of the project is validation of a new, high-resolution circulation model for tidal creek and saltmarsh environments. This project has collected a new, comprehensive, high-resolution morphological data set, including both the intertidal parts of the marsh and the subtidal portions of tidal creeks and channels, using RTK-GPS and sonar equipment, to support the computer modeling. Next, a tracer study was conducted to provide real-world data against which to test the model's predictions. Concentrated dye was injected into Groves Creek and then followed by boat, helicopter, and in-situ instruments that collected dye concentration, tidal height, current velocities and salinity data throughout Groves Creek. The instruments remained in the field and continued to collect data for several weeks after the dye release, and that data will be discussed in Dr. Blanton's presentation at this meeting.

A third phase of the project also provided the opportunity to test whether a new low-power, high-frequency radar system can detect water flow through tidal creeks. This system, similar to radar systems used to study offshore ocean currents but with shorter range and higher sensitivity, was operated in conjunction with the dye study in the salt marsh.

Each phase of this experiment and results to date will be discussed with reference to management applications. The Groves Creek project continues through the end of 2012.

Living Oyster Reefs as a Significant Source/Modifier of Epizooic Microalgal Biomass in Tidal Creek Systems: Implications of Particulate Inputs

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ABSTRACT: Oyster reefs are an important habitat in coastal creeks and sounds, supporting fisheries, nursery habitat, shoreline stabilization, and filtration ecosystem functions. Oyster stocks in southeastern North Carolina tend to grow predominantly in intertidal habitats in relatively sheltered back marsh areas and tidal creek systems. We examined epizooic microalgae associated with oyster populations growing within three tidal creek ecosystems in southeastern North Carolina. Although the land use (predominantly single family dwellings) is similar among the systems, the estuaries differ in the magnitude of human impacts, based on watershed metrics of population density, percent of impervious surface, and drainage area. Initial evaluation suggests that the creeks have similar oyster coverage across most of the tidally influenced portion of each watershed. Data on microalgal biomass (as chl a levels) associated with oyster shells have been collected near the mouth and in upper regions of each of three target creeks. Samples were taken from the surface of the oyster matrix and from within the oyster matrix on each reef. Data have also been collected on the amounts and characteristics of other materials attached to the oyster shell surfaces. These data suggest an interesting and potentially significant link between intertidal oysters and epizooic microalgal production in this system. At the very least live oysters support very large microalgal biomass per unit of bottom area. Beyond this there appear to be differences in oyster associated microalgal biomass between locations and among creeks that are strongly influenced by the type and quantity of material associated with living oyster shells. These data suggest a differential link between living oyster populations and epizooic microalgal biomass in intertidal systems based on position within the creek.

Salt Marsh Restoration: The Science & Policy of Tide Gate Mitigation Bank

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ABSTRACT: Tidewater Environmental Services Inc. (Tidewater) was contracted to establish a mitigation bank through salt marsh restoration at a 273-acre site within Hunter Army Airfield (a sub-installation of Fort Stewart near Savannah, Georgia). The proposed mitigation bank is a unique partnership between Fort Stewart and the Georgia Land Trust to restore a salt marsh ecosystem within an urbanized watershed and provide revenue for the Army Compatible Use Buffer program. The site was historically part of the Buckhalter Creek watershed, which was channelized over 100 years ago during malaria fears. Within the past century, dike construction and a series of tide gates have impeded tidal exchange and severely altered the salt marsh ecosystem. The current tide gates have flapper valves that

allow freshwater to exit the system and prevent salt water intrusion. Removing the existing tide gate is intended to:

- Restore semi-diurnal flows and salinity to marsh and creek systems;
- Restore the dominance of salt-tolerant vegetation;
- Improve connectivity of essential fish habitats;
- Protect the restored tidal marsh, tidal creek, and marsh hammocks through an approved conservation plan; and
- Compensate for tidal wetland impacts within the coastal plain of Georgia.

The viability of the salt marsh restoration was assessed using aerial and historic mapping, hydrologic modeling and monitoring, and vegetation, macroinvertebrate, and water quality analyses. In addition to baseline data collection, Tidewater has been responsible for ongoing coordination with the US Army Corps of Engineers (USACE) Savannah District and Interagency Review Team (IRT) through the development of the approved Prospectus and pending Mitigation Banking Instrument. An IRT meeting is scheduled for October 12, 2011 to review the proposed mitigation bank. At the Southeast Tidal Creeks Summit, Tidewater will share the results of extensive baseline data collection and provide information regarding current policies and guidelines related to salt marsh mitigation in Georgia.

Using Sea-Level Rise Modeling and Habitat Priority Planner to Prioritize Future Land Protection in a Tidal Freshwater System

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ABSTRACT: We used a locally-adapted sea-level rise model, SLAMM 5.0 and NOAA's Habitat Priority Planner to examine 25-year and 50-year projected loss and conversion of tidal forested freshwater wetlands along the Waccamaw and Pee Dee Rivers in Georgetown County, South Carolina. Using Habitat Priority Planner, we examined the extent to which salt water intrusion would impact Swallow-tailed Kites, a flagship species for the bottomland hardwood forest system, as well as private, state, and federally protected lands in the study area. We found that over 14,000 acres of protected tidal freshwater wetlands in Georgetown County could be lost to conversion to salt marsh and brackish marsh by 2050. We identified the upper Waccamaw River in Horry County and Black River-Mingo Creek watershed in Georgetown and Williamsburg Counties as possible areas to focus future private, state, and federal land protection efforts.

