



# 2018-2019 IMPACTS AND ACCOMPLISHMENTS

## SUSTAINABLE COASTAL DEVELOPMENT AND ECONOMY

### ACCOMPLISHMENTS

#### The S.C. Sea Grant Consortium Provides Leadership to Nature-Based Travel and Tourism Industry in South Carolina

##### **April Turner, S.C. Sea Grant Consortium**

A 2016 study by the S.C. Department of Natural Resources documented that the total impact of natural resources to the state economy increased by 15 percent over the past decade to \$33.4 billion. More than 28 percent of the state's 4.96 million residents live in the eight coastal counties, and tourism is now a \$20.1 billion industry within the eight coastal counties, accounting for approximately 65 percent of the state's total. People are increasingly drawn to the South Carolina coast, with residents and tourists taking advantage of the opportunities the state's natural and cultural resources provide.

The S.C. Sea Grant Consortium supports sustainable statewide, nature-based tourism through its involvement with the S.C. Nature-Based Tourism Association (SCNBTA). The Consortium's Coastal Communities Specialist serves as president of the SCNBTA, providing technical guidance and program planning for the quarterly board meetings, annual conferences and workshops. She also serves on committees coordinating the strategic planning process, developing marketing and membership strategies, and updating the website and social media accounts. Through the activities of the specialist, coastal communities have increased support and exploration of nature-based tourism and recreation businesses. This support helps to ensure the continued sustainability and viability of the SCNBTA.

#### S.C. Sea Grant Consortium Assists McClellanville with Maintaining Sustainable Working Waterfront

## **April Turner, Susan Lovelace, Julie Davis, S.C. Sea Grant Consortium**

Traditional uses of waterfront properties are diminishing as property values soar and development increases along the coast. Much of the South Carolina commercial seafood industry has been affected by the changes in waterfront property use, and commercial fishermen find it increasingly difficult to secure dependable and affordable docking space, fuel, and ice.

In the small coastal community of McClellanville, S.C., two commercial docks, Carolina Seafood and Livingston's Bulls Bay Seafood, are used as dock facilities for larger vessels and as shoreside support facilities by the entire industry. Carolina Seafood also serves as the town's largest employer and purchaser of harvest from local fishermen. The owners are approaching retirement without a succession plan, and the likelihood the land will be sold and converted to other uses is cause for concern among the local commercial fishermen and the community.

The town reached out to the S.C. Sea Grant Consortium (Consortium) for assistance. Building on previous work identifying and assessing issues and exploring priorities for maintaining, preserving, and enhancing traditional working waterfronts, the Consortium collaborated with the town and other partners to obtain a Hometown Economic Development Grant (\$25,000) awarded by the Municipal Association of South Carolina. The project team is using the funding to develop a master plan for McClellanville's working waterfront.

The two-year planning process includes identifying options for retaining this critical economic asset in the community, as well as exploring approaches for cooperative ownership and operation of seafood wholesale and distribution business to benefit the harvesters and ensuring the long-term sustainability of the town's working waterfront and seafood trade. During the first year, the Consortium convened several workshops with local seafood industry wholesalers and harvesters to gather input into the waterfront planning process. In conjunction with these efforts, project collaborators are working to negotiate and secure funding for a conservation easement to permanently protect dock space and the associated wholesale and retail business facilities.

## **The S.C. Sea Grant Consortium Develop Accredited Continuing Education Courses on Coastal Topics for Real Estate Professionals**

### **April Turner, Susan Lovelace, Liz McQuain, S.C. Sea Grant Consortium**

South Carolina's coastal population is growing rapidly. In recent years, it has become clear that real estate professionals (REPs) are a key audience for training, information, and resources because they are often the first line of information for newcomers to the coast. They also participate in an industry that relies on healthy coastal resources and resilient coastal communities. Therefore, REPs are not only conduits to new residents and business owners, but they also can influence natural resource policy and decisions.

