

Coastwatch

NORTH CAROLINA SEA GRANT • SUMMER • 2018 • ISSUE 3 • \$3.75

SEACOAST PLANTS
Flourishing in Harsh Conditions



Summer 2018: A Fresh Look at What We Do

No summer doldrums here at North Carolina Sea Grant, as things are really heating up. New research projects getting started. New team members joining. New student fellows selected. Even a new publication is hitting bookstores.

Seems we're all constantly in motion — hopefully forward. That's a great thing as long as we can continue to learn from our current and past efforts, investments, successes and challenges. This summer, the Sea Grant team has been doing just that — reflecting on the past four years of our program. That includes looking internally at our business practices and partnerships, as well as more broadly at our productivity and accountability to reach our research, extension and educational goals and performance targets.

This is all in preparation for a NOAA/National Sea Grant Office federal program review that occurs every four years. In early October, we'll host a two-and-a-half-day site visit. An external review team will evaluate our program's overall organization, as well as our success in meeting our national and state strategic plans.

There's also an opportunity for public comment during this federally required review. Later this summer, our website's homepage will have instructions for sending comments directly to the national team. I encourage you to provide input regarding successes and opportunities for our state program to continue to move forward in the coming years to meet research, extension and educational goals. These could be not only in the coastal region, but also on related topics across the state.

This fall, we'll also survey you, our *Coastwatch* readers and online audiences, to better understand what types of information you find interesting, as well as how you'd like to receive it. Again, it's our opportunity to reflect and adapt in order to deliver news and research in



Susan White

ways that are most meaningful.

We welcome Dave Shaw and Lee Cannon to our communications team as we continue to reach new audiences through Sea Grant, WRII and Space Grant. They both bring unique storytelling and communication skills and perspectives that I know will be exciting additions to *Coastwatch* and our other media. It is a pleasure to have their energy complement that of our research and extension teams.

I also take this opportunity to celebrate our team's excellence that has been recognized within NC State, as well as by external partners in the state, region and beyond. Several examples are highlighted in the Tidings section of this issue.

Hailing from a family where plant identification is a fun pastime, I have already read through the new *Seacoast Plants of the Carolinas* (and have a few copies lined up for holiday presents, too). You can enjoy excerpts and a Q&A with author Paul Hosier in a package starting on page 13. I'm ready to stroll along our coastal nature trails with this user-friendly, informative new guide in hand!

It's a busy time, sure. But it's summer, after all. In between our efforts for purposeful reflection and celebrating successes, you'll also find me making time to dip my toes in any body of water I can find — a lake, the sound, the sea — in order to slow down and cool off with my family and friends.

I hope to hear from you regarding your summer excursions, at snwhite3@ncsu.edu. We also welcome your feedback on how our programs can continue to build on our solid foundation to meet the needs of coastal communities, and others across the state who know and love our coastal region.

—Susan White, Executive Director, North Carolina Sea Grant

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North Carolina's diverse coast offers countless interesting subjects.

The map indicates story settings in this issue — including Carteret, Dare, Hyde, New Hanover, Pender and Robeson counties.



Coastwatch



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North Carolina Sea Grant is a federal/state partnership that promotes stewardship of marine, coastal and watershed resources through research and outreach. It joined the National Sea Grant College Network in 1970 as an institutional program. In 1976, it was designated a full Sea Grant College program. Today, North Carolina Sea Grant supports research projects, along with extension and communications teams.

Susan White is executive director.

The program is funded by the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce, and by the state through the University of North Carolina.

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NATIONAL SEA GRANT CHARTER FINDS A HOME

David Duane, former director of the National Sea Grant College Program, recently entrusted North Carolina Sea Grant with a document declaring the *National Sea Grant College and Program Act* of 1966. The program was established to create and maintain a healthy coastal environment and economy.

Today, the Sea Grant network consists of partnerships between the National Oceanic and Atmospheric Administration and 33 university-based programs in every coastal and Great Lakes state, as well as in Puerto Rico and Guam. The network draws on the expertise of more than 3,000 scientists, engineers, public outreach experts, educators and students.

Duane presented the charter to Susan White, executive director of North Carolina Sea Grant. Signatories include President Lyndon B. Johnson and renowned oceanographer and meteorologist John A. Knauss, among others.



David Duane presents the gift to Susan White.

Knauss hosted the first organizational meeting to plan for the national program, which today administers annual fellowships for graduate students in his name.

Read about the 2019 Knauss fellowship finalists from North Carolina in this issue's "People and Places" on page 35. — D.S.

FISHMAN RECEIVES NATIONAL FELLOWSHIP

The National Oceanic and Atmospheric Administration has named Sydney Fishman a Coastal Management/Digital Coast Fellow. She will work with the Washington Coastal Zone Management Program, focusing on coastline erosion along Washington state's Puget Sound.

Fishman, who earned her master's degree at Duke University's Nicholas School of the Environment, is one of nine fellows who will receive on-the-job education and training opportunities in resource management and policy. The NOAA Office for Coastal Management and the National Sea Grant College Program sponsor the fellowship.

"Fellows often find this professional experience formative for their future careers," says John Fear, North Carolina Sea Grant's deputy director. "Sydney's interest in resilient coastal communities aligns with North Carolina Sea Grant's strategic priorities, and we look forward to the great work she will do in Washington."

The fellowship will bring together her field skills in geospatial and remote sensing technologies, along with her expertise in policy review and development.

"I am most excited to be working with a team of people who are passionate about coastal issues and committed to advancing these causes at the state level," Fishman says. "My fellowship has a lot of flexibility for me to explore my interests and apply my knowledge, and I will have the opportunity to learn from people doing all types of coastal work in the state."

Learn more about North Carolina Sea Grant fellowship opportunities: ncseagrant.ncsu.edu/fellowships. — M.I.



Sydney Fishman's fellowship will be in Washington state.



COASTAL TIDINGS

John McCord, Coastal Studies Institute

ABOVE: Green dye shows the path of a rip current.

BELOW: In some communities, red flags warn swimmers of potential rip currents.

TIPS HELP SWIMMERS AVOID LETHAL RIP CURRENTS

“Safety first” is a key message for all who head to North Carolina beaches this summer. Already this year, multiple deaths have been attributed to strong rip currents that pull swimmers away from shore.

One N.C. death occurred on Bogue Banks, as a father tried to save his daughters. Others included deaths along the Cape Hatteras National Seashore in areas that do not have lifeguards.

Stacey Sigler, safety manager for the National Park Service’s Outer Banks Group, encourages swimmers to use three designated areas. “There has never been a swimming-related fatality at a lifeguarded beach at Cape Hatteras National Seashore,” she notes.

Not all rip currents are deadly, but they are dangerous. The U.S. Lifesaving Association recently updated its statistics that reveal nationwide, nearly 82 percent of all surf-zone rescues are related to rip currents — including along the Great Lakes.

The Park Service team realizes visitors and residents alike often head to unguarded beach locations. Since March 2017, Sigler and colleagues partnered with North Carolina Sea Grant to install more than 150 new rip current safety signs at parking areas and dune walkovers. These are in addition to the dozens of “Break the Grip of the Rip” signs already in place.

The rangers join

other partners — ocean rescue teams and local emergency responders, National Weather Service forecasters, Sea Grant specialists, and members of the media — to reinforce safety messages.

If you are caught in a rip current:

- Don’t fight the current.
- Swim out of the current, then parallel to shore.
- Or, float and tread water. Then, call or wave for assistance.

“No matter what happens, the victim has the best chance of recovering if they can avoid overexertion — and panic often drives that,” Spencer Rogers explained in an Associated Press story that ran in media outlets from *The New York Times* to *The Sacramento Bee*.

Rogers, a specialist in coastal processes with North Carolina Sea Grant, also suggests you pack flotation devices with your beach items.

Other tips include: Never swim alone. Assign someone to stay on shore and watch swimmers of all ages. Save your exact location in your cell phone as a text or note.

Before you head to any beach, check daily online rip current forecasts from NWS coastal offices at weather.gov.

