



SOUTH CAROLINA SEA GRANT CONSORTIUM

Impacts and Accomplishments

2019-2020



S.C. Sea Grant Consortium
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HEALTHY COASTAL ECOSYSTEMS

ACCOMPLISHMENTS

Research Highlighted at National Watershed and Stormwater Conference Co-Organized by S.C. Sea Grant Consortium

Hamed Majidzadeh and April Turner, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium and partners organized and led a mobile workshop at the National Watershed and Stormwater Conference in Charleston, S.C. Participants learned about the latest research from the Consortium's Stormwater Ponds Research and Management Collaborative and were given a tour during which municipal stormwater managers highlighted local community examples of best management and maintenance practices.

Relevance: Stormwater ponds (SWPs) are among the most widely used engineering practices controlling stormwater quantity and improving water quality in South Carolina, with more than 9,000 of these ponds located across the state's eight coastal counties. SWP systems can play a significant role in watershed function, providing flood management, pollution mitigation, and other amenities to communities if managed properly. Without regular inspections and proper maintenance, SWPs can be transformed from pollutant sinks to pollutant sources, with implications for downstream ecosystems and human health.

Response: The Consortium, along with partners, organized and led a mobile workshop for the National Watershed and Stormwater Conference in Charleston, S.C. on May 1, 2019. The field tour highlighted the latest research from the Consortium's Stormwater Ponds Research and Management Collaborative and focused on local community examples of pond functionality and best practices for management and maintenance.

Results: Thirty participants, including design engineer consultants, stormwater management professionals, and state and local government agency staff from across the country, joined this 3.5-hour mobile workshop to learn about stormwater pond best management practices implemented in coastal South Carolina communities. This field tour provided participants an opportunity to interact with municipal stormwater professionals from Charleston County, the Town of Mount Pleasant, and the City of Charleston. Topics discussed included: pond design, maintenance, and management; roles and responsibilities for pond owners and local government; managing tidally influenced stormwater ponds; and retrofits, littoral shelves, and other enhancement features. The planning, organization, and administration provided by the Consortium for this workshop are estimated to have provided an economic benefit of \$5,299 based on registration fees paid and opportunity costs of time.

S.C. Sea Grant Consortium Co-Organized Panel Session on Stormwater Pond Management at National Watershed and Stormwater Conference

Hamed Majidzadeh and April Turner, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium, along with its partners, organized and led a panel session at the National Watershed and Stormwater Conference in Charleston, S.C. Participants learned about Consortium research topics focusing on a geospatial inventory of stormwater ponds, the impacts of ponds on flooding, integration of ponds

into the watershed and water quality of receiving waters, the economic benefits of pond management, and tools for outreach about pond maintenance.

Relevance: Stormwater ponds (SWP) are the most common structural best management practice for regulating stormwater runoff in S.C., particularly in coastal areas where development rates are high. SWP systems can play a significant role in watershed function, providing flood management, pollution mitigation, and other amenities to communities if managed properly. Without regular inspections and proper maintenance, SWP can be transformed from pollutant sinks to pollutant sources, with implications for downstream ecosystems and human health.

Response: The Consortium co-organized and led a panel for the National Watershed and Stormwater Conference in Charleston, S.C. on May 1, 2019. The panel, focusing on the function of stormwater management under current and future climate scenarios, highlighted Consortium research including a geospatial inventory of SWP, the impacts of SWP on flooding, integration of SWP into the watershed and water quality of receiving waters, the economic benefits of SWP maintenance and management, and tools for outreach about proper maintenance of SWP.

Results: Thirty-two participants representing federal, state, and local government agencies, universities, design engineering firms, stormwater management professionals, and non-profits attended this panel. As part of the session, participants had the opportunity to engage with scientists, managers, and outreach professionals working on SWP issues and have their questions answered.

S.C. Sea Grant Consortium Organizes Stormwater Workshop: “Shem Creek Water Quality, Past, Present and Future”

Matthew Gorstein and Susan Lovelace, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium (Consortium) fully supported a stormwater workshop, “Shem Creek Water Quality, Past, Present and Future,” to bring stormwater engineering and hydrology consultants together with local government staff and Consortium extension specialists. The planning, organization, and administration provided by the Consortium for this meeting is estimated to have provided an economic benefit of \$3,589.

Relevance: Shem Creek is a multi-use working waterfront in an increasingly urbanized part of the Town of Mount Pleasant. Urbanization and polluted stormwater runoff have led to water quality concerns in the area. The EPA would like the town to set TMDLs. The town is seeking information to determine if there are still measures they can take to improve the water quality in the creek.

Response: The Consortium staff worked with the town to develop and hold a “State of the Knowledge of Shem Creek” Workshop to share and synthesize what we know about Shem Creek, how water quality has changed over time, and to strategize elements and research needs for a watershed management/watershed restoration plan to improve water quality. Several presentations provided overviews of larger or longer projects to understand water quality in the creek.

Results: Participants identified and prioritized short- and long-term strategies for improving the watershed as well as data sets available and research needed. They developed “big ideas” that the town can put into action. The planning, organization, and administration provided by the Consortium for the Shem Creek Water Quality, Past, Present and Future workshop is estimated to have provided an economic benefit of \$3,589 based on travel costs and opportunity costs of time. Twenty-three (23) non-Consortium participants traveled an average of 10 miles to attend, and these participants were roughly evenly split between stormwater consultants and local government staff. Based on the General Services Administration’s (GSA’s) privately owned vehicle mileage reimbursement rate

of \$0.545 per mile, each participant incurred (10*\$0.545) \$5.45 in vehicle travel costs. Based on the U.S. Bureau of Labor Statistics (BLS) occupational employment statistics program's mean hourly wages for hydrologists and for urban and regional planners in South Carolina (US BLS, 2019), the mean hourly wage of participants is assumed to be \$27.38. Participants obtained value from this workshop as attending the workshop was deemed an appropriate use of their time by either themselves or their supervisor, they deviated from normal work duties to attend the workshop, and they obtained knowledge and skills. The workshop lasted five and a half hours, therefore each participant has an associated opportunity cost of time of \$150.59 (\$27.38*5.5). Summing with travel costs (\$5.45) yields an economic benefit of \$156.04 per participant. When multiplied by the 23 participants, a total economic benefit of \$3,589 is derived.

Economic Benefit of Stormwater Salinity Study Workshop for Practitioners

April Turner and Matt Gorstein, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium (Consortium) engaged watershed practitioners to gather feedback from the stormwater salinity study advisory committee members to ensure the results are adequately addressing previously identified stormwater management needs. The planning, organization, and administration provided by the Consortium for this meeting is estimated to have provided an economic benefit of \$578.

Relevance: A Consortium-funded research project, *Linking Land Use to Physical Processes in Creeks and Estuaries: Implications for Increased Development and Changes in Climate and Weather*, measures rainfall-runoff-water quality relationships in Charleston-area tidal creeks, develops models to identify relationships to watershed characteristics, and disseminates information to stakeholders. Consortium staff is taking the lead on the engagement process.

Response: The Consortium engaged watershed practitioners on June 4, 2019 to gather feedback from the stormwater salinity study advisory committee members to ensure the results are adequately addressing the stormwater management needs the group had earlier identified and to identify and address any concerns from the managers.

Results: The planning, organization, and administration provided by the Consortium for this meeting is estimated to have provided an economic benefit of \$578 based on travel costs and opportunity costs of time. Ten participants traveled an average of 20 miles to attend. Based on the General Services Administration's (GSA's) privately owned vehicle mileage reimbursement rate of \$0.545 per mile, each participant incurred (20*\$0.545) \$10.90 in vehicle travel costs. The occupations of the participants were a mix of local government stormwater management staff, non-profit organization representatives, university outreach staff, and engineers. Based on the U.S. Bureau of Labor Statistics (BLS) occupational employment statistics program's mean hourly wages for all occupations in South Carolina (US BLS, 2019), the mean hourly wage of participants is assumed to be \$21.34. Participants obtained value from these meetings as attending was deemed an appropriate use of their time by either themselves or their supervisor, they deviated from normal work duties to attend the workshop, and they obtained knowledge and skills. Approximately 90% of the effort (e.g., funding, resources, logistics, organizing, outreach, etc.) needed for the implementation of these meetings is attributed to the Consortium. The workshop lasted 2.5 hours, therefore each participant is estimated to have an associated opportunity cost of time equal to \$53.35 (\$21.34*2.5). Summing opportunity costs (\$53.35), travel costs (\$10.90), multiplying by the number of participants (10), and multiplying by the attribution factor (90%) yields a total economic benefit of \$578.

S.C. Sea Grant Consortium Contributes to Panel Discussion on Faith Perspectives of Environmental Conservation

Matt Gorstein, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium staff contributed to a panel focused on faith perspectives in environmental conservation.

Relevance: People of many faiths strive to weave values and programs of care for the environment throughout the entire fabric of their religious life. By the mid-to-late 1980s, portions of the religious community had begun to create responses and programs to address environmental stewardship. In the 1990s, after an open letter sent from 32 Nobel laureates and other eminent scientists, senior religious leaders affirmed the need for theologically grounded, scientifically informed religious initiatives. What followed was a formal consultation with senior religious leaders to lay the groundwork for such action. In October 1993, the National Religious Partnership for the Environment formally began its activities as an alliance of the U.S. Conference of Catholic Bishops, the National Council of Churches, the Coalition on the Environment and Jewish Life, and the Evangelical Environmental Network.

Response: The National Religious Partnership for the Environment, an organization that brings together a diverse alliance of faith institutions and leaders on behalf of caring for the environment, organized a forum at Circular Congregational Church in Charleston, S.C. The focus of the forum was faith perspectives on environmental conservation, and how faith may inspire and call people to be environmentally conscious.

Results: Faith leaders representing different belief systems and diverse communities were invited to speak on these topics. Consortium staff participated and added a scientific, socioeconomic, and Jewish perspective to a panel discussion, focusing on how humans receive a variety of benefits from healthy ecosystems but also must act as stewards of the environment to ensure the future provision of these benefits. Contributing to the panel discussion provided a means for the Consortium to engage with the faith community on a local scale.

S.C. Sea Grant Consortium Co-Organized a Beaufort Stormwater Pond Management Conference

April Turner, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium co-organized a pond management conference that provided training and technical assistance to build capacity and inform 85 stormwater professionals, homeowners, and local government officials and staff in Beaufort County. Similar conference planning is underway for the greater Charleston and the Grand Strand regions of the South Carolina coast in 2020.

Relevance: In South Carolina, stormwater ponds are the most common structural best management practice for regulating stormwater runoff, particularly in coastal areas where development rates are high. Stormwater pond systems can play a significant role in watershed function, providing flood management, pollution mitigation, and other amenities to communities. They also create a unique set of management issues if not properly managed, especially as they age. Without regular inspections and proper maintenance, stormwater ponds can be transformed from pollutant sinks to pollutant sources, with implications for downstream ecosystem and human health. Some of the most common barriers to pond maintenance include lack of awareness of responsibility, misinformation on best management techniques, and financial costs.