The S.C. Sea Grant Consortium is collaborating with academic, organizational, and agency partners to develop a continuing education program for coastal real estate professionals (REPs) to provide science-based information on important coastal topics relevant to coastal and ocean property ownership, maintenance, and use. Those topics include sea level rise, shoreline management, land use, and regulatory requirements for coastal development. All collaborators committed to the project are members of the S.C. Coastal Information Network (SCCIN; [www.sccoastalinfo.org](http://www.sccoastalinfo.org)).

As a first step, key real estate and insurance industry members were asked to serve on an advisory committee to provide insight into the needs of the REP audience and guidance throughout the training curriculum development. Meetings with the REP Advisory Committee were convened (September 26 and December 6, 2018). Currently, project partners are developing a clearinghouse of resources (accessible through the SCCIN website) which they may use to help prospective property owners navigate through potential challenges, policies, and issues associated with coastal home and business ownership.

## S.C. Sea Grant Consortium Supports Development of the Neighborhood Open Space Comparative Analysis for Horry County

### **April Turner, S.C. Sea Grant Consortium**

Increased development in South Carolina coastal counties is often resulting in the loss of open space. Horry County last revised its Land Development Regulations, including its open space requirements, more than 10 years ago and was interested in updating and creating new open space standards. Having language addressing the criteria is not enough to create valuable open space. The county was interested in looking to comparable counties and performing an open space analysis to identify how best to improve certain approaches and update regulations.

The S.C. Sea Grant Consortium awarded a \$2,500 Sustainable Coastal Communities Initiative mini-grant to the Horry County Planning Department to research and map platted open space within subdivisions as part of an effort to update the Parks and Open Space Plan and the land-use element of its Comprehensive Plan. Using the mini-grant funding, Horry County hired a student intern to create a consolidated GIS database of all open space within existing subdivisions. The goal was to evaluate how these properties coincide with the county's open space network and determine the value they provide to the community.

The county identified all federal, state, and privately protected land, but there is a gap regarding dedicated open space within residential subdivisions. This project provided insight into the effectiveness of the current open space regulations and guidance to make necessary changes to improve the quality of open space in Horry County.

## S.C. Sea Grant Consortium Researchers Evaluate the Economic Impact of Nature-Based Tourism in South Carolina

**Lauren Duffy, William Norman, and Lori Dickes, Clemson University; Ray Rhodes, College of Charleston**

What is known about the economic impact of tourism in South Carolina comes from travel models, accommodation tax revenue, occupancy rate, average room rates, and calculations of revenue per available hotel room. Developing and sustaining nature-based tourism (NBT) has the potential to generate a number of economic benefits. However, when it comes to sub-sector niche markets, such as those that result from NBT, it can be much more difficult to ascertain accurate measures of economic contributions.

Through a two-phase mini-proposal, S.C. Sea Grant Consortium researchers at Clemson University analyzed existing information to develop an initial estimate of the overall economic impact of the NBT industry in South Carolina, particularly within the eight-county coastal region, and identify gaps in this information. What they found is that, beyond wildlife watching, there are no available recent (i.e. post-2010) South Carolina-specific NBT-related economic activity data that can be used to conduct a credible analysis for coastal or state-level economic sectors directly affected by NBT participant-related expenditures. This was noted as one of the critical gaps in information.

Researchers did delve into the wildlife watching data, and averages from analyses found the economic impact to be \$471 million supporting 6,921 jobs and labor income of \$217 million. The impacts included adding an estimated \$267.5 million to South Carolina's gross regional product. Ongoing efforts will synthesize relevant data to conduct a thorough economic impact analysis.

## A Look into the Future: Sea Grant's 10-Year Visioning Plan for Sustainable Coastal Tourism

**April Turner, S.C. Sea Grant Consortium**

Tourism plays a significant role in the economies of coastal and Great Lake states, with significant contributions to jobs, tax revenues, and quality of life. However, as growth and development along the coast increases, the tourism economy might negatively affect the very resources on which the industry relies. Science-based management of tourism in coastal communities is a vital need.