For more information on Sea Grant rip current research and outreach, and links to partners, visit ncseagrant.ncsu.edu/ripcurrents. — K.M.



Dare County Emergency Management



Sasha Campbell/NC State

Mary Beth Barrow earned honors for her many roles.

BARROW COLLECTS AWARD FOR EXCELLENCE

Mary Beth Barrow, fiscal officer for North Carolina Sea Grant and the state’s Water Resources Research Institute (WRRRI), recently received an Award for Excellence from NC State University’s Office of Research, Innovation and Economic Development.

As fiscal officer, Barrow manages budgets totaling over \$30 million and oversees technology projects.

She also has played a key leadership role in supporting the effectiveness of colleagues through varied changes in recent years, such as two office moves and the addition of North Carolina Space Grant members to a collaborative team working under the leadership of Susan White, executive director for Sea Grant, WRRRI and Space Grant.

“Mary Beth could give us all lessons in multitasking with a smile,” White says. “It is a pleasure to work with her on a daily basis.” — D.C.

ANTIBIOTICS DISCOVERED IN STREAMS AND GROUNDWATER

A North Carolina Sea Grant/Water Resources Research Institute Fellow has detected antibiotics in samples from groundwater and streams in three N.C. counties.

Austin Gray — a doctoral student in environmental health science at the University of North Carolina at Greensboro — sampled properties in Alamance, Randolph and Guilford counties. Mass spectrophotometry revealed antibiotics in the surface water of streams, in stream sediment and in the groundwater.

The results suggest that antibiotic pollution in these counties could affect human health. In a recent interview with *UNCG Research Magazine*, Gray explained that exposure could cause people to become resistant to antibiotics, rendering the drugs ineffective.

“There is also concern that antibiotics in the water can change microbial functions, which play key roles in the nitrogen cycle, carbon cycle and methane cycle,” said Gray, who presented his research in Europe earlier this year.

Gray was one of five recipients of the 2017 Sea Grant and WRRI joint research fellowship, which focuses on diverse audiences who have been underserved and underrepresented. This competitive funding opportunity is expected to open again in August to graduate students across the state.

Read more about this and other funding at ncseagrant.ncsu.edu/fellowships and wrri.ncsu.edu/research/funding/.

— D.S.

Austin Gray found antibiotics in water supplies in three N.C. counties.

HARRISON CO-LEADS DIVERSITY INITIATIVE

“It’s critical for Sea Grant programs to be aware of demographic shifts in our coastal communities,” says Jane Harrison, coastal economics specialist at North Carolina Sea Grant, “and to maintain relevance with diverse partners.”

Harrison co-leads the National Sea Grant Network effort to build resilience in the realm of diversity, equity and inclusion. The project has involved all 33 Sea Grant programs in developing a strategic vision to broaden participation in Sea Grant programming. Harrison says this vision includes establishing and increasing engagement with coastal communities’ diverse populations.

As part of the effort, she and her colleagues are gathering baseline information about how Sea Grant programs currently apply these principles in their operations. The team also is formulating goals and objectives for the next 10 years, along with a plan to identify initiatives to help the network reach those goals, and to measure success.

Harrison says Sea Grant programs have ties with people in rural and urban areas, and across race and ethnicity, economic base and culture. “I’ve been impressed by the creativity of Sea Grant program staff to reach new audiences in communities that vary along so many dimensions.”

For more information on the Sea Grant network’s efforts on these topics, contact Harrison at jane_harrison@ncsu.edu. — D.S.



Courtesy Jane Harrison

Jane Harrison is among leaders of a national diversity initiative.

PERRIN EARNS EQUAL OPPORTUNITY CERTIFICATION

Christy Perrin recently completed a certificate program through the Equal Opportunity Institute at North Carolina State University.

Perrin focuses on sustainable waters and communities for the North Carolina Water Resources Research Institute (WRRI) and the state’s Sea Grant program.

As a participant in the yearlong training, Perrin considered equal opportunity issues in the workplace and developed skills to excel in diverse working and learning environments.

“We don’t know what we don’t know,” Perrin says. “Experiences of discrimination, microaggressions, exclusion and institutional barriers can be invisible to those who haven’t experienced them.”

By learning about federal and university equal opportunity protections, Perrin developed skills for forming new partnerships. “For me, the most powerful part of the institute came with hearing stories from — and conversing with — fellow participants.”

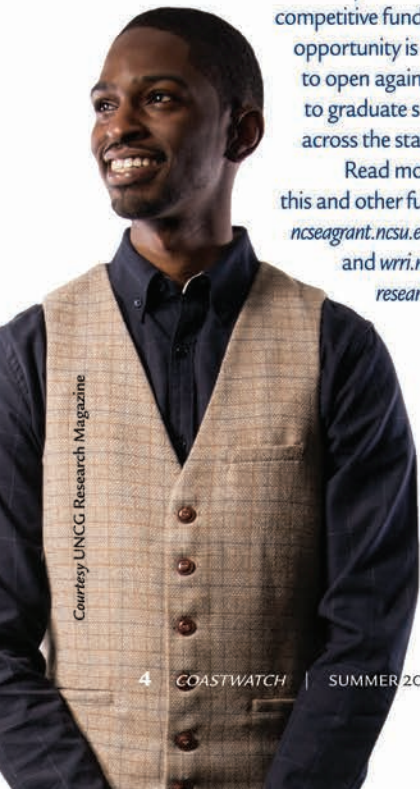
Through WRRI and Sea Grant, Perrin leads initiatives that involve multiple sectors and citizens in planning, studying, protecting and restoring water resources in a sustainable manner. Her special interests include helping organizations enhance community development, particularly in historically underserved areas.

For more on Perrin and her work, visit go.ncsu.edu/christyperrin. — D.C.



Courtesy NC State University Office for Institutional Equity and Diversity

Christy Perrin completed the yearlong training program.



Courtesy UNCG Research Magazine

POPULATION
EBBS AND FLOWS

Photo courtesy Chip Henderson/VisitNC.com

A beach view in Onslow County, the county with the highest share of non-native residents.

Population estimates released by the U.S. Census Bureau in March tell contrasting stories about counties on the North Carolina coast. While Brunswick County outpaces the rest of the state with its 21.8 percent growth since 2010, coastal areas in the northeastern region have experienced stagnating or declining populations over the same period.

“Brunswick County is the fastest-growing county in the state, in spite of having more deaths than births in recent years,” says Rebecca Trippett, founding director of Carolina Demography at the Carolina Population Center at the University of North Carolina at Chapel Hill. “The county’s population growth is fueled entirely by large in-flows of people from other places, primarily retirees.”

According to Trippett, a growing share of Brunswick residents were born outside of North Carolina. “The only coastal county with a higher share of non-native residents is Onslow County, home to Camp Lejeune and a large military population,” she says.

Onslow, Brunswick and the two coastal counties between them — Pender and New Hanover — are all growing faster than the state as a whole. In stark contrast, though, are the population trends in northeastern North Carolina, which Trippett attributes to a long-term decrease in agricultural and manufacturing jobs.

“As economic opportunities in the northeast declined, young adults were more likely to move away to seek education and employment elsewhere,” Trippett says. “The age structure of the population makes it very difficult to grow unless people move in.”

According to the U.S. Census Bureau, North Carolina has experienced the fifth largest growth in population size from 2010 to 2017 and remains the ninth largest state in the nation. — D.S.



Gregory Breese/USFWS

Atlantic horseshoe crabs are a keystone species.

BLUE BLOODS
SPAWN RESEARCH

BY ANTHONY DELLINGER,
KEPLEY BIOSYSTEMS INC.

The Atlantic horseshoe crab is a keystone species, meaning that it plays a vital role in its ecosystem. For example, many migratory shorebirds rely on horseshoe crab eggs for fuel. But the species also is critical to human medicine.

Horseshoe crab blood contains a unique cell called an amebocyte. When amebocytes are exposed to bacteria like *E. coli* and *Salmonella*, they form a clot around the pathogen, preventing infection from spreading. These specialized cells form the basis for the most widely used, FDA-approved safety assay for detecting certain bacterial contaminants in injectable drugs and implantable medical devices.

