

# WEATHER AND CLIMATE RESILIENCE

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## IMPACTS

### **S.C. Sea Grant Consortium Provides Expertise to Guide Charleston, S.C. All-Hazards Vulnerability and Risk Assessment**

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**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 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.

**Results:** A report detailing the results of the assessment was released by the City of Charleston on November 12, 2020 along with a presentation of findings to the City's Resiliency & Sustainability Advisory Committee on the same day. In addition to identifying vulnerabilities and risks, the report provides adaptation options and sets priorities for reducing those vulnerabilities and risks.

**Partners:** Charleston, S.C.; College of Charleston

### **S.C. Sea Grant Consortium and College of Charleston Provide Assessment of U.S. Department of Agriculture Foundational Dataset**

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** An analysis was conducted to improve the utility of the foundational U.S. Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP), which is a vital resource for research professionals and resource managers across the country.

**Relevance:** The USDA NAIP Program is the authority on curating biennial aerial imagery for every state in the country, used as a foundational dataset by experts in every scientific discipline employing remote sensing techniques. Included with these data is a key supplemental file detailing the date, time, and coverage of each flight path during photo collection.

**Response:** A research team from the S.C. Sea Grant Consortium and the College of Charleston conducted an analysis to verify the alignment of the reported data with the ground conditions observed on the aerial images. The team used GIS software to model the position and angle of the sun during the reported time of photo collection and compared the shadows cast across the landscape to those observed on the NAIP images.

**Results:** The team concluded that the time zone reported was incorrect for several years of data, resulting in inaccurate application of the data for time-sensitive analyses. A report was generated and provided to USDA NAIP staff. Staff of USDA NAIP provided the report to their Geospatial Inspection teams in order to correct the issue.

**Partners:** College of Charleston

## **S.C. Sea Grant Consortium and College of Charleston Flood Modeling and Visualizations Enhance Community Resilience**

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** S.C. Sea Grant Consortium co-developed resilience science and engagement products with several coastal communities in S.C. for use in their adaptation planning initiatives.

**Relevance:** The coastal S.C. 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:** In Partnership with researchers at the College of Charleston's Lowcountry Hazards Center, S.C. Sea Grant Consortium staff developed tidal flood models and data visualization portals for three coastal communities (Town of Edisto Beach, Town of Edisto Island, and Town of Hilton Head Island). In response to requests from local administrators in each area, researchers obtained digital elevation models and mean higher high water (MHHW) tidal surfaces and generated simple "bathtub" flood models by uniformly elevating the tidal surface in 6-inch increments and extracting areas where the tide height exceeds ground elevation. Web mapping applications were developed for viewing the resulting flood maps and provided to stakeholders in each community.

**Results:** Maps and data viewers are being utilized by local municipalities as part of their resilience planning initiatives. The flood monitoring application received 21 submissions from residents of the Town of Edisto Beach in 2020 and remains an ongoing resource for the community.

**Partners:** Edisto Beach, S.C.; Edisto Island, S.C.; Hilton Head, S.C.; College of Charleston

## **S.C. Sea Grant Consortium and CISA Provide Coordination and Technical Assistance for Beaufort County Sea-Level Rise Task Force**

**Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C. and Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** Beaufort County, S.C. continues to develop a new Long-Term Resilience Plan and update its comprehensive plan with requested technical assistance from S.C. Sea Grant Consortium. The Consortium is drafting the resilience plan, facilitated in-person and virtual workshops to help shape recommendations, and provided feedback for applying recommendations to the 2021 comprehensive plan update.

**Relevance:** Beaufort County, S.C. 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 the comprehensive plan, it wanted to highlight how sea-level rise planning could be further implemented and integrated.

**Response:** Consortium staff participated in and facilitated meetings, drafted a report, and provided 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. The Consortium leveraged its longstanding relationship with the College of Charleston 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 Long-Term Resilience Plan that highlights specific steps the county can take to increase resilience throughout county policy. Municipalities that are serving on the task force can incorporate the recommendations and other work into their future planning work. Several key recommendations in the draft plan also have been woven throughout the draft comprehensive plan, which will go out for public comment in spring 2021. The county also is a core partner in a research grant application to the Adaptation Sciences grant Program through NOAA's Climate Program Office.

**Partners:** Beaufort County, S.C.; Carolina's Integrated Sciences and Assessment Center; College of Charleston

## **S.C. Sea Grant Consortium Assists Kiawah Conservancy in Obtaining \$172,758 in Grants for Coastal Resilience Projects**

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston and Susan Lovelace, S.C. Sea Grant Consortium**

**Recap:** S.C. Sea Grant Consortium builds capacity within Kiawah Conservancy by providing staff time and expertise to obtain \$172,758 in grant funding for coastal resilience projects.