Understanding the Rainfall Response on Tidal Creek Headwaters

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ABSTRACT: Climate change, rising sea levels, and increasing development and urbanization in the Lower Coastal Plain of South Carolina have the potential to degrade surrounding water bodies and increase downstream flooding. Pre-development hydrologic conditions must be fully characterized so that the dynamic rainfall response in the area can be best managed as these changes occur. A seasonally shallow water table and low topographic gradient present unique challenges for watershed protection, and a better understanding of the interaction between groundwater and surface water is needed across all antecedent conditions. Stream flows, rainfall, groundwater elevation, and source and stream water chemistry are being monitored on two first-order forested watersheds in the lower coastal plain of South Carolina. Upper Debidue Creek in coastal Georgetown County, SC, is slated for development, while Watershed 80 of the Santee Experimental Forest in the Francis Marion National Forest is a comparable reference. Both are headwaters to tidal creeks. Graphical hydrograph separation was performed for storm events to separate streamflow contributions into baseflow and quickflow components that represent the timescale of discharge. Baseflow represents the gradual release of groundwater to the stream, while quickflow is taken as the more accelerated runoff response of the watershed. Samples of streamwater and potential source contributors were analyzed for major-ion chemistry. Chemical hydrograph separation was then performed using end-member mixing analysis to estimate the contributions of various sources of streamflow and to assess runoff production dynamics. Initial comparisons of the results of the two methods show strong agreement for some storm events. In particular, both sets of results demonstrate the critical relationship between runoff production and antecedent water table elevation. Variability exists for other storm events, likely as a result of the assumptions made for each method, and this is largely due to differing concepts of baseflow and quickflow in the coastal plain.

Quantifying the Water Quality Benefits of a Restored Tidal Stream Using Intensive Nitrate and Flow Monitoring

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ABSTRACT: A salt marsh and tidal stream were constructed between land used in row crop agricultural production and a sensitive estuary. One goal of this restoration was to reduce the nutrient load reaching the estuary. The reduction of nutrient loads by salt marshes is one of the primary ecosystem services used to promote the restoration of these systems. Quantifying the reductions in nutrient loads is difficult due to

the complex flow and nutrient dynamics in systems influenced by tides. Nutrient concentrations in the stream can vary in a matter of minutes due to water input from upstream agriculture and the downstream estuary.

The goal of this project was to develop an accurate nitrogen mass balance for the tidal stream using an upstream-downstream monitoring design. The flow is being monitored by Doppler flow meters that were installed in trapezoidal flumes at each monitoring station. New technology has made long-term intensive monitoring of these systems possible. Recently developed UV-Visual spectrophotometers are being used to monitor the in-stream nitrate concentrations at short intervals (15 minutes). The use of this new technology presents a new set of monitoring challenges. Details about the challenges of using this new technology and some preliminary results from the study will be presented.

Linking Phytoplankton Assemblage Variability, Nutrient Loading, and Microbial Indicators with Land Use: A 3-Year Study of the Ashepoo-Combahee-Edisto (ACE) Basin, South Carolina, USA

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ABSTRACT: Elucidating linkages between human activity and coastal processes is paramount to estuarine preservation and management. For example, land use patterns can profoundly influence nutrient loading, primary productivity, and overall trophic status. Here we present results from a 3-year study (2008-2011) examining the effects of land use patterns on phytoplankton growth, community composition, microbial indicator levels, biogeochemical cycling, and water quality within the Ashepoo-Combahee-Edisto (ACE) Basin (South Carolina, USA). A combined field and experimental approach was used. This included seasonal surveys of basic water quality parameters, inorganic and organic nutrients, phytoplankton, and bacteria forms from several tidal creek systems within the ACE Basin representing multiple land uses (forest, silviculture, agriculture, residences, waterfowl impoundments, and others). Seasonal *in situ* nutrient addition bioassays were performed over a two-year period (2009-2011) to examine phytoplankton responses to various nutrient conditions. Both field and experimental results suggested that the systems were limited by inorganic-N relative to P, but organic nutrients were likely the key drivers of overall system productivity. In addition, correlations were found between water quality, nutrient levels, phytoplankton, and bacteria with land useage. Fecal coliform levels in particular varied substantially in time and space, but higher concentrations tended to be associated with freshwater river inflows, suggesting that local hydrography may influence the distribution of bacteria within the water column.