Response: The Consortium, along with partners, organized and led a regional pond conference on November 14,

2019, extending the latest stormwater pond scientific information, resources, and tools to public and private sector pond managers and owners in an effort to encourage and promote proper pond maintenance. The goals of this event were to increase awareness about the purpose of ponds and their need for regular maintenance; provide information and tools to overcome common challenges in pond management; and integrate pond owner and pond manager audiences with service providers to assist in inspections and management actions.

Results: Eighty-five participants, including property managers, homeowners' association representatives, and pond management professionals, attended the conference. The event was an opportunity for participants to hear from local and regional experts, interact with organizations and businesses in the pond management industry, and receive valuable resource information and continuing education credits. Coastal pond research, pond inspection and maintenance, integrated pest management, aquatic weed management, wildlife habitat, sea-level rise impacts, upland management, and capital reserves planning were among the topics addressed. Conference evaluations indicated 94% of participants increased their knowledge of ponds/pond management as a result of the trainings offered, and more than 90% said they learned something new to apply in their future work. Overall, participant feedback revealed attending this event was a good use of their time (95%). The planning, organization, and administration provided by the Consortium for the 2019 Beaufort Stormwater Pond Management Conference is estimated to have provided an economic benefit of \$9,283 based on the provision of continuing education credits (CEUs) at a discounted rate, registration fees, travel costs, and opportunity costs of time.

S.C. Sea Grant Consortium Researchers Measuring Marsh Sensitivity to Increased Flow and Sea-Level Rise

Thomas O'Halloran, Clemson University; Erik Smith, University of South Carolina

Recap: Measuring marsh productivity and sensitivity related to environmental drivers is essential to understanding how salt marshes will respond to future changes in sea level. S.C. Sea Grant Consortium research will inform models on how marshes build vertical elevation that allows them to adapt to sea-level rise.

Relevance: Along the Southeast U.S., intertidal salt marshes represent a critical habitat at the interface of the terrestrial and marine environments, performing a variety of ecological functions and services that make them of great economic importance for coastal communities. Salt marshes stabilize the shoreline and represent the first line of defense against flood and storm events, and they provide essential fish and shellfish habitat. However, the ability of intertidal marshes to maintain their elevation and persist in the face of rising sea level is dependent on relationships between tidal inundation, plant growth, and accretion of organic matter and sediments. Measuring marsh productivity and sensitivity related to environmental drivers is essential to understanding how salt marshes will respond to future environmental and man-made stressors.

Response: To enable better prediction, S.C. Sea Grant Consortium researchers are measuring marsh production from tidal to seasonal time-scales. This information is essential to determining the importance of future physical changes on South Carolina's coastal ecosystems due to increased variability in freshwater flow and sea-level rise. In particular, project results will lead to the improvement of models that forecast salt marsh responses to changes in sea level.

Results: Researchers have had success collecting significant data on salt marsh production and related environmental drivers. Pending final analysis of results, soil flux and photosynthesis measurements will inform models on how marshes build vertical elevation that allows them to adapt to sea-level rise.

S.C. Sea Grant Consortium Researchers Analyze Impacts of Development on Estuarine Habitat Quality

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

Recap: S.C. Sea Grant Consortium research has demonstrated that there are significant positive relationships between various metrics of sediment contamination (ERMQ) and development intensity, precipitation amount, and temperature. While the correlation to development intensity is fairly well-documented, the potential compounding effect that increases in temperature and/or precipitation may have may exacerbate this relationship, leading to increases in contamination at already-impacted sites or an increase in the proportion of sites identified as impacted.

Relevance: Preliminary analysis of several long-term environmental datasets reveals that high-density development increases sediment toxicity and degrades water quality but does not seem to significantly impact benthic communities. As coastal populations continue to grow, increasing stress is placed on downstream ecosystems. These relationships between watershed land use and estuarine quality have been quantified at a variety of spatial scales and response variables. How these relationships will interact with predicted changes in climate and weather patterns, however, has not been identified. Coastal planners and stormwater managers can utilize this information to design best management practices that account for increases in stormwater runoff, install targeted retrofits of stormwater infrastructure to maximize benefit, and to predict and manage potential decreases in environmental quality before water bodies are classified as impaired.

Response: S.C. Sea Grant Consortium researchers at the S.C. Department of Natural Resources (SCDNR) are synthesizing several long-term environmental monitoring datasets, dating from the 1990s to present. Several databases have been compiled to house water quality, environmental, land-cover, and weather data.

Results: Initial water quality data demonstrated that some indicators, such as fecal coliform bacteria, are responsive to short-term precipitation patterns, while other indicators, such as sediment contamination, are more strongly correlated to seasonal-level precipitation patterns. Additionally, preliminary data has informed predictive tools that have already shown promise. Analysis found statistically significant positive relationships between various metrics of sediment contamination (ERMQ) and development intensity, precipitation amount, and temperature.

S.C. Sea Grant Consortium Examines Coastal Water Quality Response to Increasing Nitrogen Inputs

James Pinckney and Erik Smith, University of South Carolina

Recap: S.C. Sea Grant Consortium research results suggested that ambient nutrient concentrations should not exceed nutrient tipping point concentrations to prevent possible shifts from one ecological state to another.

Relevance: In the Southeast U.S. region, nitrogen is typically the nutrient that controls primary production in estuaries. Excessive nitrogen inputs from anthropogenic sources have been identified as contributing to a general decline in related water quality, including hypoxia, anoxia, fish kills, and harmful algal blooms. Concerns about this decline have led to development of targets for pollution reduction that are meant to ensure a minimum level of acceptable water quality for both ecosystem and public health. Nutrient tipping points may be indicative of the point (i.e., nutrient concentration) at which there is a fundamental change in the way phytoplankton respond to further increases in nutrient loading. The ecological implication is that phytoplankton community processes and functions may shift from one state to another alternate state at tipping points.

Response: Researchers from the University of South Carolina (USC) Baruch Institute met with staff from the S.C. Department of Health and Environmental Control (SCDHEC) Bureau of Water to discuss the agency's priority research needs and select sites in Winyah Bay and North Inlet for sampling. SCDHEC agreed to provide phytoplankton from their summer surveys to the USC researchers, who quantified nutrient responses of different algal groups (diatoms, cyanobacteria, etc.) and calculated nitrogen uptake rates of the samples.

Results: Preliminary results demonstrate that planktonic diatoms were the algae most responsive to elevated nitrogen inputs, though no obvious significant changes to community composition were observed. The implication is that the tipping point signaled a change in responses that may signal a transition from a relatively stable state to an alternate state with marked changes in community structure and, by extension, function. The consequences for nutrient management are that these tipping points may represent critical values for the determination of water quality nutrient criteria based on fundamental changes in phytoplankton responses to nutrient loading.

SUSTAINABLE COASTAL DEVELOPMENT AND ECONOMY

IMPACT

S.C. Sea Grant Consortium Scientists Design Tool that Allows Evaluation of Stormwater Best Management Practices

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

Recap: S.C. Sea Grant Consortium research results in stormwater managers using cost-benefit methodologies to implement BMPs and related cost-benefit information being incorporated into a realtor continuing education course “Calling the Coast Home.”

Relevance: 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 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.

Response: S.C. Sea Grant Consortium researchers at Clemson University and the University of South Carolina Baruch Institute built from the foundation provided in the Guide by adding necessary socioeconomic knowledge to better inform stormwater decision-making in coastal South Carolina. The effort examined detailed operation and maintenance costs, cost effectiveness, and benefit valuation of BMPs.

Results: Researchers designed a participatory story 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. Several economic analyses were performed to determine costs of installing and maintaining BMPs, and residential willingness-to-pay for related measures. As a result, the South Carolina Association of Stormwater Managers (SCASM), Town of Mt. Pleasant, and Town of Bluffton will be using this methodology for cost benefit analyses of implementing BMPs in their areas. Additionally, cost-benefit information is being incorporated into a realtor continuing education course, “Calling the Coast Home.”

ACCOMPLISHMENTS

S.C. Sea Grant Consortium Develops Methods to Document the Status and Trends of South Carolina's Ocean Economy in a Recurring Fashion

Matt Gorstein, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium develops ocean economy report to detail the status, trends, and future outlook for South Carolina's ocean economy.

Relevance: Documenting and monitoring the market and non-market economic benefits of ocean and coastal natural resources is important when evaluating policy decisions, and for understanding the level of dependence that a given coastal community may have on ocean and coastal natural resources. South Carolina's ocean and coasts support a wide variety of industries including commercial fishing, recreational fishing, aquaculture, tourism, ports/harbors, shipbuilding, and sand mining.

Response: Datasets and relevant studies were identified, and a South Carolina ocean economy report was drafted. The purpose of this report was to provide an overview of South Carolina's ocean economy based on the data that are available; expand upon information provided by the National Oceanic and Atmospheric Administration (NOAA) to examine other market and non-market economic values, impacts, and contributions derived from ocean resources; identify ocean economy sectors for potential future growth; and discuss how the health of natural resources provides a foundation for economic activities along South Carolina's coast. Also contained in this report is an examination of often overlooked non-market ecosystem service values provided by coastal habitats in South Carolina, including shoreline protection, carbon storage, and water quality. The report will be accompanied by an infographic, designed for a more general audience.

Results: The ocean economy contributed almost \$4.8 billion to South Carolina's gross domestic product (GDP) in 2017, 7.6% of total GDP in the eight coastal counties. Over 80,000 people were employed in the ocean economy in 2017, 12.2% of total employment in the eight coastal counties. Since the end of the recession (2009), ocean economy real GDP has increased by 53%, compared to 22% for the entire state economy.

LID Hot Topics: Costs, Perceptions, and Maintenance of Low Impact Development Practices in Coastal S.C.

April Turner, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium co-organized a workshop series for 147 stormwater management professionals, design engineers, developers, and landscape architects, providing training focused on economic costs and benefits, perceptions, and maintenance of low impact development practices for better site design implementation in South Carolina coastal communities.

Relevance: Many coastal decision-makers, stormwater management professionals, and design engineers find it challenging to implement low impact development (LID) techniques for mitigating stormwater impacts. They need expertise, guidance, and resources to remove barriers to implementing LID practices on the community level, neighborhood scale, and site scale. Despite the availability of a South Carolina-specific guidance manual published five years ago, there are still perception issues surrounding the use of LID, a lack of understanding on how to use the manual tools, and a need for more trainings for local government staff and design engineers.

Response: The Consortium and partners launched the LID Hot Topics Workshop series in August 2019 in two coastal locations (Charleston County and Myrtle Beach) for stormwater managers, engineers, landscape architects, developers, and other design and maintenance professionals. These were full-day events, organized to provide training focused on better site design principles and LID practices to successfully manage stormwater in an effort to dispel some of the misconceptions and concerns about implementing these practices instead of more conventional practices.

Results: The workshops were well-attended, with 97 individuals at the Charleston event and 49 at the Myrtle Beach event. Participants heard from researchers and design engineer experts about stormwater best management practices, and in particular LID strategies, including information on coastal S.C. residents' perceptions of these practices, the application and use of a maintenance cost calculator tool for better site design, and successful local case study examples. The planning, organization, and administration provided by the Consortium for these workshops is estimated to have provided an economic benefit of \$8,101 based on the provision of professional development hours (PDHs) at a discounted rate, registration fees, travel costs, and opportunity costs of time.