**Relevance:** Kiawah Island, like most barrier islands in South Carolina, is vulnerable to climate change impacts including sea-level rise, erosion, and coastal flooding. As is the case with other coastal communities, Kiawah Island must take steps to ensure their resilience to these impacts so that quality of life and community well-being can be maintained.

**Response:** S.C. Sea Grant Consortium (Consortium) partnered with Kiawah Conservancy to assist them in obtaining \$172,758 for two resilience projects. National Fish and Wildlife Foundation granted \$123,758 to conduct a series of engagement exercises to identify ecologically and socially suitable nature-based solutions and establish an implementation plan. Town of Kiawah Island granted \$49,000 to study fluctuations of the shallow groundwater table and characterize the vulnerability of marsh habitat to identify hazard mitigation options.

**Results:** Consortium staff provided data, maps, grant writing, and proposal management expertise, playing an essential role in obtaining \$172,758 in grant funds for the Kiawah Conservancy. By providing these resources, the Consortium built capacity within this organization to identify relevant coastal resilience project funds and to understand how to use scientific information to increase the strength of grant proposals. The Consortium's role in

both projects consists of supervising employees, facilitating meetings, and advising on analysis methods.

**Partners:** Kiawah Conservancy; Kiawah Island, S.C.

## ACCOMPLISHMENTS

### S.C. Sea Grant Consortium Partnership to Develop and Deliver High-Resolution Land Use/Land Cover Data Products for Coastal S.C.

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**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 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. Using newly acquired software for the project and adapting techniques developed by the C-CAP team, staff at the Consortium and the College 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 2021. A supplemental analysis was requested from staff of the Consortium and LHC by The Post and Courier, the leading newspaper in Charleston, S.C., to measure changes in the area's tree canopy over the past several decades - with special attention to how this could affect flooding. Findings of the analysis were published December 12, 2020 as part of the newspaper's Rising Waters series.

**Partners:** College of Charleston; Office for Coastal Management (NOAA, NOS, OCM)

### S.C. Sea Grant Consortium Initiates Long-Term Monitoring of the Groundwater Table in Coastal S.C.

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** With the importance of understanding characteristics of the groundwater table for both hazard mitigation and environmental health, the S.C. Sea Grant Consortium, alongside a team of experts, began a long-term monitoring study with the installation of a network of groundwater wells across a barrier island system.

**Relevance:** While much attention is paid to the flow and accumulation of surface water, little is known about the characteristics of the groundwater table and its influence on the plant, animal, and human communities in coastal areas. The depth and salinity of subsurface groundwater are major factors influencing both the health of coastal

ecosystems and flood conditions impacting human populations.

**Response:** Recognizing this gap in knowledge, the Town of Kiawah Island funded a collaborative research project led by experts from S.C. Sea Grant Consortium, Kiawah Conservancy, and the College of Charleston (CofC). The project funded graduate-level students from CofC to install 18 monitoring wells via a stratified sampling design created to sample groundwater conditions across different elevations soil types and locations on the island. Each well was equipped with continuous dataloggers measuring the depth of the groundwater table, with five wells additionally recording salinity.

**Results:** The National Fish and Wildlife Foundation awarded funds to the project team to conduct informed scenario planning, engaging with the local community to discuss green infrastructure and habitat restoration projects to be implemented. Data from this effort will play a major role in informing those discussions and future implementations on the island.

**Partners:** College of Charleston; Kiawah Island, S.C., Kiawah Conservancy

## **S.C. Sea Grant Consortium's New Tidal Monitoring Initiative Puts Local Data in the Hands of Local Communities**

**Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** A tidal monitoring initiative supported by the S.C. Sea Grant Consortium has resulted in seven new tide gauges installed along the state's coast, with an additional 40 planned for installation across coastal North and South Carolina in 2021.

**Relevance:** The low-lying coastal region of South Carolina is highly vulnerable to tidal flooding and has experienced repeated impacts from both extreme and chronic flooding over the last decade. The complexity of these tidal systems combined with the lack of widely distributed monitoring equipment has resulted in a lack of understanding of how to prepare for and respond to these events for local communities.

**Response:** Staff of the S.C. Sea Grant Consortium provided expert guidance and consultation to S.C. Beach Advocates and the American Shore and Beach Preservation Association to support the installation of tidal monitoring stations along the S.C. coast. The tide gauges continuously collect tide height data and were funded through a public-private Partnership where each municipality only had to provide \$500 of the \$2,500 total cost.

**Results:** Seven new tide gauges were installed in the state, with an additional seven installed in North Carolina, greatly increasing the coverage of tidal monitoring in the region. Local administrators from each municipality receiving a gauge participated in a monthly call to provide feedback on installation, lessons learned, and data usefulness-creating a coalition for the use of these new technologies at the local level that persists today. Additionally, a grant application supported by the Consortium was awarded in 2020 by the Southeast Coastal Ocean Observing Regional Association to expand the deployment of sensors to an additional 40 communities across coastal North and South Carolina in 2021.