Coliphage Versus Fluorescent Dye as Tracers of Fecal Contamination Sources in Coastal Waters

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ABSTRACT: In coastal areas tidal creeks are primary recipients of waste from leaking septic systems. As of 2011 in the U.S. state of Georgia there are over 1.5 million septic systems in existence with 40,000 new systems installed annually. An estimated 2.8 million gallons of wastewater are discharged from these on-site sewage systems daily, 675 million gallons annually. Non-point source fecal contamination of tidal waterways will likely be exacerbated by the predicted increases in sea level elevation. Identification of septic systems that are contributors to coastal waterway pollution will be increasingly important. Current detection of septic system effluent in the environment relies on inert dye and is generally only useful in cases of catastrophic system failure. However, it is believed that many more septic systems are chronic leakers and contribute significantly to non-point source fecal contamination of receiving coastal waters. The goal of this study was to develop novel technology based on bacteriophage tracking approaches to improve assessment and management of on-site sewage disposal. We explore the hypothesis that a benign coliphage can be used to detect chronically failing septic systems with greater sensitivity, and longevity than inert dye technology. Testing was conducted in both tidal estuarine, and groundwater systems. Results in open water demonstrated correlation between dye and phage presence initially, but the phage was detectable at greater distances and longer durations than the dye. Phage detection in groundwater did not correlate with dye presence, indicating that phage moves more quickly through soils than dye. The developed method appears promising as an improved assessment tool for the source identification of coliform contamination, and as an eventual public policy development tool for the determination of adequate site-based setback distances for septic systems.

A Framework for Identifying Appropriate Compensatory Mitigation in the Charleston Harbor Estuarine Drainage Area

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ABSTRACT: Tidal creeks and salt marshes provide important ecosystem services such as serving as nursery habitat for penaeid shrimp, snapper, grouper, red drum, and blue crabs, as well as enhancing water quality and flood protection. These habitats are designated as Essential Fish Habitat (EFH) for federally managed fisheries under the Magnuson-Stevens Fishery Conservation and Management Act. NOAA's National Marine Fisheries Service is charged with providing conservation recommendations, including an evaluation of proposed compensatory mitigation, when a Federal agency undertakes an action that will adversely impact EFH. Coastal development, including proposed large-scale public works projects in the Charleston Harbor estuary (e.g., I-526 beltway completion, harbor deepening) have the potential to significantly impact tidal creeks and associated marshes; often the proposed mitigation is not adequate to fulfill requirements of state and federal mandates. Hence, NMFS has developed a framework intended to guide both applicants and resource managers in developing and selecting appropriate compensatory mitigation in the Charleston Harbor estuarine drainage. The goal of the framework is to facilitate review, approval and implementation of proposed projects while ensuring ecologically meaningful mitigation.

The framework consists of a prioritized and spatially mapped inventory of current and select historical tidal creek and salt marsh restoration opportunities. The sites were identified from existing assessments of the Charleston Harbor watershed and site visits with local partners. After inventorying sites, we developed a prioritization method to evaluate the existing condition, feasibility and ecological benefits of restoring each location. The results will be shared with state and federal agencies and NGOs engaged in restoration within the Charleston Harbor estuary. NMFS anticipates this tool to be a living document that can be updated to reflect new restoration and conservation opportunities around Charleston, and serve as a model for similar products that could be developed in other Southeast watersheds.

Pollution Has No Boundaries: Regional Cooperation for Restoring Water Quality

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ABSTRACT: Since pollution passes beyond political boundaries, a multijurisdictional partnership made up of 12 public and private sector organizations including the Lowcountry Council of Governments, Beaufort and Jasper Counties, and the Sun City Hilton Head Community Association was organized to carry out the implementation of a project funded by a §319 grant through DHEC to restore water quality in the Okatie River and its tributary tidal creeks. This poster presentation aims to highlight the policies used to achieve multijurisdictional coordination while also addressing lessons learned about the teamwork

approach used throughout the project. Each partner brings a unique set of strengths collectively used to implement a plan that will foster the most successful results to restore and preserve the ecological and economic integrity of the Okatie in the long-term.

The Okatie River is a riverine tidal estuary located within Jasper and Beaufort counties and includes portions of the Towns of Bluffton, and Hardeeville. The riverine part of the waterbody flows about 8.7 miles to its confluence with the Chechessee River and because of its ecological value, the Okatie has been classified as Outstanding Resource Waters in state regulation.

The watershed faces unprecedented growth pressures that have contributed to an increase in nonpoint source pollution and stormwater runoff that in turn elevate levels of fecal coliform within the Okatie River. Primary sources of fecal coliform pollution include malfunctioning septic tanks, livestock operations, runoff from impervious surfaces, pet waste, and boating activities. SCDHEC has developed Total Maximum Daily Loads (TMDLs) for the Okatie River. The calculated fecal coliform TMDLs require reductions ranging from 21 to 51 percent for three impaired shellfish monitoring stations in order to meet State Water Quality Standards.