Sea Grant has the opportunity to greatly increase the well-being of our coastal communities by taking on a prominent role in tourism and outdoor recreation management science and community training through its research, extension, and communication programs. Sea Grant has responded to community needs and has been invested at some level in coastal tourism for multiple decades. A significant number of state Sea Grant programs are currently working on coastal tourism

issues and impacts to coastal ecosystems, yet there is no unified national strategy to address this important subject.

Realizing a network-wide approach was needed, the National Sea Grant Office solicited proposals and provided funding support for state programs to engage in a visioning process. Led by Georgia Sea Grant and the S.C. Sea Grant Consortium, extension agents and specialists from 13 Sea Grant programs, in collaboration with federal and state partners, participated in the development of a 10-year visioning plan for sustainable coastal tourism. The plan identifies four priority areas – Business and Community Tourism Management, Workforce Training, Economic Analysis, and Environmental Stewardship. For each of these priority focus areas, the plan presents the types of research and extension and outreach programs Sea Grant should address.

To increase the likelihood of accomplishing the tasks, the plan also establishes implementation plans for one to three years, three to five years, five to 10 years, and 10-plus years. Measurable outcomes for each priority area are included to help assess the efficacy of the plans. The team also developed a survey and distributed it to the National Sea Grant Network to assess current Sea Grant tourism efforts and needs.

The group began exploring a partnership with the National Extension Tourism (NET) Network in an effort to continue strengthening relationships among Sea Grant professionals working in tourism. Staff from Oregon Sea Grant and the S.C. Sea Grant Consortium are participating on the 2019 NET Conference planning committee and organizing a Sea Grant meeting at the event slated for October 8-11 in Astoria, Oregon. This biennial event will serve as a platform for Sea Grant Network members to stay engaged with one another at the national level.

This plan is the first step in the effort to build an effective national Sea Grant presence in sustainable coastal tourism. By strengthening relationships with tourism-related partners at the local, state, and national level, we will build the capacity, skills, and institutional structure to assist communities with coastal tourism issues and opportunities.

## S.C. Sea Grant Consortium Scientists Examine Socioeconomic Aspects of Stormwater Control Measures to Guide Decision-Making in Coastal South Carolina

**Marzieh Motallebi and Dan Hitchcock, Clemson University; Erik Smith, University of South Carolina; Susan Lovelace, S.C. Sea Grant Consortium**

Effectively managing stormwater has been an ongoing challenge in coastal South Carolina. Coastal development dramatically increases rates of stormwater runoff and impacts coastal resources. Stormwater management is thus a vital and required component of coastal zone development in the state.

A great deal of research has been conducted in South Carolina on stormwater management practices, and a wealth of information exists on the design, management, and maintenance of a variety of stormwater best management practices (BMPs). In 2014, the S.C. Sea Grant Consortium (Consortium) and several of its partners published *Low Impact Development in Coastal South Carolina: a Planning and Design Guide (Guide)*, describing a variety of stormwater BMPs. While the Guide provided an initial economic analysis of the cost of implementing various BMPs, the limited analysis focused primarily on installation costs.

Stormwater management research has been lacking in informing a full socioeconomic understanding regarding the various options for BMP implementation decisions. Consortium researchers at Clemson University and the University of South Carolina Baruch Institute are building from the foundation provided in the Guide by adding necessary socioeconomic knowledge to better inform stormwater decision-making in coastal South Carolina. The effort proposes to examine detailed operation and maintenance costs, cost effectiveness, and benefit valuation of BMPs.

Researchers designed a participatory map (<https://clemson.maps.arcgis.com/apps/MapJournal/index.html?appid=5edfc174e5dc4cc08430b3a2df25e8a5>) for stormwater managers to include type and costs of their installed BMPs in the eight coastal counties, as well as a survey to select the most common BMPs in different coastal counties. Wet ponds are the most common BMP in the majority of counties, while dry ponds, bioretention cells, and pervious pavement ranked second in various counties. The main reason managers cited for their implementation are flood mitigation, water quality, and importance as wildlife habitat.