Each year, about 500,000 horseshoe crabs are collected from the Atlantic seaboard for this purpose. Most are taken while spawning. Although the majority of crabs are returned to the water after their blood is harvested, an estimated 15 percent don’t survive.

This past June, researchers from Kepley BioSystems in Greensboro published a review in *Frontiers in Marine Science* that describes our company’s innovative efforts to improve how horseshoe crab blood is harvested. The ultimate goal is to provide a sustainable supply of blood while also conserving the species.

In 2017, our company received a North Carolina Sea Grant minigrant.

“We are excited about this industry partnership,” notes John Fear, Sea Grant’s deputy director. “We hope the research results will help ensure the viability of the horseshoe crab population and the species’ role in coastal ecosystems.”



THE

Yvonda Lewis

Continued



The Town of Nags Head has incorporated sea level rise into a comprehensive planning effort, setting an example for municipal policy in oceanfront communities.

LONG VIEW

BY JULIE LEIBACH

Jennette's Pier was rebuilt as an educational center several years after Hurricane Isabel struck in 2003.

Continued



Vol. 12 Aquatic / Jitay / CC BY-NC-SA 2.0

On June 14, Ben Cahoon, mayor of the Town of Nags Head on the Outer Banks, testified before a Congressional subcommittee in Washington, D.C. While the focus was offshore oil drilling, the discussion touched on climate change.

At one point, U.S. Rep. Nanette Diaz Barragán, from California, posed a question to Cahoon: “Is climate change something that you talk about in your city? Is this something that, when you guys talk about sea level rise, you guys make that connection?”

Although the query surprised Cahoon, he answered right away. “We’ve had a number of community forums, and we’ve had community discussion about the issue — what the potential impacts will be,” he replied.

In fact, climate adaptation is official business in Nags Head. In 2015, the town launched a new project called FOCUS Nags Head, an effort to overhaul its land use policies and ordinances. Last summer, the town completed the project’s first phase: a comprehensive plan that explicitly addresses climate change and sea level rise.

The new plan makes the town “the first in northeastern North Carolina to adopt some kind of policy on sea level rise,” says Jessica Whitehead, Sea Grant’s coastal communities hazards adaptation specialist.

Whitehead has witnessed first-hand Nags Head’s commitment to coastal resilience. For the past three years, she has been part of a collaborative team that has been engaging the community in conversations about the town’s unique vulnerabilities — and how to adapt to them.

“The residents of the Outer Banks are extremely resilient to coastal storms, but they will continue to be exposed to sea level rise and climate change in the future,” Whitehead says. “Sea Grant has extensive expertise at helping communities build on their resilience today and continue to adapt and improve that resilience for the future.”



LIVING ON THE EDGE

Since the 1750s, visitors have sought respite along the chain of barrier islands that form the Outer Banks. It wasn’t until 1838, however, that the region’s first public accommodations were built. With room for 200 guests, the Nags Head Hotel set the stage for a tourism boom that continues today.

Although Nags Head’s year-round



Courtesy Town of Nags Head

CLOCKWISE FROM LEFT: • The Town of Nags Head adopted its first Land Development Plan in 1964. • A compound of geodesic domes perches on an escarpment in 1980. • The Ash Wednesday Storm of 1962 was a devastating nor'easter that caused widespread damage along the mid-Atlantic coast. Here, ocean waters run toward the sound over Old Nags Head Woods Road. • Jockey's Ridge State Park in Nags Head encompasses the tallest natural sand dune on the East Coast.

nuisance flooding, erosion and sea level rise.

The sea is rising across the entire coast of North Carolina, but the rate varies depending on location. For instance, geological data and measurements from tidal gauges indicate that the ground is naturally sinking along the Outer Banks faster than it is along the southern coast, according to a 2015 report prepared by the N.C. Coastal Resources Commission's Science Panel. Subsidence alone substantially hastens the rate of sea level rise in northeastern communities like Nags Head compared to other parts of the state. A warming climate will likely accelerate that trend, Whitehead notes.

Nags Head officials also are concerned that storms with heavy rainfall are becoming more frequent. Intense rainfall events tax the town's drainage infrastructure, which primarily relies on a series of discharge pipes that feed into the ocean and the sound.

Because a significant portion of Nags Head sits at or just above sea level, excess stormwater has little place to go. During periods of heavy rainfall, the town has experienced significant flooding — as much as three feet in some areas.

"If you've got water in your yard, you've got a nuisance. You've got water in your house, you've got a problem," says Cliff Ogburn, Nags Head's town manager. "I think we are recognizing an increase in problem flooding."

Managing excess water is not just a matter of safety, but of health. Approximately 85 percent of Nags Head properties are on septic systems, which rely on sandy soils in the ground to filter out liquid waste. According to Ryan, when the ground becomes saturated with water — say, after a series of heavy rainfalls — that natural filtration process "has the potential to be short-circuited."

COMING TOGETHER

Since the town was incorporated in 1961, Nags Head has had a strong tradition of policy and planning. In 1987, an article in the magazine *Planning*, published by the American Planning Association, noted that "Nags Head may be the planningest little town in North Carolina."

What's more, the article stated, "Nags Head has also set a standard for local planning along the North Carolina coast."

The town already has been working to address problems that could be exacerbated by sea level rise. For instance, five years ago, a pilot project designed to provide drainage relief

Continued



David Stick/Courtesy of the Outer Banks History Center, State Archives of North Carolina

Courtesy Town of Nags Head

population hovers around 3,000, its seasonal population can surge to 40,000 at summer's peak. Welcoming visitors while preserving an intimate neighborhood vibe is a balance the town strives to maintain.

"I think Nags Head has always seen itself as a small-town beach community that prides itself in being a family vacation tourism location," says Holly White, the town's principal planner. "Of course, there's always been an emphasis on and commitment to environmental conservation."

Situated adjacent to the Cape Hatteras

National Seashore in Dare County, Nags Head comprises more than 11 miles of ocean shoreline — the longest of any municipality in the county — and more than 45 miles of estuarine shoreline.

"It's a very dynamic environment, one that can change continually," says David Ryan, the town's engineer.

Like other Outer Banks towns, one of Nags Head's most alluring features — its proximity to sound and sea — also makes it vulnerable to coastal hazards, including tropical storms and nor'easters, inundation from storm surge,



Jon Taylor/istock, CC BY-SA 2.0

▪ TOP: A faint rainbow echoes the arc of dune vegetation in Nags Head. ▪ RIGHT: Town officials have easy access to activate well pumps that offer relief for a low-lying area.

for a particularly low-lying neighborhood has since evolved into a permanent solution. The system relies on a series of pumps that draw in groundwater, channeling it to a higher elevation for discharge.

“I think we’re looking more and more toward pumped solutions in order to help improve the efficiency of lowering the groundwater and improving storage in the system that will have a net effect — not only on flood control, but also water quality over time,” Ryan says.

The town’s planning prowess was again evident in its decision to specifically address sea level rise in the FOCUS Nags Head project. “The fact that we’re even having this conversation — you know, we’re saying the words ‘sea level rise’ — I think it’s extremely progressive,” White says.

Town officials knew that outside expertise would be valuable as they developed a climate adaptation strategy. As White tells it, “it became very obvious that the ideal situation would be to run this process with Sea Grant.”

In summer 2015, Sea Grant began a collaborative extension project to provide Nags Head with scientific, policy and legal information to help the town better understand

its vulnerabilities and plan for the future. NC State University, the University of North Carolina Coastal Studies Institute, Carolinas Integrated Sciences and Assessments, or CISA, and Binghamton University in New York have provided additional assistance.

Involving the community was integral to the project. To that end, the team introduced to the town a participatory process designed to enhance public education and discourse about coastal resilience. Sea Grant’s Whitehead had co-created the methodology, known as VCAPS, for Vulnerability, Consequences, and Adaptation Planning Scenarios. (See page 11 for more information on VCAPS.)