Development Mechanics and Morphology of Point Bars in Tidal Creeks, Observations from Sapelo and the Altamaha, GA

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ABSTRACT: Many tidal creeks exhibit sandy bars close to meander bends, however, hydrodynamic and morphodynamic studies of these point-bars are scarce, compared to extensive studies of fluvial-point bars. The few studies that have addressed these bars suggest that there are significant differences between tidal bars and their fluvial counterparts, demonstrating low rates of channel meander and a unique morphology resulting from the bi-directional tidal flows and variation in tidal asymmetry. We examine tidal point-bars in two closely sited estuaries on the Georgia coast; the Altamaha and Sapelo Sound. The region is meso-tidal, however, the marshes of the Altamaha have a significant fluvial input, whereas in Sapelo River and Sound creeks are purely tidal with minimal freshwater input. Both sites exhibit sand-mud mixed point bars of various sizes. Vessel-mounted and moored acoustic Doppler current profilers indicate a separation of flood and ebb flows to either side of the bars leading to a residual circulation over the bar. Large surface bedforms in opposing directions are seen on each side of the bar, suggesting that each side of the channel experiences a separate sediment transport regime. We compare and contrast the hydrodynamics and resulting morphologies of the bars and identify differences between fluvially-influenced and purely tidal environments and address the hypothesis that these forms are scale invariant by examining a wide range of bar scales in both large and small tidal creeks.

Recent Expansion of Tidal Creek Networks in the South Atlantic Bight: An Ecogeomorphological Response to Sea Level Rise?

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ABSTRACT: Analyses of aerial photographs show the development of new low-order creeks throughout coastal marshes in South Carolina and Georgia over the past ~50 years. Tidal creeks in both the Santee Delta, SC and near Savannah, GA, are lengthening at a rate of 1.9 m/yr. It is likely that such a widespread phenomena is driven by sea-level change, however, the geomorphic evolution of the creeks is closely linked to ecological factors including burrowing and herbivory by crabs, vegetation density, belowground biomass and, consequently, soil strength. The heads of the creeks are de-vegetated as a result of high densities of *Sesarma reticulatum* (up to 35 individuals/m^2 in creek heads compared to 2 individuals/m^2 at control sites on the marsh platform). Grazing and burrowing by these crabs removes organic and inorganic matter. This occurs directly by reducing above and belowground biomass (belowground reduction from 1.9 ± 0.7 kg/m^2 to 0.8 ± 0.3 kg/m^2) and indirectly by increasing aerobic decomposition. The result is: 1) reduced soil strengths in the creek head (reduction from 10 ± 7 kPa to 2 ± 1 kPa) and; 2) the deflation of the marsh surface (~ 0.6 m) in the same area that focuses ebb tidal flows into the creek, increasing local velocities and, thus, erosion. A net export of sediment is observed through the creek mouth. The enhanced erodibility of marsh soil, attributable to the fauna, facilitates erosion as creeks grow in response to increasing tidal prisms. The removal of vegetation is also likely to be responsible for the very low sinuosity observed in the creek morphology.

How Will Tidal Freshwater Forested Wetlands Respond to Sea Level Rise?

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ABSTRACT: Sections of the southeastern Atlantic lower coastal plain are characterized by a low topographic gradient with drainage systems that interface with estuaries affected by large tidal amplitude resulting in long reaches of freshwater tidal streams. Assured continuance of sea level rise will expand the reach and area of freshwater tidal streams; unfortunately, there is very little information available to provide insight into how ecological functions and ecosystems services will be altered as non-tidal forested wetlands are impacted by freshwater tides. Most of the research on tidal freshwater forested wetlands associated with sea level rise is focused on potential changes in salinity and the concomitant ecosystem responses. Our considerations are (a) functional linkages between freshwater tidal streams and the riparian zone, and (b) non-tidal forested wetland processes that may be affected when influenced by a

persistent freshwater tide. To provide the basis to assess those questions we have expanded the watershed research on the Santee Experimental Forest to include Huger Creek, the headwaters of the East Branch of the Cooper River, a 4th order freshwater tidal stream with a drainage area of approximately 16,500 ha. We instrumented a stream and its riparian zone to determine whether the freshwater tide influences the hydrology of the riparian zone and whether ecological functions are affected. The study initiated in 2010, and early findings demonstrate that the tidal stream does affect the water table dynamics of the floodplain. Approximately 30 km inland from the ocean, the diurnal tidal amplitude of the stream is 0.8 - 1.1 m, with a corresponding water table amplitude of 0.3 – 0.5 m. Accordingly, we anticipate that there are functional linkages with the freshwater tide. Results from this work will provide new ecological insights, and will have important ramifications on the effects of sea level rise in freshwater tidal watersheds.

Short Term Sedimentation Rates in the North Inlet Estuary, South Carolina

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ABSTRACT: We conducted a short but focused study to quantify short term sediment loading rates within the North Inlet marsh system in Georgetown, SC. Long term sediment accretion rates on the North Inlet marsh system have been carried out by Dr. Smith over the past three years as part of a larger study. While most of those measurements were taken seasonally to quantify long term trends, short term variability of sediment accretion and scour had not been characterized effectively. We proposed a series of experiments to be conducted by a summer student to measure sediment dynamics on the marsh platform and within the water column. Specific objectives were to quantify suspended sediment fluxes at a high temporal resolution, and to characterize suspended sediment quality in terms of particle size distribution and organic content. This work builds upon and further extends the foundation of research built by previous summer student workers. We anticipate that the information generated from this study will provide invaluable insight into processes that govern deposition and scour on a tidal marsh. Techniques used and data generated from this study will also serve to support future proposals to seek long term funding for similar but more extensive sediment dynamic studies in North Inlet. Preliminary results from this study will be presented at the Southeast Tidal Creeks Summit Charleston, SC.