## S.C. Sea Grant Consortium Research Suggests Algal Production May Be Primary Source of Dissolved Oxygen Impairment in Stormwater Ponds

### **Erik Smith, University of South Carolina**

The presence of a sufficient minimum concentration of dissolved oxygen (DO) is a fundamental requirement for sustaining aquatic life in coastal waters. Low DO is the number one cause of impairment to the ability of waters to support aquatic life use in South Carolina's coastal zone; however, preventing the occurrence of low DO remains a challenge for water quality management. Understanding the impacts of coastal development on water quality impairment, and specifically the prevalence of DO impairment, in coastal waters is vital to sustaining aquatic resources.

Specifically, S.C. Sea Grant Consortium researchers at the University of South Carolina Baruch Institute are examining how stormwater conveyances and control structures impact inputs of oxygen-demanding substances in coastal waters, measured as biochemical oxygen demand over a five-day period (BOD5). Samples were collected during rain events and dry periods from sites representing a variety of land uses and stormwater management practices.

Preliminary results demonstrated that algal production was a dominant source of BOD5 in stormwater ponds, and all sites had higher measurements of BOD5 than the downstream receiving waters of the Waccamaw River. Analysis continues, but researchers anticipate efforts could lead to improved stormwater management and more realistic regulatory targets for inputs of oxygen-demanding substances in coastal receiving waters.

## S.C. Sea Grant Consortium Scientists Develop and Refine Low Impact Development Technologies to Respond to Increased Rainfall, Stormwater

**Nigel Kaye and Will Martin, Clemson University**

Climate change will lead to increased rainfall frequency and intensity across South Carolina. At the same time, the South Carolina coastal plain faces increased flooding impacts from sea level rise. One way to mitigate the impacts of increased rainfall and sea level is the use of low impact development (LID) stormwater management technologies.

S.C. Sea Grant Consortium researchers at Clemson University ran a series of experiments to establish the hydraulic behavior of one such technique, modular green roof systems. The goal was to improve the design of modular green roof systems so they are more effective at reducing peak discharge from a roof. Tests showed modular green roof systems as most commonly designed fail to detain significant amounts of rainfall for significant periods of time.

Researchers proposed modifying green roof modules by raising them and putting empty storage modules underneath. The storage modules would have significantly smaller outlet orifices than the green roof modules on top and primarily provide detention volume. Testing of this design tweak found the peak runoff discharge was reduced by 88% compared to a standard impervious roof with a time of concentration of six minutes.

A second component was to assess the impact of LID technologies on an individual land development scale to determine reduction in peak discharge and total runoff when a traditional stormwater design is enhanced with the addition of modular green roof systems and porous pavements. The data indicated the use of the newly designed green roof system reduced the peak discharge but provided no significant reduction in total site discharge. Porous pavement systems did not make a major difference to the peak site discharge but did reduce total site runoff.

A third component focused on the potential benefits to municipalities of land developers using LID technologies, thus indicating whether there are benefits to requiring LID technologies in their stormwater regulations. The study found LID technologies could allow a municipality to handle 20% higher peak runoff and 10% higher total discharge.



## South Carolina Sea Grant Consortium Researchers Investigate Water Quality Impacts of Development in Tidal Creek Watersheds to Improve Land-Use Planning

**Andrew Tweel and Denise Sanger, S.C. Department of Natural Resources Marine Resources Research Institute**

The rate of coastal population growth and associated development has increased rapidly along the South Carolina coast and ranks among the highest nationally. Impervious cover increases proportionately with development, and these surfaces contribute to increases in stormwater runoff. This runoff can alter coastal salinity regimes, lead to shifts in biological communities, and is associated with increases in fecal coliform and other contaminants. Coastal communities are responsible for developing and implementing stormwater management plans, but significant knowledge gaps remain as to watershed characteristics that are associated with the greatest impacts, and how these impacts vary within and between tidal creek systems.