To start the process, the team first conducted a series of interviews in Nags Head with a sample of community stakeholders and decision makers. The idea was to gather a baseline read on how the town perceives sea level rise and challenges inherent to resilience.

Information gleaned during those interviews guided the next phase: facilitated group discussions with community members, which took place over two days in late 2015.

More than 60 people attended, according



Courtesy Town of Nags Head

to White. “It was a broad range of representation there,” she says, including real estate representatives, homeowners, business owners and academics, and even several curious residents from Hatteras.

The workshops gave participants the opportunity to ask questions, identify problems unique to their town, and brainstorm ways to address them.

“One of the things that we heard during the breakout group discussion is that the environment is their lifeblood because they’re a tourist town,” says California Sea Grant’s extension director, Lisa Schiavinato. She served as North Carolina

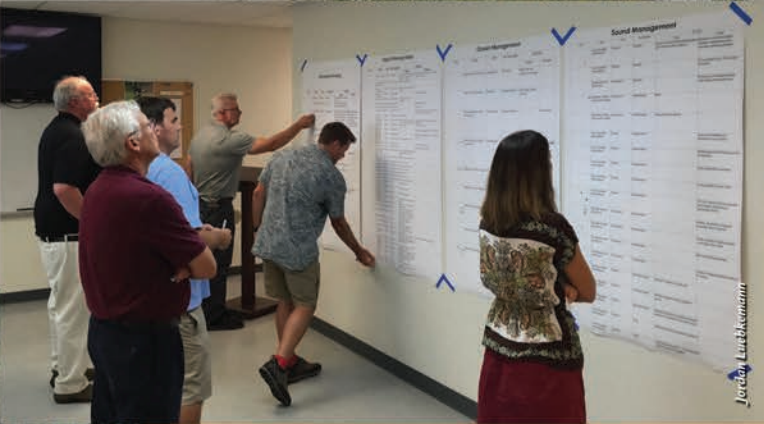
Continued on page 12



Dave Gaitley/FEMA News Photo



Rob Morris/Outer Banks Voice



Jordan Lubkemann

- TOP LEFT: In 1999, Hurricane Dennis fueled flooding along Old Oregon Inlet Road.
- RIGHT: Nags Head officials urged caution in July 2018 after heavy erosion caused an escarpment, or steep slope, in a dune.
- BOTTOM LEFT: Subcommittee members met in August 2016 to continue to prioritize actions suggested during the VCAPS process.

PLANNING FOR UNCERTAINTY

Adaptation is not a one-size-fits-all approach.

To improve their resilience to hazards, coastal communities must understand their specific vulnerabilities. One approach to helping decision-makers better prepare their towns for the future is a process called VCAPS, for Vulnerability, Consequences, and Adaptation Planning Scenarios.

Jessica Whitehead, Sea Grant's coastal communities hazards adaptation specialist, co-developed the process in 2009, with partners from the Social and Environmental Research Institute

The VCAPS process hinges on engaging community members in open dialogue. The idea is that talking candidly builds an atmosphere of trust and understanding, which can lead to greater local support for adaptation strategies.

Those conversations are "the value-add of doing VCAPS," says Whitehead, who's also a member of the Independent Advisory Committee on Applied Climate, which is developing recommendations to help federal, state and local governments, communities and businesses plan for the effects of climate change.

The VCAPS process entails three phases. First, team leaders — such as Sea Grant extension specialists — interview

(SERI) and Carolinas Integrated Sciences and Assessments (CISA), through funding from the NOAA Climate Program Office. At the time, Whitehead had a joint appointment as the regional climate extension specialist for the South Carolina Sea Grant Consortium, North Carolina Sea Grant and CISA.

local community stakeholders and decision-makers. Those interviews then guide the second phase, which unfolds over a series of facilitated group conversations open to the public.

As part of those discussions, facilitators lead a diagramming exercise that encourages participants to consider several categories: management concerns, such as public health; location-specific hazards, such as beach erosion; the effects of those hazards; and the implications of those effects. Participants also brainstorm ways to improve resilience.

In the third phase of VCAPS, team leaders create reports based on the discussions. Communities can then use those reports as guides for developing local adaptation plans, or for integrating new adaptation strategies into existing plans and processes.

So far, seven state Sea Grant programs have worked with academic and community partners and local jurisdictions to incorporate VCAPS into projects with 18 communities or industries. The Town of Swansboro is next on the list.

For more information on VCAPS, visit vcapsforplanning.org.

Sea Grant's law and policy specialist from 2007 to 2016 and was part of the project team. "They really care about having clean water, they really care that their roads are not flooded, they care about having healthy beaches, they care about having healthy wetlands."

A critical component of the workshops was an exercise that helped participants identify actions the community could take to avoid or mitigate certain hazards. Participants poured themselves into the activity.

"We had a huge number of actions that had to be pared down and then prioritized," White says. In fact, there were more than 150.

In 2016, Sea Grant guided a town subcommittee in pruning those actions. The team included the trimmed list in a final VCAPS report, which the town's Board of Commissioners adopted in 2017.

The report is intended as a "road map" for Nags Head as it continues developing adaptation strategies, Sea Grant's Whitehead says. Indeed, the town's comprehensive plan incorporates several actions identified in the report, along with a scientific synthesis of sea level rise drafted by Whitehead.

For White, community participation has been essential to gaining public support for Nags Head's planning efforts.

"When you begin to engage the community and you're asking them, what do you think? Or, what's important to you? Or, how do we accomplish this? Then it becomes really important for us to take the time to listen to what the community has to say and then figure out how to implement that, if possible. And all that takes a large amount of time," White says.

"But the result is that you have a really thorough, comprehensive document, and you have a citizenry that's extremely educated about the topics that they've been involved with. And as a result of that, they become champions of the plan."

FACING THE FUTURE

Whitehead continues to work with Nags Head. When it comes to adaptation, the long view is key, she says. The time span of a typical 30-year mortgage won't cut it.

"When you put in a stormwater pipe, it has to be there for longer than 30 years. When you put in a road, that road is in there, and you are stuck maintaining it as long as you can," Whitehead says.




• ABOVE: Nags Head's small-town, family-friendly vibe attracts many tourists each year.

But improving resilience is, fundamentally, a learning process — one that takes time and patience. "Adaptation is a marathon, not a sprint. And in fact, it's probably an ultramarathon," she says.

As White sees it, Nags Head is already on the right track. "What I think I have learned through this process — of looking at how we adapt and become more resilient — is that there are a lot of things that we're already doing," she says.

"We're already doing stormwater management planning. We're already looking at beach renourishment. We're already looking at hazard mitigation and how we respond. But we're adding an extra layer, or lens, into these planning efforts."

By weaving sea level rise into its policy and ordinances, Nags Head has set a precedent that could inspire others to follow suit.

"I would say to any town who came and said, 'Hey, how do you do this?' that it's a long-term exercise," says mayor Ben Cahoon. "You need to get started. Don't wait on it. Go ahead and commit to it." 

MANAGING RELATIONSHIPS

New planning processes that holistically consider water, wastewater and public health sectors are necessary to improve emergency response to coastal hazards.

Under the South Carolina Sea Grant Consortium's leadership, North Carolina Sea Grant helped develop a protocol designed to bring emergency managers, municipal planners, water and wastewater operators, and health officials together to consider the potential impacts of hurricanes as sea level rises. The goal is to identify where priority assistance is needed when planning for possible outcomes.

The team — which also includes researchers from East Carolina University, Old Dominion University and Virginia Tech University — tested the five-hour protocol during workshops in Charleston, S.C., and Morehead City, N.C., and has plans to create a guide for its use in other areas. For more information, contact Jessica Whitehead at j_whitehead@ncsu.edu.