Primary Nursery Areas and Tidal Creek Protection in North Carolina

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ABSTRACT: North Carolina's extensive estuarine systems serve as a nursery ground supporting the vast majority of the state's important fishery species. These areas provide protection, foraging opportunities, and suitable environmental conditions for the growth and development of young finfish and crustaceans during critical stages in their life history. Failure to adequately protect these areas could result in a recruitment bottleneck to multiple fisheries. Primary Nursery Areas (PNAs) were designated by the Marine Fisheries Commission to provide protection to the upper portions of estuaries in tidal creeks and shallow bays where initial post-larval development takes place. The PNA designation is intended to maintain these habitats, as much as possible, in their natural state allowing juvenile populations to develop in a normal manner with as little interference from man as possible. Approximately 80,000 acres have been designated as PNAs in North Carolina. Multiple state agencies use the PNA designation to protect tidal creeks and their dependent fisheries from threats such as bottom-disturbing fishing gear, dredging, and poor water quality. In addition, recommendations of the North Carolina Coastal Habitat Protection Plan resulted in an increase in the role of the Division of Marine Fisheries in the permit review process. Two positions dedicated to permit review and habitat protection help to ensure that there is no dredging in PNAs, no new slips in shallow water, and that impacts to shellfish, submerged aquatic vegetation, and tidal creeks are minimized.

Use of Volunteer Water Quality Monitoring in the Management of Water Quality in the Tidal Creeks of Murrells Inlet and Surfside Beach, SC

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ABSTRACT: Since May 2008, Horry and Georgetown counties have partnered to support a volunteer water quality monitoring program in Murrells Inlet, SC. This effort was expanded into the northern adjacent municipality of Surfside Beach, SC in 2010. Sampling is focused in the tidal creeks to test the hypothesis that flows from these creeks carry significant amounts of contaminants into the coastal waters. Both areas have chronic exceedances of bacterial water quality standards causing impaired uses for recreation and shellfish harvesting. In Murrells Inlet, a TMDL was issued in 2005 requiring an 80% load reduction in fecal coliforms inputs.

The monitoring programs were implemented to help meet regulatory requirements under the NPDES Phase II Stormwater Program. They are structured to use a watershed approach for tracking the sources of known and suspected pollutants. Other issues of concern that are being monitored are hypoxia, eutrophication, and sediment pollution. The programs are designed to detect long term trends, geographic

hot spots, and illicit discharges. The volunteers use an online data entry process to produce rapid reports that are sent to the stormwater managers. To facilitate management follow through, percentile-based site-specific water quality "standards" have been developed from the biweekly sampling conducted at ten sites.

Funding is provided via allocations from municipal stormwater utility fees. Management is overseen by a field leader from Murrells Inlet 2020 and staff from Coastal Carolina University's Environmental Quality Lab. Data are provided online in user-defined tables and graphs at http://www.coastal.edu/wwa/vm. Four of the tidal creeks exhibit high levels of *E. coli*. Almost all of the sites have relatively low oxygen levels. These findings have stimulated research projects to locate pollution sources upstream of the sampling sites using sedimentary bacteria, optical brighteners and qPCR-based techniques. Management responses implemented include reduction of pet waterfowl populations and road improvements by SC DOT.

Development of New Technology for the Improvement of a Citizen Science Project: Clean Marine Smartphone APP

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ABSTRACT: Marine debris is a serious problem, and presents a series of detrimental outcomes not only for South Carolina's coast, but water-based ecosystems nationwide. Marine debris can pose navigational hazards, increase water pollution by leaking fuel or other pollutants, degrade coastal ecosystems or impair the aesthetics of a tidal marsh or estuary. Currently, there is a Marine Debris Initiative being led by various federal, state, and local regulatory groups. The purpose of this initiative is to coordinate efforts to manage marine debris removal and to raise public awareness about the problem. A current award from the National Office of Oceanic and Atmospheric Administration Office of Marine Debris to state and local agencies lead to the creation of the Clean Marine Program (CMP). The program instructs volunteers in how to take GPS coordinates, properly complete a paper form while boating, and then digitally submit the data to a web form when back on land. This process was improved by the development of an application for smartphones that performs all the functions of the paper/web form. This application allows users to immediately report the debris sighting using a quick and convenient electronic medium. The application was initially programmed for use on the popular Android operating system. Once the application was developed and tested, it was promoted via nationwide nautical groups alongside the CMP. Surveys taken from willing anonymous participants were used to improve the applications usefulness. Based on survey responses and the app's market performance, it was successful in being user friendly and more appealing than the paper form.