S.C. Sea Grant Consortium Assists McClellanville with Planning for a Sustainable Working Waterfront

April Turner, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium and partners assisted the Town of McClellanville with developing a working waterfront master plan to help sustain the local seafood industry. The plan report identifies options for retaining this critical economic asset in the community and explores approaches for cooperative ownership and operation of a seafood wholesale and distribution business to benefit the harvesters and ensure the long-term sustainability of the town's working waterfront.

Relevance: 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 there are two commercial docks used for larger vessels and as shore-side support facilities by the entire industry. One of these docks, Carolina Seafood, also serves as the town's largest employer and purchaser of harvest from local fishermen. The owner is 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 Consortium for assistance.

Response: Building on the Consortium's previous work identifying and assessing issues and exploring priorities for maintaining, preserving, and enhancing traditional working waterfronts, it collaborated with the town and other partners to successfully 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.

Results: As part of the planning process, the project team met with local seafood industry wholesalers and harvesters to gather input. The Consortium also convened and facilitated several community meetings to solicit input from more than 90 local residents, business owners, and local government officials who attended. Identified in the plan report were options for retaining this critical economic asset in the community. Approaches for cooperative ownership and operation of a seafood wholesale and distribution business were also explored

to benefit the harvesters and ensure the long-term sustainability of the town's working waterfront and thriving seafood trade. The project team will continue to work with the town to implement the actions outlined in the plan, including working to negotiate and secure funding for a conservation easement to permanently protect dock space and the associated wholesale and retail business facilities. The planning, organization, and administration provided by the Consortium for the two McClellanville stakeholder engagement meetings is estimated to have provided an economic benefit of \$4,723 based on travel costs and opportunity costs of time.

National Extension Tourism Strengthens Partnerships within Sea Grant, with Land Grant Extension, and Other Partners

April Turner, S.C. Sea Grant Consortium

Recap: Through the leadership of S.C. Sea Grant Consortium and Georgia Sea Grant as part of the National Extension Tourism (NET) Design Team, greater integration and participation with the NET Network has provided opportunities for increasing Sea Grant's ability to share best practices and strengthen relationships with Land Grant and other extension professionals working in tourism.

Relevance: Tourism plays a significant role in the economies of our coastal and Great Lakes states, with significant contributions to jobs, tax revenues, and quality of life. 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 outreach, and communication programs. The first step in accomplishing this goal was to create the National Sea Grant 2018-2028 Sustainable Coastal Tourism Vision Plan. One important recommendation was to re-establish/build upon relationships with other extension professionals working in the realm of tourism through the National Extension Tourism (NET) Network.

Response: The Consortium and Georgia Sea Grant worked with the NET Design Team to re-establish and strengthen relationships with Land Grant Extension engaged in tourism-related programming. The Consortium's Coastal Community Specialist was asked to serve on the NET Design Team, whose members were responsible for organizing the 2019 NET Conference in Astoria, Oregon from October 8-11, 2019. In addition to assisting with conference planning, the Consortium and partners organized a Sea Grant meeting as part of the conference.

Results: More than 80 people participated in the NET Conference in Astoria, Oregon from October 8-11, 2019. Attendees included Sea Grant staff from various state programs, the majority of which had never previously attended a NET event. This significantly increased Sea Grant participation at a predominantly Land Grant event. Prior to the conference a national survey was administered to assess the status of tourism extension efforts across the country (both Land Grant and Sea Grant), and results were shared during a conference session. As part of this concurrent session, the Consortium presented an overview of the National Sea Grant Office visioning planning process. The biennial meeting was also an opportunity for Sea Grant to share and learn about best practices for working with tourism stakeholders across the country and re-establish itself as an active member of the NET network. As a result of this re-established relationship between Land Grant/Sea Grant at the NET Conference, the next NET conference will be hosted by Georgia Sea Grant and the Consortium in 2021.

Calling the Coast Home: Developing Accredited Continuing Education Courses for Real Estate Professionals

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

Recap: S.C. Sea Grant Consortium collaborated with academic, organizational, and agency partners to develop a continuing education program for coastal real estate professionals.

Relevance: South Carolina's coastal population is rapidly growing. 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 contact 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 can also influence natural resource policy and decisions.

Response: As part of a S.C. Coastal Information Network (SCCIN) project to provide science-based information on important coastal topics and issues, the Consortium collaborated with academic, organizational, and agency partners to develop a continuing education program for coastal REPs. Key real estate and insurance industry professionals served in an advisory capacity, providing insights throughout the curriculum development.

Results: Priority topics were identified for course development with the assistance of the REP Advisory Committee. Coastal ecosystem/biodiversity, water quality at the neighborhood level, flooding and flood maps, and rebuilding regulations were the topics developed into four courses titled: Coastal Lifestyle for Clean Water; Living with Water; The Land-Water Connection; and Tidelands, Water, and Beach: Regulations and Rebuilding. Once the state approval process was completed, each of these two-hour courses was piloted at one of the regional real estate associations, where a total of 215 REPs received licensing credit in January 2020. A clearinghouse of resources accessible through the SCCIN website was compiled for the REPs to use to help their prospective clients navigate policies, regulations, and other potential challenges associated with coastal home and business ownership. The planning, organization, and administration provided by the Consortium for the "Calling the Coast Home" trainings are estimated to have provided an economic benefit of \$6,146 based on the provision of continuing education credits (CEUs) at a discounted rate, travel costs, and opportunity costs of time.

S.C. Sea Grant Consortium Organizes Two South Carolina Coastal Information Network Meetings, One in Spring-Summer and One in Fall-Winter

April Turner and Matt Gorstein, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium (Consortium) planned and organized two meetings for the South Carolina Coastal Information Network (SCCIN), together yielding a total economic benefit of \$2,091.

Relevance: The SCCIN grew out of the shared goals of coastal institutions and organizations to enhance coordination of community outreach efforts in the state. Established in 2006 and led by the Consortium, the SCCIN includes partners from more than 20 federal and state agencies, regional government entities, and private organizations seeking to coordinate and/or jointly deliver outreach programs that target coastal community constituents. As the SCCIN has developed and expanded, it has fostered inter-agency communication and cooperation.

Response: The Consortium organized two SCCIN meetings in FY2019, one in June and one in December. Outreach educators from local, regional, and state agencies and universities attended as well as coordinated the addition of

resources and activities to the SCCIN web portal.

Results: In addition to sharing information and locating partners for outreach activities, meetings this year also helped coordinate a realtor education program developed by the SCCIN. The planning, organization, and administration provided by the Consortium for the two SCCIN meetings is estimated to have provided an economic benefit of \$2,091 based on travel costs and opportunity costs of time. Fifteen and ten participants attended the June and December meetings, respectively. Participants traveled an average of 40 and 30 miles to attend the June and December meetings, respectively. Based on the General Services Administration's (GSA's) privately owned vehicle mileage reimbursement rate of \$0.545 per mile, each June participant incurred ($40 * \$0.545$) \$21.80 in vehicle travel costs, and each December participant incurred ($30 * \$0.545$) \$16.35 in vehicle travel costs. The occupations of the attendees were mixed. Based on the U.S. Bureau of Labor Statistics (BLS) occupational employment statistics program's mean hourly wages for all occupations in South Carolina (US BLS, 2019), the mean hourly wage of participants is assumed to be \$21.34. Participants obtained value from these meetings as attending was deemed an appropriate use of their time by either themselves or their supervisor, they deviated from normal work duties to attend the workshop, and they obtained knowledge and skills. Each meeting lasted 3 hours, therefore each participant has an associated opportunity cost of time of \$64.02 ($\$20.78 * 3$). Summing with travel costs (\$21.80), and multiplying by the number of participants (15) yields a total economic benefit of \$1,287 for the June meeting. Summing opportunity costs (\$64.02), travel costs (\$16.35), and multiplying by the number of participants (10) yields a total economic benefit of \$804 for the December meeting. Summing these two figures together yields a total economic benefit of \$2,091.

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

April Turner, S.C. Sea Grant Consortium

Recap: The support of the S.C. Sea Grant Consortium and the activities of the Coastal Communities Specialist assisted the S.C. Nature-Based Tourism Association with its 25th Annual Conference and website redesign to help ensure an economically viable and resource-sustainable nature-based tourism industry in South Carolina, promoting recreation opportunities and accessibility.

Relevance: 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% over the past decade to \$33.4 billion. More than 28% of the state's 4.96 million residents live in the eight coastal counties, and tourism is now a \$20.1 billion industry within those coastal counties, accounting for approximately 65% of the statewide total. People are increasingly drawn to the South Carolina coast, with both residents and tourists taking advantage of the opportunities the state's natural and cultural resources provide.

Response: The Consortium supports sustainable statewide, nature-based tourism through its involvement with the S.C. Nature-Based Tourism Association (SCNBTA).

Results: The Consortium's Coastal Communities Specialist serves the SCNBTA as its Past President on the Board of Directors, providing technical guidance and leadership service, including program planning for the quarterly board meetings and annual conferences, as well as coordination and development of marketing and membership strategies. As the conference co-chair, the specialist organized the SCNBTA annual event in Newberry, S.C. Additionally, the specialist spearheaded the redesign for the SCNBTA website that began in the fall of 2019. The specialist surveyed the membership for input into the redevelopment process, organized a website redesign team,

and coordinated weekly meetings with the web designer. The website is scheduled to be publicly launched in February 2020. The overhauled website should aid in the promotion of the state tourism regions and the support of nature-based tourism and recreation businesses. By providing increased exposure to potential clientele, the website should boost the sustainability and viability of the SCNBTAs. The planning, organization, and administration provided by the Consortium for the SCNBTAs Annual Meeting are estimated to have provided an economic benefit of \$14,935 based on registration fees, travel costs, and opportunity costs of time.

S.C. Sea Grant Consortium Coastal Economics Specialist Gives Guest Lectures at Consortium Member Institutions

Matt Gorstein, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium Coastal Economics Specialist gives guest lectures at Consortium member institutions on topics related to ecosystem service valuation, both market and non-market techniques.

Relevance: In an era of climate change and frequently occurring coastal hazards, addressing complex environmental issues with interdisciplinary science has become increasingly important. This involves the marriage of socioeconomic research with existing natural science research, including the estimation of ecosystem service values. Ecosystem services refer to the benefits that humans receive from healthy functioning ecosystems; and while their values are often overlooked when making policy decisions, they are important to track.

Response: In an effort to raise awareness about ecosystem service concepts, which ecosystem services are provided in South Carolina, and techniques used to value ecosystem services, S.C. Sea Grant Consortium Coastal Economics Specialist Matt Gorstein gave two guest lectures on these topics: in an environmental economics graduate class at the College of Charleston and in a forestry economics undergraduate class at Clemson University. The main themes included ecosystem service classification, use and non-use benefits, market versus non-market valuation techniques, cost benefit analysis, and conceptual models. These guest lectures also served as an opportunity to share information on student fellowship and other funding opportunities.

Result: University students are exposed to coastal ecosystem services and methods to evaluate them.