THRIVING IN SUN, SALT AND SAND

BY PAUL E. HOSIER

Excerpts from *Seacoast Plants of the Carolinas:
A New Guide for Plant Identification and Use in the Coastal Landscape*

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The coast of the Carolinas stretches from the unincorporated community of Carova Beach, N.C., located north of the Outer Banks, to Daufuskie Island, S.C., near the mouth of the Savannah River. Distinctive in many ways, the Carolinas' coastal environment differs from the roller coaster-like Piedmont and the imposing Appalachian Mountains. A complex interplay of features gives the coast its identity. There are salty ocean waters and muddy estuaries, nutrient-poor and highly mobile sandy substrates, salt-sheared forests and expansive coastal grasslands, occasional nor'easters and punishing hurricanes. These elements, combined with the dynamic wave and

tide actions, merge in time and space to create a unique complex of conditions to which only a limited number of plants and animals have adapted.

The uncommonly attractive yet alien-appearing plant and animal communities created by the intersection of land, sea, and air draw many people to this coastal setting. Millions of people visit this region for action- or leisure-filled vacations each year; hundreds of thousands call the area home, and

tens of thousands find fulfilling work there, ranging from commercial fishing to tourist-oriented service positions. This is all facilitated by — or because of — the existence of coastal communities and their natural surroundings.

While the Carolinas coast presents a somewhat varying geologic history and pattern of human land use, many environmental factors interact to create the distinctive setting that we sense and recognize as “the coast.” These include water (primarily salt water), sand, sun, wind, and storm activity. Here we find unique assemblages of plant and animal communities, including the beaches, dunes, forests,

Continued

Gary Allen

BELOW: *Blanket-flowers bring color to the coastal landscape.*



and wetlands. It is in these communities that we discover scores of plants, each exceptionally well adapted to the environment and coexisting with other plants and animals.

The Carolinas coastline varies from the long, narrow barrier islands of the Outer Banks anchored by Cape Hatteras to the high, wide iconic Sea Islands such as Kiawah and Hilton Head islands. Extensive dunes, maritime grasslands, and maritime shrub thickets dominate mile after mile of shoreline along the Outer Banks. In contrast, the topographically diverse and vegetationally complex islands of the southern North Carolina and the South Carolina coasts exhibit a preponderance of salt-aerosol-sheared arborescent vegetation, often with a narrow strip of grassy dunes along the seaward edge. Brackish marshes and salt marshes sharply define the edges of the upland communities along the estuarine shorelines of the Carolinas. Freshwater swamps, marshes, and ponds are embedded within the dunes and maritime forests.

Compared to the multifaceted and diverse dunes, grasslands, and forests, the marshes appear superficially similar. However, on closer inspection, we see that they range from structurally and vegetationally complex freshwater plant communities found in Currituck Sound to seemingly endless, monotonous expanses of estuarine marshes where but a single plant species dominates thousands of acres of intertidal environments in Port Royal and St. Helena sounds.

• Climate

Proximity to open water influences the climate along the Carolinas coast; large water bodies tend to moderate the climate by narrowing temperature extremes along the adjacent shores. This region experiences mild winters and hot, humid summers. Temperatures in the coastal Carolinas reach their average maxima of approximately 90°F in July and August and the minima in the mid-30's F in January and February.

The Outer Banks of North Carolina report generally cooler average high temperatures during July and August (mid-80's) and warmer average lows in the winter (high 30's) than the rest of the coast. Because the United States Department of Agriculture (USDA) defines its plant hardiness zones by the average minimum temperature experi-



Paul E. Hosier

enced in an area, species adapted to higher minimum temperatures often thrive along a generally cooler coast. Conversely, species adapted to very hot temperatures rarely inhabit coastal plant communities.

Extraordinarily warm or cold temperatures experienced in the coastal Carolinas influence plants, since they have few thermoregulatory mechanisms compared with the animal world. However, plants adapt to at least short periods of heat and cold stress. Excessive heat during the summer leads to water deficits as water moves from roots to leaves and then to the atmosphere. This process desiccates plants and sometimes leads to the death of the plant.

Precipitation is abundant; however, summer droughts lasting for a month are not unusual in the coastal Carolinas. Annual precipitation in the region is evenly distributed throughout the year and averages 50 to 55 inches. The region experiences rainfall maxima in July and August; the least precipitation occurs in November and April. Rains accompanying hurricanes contribute significantly to summer rainfall totals.



Gary Allen

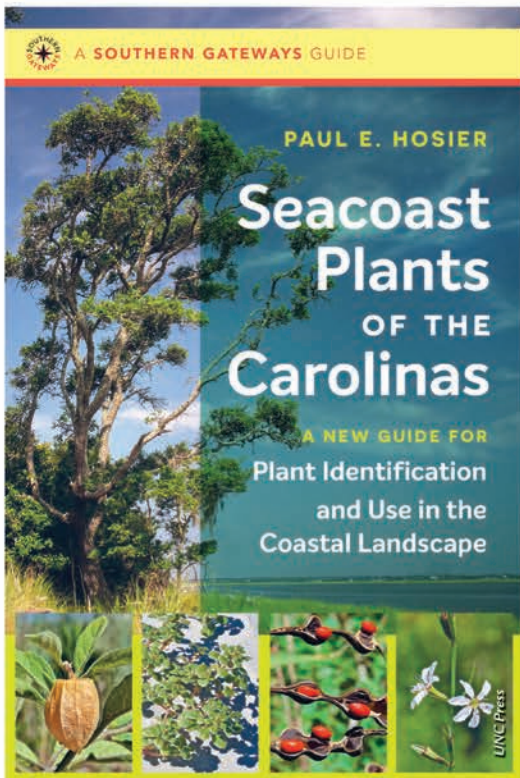
CLOCKWISE FROM TOP: • Where trees are far from the ocean, salt aerosols are so diminished that they have little influence on the growth of leaves and branches. • Beaches, dunes, maritime grasslands, maritime shrub thickets, and occasional freshwater wetlands separate ocean and estuarine environments along the narrow portions of the Outer Banks. • Paul Hosier has written a completely new edition of *Seacoast Plants of the Carolinas*. • Now retired from UNC Wilmington, Hosier still leads tours for the state's Native Plant Society and other groups.

The water table is usually close to the surface compared with more inland areas. Many trees and other deeply rooted plants can reach either the water table or the moist zone just above the water table. These deeply rooted plants can survive short periods of drought during the summer, a time when evapotranspiration lowers the water table. Similarly, deep taproots aid dune plants in collecting water during dry periods.

In extended drought conditions, coastal plants react by dropping leaves, which effectively reduces transpiration and therefore water loss. Deep taproots aid dune plants in collecting and storing water during dry periods.



Outer Banks Visitors Bureau



• **Tides and Salt Water**

Tides are diurnal in the coastal Carolinas and increase in range from north to south. The spring tide range at the ocean edge varies from around 3 feet at Duck, N.C., to more than 7 feet at Hilton Head Island, S.C. In the estuaries, spring tides range from less than 1 foot in portions of Pamlico Sound to more than 9 feet in Port Royal Sound.

The presence of salt water is the most influential factor defining the coastal environment. Salt water is ubiquitous in the coastal zone; it is obviously dominant in the ocean and estuaries, but it is also important in the atmosphere in aerosol-sized droplets. In addition, salt water may intrude into the groundwater when coastal

aquifers experience excessive freshwater withdrawal. The tidally controlled ebb and flow of estuarine water defines and often delimits the environment in which saltwater-adapted plants live. Adaptation to the presence of salts in their environment is a unique and important attribute of coastal plants.

• **Soils**

Unconsolidated sands — geologically young with poorly developed soil profiles — comprise the soils of the coastal Carolinas. Much of the coastal plain of the Carolinas is composed of sands successively deposited in thin layers when sea level was considerably higher than it is today. Once the ocean retreated, wave and tidal action separated coarse sands from fine silts and clays. Over time, these processes created today's estuaries, barrier islands, and barrier beaches. Today, winds move sand onshore, where native plants arrest this sand and form dunes. These sandy upland soils are typically coarse, dry, mobile, and nutrient deficient.

Moving water generated by the tides and river currents carries silt and clay into the low-energy estuaries typically found landward of the barrier islands in the coastal Carolinas. In sharp contrast to the dunes, tidal marsh soils are composed of silt and clay particles, and they are poorly aerated, often waterlogged, and frequently flooded with salt water. These markedly different environments support distinctive, easily recognized plant communities.