A Comparison of Tidal Creek and Open Water Estuarine Habitats in South Carolina

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ABSTRACT: The South Carolina Estuarine and Coastal Assessment Program (SCECAP) has been monitoring estuarine habitat condition throughout the state's waters since 1999. The program has sampled 30-60 stations per year using a probability based sampling design, in which half the stations sampled each year are located in tidal creeks and the other half are located in larger water bodies. The program has developed four indices of condition using measures of multiple parameters that provide a Water Quality Index (WQI), Sediment Quality Index (SQI), Benthic Condition Index (B-IBI) and an overall Habitat Quality Index (HQI) that merges the other three indices. These indices are applied at the station level, and are used to evaluate the condition of the habitats at the strata level, and state-wide using both strata combined. Analysis of the indices in each strata has continued to indicate that a higher percentage of tidal creek habitats tend to be more degraded that open water habitats. WQI measures that are significantly ($P < 0.05$) worse in tidal creeks include pH, total phosphorus, chlorophyll-a, and fecal coliform bacteria when all surveys are evaluated collectively. SQI variables that are significantly worse in tidal creeks include total organic carbon and contaminants (measured as Effects Range Median Quotient). Finally, the B-IBI is degraded in a greater proportion of the tidal creek habitat relative to open water habitats. This is driven by significant differences in overall density and number of species. The collective assessment of tidal creek condition relative to larger water bodies continues to confirm that tidal creeks serve as a good early warning sentinel habitat for monitoring estuarine condition.

Using Passive Integrated Transponder (PIT) Tags to Estimate Movement and Survival of Mummichog (*Fundulus heteroclitus*) in a Saltwater Estuary

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ABSTRACT: We tested passive integrated transponder (PIT) tags and interrogation antennas as a tool to monitor movements and vital rates of estuarine fishes in anthropogenically altered saltwater marshes. Mummichog (*Fundulus heteroclitus*) were tagged in a North Carolina tidal creek in November 2010 and interrogated using a multiplexing transceiver and an array of three vertical antennas located near the creek mouth. The proportion of fish upstream of the antenna array was modeled as a function of tidal

stage height and moon phase using generalized linear models. Apparent survival (phi) and detection probability (*p*) were modeled with the Cormack-Jolly-Seber (CJS) model using data collected by the three-antenna array from November 2010-March 2011, and by a single flat plate antenna from April-May 2011. Forty out of forty-three individuals were resighted over the six month monitoring period. The majority of resightings occurred at depths less than 0.5 m. The proportion of fish upstream was explained as a function of both tidally influenced depth measured hourly and lunar-influenced depth measured daily, as well as the interaction between these two factors. These movement patterns maximized marsh residency by mummichog for feeding and refuge as the majority of mummichog stayed upstream during all tidal cycles with the exception of lunar spring low tides. The median occasion-specific value of phi (137 occasions) was 0.984 which corresponds to a loss of ~90% of the mummichog over ~6 months. Greatest probabilities of detection were associated with the warmest occasions over the period. Findings demonstrate that PIT tags and autonomous detection arrays can be applied in low-energy saltwater creeks, where resighting fish is difficult with traditional methods, to increase precision about estimates of movement and vital rates of marsh fishes. Future work in multiple marsh creeks will determine if these vital rates vary with anthropogenic habitat alteration.

Microbial Heterotrophy in a Salt Marsh Tidal Creek: Influences of Material Inputs and Effects on Dissolved Oxygen Concentrations

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ABSTRACT: Tidal creeks represent the conduits for material exchange between uplands, salt marshes and the coastal ocean. They are also areas of substantial net heterotrophy (total respiration > in situ primary production), fueled by organic matter produced by adjacent marshes. This study seeks to quantify how microbial metabolism in tidal creek waters responds to variability in the magnitude and form of salt marsh exports over tidal, seasonal, and interannual time-scales, and to explore the utility of microbial metabolic response to serve as a sensitive, integrative and quantifiable ecological indicator for assessing the effects of material inputs on the ecological functioning of tidal creeks.

This study, initiated in 2005, is being conducted in Crabhaul Creek, a first-order tidal creek in North Inlet, South Carolina, that drains an undeveloped forested watershed. Microbial metabolic responses are determined every 20 days on ebb and flood tides by quantifying rates of microbial production (via 3H-leucine incorporation rates) and respiration (via short-term in vitro oxygen consumption rates) in both whole and size-fractionated water samples. Sampling is conducted in conjunction with routine water quality and water chemistry monitoring conducted by NOAA's National Estuarine Research Reserve System, which provides abiotic (water temperature, salinity, pH, dissolved oxygen and turbidity), and water chemistry (dissolved and particulate forms of inorganic and organic nitrogen and phosphorus; dissolved and particulate organic carbon, organic and inorganic suspended solids, and chlorophyll) variables.

Seasonal variability in microbial metabolism, especially respiration, is highly sensitive to water temperature, and strongly influences dissolved oxygen dynamics. Pronounced ebb-flood differences in metabolism clearly indicate the importance of salt marsh exports in fueling tidal creek heterotrophy. Significant relationships between ebb-flood differences in metabolic rates and time of day suggest that a substantial portion of the organic matter fueling this heterotrophic metabolism is being produced on very short time-scales.