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 and Matt Gorstein, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium researchers investigate the costs and benefits associated with low impact development stormwater control measures.

Relevance: 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. Stormwater management research that informs a full socioeconomic understanding regarding the best management practices (BMPs) has been lacking.

Response: 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 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. Consortium researchers at Clemson University and the University of South Carolina are building from the foundation provided in the Guide by adding necessary socioeconomic knowledge to better inform stormwater decision-making in coastal South Carolina.

Results: Researchers determined that proximity to stormwater ponds has a positive effect on property values in Charleston, Horry, Beaufort, Georgetown, and Berkeley counties. South Carolina residents were surveyed concerning their preferences and willingness to pay for ecosystem services associated with dry stormwater ponds. The survey found that residents are willing to pay for flood reduction, pollutant removal, biodiversity, and aesthetic/scenic beauty when considering trade-offs in stormwater pond management. Finally, a “Low Impact Development – Hot Topics” workshop was convened to share information on the benefits of low impact development BMPs with researchers, engineers, property developers, and local government staff.

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

Recap: Tourism is one of the largest industries in South Carolina and nature-based tourism, as analyzed in this study, makes a substantial impact to the eight coastal economies, generating up to 21,000 related jobs and \$1.5 billion total economic contribution.

Relevance: 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.

Response: 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 identified gaps in this information. During Phase Two, on-site and phone surveys were conducted, and the USTA’s Travel Economic Impact Model and IMPLAN were used to estimate NBT economic impacts in the eight coastal counties.

Results: Phase Two results showed 2019 estimated coastal NBT economic contribution to the state of South Carolina ranging from \$766.8 million-\$1.5 billion. The total employment contribution ranged from 10,576 part- and full-time positions supported, to over 21,000 positions attributable to the economic contribution of NBT S.C. coastal tourism. For 91.5% of the tourist sample, the S.C. coast was the primary destination for their trip and when asked if, “nature or nature-based recreation” activity was a primary motivation for selecting the S.C. coast for their trip, 67.6% indicated that it was, with a similar majority classifying themselves as a NB tourist.

S.C. Sea Grant Consortium Researchers Assess Stormwater Drainage and Compound Flooding in a First-Order Tidal Creek

Tim Callahan, College of Charleston

Recap: S.C. Sea Grant Consortium researchers developed a model that predicts tidal influence within the drainage ditch attached to the tidal creek and updated streamflow rating curve models.

Relevance: The threat of increasing rates of climate change has presented unique problems to all types of land and environmental managers. Predictive scenarios indicate the future holds sea-level rise, increased intensity of precipitation events, and increased urbanization. Any one of these occurrences has the potential to present consequences, yet Charleston, S.C. will likely experience all of them. Complicating this issue is the issue with aging infrastructure, including roads, bridges, septic tank systems, and sanitary sewer pipes crossing over and under the coastal environments. It is of great importance to gain a better understanding of the relationship between tidal flow and stormflow to provide guidance on better stormwater controls and to predict the impacts of flooding events.

Response: S.C. Sea Grant Consortium researchers at the College of Charleston proposed to create a model of stormflow, tidal discharge, and stream flow response of tidal creeks. The model will be used to better understand the responses of tidal creeks to both tidal and stormflow flows. Existing data from other studies will be tested at a controlled site which has a stormwater drainage ditch that has an outfall into Church Flats Creek, a tidal creek that connects to the Stono River.

Results: Initial results indicate that this new model better predicts the amplitudes of tidal discharge associated with specific tidal cycles (i.e., king tide events). Additionally, results demonstrate that the tidal influence will increase such that the entire drainage system will be nearly completely tidal by 2050. Infrastructure has altered the catchment basins of first-order tidal creeks in the area, and in some extreme cases this has caused runoff delivered to these first-order systems to change by >100% in some extreme cases.

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 Baruch Institute

Recap: S.C. Sea Grant Consortium research on stormwater conveyances and control structures suggests that reducing particulate and algal loading from runoff could reduce oxygen demand in local receiving waters.

Relevance: 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.

Response: 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.

Results: 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. There was little significant difference in BOD5 concentrations among land use categories or stormwater management practices and much of the variability in BOD5 can be predicted by particulate matter concentrations, especially chlorophyll-containing particulate material, suggesting the importance of reducing particulate and algal loading from stormwater runoff as a means of reducing oxygen demand in local receiving waters. 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 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

Recap: Research supported by the S.C. Sea Grant Consortium revealed greater salinity, fecal coliform, and enterococcus fluctuations in areas of high development intensity.

Relevance: 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.

Response: 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. 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. Salinity and weather data were collected from each site.

Results: Analysis of a full year of data from each site suggests greater salinity fluctuations in areas of high development intensity. Fecal coliform and enterococcus also followed this gradient. The Dupont-Wappoo system exhibits several signs of water quality degradation and is also the most densely developed system.

WEATHER AND CLIMATE RESILIENCE

IMPACTS

Folly Beach Adopts Suite of Ordinances to Improve Flood and Weather Resilience

Sarah Watson, S.C. Sea Grant Consortium

Recap: The city council of Folly Beach, South Carolina, with technical assistance provided by the S.C. Sea Grant Consortium, adopted a suite of land use and building code ordinances and marsh and beach management plans to improve the community's resilience to sea-level rise and other coastal hazards.

Relevance: The City of Folly Beach is a small barrier island community that faces a variety of coastal hazards, including sea-level rise (SLR). The city has worked with the S.C. Sea Grant Consortium (Consortium) for several years on understanding SLR risks and developing a comprehensive SLR action plan. In May 2018, council passed a six-month waterfront building moratorium. The city used this time to identify and discuss a suite of land use, zoning, and building code ordinances that would improve resilience in the near and long term (<https://www.cityoffollybeach.com/city-departments-services/building-planning-and-business-licenses/planning-documents/>).

Response: The city requested technical assistance from the Consortium on applying SLR projections to a suite of ordinances and building codes to improve the community's resilience. Folly Beach held multiple public hearings and discussions about the proposed ordinances, and in January 2019, the ordinances were formally introduced. As part of our outreach to coastal communities, the Consortium, in collaboration with Elko Consulting and the Carolinas Integrated Sciences and Assessments (CISA) program provided technical assistance on understanding how SLR affects community function. The Consortium made multiple public presentations about SLR to the planning commission and city council and led discussions on what the hazards mean to the island now and in the future. The Consortium also provided technical assistance on the development of a marshfront management plan, which was a key recommendation in a 2017 SLR plan.

Results: The city adopted the suite of eight land-use, zoning, and building code ordinances formally in April and May 2019. The city also formally adopted the Marsh Management Plan, which is the first of its kind in S.C., in May 2019.

Folly Beach Uses Story Map Created by S.C. Sea Grant Consortium to Help Prepare for Hurricane Dorian

Landon Knapp and Sarah Watson, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium staff developed a Story Map for the City of Folly Beach illustrating flooding at various levels at a parcel level. The Story Map was initially for a public engagement event held in July 2019. As the city prepared for Hurricane Dorian, Consortium staff worked with city staff to interpret and translate for flooding potential due to the storm and connect what was illustrated with National Hurricane Center forecasts.

Relevance: S.C. Sea Grant Consortium has developed a long-term working relationship with the City of Folly Beach, a barrier island municipality, regarding climate change and sea-level rise preparedness. The city requested S.C. Sea

Grant Consortium's assistance to hold a flood engagement event at a family fun night in July 2019. This resulted in the development of a Story Map with high resolution bathtub mapping illustrating how the city would flood during specific water levels. In September 2019, as Hurricane Dorian was forecast to affect the city, city staff reached out to Consortium staff for assistance in translating the flood model to National Hurricane Center (NHC)/National Weather Service (NWS) forecasts.

Response: As the region was in the middle of an evacuation, S.C. Sea Grant Consortium staff helped interpret the flood map and connect the model with existing city emergency plans and policies. Consortium staff, while in the process of preparing to evacuate themselves, was able to do this remotely and connect with city staff and the city's engineering consultant to help them translate the datums used in the modeling, help city staff understand how the flood model could be used to interpret highly localized impacts based on the weather forecasts, and help connect to the proper NHC and NWS resources.

Results: The City of Folly Beach was prepared for the impacts of Hurricane Dorian through understanding the NOAA science and forecast products related to the storm and interpreted to their planning and mapping.

S.C. Sea Grant Consortium Provides Technical Assistance and Support for the City of Charleston's Dutch Dialogues Effort

M. Richard DeVoe, Sarah Watson, and Landon Knapp, S.C. Sea Grant Consortium

Recap: The City of Charleston partnered with the Water Institute and the Dutch Embassy to host a research and visioning event that would provide the city a new way to examine flooding problems. The S.C. Sea Grant Consortium worked with the College of Charleston to provide various data products and participated in the workshops, providing feedback and technical guidance.

Relevance: The City of Charleston is highly vulnerable to flooding from a variety of sources. Some parts of the city already are seeing frequent saltwater flooding due to sea-level rise and other parts of the city experience frequent freshwater flooding from heavy rain due to hydrology changes from decades of development. The city and the Charleston Resilience Network worked to bring the Dutch Dialogue team to Charleston, partnering with the Historic Charleston Foundation, The Nature Conservancy, and others.

Response: The Consortium assisted the College of Charleston with providing data products developed through other research that assisted the Dutch Dialogues team with understanding and visualizing flood vulnerabilities in the study areas selected by the city. The Consortium also participated in kick-off meetings and a week-long charrette held in July 2019, providing feedback and input as requested.

Results: The City of Charleston adopted the vision developed by the Dutch Dialogues team and the city also received two grants through the National Fish and Wildlife Foundation to implement several recommendations identified in the plan. The Consortium is a partner on both grants.

NOAA Resilience Grant Flood Modeling and Engagement

Sarah Watson and Landon Knapp, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium received a NOAA Regional Coastal Resilience Grant in 2016 on behalf of the Charleston Resilience Network to develop a parcel-level flood model and conduct neighborhood-level engagement activities to ground-truth data and educate residents about flood risks. The flood methodology developed through

the College of Charleston and the Consortium has been transferred to other parts of coastal S.C. In this reporting year, the Consortium conducted engagement events in Folly Beach and the Eastside neighborhood in the City of Charleston.

Relevance: The Charleston region is highly vulnerable to tidal flooding and flooding from heavy rain. Municipalities in the region need specific local data to better understand under what conditions flooding occurs so they can plan and respond effectively.

Response: As part of a NOAA Regional Coastal Resilience Grant and on behalf of the Charleston Resilience Network, S.C. Sea Grant Consortium and College of Charleston developed a flood modeling methodology over several years. The Consortium ground-truthed the methodology using a variety of methods, including community member participation at four engagement events because residents have much more on-the-ground knowledge of how and when flooding occurs in their neighborhoods. The first two events, which combined flood risk mitigation information with the ground-truthing, were held in 2018 and the final two were held in the City of Folly Beach and the Eastside neighborhood in the City of Charleston in July 2019. The Folly Beach event was a joint project with the city, bringing the mapping to a family fun night in a city park, with about 20 residents interacting with the maps. The Eastside event was planned in close coordination with the City of Charleston and served a community that has severe flooding problems, with about 10 residents attending.