• **Wind**

Residents and visitors alike usually comment on the omnipresence of wind along the coast. The differential heating and cooling of ocean water and upland environments, as well as the low, flat nature of the coastal plain, creates conditions that generate and sustain nearly constant winds. The winds are important in shaping coastal environments; for thousands of years, wind and vegetation have interacted to form and reform the hummocky dunes and swales that characterize the Carolinas coast. Over time, winds move prodigious quantities of sand and subject coastal plants to burial of their stems or erosion of sand from around their roots. Winds are responsible for carrying salt aerosols shoreward, where they

are deposited on the aerial portions of trees, shrubs, herbs, and grasses.

The coastal Carolinas experience winds from all directions in the course of a year; however, the strongest and most frequent winds blow predominantly from the northeast and southwest quadrants along the Carolinas coast. Variations occur depending on the location, season, and weather patterns.

• **Salt Aerosols**

Rooted in place, plants cannot escape salt aerosols carried ashore by onshore winds flowing over breaking waves. Salt aerosols are intense near the beach, and only salt-tolerant plants survive here. Onshore winds deliver salt aerosols in large quantities to the highest dunes closest to the ocean, and aerosols decrease with increasing distance from the beach. In shallow, open estuaries where winds can generate breaking waves, salt aerosols can be carried considerable distances inland by brisk winds. Thus, plants growing near estuaries, sounds, and lagoons must tolerate atmospheric salts as well as elevated soil salinity. Many of the plants described in this guide grow along the estuarine shoreline.

Coastal Carolina native plants vary in response to salt aerosols. Most coastal species exhibit some tolerance. Plants occupying open dunes are well adapted to salt aerosols, while other species occupying, say, the maritime forest floor have no tolerance to elevated salts in the atmosphere — or in the forest soil for that matter. Injury is proportional to the concentration of salt aerosols reaching the plant. Near the ocean, atmospheric salt concentrations are high; at a distance from the ocean, atmospheric salt aerosols are nominal.

There are telltale symptoms of salt-aerosol damage: reduced stem growth, browning on the tips and margins of leaves, thinning of the leaf crown, premature leaf fall, earlier coloration of leaves, and death of twigs on the windward side of a tree or shrub. These symptoms often gradually appear in landscapes as salts build up on plant leaves and twigs or in the surrounding soil. When plants are exposed to chronic salt aerosols, expect to see crown dieback, insect and fungal invasion, and plant mortality. Salt aerosol damage is intensified when the coastal Carolinas experience drought conditions or low humidity for an extended time.

Continued

Sea rocket *Cakile harperi*

- **Family:** Brassicaceae (Mustard)
- **Other Common Names:** Southeastern sea rocket, American sea rocket
- **Range:** Coastal: North Carolina south to Florida
- **Habitat:** Wrack lines, dunes, and maritime grasslands
- **Habit:** Annual herb
- **Flowering/Fruiting Period:** FL & FR April–June
- **Wetland Status:** Facultative Upland Plant
- **Origin:** Native



pod. The shape of the transverse joint is nearly flat; the fruit is 4-angled, and the top and bottom are similar in shape. The 1/4-inch-long seeds are orange-tan to dark brown, laterally flattened, and ovoid.

The lightweight and buoyant top seed breaks away from the plant and is dispersed by wind or water. The lower portion of the fruit typically remains on the plant and germinates in place if buried by sand accumulating around the dead stem.

Authorities consider sea rocket a “winter annual” in the Carolinas coastal setting: seeds germinate in late summer or early fall and overwinter as small plants. During the following spring and continuing throughout the early summer, the plants flower, set seed, and die. North of the Carolinas, a closely related species, northeastern sea rocket (*Cakile edentula*) reflects the typical annual habit of spring germination followed by summer flowering.

Sea rocket requires full sun and well-drained sandy soil. It tolerates salt aerosols and low soil nutrients. A poor competitor, it occupies the sparsely vegetated wrack line with plants such as northern saltwort, seabeach amaranth, and northern seaside spurge.

The shape of the transverse joint in the fruit aids in differentiating between the two native coastal Carolina species of sea rocket. In northeastern sea rocket, the lower portion of the silique is deeply notched—clearly V-shaped—and the upper portion is more rounded, almost balloon shaped. The ranges of the species overlap in northern North Carolina.

A member of the nearly ubiquitous Mustard family, sea rocket is a conspicuous plant of the wrack-line and foredune habitat of the Carolinas coast. During any given year, beach scraping, beach grooming, storm overwash, erosion, off-road vehicle use, and development may erase the ephemeral wrack lines occupied by sea rocket; however, extirpation of this resilient plant is not as likely as with seabeach amaranth, a species with an even narrower ecological niche.

Sea rocket is the only large, common herbaceous plant growing near the foredunes. It is 6 to 20 inches tall with bright

green, succulent stems and leaves. The smooth, glabrous, entire, or crenate leaves range from 1 to 3 inches long and 1/2 to 1 1/2 inches wide.

Flowers are arranged in racemes that elongate as the fruits mature. The racemes often reach a length of 8 inches. Pale lavender to white flowers are 1/4 inch across and possess 4 sepals and 4 petals. Bees, flies, beetles, moths, and butterflies pollinate the flowers.

Botanically, the fruit of sea rocket is a silique distinguished by the presence of a horizontally transverse joint separating 2 seeds enclosed in a dry, corky, lightweight

Marsh pink *Sabatia stellaris*

- **Family:** Gentianiaceae (Gentian)
- **Other Common Names:** Sea pink, salt marsh pink, annual sea pink
- **Range:** Coastal: Massachusetts south to Florida and west to Louisiana
- **Habitat:** Dune swales, maritime grasslands, and upper edges of brackish and salt marshes
- **Habit:** Annual herb
- **Flowering/Fruiting Period:** FL July–September; FR August–November
- **Wetland Status:** Obligate Wetland Plant
- **Origin:** Native



While many plants flaunt attractive flowers with a single color, marsh pink displays a striking flower revealing petals with touches of pink, red, yellow, and white that create an interesting and attractive star-shaped center. Occasionally, this species grows in such profusion that the plants turn acres of maritime grasslands into a multicolored display of flowers swaying in the summer breeze.

Marsh pinks are 6 to 20 inches high with slender, erect, loosely branched stems. Leaves, ranging from 1/2 to 2 inches long, are oppositely arranged, simple, entire, glabrous, and sessile.

Each flower grows on a single pedicel. The 1-inch-wide flowers have 5 short sepals and 5 petals. The stamens

and style are yellow. Bumblebees and other small bees such as sweat bees pollinate flowers. Each fruiting capsule contains about 100 tiny black or brown seeds.

Marsh pink is salt tolerant and commonly associated with brackish environments. It frequently grows amid sea ox-eye, sea lavender, saltmeadow cordgrass, dune finger grass, beach blanket-flower, saltmarsh fimbriatilis, and southern seaside goldenrod.

The plant provides nectar for pollinating insects, and various herbivorous insects feed on parts of the plant.

Propagation is only by seeds.

Unfortunately, the plant is not commercially available. Collect seeds only where marsh pink is growing in abundance;

avoid overcollecting and depleting the annual seed crop. The seeds are tiny, tiny, tiny; just a few seed capsules will generate a lot of seeds!

Marsh pink is either “endangered” or “threatened” in states at the northern limits of its range (Rhode Island, Massachusetts, Connecticut, and New York). This is due, in part, to the expansion of the invasive species common reed into habitats occupied by marsh pink.

Occasionally, we find a similar species, perennial sea pink (*Sabatia dodecandra*), in brackish or freshwater marshes in the coastal Carolinas. Its flowers are twice as large and have 9 to 11 petals.