The CRI-SC, Community Resource Inventory Online: A Mapping Resource for South Carolina Communities

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ABSTRACT: In order to effectively plan for a community's future, while protecting the quality of the environment, officials need to have detailed knowledge of the resources a community possesses. A Community Resource Inventory (CRI) is the foundation of good planning. A CRI is a list or atlas of the natural and cultural resources, as well as human dimensions data (e.g., land parcels, urban areas, streets and highways), in a community. The CRI-SC tool, developed by the South Carolina Nonpoint Education for Municipal Officials (SCNEMO) Team, presents a list of resources in the form of online map data, and is intended for quick creation of resource inventory maps. No formal mapping or Geographic Information Systems (GIS) training and capabilities are required. The initial version was piloted in Georgetown County with the overarching goal of expanding the tool to include all of the S.C. coastal counties.

The development of the tool has relied heavily on stakeholder input gathered through surveys and training workshops. The information was used to: assist with the identification of data resources for project content; provide valuable input from a local perspective on the development and functionality of the tool based on community needs; and provide data and mapping resources that are relevant and would improve this GIS-based application.

The tool can be used to overlay data layers with USGS topo maps, satellite imagery, and street maps. Example data layers include: zoning, land cover, watershed boundaries, and water quality (303d). In addition, a user guide with instructions for navigating and using the CRI-SC tool and Web site have been created, in conjunction with a county-wide public launch introducing the tool to elected and appointed officials and the appropriate local government staff.

National Estuarine Research Reserve System (NERRS) Sentinel Site Program for Understanding Climate Change Impacts on Estuaries

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ABSTRACT: The NERRS recently launched a Climate Change Initiative with "the goal to better understand, mitigate, and adapt to climate change impacts on estuaries and coastal communities." The NERRS Sentinel Sites Program is a key component of that initiative and will be implemented at all 28 reserves nationwide. The goal of the program is to monitor and assess the impacts of sea level change and inundation on key coastal habitats. The findings will provide information to assess reserve vulnerabilities to climate change, and NERRS staff will translate this new understanding to coastal communities and coastal managers. Sentinel Sites are specific locations within the estuarine environment that have the operational capacity for intensive study and sustained observations to detect and understand changes in the ecosystems they represent. The foundation of this program is the more than 15 years of water quality, nutrient, and meteorological monitoring that has been conducted through the NERRS System-wide Monitoring Program (SWMP) which includes GIS habitat mapping, extensive QA/QC assessment, and a centralized national database repository. Using SWMP as a model, all reserves will use the same standardized protocols, sampling designs, and reporting requirements for establishing the new components required of designated sentinel sites. Each reserve will install and operate a vertical reference control network to which all the required SWMP stations, emergent and submersed vegetation monitoring transects, Surface-Elevation Tables (SETs), tide gauges, ground water wells, and digital elevation models will be linked. The core functions are to provide: 1) measurements of sea level change; 2) measurements of land height referenced to benchmarks with geodetic control; and 3) measurement of sediment elevation change, using surface elevation tables, and 4) quantification of the impacts observed on vegetation and tidal marsh habitats. Each reserve will implement programs for analyzing the generated data and sharing it with local and national stakeholders.

Assessment of the Impact of Urbanization on the Microbial Water Quality of Tidal Creeks of the Southeastern United States and the Gulf of Mexico

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ABSTRACT: Tidal creeks serve as nurseries for many pelagic species, while other species spend their entire lives in these systems. Areas adjacent to tidal creeks are popular places for humans due to their aesthetic, economic (tourism and fisheries) and recreational value. These areas are often the first to be impacted by human activities. The microbiological data presented here were collected as part of a larger study to assess the impact of urbanization on tidal creek systems in the Southeastern United States (SE) and Gulf of Mexico (GoM). Concentrations of microbial indicators of fecal pollution, fecal coliforms (FC), enterococci (ENT) and coliphages (somatic = F- and male-specific = F+), were determined for water samples using standardized methods. ArcGIS 9 was used to identify watersheds and evaluate land use and impervious cover. The geographic region, land use and creek order (e.g. headwaters) affected the bacterial and viral densities. ENT and F- levels were significantly higher in the SE than in the GoM, but the FC and F+ levels were similar between regions. FC, ENT and F+ exhibited a pattern of increasing concentrations from forested to urban watershed class. FC and F+ concentrations were significantly higher in urban areas than forested and suburban areas. Indicator concentrations increased significantly with increasing impervious cover in the watersheds. There was a significant positive relationship between increasing impervious cover and ENT (headwaters), FC, F+ and F- coliphage numbers, but there was no significant relationship for ENT and impervious cover for samples collected from the lower (more tidally influenced) sections of the creeks. FC, ENT and F- levels were significantly higher in the headwaters than in the lower sections of the creeks. F+ demonstrated a similar trend but was not statistically significant. Our findings suggest that urbanization, particularly impervious cover, may significantly impact the microbial water quality of tidal creeks.

POSTER PRESENTATIONS

1. **Southeast Coastal Monitoring Using the Student Friendly Basic Observation Buoy (BOB)**
   Lisa G. Adams, Kennesaw State University, Georgia

2. **Tidal Migratory Fishes, Shrimps, and Crabs: Behavior, Geomorphological Determinants of Habitat Use in Tidal Creek Basins, and Recommendations for Management**
   Dennis Allen, University of South Carolina

3. **Multidisciplinary Tidal Creek Dynamics Study: Mapping, Monitoring and Modeling in Groves Creek, GA**
   Clark Alexander, Skidaway Institute of Oceanography, Georgia

4. **Living Oyster Reefs as a Significant Source/Modifier of Epizooic Microalgal Biomass in Tidal Creek Systems: Implications of Particulate Inputs**
   Troy Alphin, University of North Carolina-Wilmington

5. **Salt Marsh Restoration: The Science & Policy of Tide Gate Mitigation Bank**
   Michael Andersen, Environmental Services Inc.