**Partners:** College of Charleston; American Shore and Beach Preservation Association; S.C. Beach Advocates

## **S.C. Sea Grant Consortium Researchers Seek to Provide Real-Time Flood Conditions to Citizens so They Know When and Where to Avoid Driving When Roads Flood in the Charleston Region**

**Norman Levine and Emma Paz, College of Charleston**

**Recap:** S.C. Sea Grant Consortium researchers are creating a map application to provide real-time flood conditions on roads to end-users Program focus areas: Weather and Climate Resilience

**Relevance:** Citizens in the coastal South Carolina region face an ever-growing struggle with understanding when and where tidally-induced and rainfall flooding are going to impact their daily routines.

**Response:** S.C. Sea Grant Consortium researchers at the College of Charleston propose to create a map application (M-App) to address this issue. Gauge station tidal heights, and current and predicted rainfall conditions and flood hazards will be incorporated into the product via a web-based interactive mapping portal. This will not only inform citizens across the region about the timing and location of flooding on a real-time basis, but it will also provide general information and education on potential surge and hurricane and long-term vulnerability problems.

**Results:** Researchers developed a database of modeled tidal flooding severity for every road in Charleston County, S.C., linking set intervals of tide height to corresponding flood intensity for each road segment. Additionally, the foundation for the application was designed and tested, allowing querying of environmental monitoring data from around the study area and displays the projected flood conditions in real-time to end users.

**Partners:** National Weather Service, Charleston, S.C. (US DOC, NOAA, NWS); Office for Coastal Management (NOAA, NOS, OCM)

## **S.C. Sea Grant Consortium and CISA Assist Town of Edisto Beach to Plan for Sea-Level Rise and Flooding Risks**

**Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C. and Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** S.C. Sea Grant Consortium resilience specialists engaged with residents of the Town of Edisto Beach, S.C. to plan for climate resilience.

**Relevance:** Edisto Island is a tiny and very low-lying barrier island that is already experiencing substantial impacts from flooding and sea-level rise, including routinely failing septic systems, persistent street flooding from tidal flooding and heavy rain, and corroding underground infrastructure. The S.C. Sea Grant Consortium was approached in February 2020 by Edisto Beach town leaders for assistance understanding future risks and impacts related to sea-level rise and flooding.

**Response:** The Consortium identified the opportunity to assist Carolinas Integrated Sciences and Assessments (CISA) with continuing their Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) process research as the town had not done any prior planning. Due to the pandemic, the workshops were postponed multiple times, finally occurring virtually in August and December 2020. The College of Charleston Lowcountry Hazards Center assisted by providing high-resolution bathtub model mapping and using various approaches to collect flooding data from residents.

**Results:** The team is developing a comprehensive report on the findings from the VCAPS sessions and additional analyses, with the goal of helping the Town of Edisto Beach identify ways it can reduce flooding in the short term. The team is anticipating public engagement on the plan to begin in July 2021, with the final report delivered at the end of Summer 2021. The initial lessons learned from this community also resulted in an application to the Adaptation Sciences Request for Proposals by NOAA's Climate Program Office to study groundwater impacts, adaptation pathways, and adaptive capacity in a nearby county.

**Partners:** College of Charleston; Edisto Beach, S.C.; Carolina's Integrated Sciences and Assessment Center

## **S.C. Sea Grant Consortium Workshop at 2020 Social Coast Forum Focuses on Trauma Awareness in Risk Communication**

**Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C.**

**Recap:** S.C. Sea Grant Consortium held a workshop at the 2020 Social Coast Forum to discuss how to incorporate trauma awareness into climate and risk communication.

**Relevance:** As the public gets more experience with flooding and climate disasters, they are more likely to have experienced trauma with them, either firsthand or vicariously. Climate and risk communicators have experiences where they inadvertently trigger these traumas by communicating about future risks.

**Response:** In Partnership with Faith Kearns, California Institute for Water Resources, University of California Agriculture and Natural Resources, and Susi Moser with Susanne Moser Research and Consulting, S.C. Sea Grant Consortium held a workshop at the 2020 Social Coast Forum in Charleston about exploring how to make risk communication trauma aware.

**Results:** The 40-minute workshop explored what trauma is, the causes of post-traumatic stress, the term "trauma informed" and its meaning, and how to shift communication and engagement about risks and hazards to be presented in less triggering ways to those already traumatized by those same risks and hazards. Participants then discussed personal involvement of various communication situations that could have been handled differently. Nearly 50 people attended the session and left contact information for inclusion on future discussions.