Results: The flood modeling methodology developed was presented eight times at professional conferences spanning three states and six separate venues to a total of over 250 people. The infrastructure and streamlined methodology developed during the course of the project in the City of Charleston, S.C. facilitated the reproduction of this assessment for the City of Beaufort, S.C. at a fraction of the cost and time required for the initial project. Tidal and sea-level rise flooding and precipitation-based flood models, in addition to the necessary data inputs such as elevation and land cover classifications, were produced from scratch for the City of Beaufort at a cost to the city under \$15,000 and total time from implementation to final report and products of six months. These figures are at several scales of magnitude smaller than the initial project. The project provided the city with a comprehensive vulnerability assessment to flood hazards, which was presented to City Council and published on the city's website for public access.

Providing Coordination and Technical Assistance for the Beaufort County Sea Level Rise Task Force

Sarah Watson and Landon Knapp, S.C. Sea Grant Consortium

Recap: Beaufort County reconvened a Sea Level Rise Task Force and requested technical assistance from S.C. Sea Grant Consortium staff to further resilience planning and policy implementation. The Consortium helped translate sea-level rise and climate change science into local decision-making, helped facilitate meetings with local governments, and gave presentations to local elected officials. The Consortium also developed mapping analyses to assist task force members with decision-making.

Relevance: Beaufort County is comprised of sea islands, barrier islands, and tidal creeks that extend far inland. It has substantial vulnerabilities to flooding and sea-level rise. As such, the county has worked with the Consortium since 2012 on sea-level rise planning. The Consortium developed, in partnership with the Carolinas Integrated Sciences and Assessments, a sea-level rise action plan for the county in 2015. The recommendations from the plan were incorporated in the county's comprehensive plan. As the county revises its comprehensive plan, it wanted to highlight how sea-level rise planning could be further implemented and integrated.

Response: Consortium staff participated and facilitated meetings, gave presentations to local governing bodies, and helped provide expert guidance on how to incorporate sea-level rise projections into local codes and ordinances. Staff also used sea-level rise data layers developed during the City of Beaufort Flood Vulnerability Assessment to analyze the parcel impacts in Beaufort County, S.C. due to sea-level rise. Consortium staff collaborated with the Information Technology Department of Beaufort County to perform spatial intersections of high-resolution flood layers and property parcel data sets obtained from the county. The Consortium leveraged its longstanding relationship with the College of Charleston's Lowcountry Hazards Center to perform the data processing of the analysis, as the demands were too great for the county to perform in-house.

Results: The county is developing a new Sea Level Rise Action Plan that highlights specific steps the county can take to increase resilience throughout county policy. The task force now includes members from all municipalities with the goal that all municipalities will adopt a similar plan for regional cohesion. The mapping analysis resulted in an easy-to-use database of properties impacted by increasing levels of sea-level rise in Beaufort County, S.C., and the database is being utilized to guide the promulgation of two new ordinances restricting development in hazard-prone areas.

ACCOMPLISHMENTS

Adding Stakeholder Input to U.S. Army Corp of Engineers' South Atlantic Coastal Study

Landon Knapp, S.C. Sea Grant Consortium

Recap: Engineers, managers, and planners designing solutions to mitigate the impact of coastal flooding from storm surge in South Carolina will rely on technical data in the U.S. Army Corps of Engineers' (USACE) South Atlantic Coastal Study (SACS). The S.C. Sea Grant Consortium devised a web application to gather input from local experts and municipal officials and expand the study's data collection points to include chronic flooding locations.

Relevance: The impact of tidal flooding on coastal communities of South Carolina has grown in recent years, with three of the highest-recorded tide heights having occurred between 2015-2017. To aid communities with technical data to inform "coastal storm damage solutions to reduce wave attack, provide flood protection, and create robust environments that can provide a buffer to coastal flooding," the USACE is conducting a study to produce these data products. While the regional effort is designed to provide highly detailed and technical information, those data are provided for points on a map distributed across the entire Southeast U.S. and not necessarily coinciding with areas on the ground where they are needed most.

Response: S.C. Sea Grant Consortium developed a web application to display the locations the USACE planned to collect data and provided a simple point and click method of adding locations based on local expert knowledge. The application was designed for use by non-technical personnel and opened to administrators throughout coastal South Carolina to allow them to add areas they would like to have technical data coming out of the study. Consortium staff additionally used the results of a tidal flood modeling initiative in Charleston County to add collection points near critical infrastructure and residences likely to experience impacts based on those flood maps.

Results: Using the custom web application, administrators and Consortium staff added 175 additional points for data collection by the USACE study. Points were added in five of the eight counties in the coastal zone of South Carolina and included areas with known tidal flooding issues, roads, and other infrastructure critical to municipal

operations and emergency management, and areas where administrators desired knowledge on the extent and depth of the flood hazard. Results from this study will provide highly detailed and technical data to municipal staff for their use in mitigating flood hazards in the areas of highest need.

City of Beaufort, S.C. Flood Vulnerability Analysis

Landon Knapp and Sarah Watson, S.C. Sea Grant Consortium

Recap: In response to a request from the City of Beaufort, S.C. for help developing a comprehensive approach to addressing flooding issues, S.C. Sea Grant Consortium formed a collaborative team with the Carolinas Integrated Sciences and Assessments and the College of Charleston to model flood hazards and develop a report detailing the vulnerabilities of critical infrastructure.

Relevance: The City of Beaufort is at risk to tidal flooding, storm surge, and high-intensity rain events, which have increased in frequency and severity in recent years as local sea-level rise has reached 0.13 inches per year. Recognizing these threats, city administrators reached out to S.C. Sea Grant Consortium staff with the goal of developing a comprehensive approach to addressing flooding issues in the city.

Response: S.C. Sea Grant Consortium staff formed a collaborative team with researchers at our member institutions dedicated to understanding how vulnerable the City of Beaufort's assets are to tidal- and precipitation-based flooding. The highest-resolution base data products ever generated for the area were created to power flood models developed to identify exposure vulnerabilities to each flood hazard. An assessment was conducted for the entire city as well as for areas identified by city staff as "challenged" with known drainage issues. Flood maps and mapping data sets were delivered to city staff.

Results: A final report was produced by the project team, led by Consortium staff, detailing the methods and results of the vulnerability assessment as well as the historical and projected future trends of climate change hazards for the area. The full report has been published on the city's website (<http://www.cityofbeaufort.org/494/November-2019-Flood-Vulnerability-Assess>) as well as the Consortium's website (<https://www.scseagrant.org/flood-vulnerability-assessment-city-of-beaufort-sc>). The city invited Consortium staff to present the results of the study to a City Council work session and assist them as they take steps to address flood vulnerabilities. A news article was published detailing the report and the upcoming work session, which resulted in an attendance of approximately 60 people. The city agreed to openly share flood maps and data produced for this analysis with Beaufort County to guide a task force aimed at promulgating regulations for development restrictions in areas vulnerable to sea-level rise impacts.

Providing Expertise to Guide Charleston, S.C. All-Hazards Vulnerability and Risk Assessment

Landon Knapp, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium provided expert consultation and foundational data sets in flood hazard assessment and facilitated engagement with subject matter experts in earthquake vulnerability assessment at our member institutions to inform an all-hazards vulnerability and risk assessment performed for the City of Charleston, S.C.

Relevance: Due to its geographic location and low relief, the City of Charleston is vulnerable to a wide range of environmental hazards, from sea-level rise and high-intensity rain events to major earthquakes. In order to

incorporate these hazards into the city's planning and management, a vulnerability and risk assessment was conducted, which the city views as its best chance to unify all facets of its operations around mitigating these threats.

Response: S.C. Sea Grant Consortium staff worked with the consultants hired by the City of Charleston to ensure the highest quality data and methodologies were employed during the project. Consortium staff provided flood hazard data sets which were produced during previous initiatives and brought in experts at a member institution, the College of Charleston, to advise on the earthquake hazard for the area. Those data and consultations exchanged between the consultants, Consortium staff, and experts at our member institutions were critical in the successful completion of the Vulnerability Assessment and the lasting utility of its results.

Results: This report has not been released yet but is expected in the coming year.

Developing a City of Charleston Flood Monitoring Application

Landon Knapp, S.C. Sea Grant Consortium

Recap: S.C. Sea Grant Consortium staff worked with technical experts at the College of Charleston to develop and host a flood monitoring application to allow users to collect photos and document characteristics of flood waters in the City of Charleston, S.C. to better inform flood mitigation efforts.

Relevance: The City of Charleston, S.C. benefits from a wide array of initiatives aimed at mitigating the recurrent flooding stemming from sunny-day tidal floods and "rain bombs" overwhelming stormwater infrastructure. What is lacking among the entities working in the city, based on requests received by the Consortium, is a way to check the accuracy of data and computer simulations of flooding against actual flood events that have occurred on the peninsula.

Response: Working with technical experts at the College of Charleston, S.C. Sea Grant Consortium staff developed a flood monitoring application designed to allow residents of the City of Charleston to upload photos of flooding from their hand-held devices from anywhere in the city in real time. The application was designed to be easy-to-use by anyone interested in contributing information and allows the option of additionally contributing contextual information such as cleanliness of flood waters or condition of adjacent storm drains. A professor at the College of Charleston is recruiting and maintaining students to participate in photo collection. Data are being used to validate flood models produced collaboratively between the Consortium and the College of Charleston and will be shared with any entity interested in the final products. More information on the application and its use can be found in an article detailing its release (<https://today.cofc.edu/2019/09/16/lowcountry-hazards-center-project-aims-to-dry-up-area-flooding/>).

Results: A flood impacts application was created and used both for research at the College of Charleston and by the City of Charleston to locate areas of concern.

S.C. Sea Grant Consortium Partnership to Develop and Deliver High-Resolution Land Use/Land Cover Data Products for the Coast of South Carolina

Landon Knapp and Sarah Watson, S.C. Sea Grant Consortium

Recap: Staff of the S.C. Sea Grant Consortium collaborated with the College of Charleston and National Oceanic and Atmospheric Administration's Coastal Change Analysis Program (C-CAP) team to develop the highest-resolution land

cover data ever created for the coast of South Carolina in order to power environmental modeling in the state.

Relevance: Geospatial modeling, and flood hazard modeling in particular, in the coastal lowcountry of South Carolina requires high-resolution mapping products to perform accurately. Despite the need for those data, one of the most foundational base data sets for hazard modeling, land use/land cover, had never been made publicly available at a resolution fine enough for high-resolution mapping in the area.

Response: A collaboration was formed between the S.C. Sea Grant Consortium, the College of Charleston's (CofC) Lowcountry Hazards Center (LHC), and the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program (C-CAP) to develop and deliver the highest-resolution land use/land cover data products ever created for the coast of South Carolina. The collaborative team designed a work flow that relies on significant contributions from the C-CAP staff as well as the Consortium and the CofC to develop a composite final product for use by the general public. Using newly acquired software for the project and adapting techniques developed by the C-CAP team, staff at the Consortium and the CofC are developing one-meter resolution land cover data for the eight counties in the coastal zone of South Carolina.