6. **Using Sea-Level Rise Modeling and Habitat Priority Planner to Prioritize Future Lane Protection in a Tidal Freshwater System**
   Tera Baird, United States Fish and Wildlife

7. **Understanding the Rainfall Response on Tidal Creek Headwaters**
   Thom Epps, Biosystems Engineering Graduate Program, Clemson University,

8. **Quantifying the Water Quality Benefits of a Restored Tidal Stream Using Intensive Nitrate and Flow Monitoring**
   J. Randall Etheridge, NC State University

9. **Linking Phytoplankton Assemblage Variability, Nutrient Loading, and Microbial Indicators with Land Use: A 3-Year Study of the Ashepoo-Combahee-Edisto (ACE) Basin, South Carolina**
   Diane Greenfield, University of South Carolina

10. **Coliphage Versus Fluorescent Dye as Tracers of Fecal Contamination Sources in Coastal Waters**
    Heidi Hammerstein, Georgia Institute of Technology

11. **A Framework for Identifying Appropriate Compensatory Mitigation in the Charleston Harbor Estuarine Drainage Area**
    Melanie Harris, National Marine Fisheries Service, Headquarters Office of Habitat Conservation

12. **Pollution Has No Boundaries: Regional Cooperation for Restoring Water Quality**
    Josh Hoke, Lowcountry Council of Governments, South Carolina

13. **Development Mechanics and Morphology of Point Bars in Tidal Creeks, Observations from Sapelo and the Altamaha, GA**
    Zoe Hughes, Boston University

14. **Recent Expansion of Tidal Creek Networks in the South Atlantic Bight: An Ecogeomorphological Response to Sea Level Rise?**
    Zoe Hughes, Boston University

15. **How will Tidal Freshwater Forested Wetlands Respond to Sea Level Rise?**
    Brooke James, College of Charleston, South Carolina

16. **Short Term Sedimentation Rates in the North Inlet Estuary, South Carolina**
    Anand Jayakaran, Clemson University, South Carolina

17. **Primary Nursery Areas and Tidal Creek Protection in North Carolina**
    Christen Jensen, North Carolina Division of Marine Fisheries

18. **Use of Volunteer Water Quality Monitoring in the Management of Water Quality in the Tidal Creeks of Murrells Inlet and Surfside Beach, SC**
    Susan Libes, Coastal Carolina University, South Carolina

19. **Development of New Technology for the Improvement of a Citizen Science Project: Clean Marine Smartphone APP**
    Dylan Murphy, College of Charleston, South Carolina

20. **A Comparison of Tidal Creek and Open Water Estuarine Habitats in South Carolina**
    George Riekerk, SC Department of Natural Resources

21. **Using Passive Integrated Transponder (PIT) Tags to Estimate Movement and Survival of Mummichog (Fundulus heteroclitus) in a Saltwater Estuary**
    Paul Rudershausen, NC State University

22. **Microbial Heterotrophy in a Salt Marsh Tidal Creek: Influences of Material Inputs and Effects on Dissolved Oxygen Concentrations**
    Erik Smith, Winyah Bay National Estuarine Research Reserve, Baruch Marine Field Laboratory,

23. **The CRI-SC, Community Resource Inventory Online: A Mapping Resource for South Carolina Communities**
    April Turner, South Carolina Sea Grant Consortium

24. **National Estuarine Research Reserve System (NERRS) Sentinel Site Program for Understanding Climate Change Impacts on Estuaries**
    Saundra Upchurch, South Carolina Department of Natural Resources

25. **Assessment of the Impact of Urbanization on the Microbial Water Quality of Tidal Creeks of the Southeastern United States and the Gulf of Mexico**
    Laura Webster, National Oceanic and Atmospheric Administration, South Carolina

Program Sponsors

The organizers of this event would like to extend a special thanks to The Coastal Society and the Taylor and Francis Group, publishers of the journal *Coastal Management*, for providing financial support to hold this event. For more information about these organizations visit: www.thecoastalsociety.org.

Thanks also to those that helped plan and organize the event, including:

- North Carolina Sea Grant
- South Carolina Sea Grant Consortium
- Georgia Sea Grant
- Clemson University's Belle W. Baruch Institute of Coastal Ecology and Forest Science,
- College of Charleston's Grice Marine Laboratory,
- National Oceanic and Atmospheric Administration's Coastal Services Center,
- North Carolina State University's Biological and Agricultural Engineering Department,
- North Carolina Cooperative Extension, and
- South Carolina Department of Natural Resources Marine Resources Research Institute.

Additionally, thanks go to all of the speakers and poster presenters for providing the program content for this event.

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UNC-SG-11-02 (*Program Updated December 7, 2011)*