Continued

Sea oats *Uniola paniculata*

- **Family:** Poaceae (Grass)
- **Range:** Virginia south to Florida and west to Texas and Mexico; also Bahamas and Cuba
- **Habitat:** Dunes and dune swales
- **Habit:** Perennial graminoid
- **Flowering/Fruiting Period:** FL June–July; FR July–November
- **Wetland Status:** Facultative Upland Plant
- **Origin:** Native



Sea oats is a botanical superhero. It can survive rapid sand burial, drought, high winds, salt aerosols, saltwater inundation, high temperatures, and full sun, so it is uniquely adapted to the Carolinas coastal dunes.

Sea oats, a warm-season grass, thrives in a range of shore habitats ranging from the wrack line landward to the seaward edge of shrub thickets and

sand. Sea oats tolerates sand burial up to 3 feet per year, with stem growth and tillering stimulated by this burial.

The glaucous green leaves gracefully arch upward from their underground origin, and the tips return to the sandy surface in a seemingly unorganized fashion. Sea oats leaves grow up to 24 inches long and 1/4 to 1/2 inch wide and have a long, tapered point. During protracted drought, leaves

maritime forests. In fact, it rarely occurs inland from the coastal dunes. The plant is the principal dune-building and sand-binding grass of the southeastern United States. It is planted extensively to stabilize sand along shorelines disrupted or eroded by natural or human changes, such as by hurricanes or development.

Sea oats is a coarse rhizomatous plant with an extensive network of near-surface roots complemented by deep, sand-binding roots. Culms arise from the rhizomes that extend laterally and root at nodes when buried by

roll inward, forming long tubes that reduce water loss through the stomata.


The sea oats inflorescence is the most familiar and striking feature of the plant. It is composed of dozens of spikelets crowded at the top of 3- to 6-foot culms. The spikelets are flat, 1/2 to 1 1/2 inches long, 1/2 inch wide, and composed of 10 to 20 florets. During their maturation, sea oat spikelets turn from blue-green to golden brown. Most flowers do not produce seeds, and research scientists report that spikelets average fewer than 2 seeds each. Spikelets persist on the culms well into the winter. Over time, wind, water currents, and animals disseminate the spikelets.

Birds and small mammals, such as song sparrows, red-winged blackbirds, and mice, consume seeds not quickly buried by blowing sand. Seeds usually remain in the spikelet, as evidenced by the presence of a spikelet almost always entwined by the roots of each germinating seed.

The primary method of reproduction is vegetative growth through rhizome extension and bud formation. Vegetative vigor and flowering of sea oats decrease noticeably in the absence of sand accretion.

The plant grows poorly in habitats with a high water table or continuously saturated soils. Human impacts such as trampling, off-road vehicle use, and urbanization harm the growth and development of sea oats.

It is illegal to collect plants or inflorescences of sea oats in most municipalities in North Carolina and South Carolina without a permit.

Sea oats is available from dune plant growers in the coastal Carolinas. Plugs should be planted in spring or early fall. 

From the Adirondacks to the Carolinas

Compiled by Debbi Sykes Braswell

Coastal plant ecologist Paul E. Hosier is the author of *Seacoast Plants of the Carolinas: A New Guide for Plant Identification and Use in the Coastal Landscape*. This new edition of a classic resource is published by the University of North Carolina Press, in partnership with North Carolina Sea Grant.

Hosier writes about diverse coastal plant communities, explaining the ecology of these unique environments and sharing the benefits of native plants. The book showcases more than 200 plants in detail. Hosier took most of the 700+ beautiful photographs in the book.

A professor emeritus at the University of North Carolina Wilmington, Hosier also served as provost there. He belongs to the state's southeast coastal section of the Native Plant Society, as well as to the Friends of Plant Conservation, serving as a member of its board and as a board officer for several years.

"Paul's background in applied research and his years of coastal field work made him the obvious choice to update Karl Graetz' *Seacoast Plants*, a daunting challenge for what had become known as the bible for coastal plants in the Carolinas," says Spencer Rogers, coastal construction and erosion specialist with Sea Grant. "I think Karl would be quite pleased with Paul's update."

Katie Mosher, Sea Grant communications director, is working with Hosier in the new *Coastal Landscapes Initiative* led by Sea Grant. "We are thankful for the variety of colleagues who join us in the mission of the book and related topics," Mosher says.

• Why did you decide to write this book?

The impetus came from leading field trips for university students and the public. I would rattle off the plant names, and the trip participants would be totally lost about which species I was talking about. To address the problem, I started to provide handouts with scientific names and

common names.

They frequently asked, "Do you have a book or something I could use to find these plants later when I want to look them up?" But there was not a recent book specific enough to address just the coastal area, including the dunes, forests and marshes. Now, with this book, you can learn to identify most of the coastal plants once you see them in the field — and compare them with the photos and descriptions.

Also, for people interested in adding native coastal plants to their property, the book provides a starting point for what to plant where. There's nothing worse than spending time and energy setting out a plant and it's dead after the first season because it's in the wrong place: the salt aerosol is too intense, soil too wet or too dry, or location too windy.

• What do you hope this book will accomplish?

I'm hoping the next generation of students, be they high school or college, will be able to learn the names and understand the ecology of the coastal plants. I also hope that property owners and agency personnel who maintain plant populations will learn more about the ecology and increase their use of our native coastal plants.

When you visit a nursery and select plants for your yard, there are many plants to choose from. Most of the nursery plants offered are nonnatives that have been grown and planted for decades — even centuries. In North Carolina, the new Coastal Landscapes Initiative will encourage landowners and landscapers to install native plants — but commercial plant growers need to be assured that homeowners will seek out those native plants.

This book introduces homeowners to many potential native landscape plants: annuals, grasses, perennials, vines, shrubs and trees that are adapted to coastal conditions, as well as plants that they can ask for at their local nursery.

People spend a lot of money to water nonnative plants, to shelter them, to remove deleterious insects just to keep the plants alive. Much personal time and energy can be saved because native plants don't need nearly as much care as nonnative plants. Natives are adapted to vagaries of sand movement, chronic winds, poor soils and atmospheric salts typical of the coast. So why not use coastal plants that once were growing on your property?

• How did you come to study and love the coast?

Since I grew up in the shadow of New York's Adirondack Mountains, I had no experience with coastal shorelines until my senior year in college. Like many wide-eyed students I was just awestruck by the coast, including rocky shores dominated by myriad sessile animals and interesting algae, grass-covered dunes, forests of gnarled trees, "windswept" shrubs and tidal salt marshes made up of just one or two species.

Wow! This was all new to me, and I couldn't wait to learn more about all of these interesting organisms and their environments. When it came time to select a dissertation topic, I chose a coastal topic: the effects hurricanes have on coastal vegetation. Since my first encounter with the ocean shoreline, I have traveled everywhere I could to observe other coasts, and I compare them with the Carolinas' coastlines.

• What is your favorite part of the coast?

I've always loved the wrack line and dune environment. The native plants that live in these areas along the shore have such amazing ecological adaptations to this environment that allow them to survive where most other plants cannot. 📍

Follow North Carolina Sea Grant on social media for more tips from Paul E. Hosier.

Vonda Lewis

Coastal environments and communities are focal points for new core research projects funded by North Carolina Sea Grant.

Research Responds

Hurricane recovery, science literacy, oyster reefs and aquaculture — these are among the topics of interest spanning 10 new North Carolina Sea Grant 2018 to 2020 core research projects. Research teams will apply often novel approaches to address coastal issues creatively and efficiently.

“We are looking forward to how these innovative studies will examine various real-world needs along our coast,” says Susan White, North Carolina Sea Grant’s executive director. “These two-year projects are considered our core research to complement the organization’s major focus areas.”