S.C. Sea Grant Consortium (Consortium) researchers at the S.C. Department of Natural Resources are quantifying watershed characteristics associated with stormwater impacts, the spatial extent of such impacts, and how they may respond to predicted changes in climate and weather patterns. To achieve this, Consortium researchers are investigating how water quality following rain events varies along the length of tidal creek systems in areas with various types and intensity of development.

A Watershed Advisory Committee (WAC) comprised of stormwater managers from Berkeley and Charleston municipalities was formed in June 2018. Based on input from the WAC the following month, spatial analysis of candidate tidal creek systems was performed using a variety of factors like impervious cover, shellfish harvesting, soil permeability, and stormwater pond coverage.

Four study systems were selected: Guerin, Seaside, Toomer, and Dupont-Wappoo Creeks. Water quality instruments and a weather station were deployed at the sites, and data are being collected.

## S.C. Sea Grant Consortium Research Finds Nutrient Inputs via Groundwater in Estuaries are Modulated by Salt Marsh/Tidal Creek Features

**Alicia Wilson & Erik Smith, University of South Carolina**

Studies have shown that water quality in tidal creeks differs in developed and undeveloped watersheds, particularly in headwater areas. These studies on the impact of development on coastal ecosystems have focused primarily on surface waters; however, hydrologic changes associated with development have the potential to affect groundwater as well. In particular, the delivery of nutrients to creeks via groundwater could impact both nutrient concentration and form.



S.C. Sea Grant Consortium researchers from the University of South Carolina assessed the impact of coastal development on groundwater inputs of nutrients to 15 representative South Carolina tidal creeks. The samples were analyzed for a variety of nutrients, including nitrogen, ammonium, phosphorus, orthophosphate, and dissolved organic carbon. Initial analyses of individual creeks began to reveal trends.

The project assessed the impact of development on groundwater composition, especially nitrogen, phosphorous, and carbon, in 15 representative creeks in undeveloped, suburban, and urban areas. Carbon and nitrogen were significantly higher below undeveloped uplands, while phosphorous was significantly higher below developed uplands.

This project yielded a new database of groundwater compositions from creekbank and upland settings, in a range of forested and developed watersheds. This database complements existing work on surface water compositions in developed and undeveloped tidal watersheds. The dataset provides significant evidence that development affects porewater composition in tidal creek systems.

Overall results indicate marshes can buffer tidal creeks from the impact of development. Total nutrient concentrations were higher in marsh groundwater than in upland groundwater at all sites, which suggests that salt marshes are a larger source of nutrients than uplands, developed or not. It also demonstrates that wider marshes support increased mixing and reaction with tidal creek water, thereby buffering tidal creeks from upland development.

## A Preliminary Tool to Rapidly Detect and Quantify CyanoHABs Developed with S.C. Sea Grant Consortium Research Support

### **Dianne Greenfield and William Jones, University of South Carolina**

Knowledge of harmful algal bloom (HAB) abundances has important implications for assessing bloom severity, and rapid detection enables forecasting. Technologies that facilitate expedient and accurate monitoring of a bloom's progress will facilitate early warning of potentially toxic events and enable water quality managers and public health officials to take appropriate actions related to drinking water or swimming warnings that protect public safety.

S.C. Sea Grant Consortium researchers at the University of South Carolina and the Medical University of South Carolina developed and refined a sandwich hybridization assay (SHA) application for the detection and quantification of HAB species. Greenfield has been working for years with a process to rapidly identify and quantify microscopic organisms using their ribosomal RNA (rRNA). The SHA process traces its roots to the original identification and understanding of genetic material in the 1950s.

The SHA process features two molecular probes designed to bind with a species' rRNA in a homogenized sample placed between them, creating an rRNA "sandwich." The sandwiched rRNA, along with a series of enzymes, create a reaction that is processed using a programmed robotic

device. At the end of the reaction, a change in sample color indicates if a species is present in the sample.