Results: These data enhance the resolution of any prior product 30-fold and will be made available on NOAA's Digital Coast in the fall of 2020.

S.C. Sea Grant Consortium Fosters Professional Engagement through the Southeast and Caribbean Climate Community of Practice

Sarah Watson, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium organized, with partners, the 2019 Southeast and Caribbean Climate Community of Practice Workshop. Sixty-eight attendees learned and discussed issues related to climate change impacts in the region. The Consortium led an interactive session titled "What Does Adaptation Look Like," which was intended to give participants the opportunity to brainstorm specific steps for implementing resilient measures.

Relevance: The Southeast and Caribbean Climate Community of Practice (CCoP) brings together individuals from local, state, and federal governments, academia, non-profit organizations, and the private sector in the Southeast U.S. (NC, SC, GA, FL, and Puerto Rico) to apply climate science and assess how coastal communities and ecosystems can adapt to the impacts of climate variability and change. The S.C. Sea Grant Consortium (Consortium), in partnership with the Carolinas Integrated Sciences and Assessments (CISA) program, has fostered momentum for the CCoP since 2014.

Response: The Consortium assisted the CCoP with hosting an in-person workshop April 1-3, 2019, which was held in Wrightsville Beach, N.C., with 68 attendees.

Results: Attendees learned about the latest science of how climate change is and will impact the Southeast and Caribbean region, discussed lessons learned and best practices in preparing for, responding to, and recovering from extreme events, including hurricanes Florence, Irma, Maria, and Matthew, discussed opportunities for incorporating climate adaptation strategies into medium- and long-term planning, and explored communications strategies for engaging community members about extreme events. The Consortium led an interactive session titled "What Does Adaptation Look Like," which was intended to give participants the opportunity to brainstorm specific steps for implementing resilient measures. The workshop final report is found here: <https://seaccop.files.wordpress.com/2019/05/2019-final-workshop-report-.pdf>.

Panel on Emotional Well-Being for Climate Workers is Transferred to Feature in *Eos, Science News* by AGU (American Geophysical Union) and a *Union Session* at AGU Conference

Sarah Watson, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium organized and sponsored a special session at the Climate Predictions Applications Sciences Workshop (CPASW) on emotional well-being and empathy fatigue.

Relevance: As climate change and related effects become more pronounced, those working in the weather climate enterprise are experiencing an increasing rate of burnout and emotional fatigue related to their jobs. Preliminary research by Susanne Moser, Ph.D., has found that nearly 90 percent of extension and climate first-responder professionals report experiencing burnout compared with only 40 percent of those in other professions.

Response: The Consortium organized and sponsored a special session at the Climate Predictions Applications Sciences Workshop (CPASW) in June 2019 on emotional well-being and empathy fatigue. The session included a keynote address by Moser, who is leading a multi-disciplinary project called the Adaptive Mind, which in part is to help study and then train climate extension professionals in addressing emotional well-being involving their jobs. The panel comprised of a range of people working in the field, including a climate scientist, an extension specialist, and meteorologists for private enterprise and a federal agency. The team followed up by writing an article for the AGU's journal, *Eos*, addressing how those in the weather climate enterprise can begin to develop support systems and address the growing emotional drain from this work. The team was invited and presented the content in a Union Session panel at the 2019 AGU annual meeting in San Francisco.

Results: The article, "The Emotional Toll of Climate Change on Science Professionals," was published in *Eos* December 6, 2019. The Union Session panel was held at the AGU annual meeting, December 9, 2019 in San Francisco.

Examining Impacts of Climate Change on Vulnerability and Function of Stormwater Ponds in Coastal South Carolina

Shaowu Bao, Coastal Carolina University

Recap: A two-phase study by S.C. Sea Grant Consortium researchers developed a model for simulating and forecasting coastal and inland rainfall and flood events and the impact on stormwater management ponds (SMPs). The model simulations indicate that the highest risk SMPs along the South Carolina coast are Winyah Bay, Mt. Pleasant, Charleston Harbor, and Hilton Head Island. Statewide, the risk increases from approximately 208 SMPs at risk from high tide flooding to more than 1,700 at risk from a 100-year storm surge.

Relevance: Stormwater management ponds (SMPs) are recognized as serving both water quantity and water quality through collecting the first flush of rainwater runoff and sediment and contaminants. The SMPs function of stormwater control and flood protection, however, may be challenged under future climate-change scenarios, especially sea-level rise (SLR). The combined effect of projected SLR and more extreme rainfall is anticipated to amplify both the effect of SLR on the extent of inundation and inland flooding caused by rainfall. Little has been studied to date about the ability of stormwater ponds to mitigate potentially increased flooding from SLR and rainfall.

Response: Through a two-phase mini-proposal, S.C. Sea Grant Consortium researchers at Coastal Carolina

University assessed how projected SLR and increased rainfall due to climate change may impact the state's residential stormwater ponds.

Results: Phase one resulted in development of an atmosphere-ocean-hydrology-hydraulic coupled model for simulating and forecasting coastal and inland rainfall and flooding events. Phase two simulated SLR inundations and the impacts on SMPs affected during non-storm and storm conditions were assessed. Statewide, under current climate conditions, a non-storm high tide could inundate approximately 208 SMPs. The number would increase sharply for stronger hurricanes, reaching more than 1,700 SMPs for a 100-year storm surge. SMPs near Winyah Bay, Mt. Pleasant, Charleston Harbor, and Hilton Head Island are at the greatest risk from future SLR scenarios..

S.C. Sea Grant Consortium Researchers Visualize Sea-Level Rise Impacts to Stormwater Ponds

Jean Ellis and Erik Smith, University of South Carolina

Recap: An online stormwater pond visualization tool (<http://arcg.is/0m1Ob8>) was developed by S.C. Sea Grant Consortium researchers to predict impacts of sea-level rise (SLR) out to 2045 given current stormwater pond distribution. There is tremendous variability among counties with respect to the percentages of ponds vulnerable to SLR, as well as the rate at which pond vulnerability increases with increasing SLR, and that residential ponds tend to be proportionately more vulnerable than other pond types.

Relevance: Stormwater ponds are constructed systems engineered to meet the stormwater management requirements associated with development or other land disturbing activities. They are designed to receive and retain a substantial portion of the hydrologic flow before being discharged into coastal water bodies, and are by far the most frequently used stormwater management practice in coastal S.C. Understanding the relationship between stormwater ponds and future coastal inundation is critical so people can understand risk and make informed decisions about future development.

Response: Through a two-phase mini-proposal, S.C. Sea Grant Consortium researchers at the University of South Carolina updated a stormwater pond inventory in the Charleston and Myrtle Beach areas, including both elevation and NOAA sea-level rise (SLR) data to ultimately provide an online visualization tool predicting impacts of SLR out to 2045 given current stormwater pond distribution.

Results: The tool (<http://arcg.is/0m1Ob8>) displays 11 mapped scenarios of SLR from current sea level to 10 feet, viewable from county-scale to individual pond scale. Various scales allow the user to determine under which sea-level rise scenarios ponds are impacted, defined as disruption to the hydraulic head of the pond, because at that point stormwater mitigation is no longer occurring. Study results indicate there is tremendous variability among counties with respect to the percentages of ponds vulnerable to SLR, as well as the rate at which pond vulnerability increases with increasing SLR, and that residential ponds tend to be proportionately more vulnerable than other pond types.

S.C. Sea Grant Consortium Researchers Analyze Multi-Hazard and Multi-Impact Data for Stormwater Pond Managers

Erfan Goharian, University of South Carolina

Recap: Coastal natural hazard vulnerability maps are a low-cost and viable management alternative for assessing the impacts of sea-level rise on stormwater management ponds.

Relevance: In South Carolina, floods are multi-hazard, multi-impact, and multi-day events. Within the interactions of inland flooding, coastal flooding, and sea-level rise (SLR), stormwater management ponds play a significant regulatory role as the primary best management practices (BMP) utilized in regional flood control programs. While stormwater management ponds intended to reduce flood hazard, their functionality within multi-hazard and multi-impact contexts is still relatively unknown, especially in the coastal areas.

Response: Through a two-phase mini-proposal, S.C. Sea Grant Consortium researchers at the University of South Carolina proposed to better understand historical trends of inland flooding and SLR; identify the effects of inland and coastal floods and SLR on stormwater pond management; and identify variable effects of flood hazards on ponds.

Results: Researchers generated coastal natural hazard vulnerability maps that describe geographic locations and classes of ponds that are most at risk to SLR and provide useful information for land-use decision-making and infrastructure development in coastal environments to maintain the ecosystem services these ponds provide. If one foot of SLR is achieved by 2050, it is expected that Charleston and Beaufort will lose over 3% and 4% of their total number of ponds, respectively. For both counties, these losses will consist mainly of ponds in rural and residential areas.

S.C. Sea Grant Consortium Researchers Analyze Economic Impacts of Natural Resources in Coastal Counties

Puskar Khanal and Thomas Straka, University of South Carolina

Recap: S.C. Sea Grant Consortium-funded researchers estimated total value of ecosystem services provided by tidal marshes in coastal South Carolina alone at \$4.3 billion annually.

Relevance: Very few studies have attempted to quantify economic contributions of coastal marshes, wetlands, and tidal creeks to communities, businesses, and individuals in South Carolina. It is critical to have recent data and analysis related to economic and societal values of salt marshes to support initiatives that would encourage additional protection and preservation of coastal marshes and wetlands in South Carolina.

Response: S.C. Sea Grant Consortium researchers proposed identifying and assessing the status of key ecosystem services provided by S.C.'s coastal marshes and wetlands and estimating gross economic value provided by the coastal marshes and wetlands in South Carolina.

Results: The study estimated the total value of ecosystem services provided by tidal marshes in South Carolina at \$4.3 billion annually. It also established baseline economic impact information for the forestry sector in the eight coastal counties in South Carolina, and related factsheets are available for download at <https://www.clemson.edu/extension/timber-market/>. Additionally, forestry economic impact models for the eight coastal counties will be made available.

SUSTAINABLE FISHERIES AND AQUACULTURE

ACCOMPLISHMENTS

S.C. Sea Grant Consortium Researchers Explore Social Carrying Capacity of Expanding Oyster Mariculture Along the Coast

William Norman, Lauren Duffy, Jeffrey Hallo, and Laura Jodice, Clemson University

Recap: Overall, a preponderance of support exists for oyster farming in South Carolina, particularly when it is well-managed and does not interfere with boating.

Relevance: As a result of the promotion of local seafood and growing familiarity with shellfish products such as oysters and clams, the demand and willingness to pay a higher price for farmed shellfish has increased, especially in coastal tourism destinations on the South Carolina coast. Recent research suggests S.C. residents and tourists are broadly supportive of existing mariculture, but there is little understanding of support for expansion of oyster mariculture, which will include highly visible infrastructure.

Response: S.C. Sea Grant Consortium researchers based at Clemson University are examining social carrying capacity among residents and waterway users who will be most directly impacted by expansion. They worked with an advisory group comprised of shellfish managers, commercial growers, local officials, business owners, and recreational users to develop a survey designed to reach stakeholder groups in Charleston and Beaufort counties in coastal South Carolina. Eighty interviews were conducted, including social value data (e.g., aesthetic, recreational, ecological, land-use, cultural) to be digitized onto S.C. Department of Health and Environmental Control mariculture permit maps.