**Partners:** Susanne Moser Research and Consulting (SMRC); California Institute for Water Resources

## **S.C. Sea Grant Consortium Submits Final Report for NOAA Regional Coastal Resilience Grant**

**Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C.**

**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. The Consortium submitted the final report in October 2020.

**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.

**Results:** The research team submitted the final report, which contains write-ups of all research conducted under this grant, in October 2020.

**Partners:** Carolina's Integrated Sciences and Assessment Center; Charleston Resilience Network; College of Charleston; The Citadel

## **S.C. Sea Grant Consortium Assists College of Charleston Class to Develop Vulnerability Assessments for Two Areas in Charleston County**

**Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C.**

**Recap:** During the Fall 2020 semester, a graduate course was developed and taught at College of Charleston on applied coastal resilience. Students conducted a vulnerability assessment for their study area and offered recommendations through the engagement of stakeholders and local governments, researching and analyzing data, and gaining real world experience in the field.

**Relevance:** The College of Charleston approached S.C. Sea Grant Consortium in March 2020 to develop and teach a graduate level course on applied coastal resilience. The primary goal of the class was to give graduate students in the Master of Environmental and Sustainability Studies Program real-world experiences.

**Response:** Through a Partnership with Charleston County, two study areas were identified: James Island and the northern part of Charleston County. Eight students worked with the communities, under the guidance of the Coastal Climate and Resilience specialist, to develop a basic vulnerability assessment and recommendations for next steps in building resilience. The Coastal Resilience specialist and others with the College of Charleston Lowcountry Hazards Center provided technical assistance with GIS tools and various analyses for the reports. Municipal and county staff were involved throughout the process, giving students the opportunity to learn more about jobs and post-graduate professions.

**Results:** Over the course of the semester, students broadened their skillsets and delivered both a presentation and a report of the vulnerability assessment and recommendations. The final reports will be shared with the communities in March 2021.

**Partners:** Charleston County, S.C.; Charleston, S.C.; College of Charleston; Awendaw, S.C.; McClellanville, S.C.; Town of James Island



## S.C. Sea Grant Consortium Researchers Examine Sea-Level Rise Risks to Vulnerable Populations

### Mostafa Batouli, The Citadel

**Recap:** South Carolina Sea Grant Consortium researchers conducted a comprehensive literature review and analyzed data in an effort to understand sea level rise impacts on socioeconomically vulnerable populations.

**Relevance:** At the local, county, and state levels, recurrent flooding exacerbated by sea level rise poses a significant threat to the function and performance of coastal infrastructure systems. Local governments and infrastructure agencies in South Carolina are already planning adaptation measures such as building seawalls, rethinking roads, and planting vegetation to absorb.

Understanding the evolution of social vulnerability in the long-term enables decision makers to anticipate the future needs of vulnerable populations and design methods of responding to their needs.

**Response:** Researchers conducted a comprehensive review of climate and sea level rise resilience literature as they relate to vulnerable populations and socioeconomic equity, and analyzed socioeconomic data from the census. Data related to mean sea level rise, tidal variations, and rainfall in South Carolina was also collected.

**Results:** As a result of these efforts, researchers created a comprehensive list of traits that make an individual or a community vulnerable to sea level rise, and have begun modeling the impacts of sea level rise on vulnerable populations.

**Partners:** University of South Carolina (USC)

## Consortium Creates Climate Change Impacts Module for Community Nursing Students

**Susan Lovelace, S.C. Sea Grant Consortium, Sarah Watson, S.C. Sea Grant Consortium and Carolinas Integrated Sciences and Assessments, University of S.C. and Landon Knapp, S.C. Sea Grant Consortium and Lowcountry Hazards Center, College of Charleston**

**Recap:** At the request of faculty the Consortium extension specialists created an asynchronous climate change impacts education module for use by faculty in training 80 students at the MUSC College of Nursing.

**Relevance:** Nurses working in communities are at the ground level of climate change health impacts. However, the university medical faculty that teach them have had little training on climate change and impacts. College of Nursing faculty from the Medical University of South Carolina (MUSC) reached out to Consortium staff for assistance in providing community nursing students with basic information in their practicum population health class.

**Response:** Extension specialists developed an asynchronous learning module on climate change and impacts for faculty to use in the MUSC population health class. Responding to the educational needs and professional challenges for community nurses they created the module to meet learning objectives that included knowledge of climate change impacts in the Southeast U.S., use of sea level rise and risk tools and ability to assess public health impacts from flood to water, wastewater and public health infrastructure.

**Results:** MUSC had 80 students complete the module during the fall 2020 semester. The module included educational materials and two hands-on activities, one of which was a 5-hour field study to investigate where and

how flooding occurs and the other to use the Consortium's Susceptibility of Public Health Impacts from Flooded Water, Wastewater and Public Health Infrastructure guide to assess a location. The faculty identified the need to increase their own competence in this area.

**Partners:** Medical University of South Carolina (MUSC)