The focus was the microcystin-producing species *Microcystis aeruginosa* because it poses serious regional environmental and public health threats, as the toxin microcystin is linked to liver failure, tainted water supplies, and even death. From a management perspective, this SHA application successfully detects and quantifies harmful cyanobacteria in samples, making it a valuable tool for water quality monitoring and management.

## S.C. Sea Grant Consortium Researchers Examine Sources and Toxicity of Black Microplastic Fragments in Local Estuaries

**Peter van den Hurk, Clemson University; John Weinstein, The Citadel**

Plastics pollution of the oceans and coastal zones has been recognized as a major environmental problem. Fractionation of larger pieces of plastics leads eventually to the formation of microplastics (<5 mm diameter). This project set out to quantify and identify microplastics in the Charleston harbor area, find the possible source of these particles, and establish the potential toxicity to grass shrimp and an estuarine fish species.

Approximately 93.5% of intertidal sediment samples in Charleston Harbor area contained microplastics. Analysis of sediments and water samples demonstrated that blue fibers and black fragments were the most abundant microplastics. Further analysis of the composition and shape of the black fragments demonstrated that most are tire wear particles, which are formed during normal wear of the tread of car tires, and wash down from roads and bridges into receiving waters during rain events.

To evaluate the potential toxicity of these particles, micronized tire fragments were used for tests with grass shrimp and mummichogs. The particles were not directly toxic to the shrimp, but they were accumulating in the intestine and on the gills, thus forming physical obstructions that may interfere with normal physiology of these organisms. The mummichog experiments demonstrated that, even at low concentrations, fluorescent chemicals are leaching out of the tire fragments after they are ingested, and are excreted into the bile after being processed in the liver.

These biological effects demonstrate that tire wear particles are a source of toxic chemicals in the estuarine and coastal environment, and that further research should be conducted to assess the risks for harmful effects on estuarine life in these environments.

## S.C. Sea Grant Consortium Holds Our Coastal Future Forums, Engages Coastal Residents, and Gains Insights into Participants' Beliefs

**Susan Lovelace, S.C. Sea Grant Consortium**

The S.C. Sea Grant Consortium (Consortium) continued a series of Our Coastal Future Forums (OCFF), holding events in Myrtle Beach, S.C., May 2, 2018, on ocean mineral and energy resources in a changing climate, in Charleston, S.C., May 8, 2018 on biodiversity in a changing climate, and in Beaufort, S.C., May 17, 2018, on environmental health in a changing climate. Also, an event was held with real estate and insurance professionals September 26, 2018.

The OCCF project was developed as part of a research project entitled “Can deliberative discussions lay a foundation for integrated decision-making networks?” funded by the National Academies of Sciences, Engineering and Medicine, Gulf Research Program, under award number 200007353. The goal is to empower residents to prioritize coastal management issues and become more active in local natural resource management decisions.

Presentations and deliberative-type small group discussions focused on biodiversity, environmental health, living marine resources, and ocean energy and mineral resources. Key themes that emerged included protecting ecosystem services, increasing restoration efforts of wetlands and oyster reefs, using conservation easements and sustainable practices in development at the landscape level instead of individual lots, increasing voluntary water quality testing, providing education surrounding best management practices in stormwater management as well as information about antibiotic resistance and contaminants associated with stormwater.

Through surveys, educational activities, and small-group discussions, the research team identified insights about coastal management priorities and decision-making that they can share with local, state, and regional leaders. Analysis is on-going, but initial analysis of the survey data indicates that views about coastal issues are driven by values-based worldviews as much as, if not more than, proximity to the coast. In addition, public support for increased use of renewable energy and decreased use of fossil fuel is high even among those who do not believe climate change is happening.

Finally, the views of forum participants on several key issues shifted after deliberation. Our results indicate people were able to learn more about these issues and have thoughtful, well-reasoned discussions about them as well as generate ideas for how communities can become more resilient to the changes and challenges faced in coastal regions.