Results: Overall, a preponderance of support exists for oyster farming, particularly when it is well-managed and does not interfere with boating. Oysters and oyster farming are often supported as culturally appropriate and as a mechanism for economic growth, local food production, and community vitality. The general public seems relatively under-informed, and in cases misinformed, about oyster farming; most concerns expressed about it are often related to this lack of knowledge. However, major issues of concerns are: boating access and safety, signage, and aesthetic concerns related to equipment, including gear type, size of farm, and distance/observability. There are opportunities for improved acceptance through better communication on management policies, environmental benefits, low environmental impacts, influences on wild oysters, and oyster harvesters. The visibility of oyster farms near bridges, size of the oyster farms, as well as the linear nature of oyster farms were deemed critical in the development of social carrying capacity research.

S.C. Sea Grant Consortium Researchers Develop Novel Fish Aging Techniques

Joe Quattro, University of South Carolina (USC) Baruch Institute; Michelle Passerotti, USC Department of Biological Sciences; Joe Ballenger, S.C. Department of Natural Resources Marine Resources Research Institute

Recap: S.C. Sea Grant Consortium research led to development of novel methodologies for predicting both annual and daily ages from otoliths of red snapper, and predicting age to 17 years in sand tiger sharks. Additionally, a novel

equipment modification for use in scanning very small otoliths for use with near infrared spectroscopy (NIRS) was developed.

Relevance: The ability to quickly detect changes in age and growth trajectories of fish is a key to successfully managing them. Current methods are time-consuming, expensive, and make real-time management more challenging. In addition, climate change presents new and dynamic challenges to the management of migratory fish species, potentially altering life cycles and habitat ranges. Developing novel aging methods in fish species is important to every stakeholder and end-user of fisheries resources, as it will improve the regulatory process and enhance management.

Response: S.C. Sea Grant Consortium researchers at the University of South Carolina and the S.C. Department of Natural Resources are estimating fish ages using near infrared spectroscopy (NIRS) on red snapper otoliths, a bony structure of the inner ear, and sand tiger shark vertebrae. Over 1,200 otoliths from Gulf of Mexico and Atlantic red snapper populations were scanned using NIRS, and comparisons to traditionally-aged otoliths confirm this methodology to be both faster and highly accurate for annual and daily aging.

Results: Consortium researchers expect time and cost savings associated with the NIRS method to be substantial, as NIRS data collection and age prediction for otoliths in NIRS models could be accomplished by a single person in much less time, as compared to traditional methods. Work on NIRS age prediction in sand tiger shark vertebrae is also nearing completion, though with different outcomes relative to those of red snapper. NIRS age prediction appears successful in aging sharks to ~17 years, however, age prediction in vertebrae older than 17 years appears to be untenable. Regional management councils are aware of efforts to develop NIRS methods for age prediction in multiple species, and management recommendations have been made recently in assessment workshops to consider use of NIRS for improving the scope and timing of production aging for managed species.

SCIENTIFIC LITERACY AND WORKFORCE DEVELOPMENT

IMPACTS

S.C. Sea Grant Consortium's BioDiscovery Program Receives \$9,000 from Bosch

E.V. Bell, S.C. Sea Grant Consortium

Recap: A \$9,000 grant from Bosch to the Charleston County Park and Recreation Commission enabled the expansion of the BioDiscovery program to include training for formal and nonformal educators, online data portal tutorial development, and creation of an educator training guide.

Relevance: Maryland Sea Grant's program, Biofilms and Biodiversity, serves as a STEM (science-technology-engineering-math) opportunity for students to examine the microscopic and fouling communities in local, coastal waters. The program's framework is centered around the deployment of a "biorack": A three-meter long rope with acrylic discs evenly spaced along the length and submerged in the aquatic environment for a period of time. Removal of the biorack allows for students to observe colonization on the discs, including species such as bacteria, algae, invertebrates, and vertebrates. Extensions to this program include calculation of species diversity and abundance, water quality parameters, and species identification. In 2017, Maryland Sea Grant, S.C. Sea Grant Consortium, Clemson University Cooperative Extension Service, and Grice Marine Lab collaborated on ways in which the Biofilms and Biodiversity program could be replicated in South Carolina.

Response: In 2017, the Charleston County Park and Recreation Commission partnered with the Consortium, Grice Marine Lab, and Clemson University to submit a funding request to Bosch to support a pilot program in South Carolina, the BioDiscovery program, based on Maryland Sea Grant's Biofilms and Biodiversity program. This funding request would support teacher training, supplies (digital microscope and biorack supplies), and the development of educational materials and resources, including a teacher manual, species identification guide, and data portal.

Results: Because of the success of the BioDiscovery program in both 2017 and 2018, Bosch awarded the Charleston County Park and Recreation Commission additional funding in the amount of \$9,000 for the BioDiscovery program to continue expanding throughout the state. A 2019 summer training was conducted for more than 15 formal and nonformal educators, and supplies were procured for each participant: a biorack, phone camera lens, data portal tutorials, and revised teacher manual. Additional plans to continue and expand the BioDiscovery program throughout the state to freshwater environments are currently underway.

S.C. Sea Grant Consortium's Beach Sweep/River Sweep Litter Cleanup Saves Taxpayers \$128,015 in 2019

Susan Ferris Hill, S.C. Sea Grant Consortium

Recap: Beach Sweep/River Sweep has economic, environmental, and societal benefits. In 2019, 2,337 coastal volunteers collected over 11.36 tons of litter, covered 137 miles of South Carolina's beaches, marshes, and waterways. There were 90 site captains at 73 cleanup locations across the state. The dollar value of volunteers' time equals \$128,015. The number of volunteer hours was 5,034. The state's natural resources are cleaner, safer, and more beautiful for all to enjoy.

Relevance: Natural resources account for \$33.4 billion in annual economic output for the state (S.C. Department of Natural Resources, 2016). And according to the S.C. Department of Parks, Recreation, and Tourism, tourism spending reached \$22.6 billion in 2017. Clean beaches, marshes, and waterways are critical to support commercial and recreational boating and fishing, wildlife viewing, tourism, and other industries. A litter-free environment also contributes positively to quality of life.

Response: The S.C. Sea Grant Consortium and S.C. Department of Natural Resources organize the Beach Sweep/ River Sweep litter cleanup. Through the use of volunteers, the cleanup contributes to the economic, environmental, and societal well-being of the state. Participants and the public are more informed about natural resource issues, such as litter's detrimental effects on the landscape and wildlife, and people are empowered to take action and become environmental stewards.

Results: In 2019, 2,337 coastal volunteers collected over 11.36 tons of litter, covered 137 miles of beaches, marshes, and waterways, and recycled as much as possible. There were 90 site captains at 73 cleanup locations. The dollar value of volunteers' time is \$128,015 (Independent Sector, 2019). The number of coastal volunteer hours was 5,034.

ACCOMPLISHMENTS

S.C. Sea Grant Consortium Secures Funding and Establishes Diversity Scholarship Program for the Palmetto Environmental Education Certification (PEEC) Program

E.V. Bell, S.C. Sea Grant Consortium

Recap: Funding from the Spaulding-Paolozzi Foundation provides support for up to six diversity scholarships to be awarded for the 2020 – 2022 Palmetto Environmental Education Certification (PEEC) cohort.

Relevance: In 2013, the S.C. Sea Grant Consortium (Consortium) conducted a state-wide needs assessment for the development of the state's first environmental education certification program for formal and nonformal educators. Of the 120 respondents (formal and nonformal educators), 90% stated that a certification program would "improve skills" and 75% stated that a certification program would "increase understanding of environmental issues." Based on this study, the Palmetto Environmental Education Certification (PEEC) program was officially launched in 2018 and has four main requirements: 1) four face-to-face workshops on effective environmental education instruction, 2) eight online modules that supplement information learned during the workshops, 3) a self-directed elective component that fosters exploration of various environmental topics, and 4) a culminating capstone project that demonstrates both mastery in environmental education content and pedagogy. Four main goals frame the PEEC program, one of which is to "train educators who are representative of the diverse communities and regions within the state." Based on 2019 U.S. Census Bureau data, South Carolina has an estimated 37.4% of the population who identify as a person of color (POC); however, despite this percentage, there is still a dearth of diversity within the fields of both environmental sciences and environmental education and interpretation, both within the state and across the nation.

Response: In 2019, funding was secured from the Spaulding-Paolozzi Foundation for the creation of the PEEC Diversity Scholarship program, which will support up to six scholarships in the amount of \$600 each for the 2020 – 2022 PEEC cohort. Eligibility for these scholarships includes any person who identifies as a POC or other underrepresented minority group.

Results: The PEEC Diversity Scholarship and scoring rubric were created by members of the PEEC Advisory

Committee and will be receiving applications beginning July 1, 2020 for the upcoming PEEC 2020 – 2022 cohort.

S.C. Sea Grant Consortium Secures Two Sources of Funding to Initiate Charleston-Area, Community-Level Salt Marsh Restoration Efforts

E.V. Bell, S.C. Sea Grant Consortium

Recap: Funding from the National Oceanic and Atmospheric Administration (NOAA) and the S.C. Native Plant Society (SCNPS) provide the S.C. Sea Grant Consortium (Consortium) with support to expand the From Seeds to Shoreline® (S2S) salt marsh restoration program to a Charleston-area, community-focused initiative.

Relevance: In 2011, the Consortium launched the state’s only salt marsh restoration program for K-12 students, From Seeds to Shoreline® (S2S), in partnership with the S.C. Department of Natural Resources and Clemson University Cooperative Extension Service. The S2S program’s goal is to increase understanding about the salt marsh ecosystem among K-12 students and teachers through their active participation in cultivating and transplanting *Spartina alterniflora* to areas of degraded or eroded salt marsh. The S2S program framework has expanded over ten years to include local partners (“hubs”) within more than 15 coastal and inland counties that work closely with participating schools in their area. As the program has grown throughout the state among the K-12 audience, community-level interest in the program, specifically in Charleston County, has also increased with adult groups indicating interest in cultivating and transplanting *Spartina alterniflora* to their local salt marsh.

Response: In March 2019, the Consortium received \$450 from the SCNPS to pilot community-level restoration efforts in Charleston, S.C., focused on cultivating and transplanting *Spartina alterniflora*. In April 2019, the Consortium partnered with the S.C. Department of Natural Resources to secure funding from NOAA to support community-level salt marsh restoration efforts, specifically related to the species *Crassostrea virginica* and *Spartina alterniflora*, at 13 sites in the Charleston area. The Consortium was a sub-awardee for three years of funding in the amount of \$55,275 to retool the S2S program model to engage local communities in cultivation and transplanting techniques for *Spartina alterniflora*, as well as to develop a citizen science protocol for long-term monitoring of the restored locations.

Results: Two informational community meetings were held in late fall of 2019 and January 2020 with the goal of garnering interest in future trainings, volunteer restoration events, and citizen-science monitoring efforts scheduled to begin in the fall of 2020.

S.C. Sea Grant Consortium’s Palmetto Environmental Education Certification Program Undergoes Evaluation to Be Formally Adopted as an Official Program of the Environmental Education Association of South Carolina

E.V. Bell, S.C. Sea Grant Consortium

Recap: The Palmetto Environmental Education Certification (PEEC) program undergoes review by the Environmental Education Association of South Carolina (EEASC) Exploratory Committee for official adoption.

Relevance: In 2013, the S.C. Sea Grant Consortium (Consortium) conducted a state-wide needs assessment for the development of the state’s first environmental education certification program for formal and nonformal educators. Of the 120 respondents (formal and nonformal educators), 90% stated that a certification program would “improve skills” and 75% stated that a certification program would “increase understanding of environmental issues.” Based on this study, the Palmetto Environmental Education Certification (PEEC) program was officially launched in 2018

for both formal and nonformal educators. PEEC has four main requirements: 1) four face-to-face workshops on effective environmental education instruction, 2) eight online modules that supplement information learned during the workshops, 3) a self-directed elective component that fosters exploration of various environmental topics, and 4) a culminating capstone project that demonstrates both mastery in environmental education content and pedagogy. For the short term, the Consortium serves as the administrative and fiscal agent for the program; however, the long-term goal for the program's sustainability is to fold it under an environmental education organization, such as the Environmental Education Association of South Carolina (EEASC), that has the staff, capacity, and in-kind support for this type of program.

Response: Currently, the Consortium's Marine Education Specialist serves on the Board of Directors for EEASC and also serves as the PEEC Advisory Committee Chair. During a 2019 EEASC board meeting, the Consortium formally proposed that PEEC be considered as an official program offering of EEASC, thereby assuming the financial, logistical, and capacity responsibilities required. The Consortium would maintain its involvement in the program; however, the official organization administering the program would be EEASC.

Results: An EEASC Exploratory Committee was established in 2019 that would assume the responsibility of reviewing the feasibility of PEEC becoming an official program of EEASC. This committee is currently examining the financial, institutional, and logistical considerations of adopting PEEC as a flagship program under EEASC, with an anticipated formal adoption to be made in the fall of 2020.

S.C. Sea Grant Consortium Receives 2019 "Spirit of Cooperation" Charleston County Community Pride Award

E.V. Bell, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium received the 2019 "Spirit of Cooperation" Charleston County Community Pride Award for work on the BioDiscovery program.

Relevance: The Charleston County Community Pride awards have been given out for more than 50 years to individuals and organizations in Charleston County that "promote environmental stewardship, work to protect and conserve our natural resources, and are committed to community improvement." There are 11 award categories and each spring an awards luncheon is given to honor the recipients. The "Spirit of Cooperation Award" is awarded to individuals or organizations that have conducted projects which have both involved other partners and have worked to improve the environment.

Response: In 2019, the S.C. Sea Grant Consortium was awarded, along with the Charleston County Park and Recreation Commission, Grice Marine Lab, and Clemson University Cooperative Extension, the "Spirit of Cooperation" Charleston County Community Pride Award for work on the BioDiscovery program. The BioDiscovery program is a collaborative, STEM (science-technology-engineering-math) education program that involves the deployment of "bioracks" in aquatic environments which are three-meter long ropes with acrylic discs interspersed along the length of the rope. The bioracks, once submerged, will provide substrate for the settlement of bacteria, algae, and other organisms. Participating schools can design their own biorack and use the project data portal to identify and report species that colonize the discs. Water quality data can also be collected in the environment in which the biorack is deployed.

Results: The S.C. Sea Grant Consortium received the 2019 "Spirit of Cooperation" Charleston County Community Pride Award for work on the BioDiscovery program.

S.C. Sea Grant Consortium Marine Education Program Deemed a Best Practice by National Sea Grant Site Review Team

E.V. Bell, S.C. Sea Grant Consortium

Recap: One of the results of an August 2019 National Sea Grant Site Review was that the S.C. Sea Grant Consortium (Consortium) Marine Education program was deemed a Best Practice by the Site Review Team. According to the Site Review Team, “A challenge in Sea Grant education programs is ensuring that teachers incorporate lessons and tools into their curricula. The SCSGC overcomes this challenge by ensuring that all educational lessons and products are linked to state science standards and providing that information on its website.”

Relevance: Formal (K-12) educators in South Carolina are faced with a multitude of time constraints during their workday (and off hours), including administrative reporting demands, standards-based testing preparation, staff trainings, lesson plan/unit development, and classroom management. Time remains a precious commodity, with little extra room in their day-to-day schedule to incorporate new programs, opportunities, or curricula. Many educators must justify to their administration how external opportunities and/or materials will be used with their students, as well as outline how professional development trainings align to their specific grade-level and subject area.

Response: The Consortium’s Marine Education program, recognizing the time demands and constraints on K-12 educators, prioritizes the alignment of every classroom program, long-term stewardship project, professional development opportunity, and curriculum to the S.C. State Science Standards. The Consortium clearly outlines how content aligns with grade-specific science standards by posting this information on the agency’s website and also on specific program products, information flyers, and agendas. By making this information easily accessible, the Consortium assists an educator and the educator’s administration to be able to decide if an opportunity or resource fits well within their classroom curriculum.

Results: The S.C. Sea Grant Consortium (Consortium) Marine Education program was deemed a Best Practice by the Site Review Team as a result of the August 2019 National Sea Grant Site Review.

S.C. Sea Grant Consortium Website Redeveloped to Provide User-Friendly Experience, Ease of Navigation, and Accessibility

Susan Ferris Hill and Crystal Narayana, S.C. Sea Grant Consortium

Recap: The S.C. Sea Grant Consortium’s redeveloped website, www.scseagrant.org, was launched June 19, 2019. The website is a source of science-based information for researchers, decision-makers, educators, and the public about coastal and marine topics, as well as agency organization and administrative processes. The navigation is intuitive, content is optimized for search engines and fast performance across a broad range of devices, follows Web Content Accessibility Guidelines 2.0 for ADA compliance, and contains a robust internal search feature.

Relevance: The Communications team led the redevelopment effort because the legacy website did not have the modern design people are accustomed to, did not have a user-friendly or intuitive navigation, had restraints on the type of content that could be added, had a less-than-ideal search feature, and was not mobile-friendly.

Response: The Communications team worked with Consortium staff to develop the architecture, navigation, and content for the website. As one of the main sources for science-based information, resources, and organizational procedures, the website provides publications and information generated from the Consortium’s administration,

research, extension, communications, and education departments.

Results: The S.C. Sea Grant Consortium's redeveloped website, www.scseagrant.org, was launched June 19, 2019. The website features intuitive navigation, optimized content for better search engine results, fast performance across a broad range of devices, and adheres to Web Content Accessibility Guidelines 2.0 for ADA compliance. In addition, a robust search page with enhanced internal search function and topics by category helps users search for and find specific information quickly.

S.C. Sea Grant Consortium *Coastal Heritage* Magazine Deemed a Best Practice by National Sea Grant Site Review Team

Susan Ferris Hill, Joey Holleman, and Crystal Narayana, S.C. Sea Grant Consortium

Recap: One of the results of an August 2019 National Sea Grant Site Review was that *Coastal Heritage*, the Consortium's flagship publication, was deemed a Best Practice by the Site Review Team. According to the Site Review Team, "The quarterly, *Coastal Heritage*, provides a superb resource to the community, in South Carolina and beyond. The integration of science and scholarship with history and culture is a model of excellence and is a tradition well worth preserving."

Relevance: *Coastal Heritage* has been published by the Consortium since 1982. Over time, the publication evolved from a four-page bulletin to a 16-page magazine. *Coastal Heritage* is part of the Consortium's long-term strategy to increase scientific literacy and to improve public understanding of South Carolina's coastal and marine environment, culture, and history.

Response: Hard copies of *Coastal Heritage* are distributed to a well-maintained list of 5,000 national and international subscribers. Text and PDF versions are available on the Consortium website at www.scseagrant.org/coastal-heritage. The target audience includes students and teachers from middle school to postgraduate, scientists, natural-resource managers, urban and regional planners, coastal property owners, coastal business owners, coastal visitors, S.C. legislators, government agency and municipal staff, non-governmental organizations, news media, and the general public.

Results: *Coastal Heritage*, the Consortium's flagship publication, was deemed a Best Practice by the Site Review Team during the August 2019 National Sea Grant Site Review.

S.C. Sea Grant Consortium Publications Won Three Prestigious Awards

Susan Ferris Hill and Susan Lovelace, S.C. Sea Grant Consortium

Recap: The Consortium won three prestigious awards for three publications. *Coastal Heritage*, the agency's flagship publication, won a Distinguished Award from the Society for Technical Communication-Carolina Chapter. The Consortium's website, www.scseagrant.org, won an APEX Award of Excellence in the Most Improved Website category. The publication, *Susceptibility of Public Health Impacts from Flooded Water, Wastewater, and Public Health Infrastructure*, won a Notable State Document Award from the South Carolina State Library.

Relevance: Recognition by communications professionals and librarians from the Southeast region and the State of South Carolina is one metric by which success is measured. Acknowledgement that publications are relevant, interesting, well-researched, and provide significant information to the public confirms the Consortium's public service role is successful.

Response: The Consortium regularly submits publications to various award competitions. The primary contributors to these three publications are staff in the communications, extension, education, and administration departments, as well as university partners.

Results: The Consortium won three prestigious awards from the Society for Technical Communication-Carolina Chapter, APEX, and the South Carolina State Library.

S.C. Sea Grant Consortium Fosters Student Support through Internships, Fellowships, and Research Opportunities

Susannah Sheldon, S.C. Sea Grant Consortium

Recap: In 2019, S.C. Sea Grant Consortium supported eight undergraduates, 18 master's-level students, and 17 Ph.D. students in conjunction with Consortium-funded research, projects, and fellowships.

Relevance: Supporting undergraduate and graduate students and early career professionals leads to an informed, engaged, and well-trained workforce.

Response: The S.C. Sea Grant Consortium is involved in several initiatives that support education and professional development for these individuals. Fifty-five Knauss fellows have been selected from South Carolina since 1984, and 20 Coastal Management fellows from South Carolina have been placed with various state agencies nationally since 1997. In addition, the Consortium partners with the S.C. Space Grant Consortium to support the annual Kathryn D. Sullivan Earth and Marine Science Fellowship, designed to increase the number of highly trained earth and marine scientists and to enable graduate students to conduct NASA- and NOAA-related Earth/marine science research.

Results: In 2019, S.C. Sea Grant Consortium supported eight undergraduates, 18 master's-level students, and 17 Ph.D. students in conjunction with Consortium-funded research, projects, and fellowships. Of these, 18 were new to Sea Grant support and 25 were continuing to receive support. Five of the graduate students were S.C. Sea Grant Consortium extension, education, and administration interns for the Consortium. Three Consortium-nominated students were selected for the Knauss fellowship and one for the Sullivan award. S.C. Sea Grant Consortium student support has improved ocean and coastal literacy among university students and early professionals and encouraged their success in securing coastal- and marine-related employment.