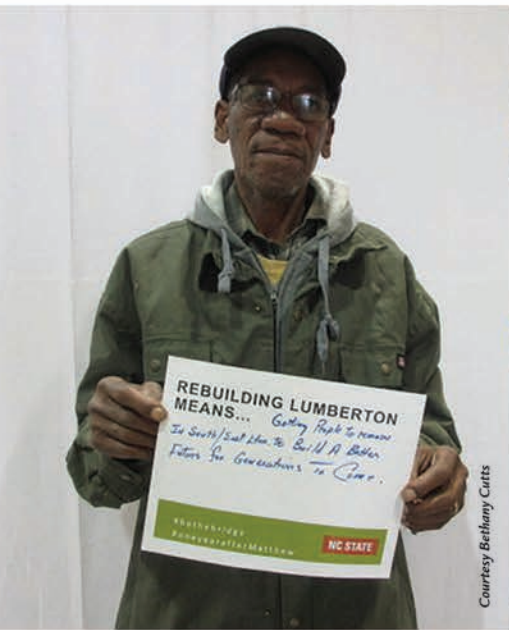
The new projects include researchers from five campuses in the state: East Carolina University, North Carolina State University, the University of North Carolina at Chapel Hill, UNC Wilmington and Duke University.

Four of the projects feature collaborations with researchers at other universities and partners, such as the National Oceanic and Atmospheric Administration lab in Beaufort and Stanford University. Eight of the projects include student support. All provide training opportunities.

NOAA funds these projects through the National Sea Grant College Program, along with state funding through the University of North Carolina system. Each project also includes matching funds from the respective university. *Continued*

to KEY CHALLENGES

BY MARISA INCREMONA



Courtesy Bethany Cutts



Olivia Gnetti



Courtesy Devon Eulie

LEFT TO RIGHT: • Lumberton residents participated in NC State researchers' photo booth to share their stories about community resilience. • A hydrophone has just been retrieved from an unstructured control site after a three-month deployment. • UNC-CH graduate student Carter Smith (right) and UNCW undergraduate student Evan Hill (left) assess living shorelines.

COORDINATING COMMUNITY RESILIENCE

Building Resilience by Innovating through Diverse Group Engagement: Long-Term Recovery from Hurricane Matthew; Bethany Cutts of NC State.

Robeson County is still feeling the effects of Hurricane Matthew, which struck in fall 2016. The county grapples with persistent poverty, and experienced record-breaking high-water marks during the storm. To explore how Robeson residents perceive the relationship between coastal hazards and resilience, researchers will develop a comprehensive “community voice” framework that builds upon interviews, mapping and public videos.

“This project is full of stories of hard work and hope,” says Bethany Cutts, a social scientist in NC State’s Department of Parks, Recreation, and Tourism Management. “Even our early efforts to launch a photo booth as part of community events have allowed us to learn a lot about the strength and creativity of disaster survivors.”

Results will be shared with residents and local decision-makers, including Lumbee tribal leaders, recovery professionals, city planners and community-based organizations. Long-term, the team will continue empowering small museums, libraries and cultural centers to document recovery experiences and share the

information to many audiences.

“Community members in Lumberton and Robeson County are working every day to create a more resilient future,” Cutts says. “They are looking to find ways to connect with other locations to share knowledge, experiences and strategies to create meaningful change in the ways humans interact with their local environment.”

EXPLORING OYSTER REEFS

Evaluating Cultch Oyster Reefs as Essential Fish Habitat; David Eggleston of NC State.

With historically low oyster populations, reef restoration efforts have increased globally. In North Carolina, these habitats also provide important health benefits for the ecosystem, such as removing excess nutrients, stabilizing shorelines and creating essential fish habitat.

A team from NC State will look at cultch, or the mass of broken shells and grit on which an oyster bed is formed. Reefs formed from cultch not only increase commercial oyster harvests, but also support fish species such as black sea bass, gag grouper, sheepshead, weakfish, red drum and tarpon.

“We know that planting of cultch materials on the estuarine bottom by the N.C. Division of Marine Fisheries has a positive effect on oyster populations by providing a place for larvae to

settle and grow, with subsequent harvest by fishermen when oysters reach a legal size,” says David Eggleston, a marine ecologist who also leads NC State’s Center for Marine Sciences and Technology.

“With funding from Sea Grant, we’re excited to determine how the planting of structurally complex cultch materials will provide important habitat for recently juvenile fish, as well as larger predatory fish that may use these cultch oyster reefs as foraging areas.”

By partnering with state fisheries officials, the team will share the research results with management experts. The data also will be a key element for an educational website.

UNDERSTANDING SHORELINE MANAGEMENT

Quantifying the Geomorphic, Ecological, and Socioeconomic Impacts of Shoreline Management Strategies: A Multidisciplinary Approach; Devon Eulie of UNCW; with Rachel Gittman of ECU and Charles Peterson of UNC-CH.

As natural and human pressures continue to affect estuarine shoreline habitats, understanding both the temporal and spatial causes is vital. By using a multidisciplinary research approach, a team representing three universities will assess long-term patterns of



Courtesy Erin Field



Courtesy Joel Fodrie

• **LEFT:** Roger Rulifson samples river herring, which has had declining populations. His team will use innovative technology to study herring's spawning habitats. • **RIGHT:** Jim Morley (left) and Chris Taylor (right) set up survey equipment known as DIDSON. They will monitor fishes in and around shellfish aquaculture operations, analyzing habitat patterns surrounding bottom leases.

change in shoreline and habitats, as well as socio-ecological factors influencing those changes.

"The project team is excited to work on such a collaborative, interdisciplinary study that will enhance our understanding of the impacts on estuarine shoreline habitats," says Devon Eulie, a coastal resource management expert in the UNCW Department of Environmental Sciences and leader of UNCW's Coastal and Estuarine Studies Lab. "We look forward to working with citizens and other stakeholders throughout the project."

The team will develop and test a citizen-science based approach for future shoreline monitoring. The results will help educate homeowners on shoreline conservation and management, which could lead to long-term change at the state and regional levels.

SURVEYING RIVER HERRING

Quantifying Spawning Populations of River Herring Using Environmental DNA; Erin Field of ECU; with Michael Brewer and Roger Rulifson, also of ECU.

River herring, prey for commercial and recreational fish species, is in decline. Using cutting-edge eDNA surveying methods, researchers from ECU will build on an earlier pilot study and continue to analyze N.C. spawning habitats for river herring.

The team will develop a two-week, field-based fisheries quantification course to provide ECU students hands-on experience with traditional and innovative eDNA surveying methods for river herring. In addition, researchers will also develop a citizen-science network for K-12 schools and community colleges to aid in sample collection during the spawning season, thus building a repository of eDNA samples from across eastern North Carolina.

Erin Field, a biologist at ECU, says these results will be compared to the results of collaborators across the Mid-Atlantic region to better assess the current river herring stock along the East Coast. "We are thrilled to begin this project, as we have the opportunity to work with so many amazing scientists, students, and community members to develop a fast and accurate way to monitor this important fishery in North Carolina and ultimately aid in its recovery."

OBSERVING OYSTER-LEASE HABITATS

Habitat Value of Oyster Leases within Estuarine Landscapes for Finfish and Crustaceans; Joel Fodrie of UNC-CH; with James Morley and Abigail Poray, also of UNC-CH. Christopher Taylor of NOAA Ocean Service also will participate.

As marine aquaculture — and especially oyster production — increases in North Carolina,

effects of these mariculture habitats on fish and crustaceans are unclear. To learn more, researchers will survey commercial oyster leases known as "bottom leases" and surrounding landscapes to record data that will be used to create descriptive models of fish density and biomass. By studying leases and the surrounding areas, researchers can monitor residency patterns of fish and crustaceans.

"Our preliminary results show that fish and shellfish are using leased bottom, but the species composition differs when compared to adjacent undisturbed habitats," says James Morley, an ecologist at UNC-CH. "Some desirable species that appear to aggregate towards culture gear include juvenile gag grouper and sheepshead."

The scientists will extend an ongoing field experiment in the Pamlico Sound that is examining how seagrass communities respond to the establishment of oyster culture gear. Overall, the project will help determine the effect of commercial oyster leases on fisheries habitats within an estuarine landscape.

DIAGNOSING HEALTHY OYSTERS

Characterizing and Manipulating Oyster Microbiology for Aquaculture Applications; Brett Froelich of UNC-CH; with Rachel Noble, also of UNC-CH.

Continued



LEFT TO RIGHT: • Brett Froelich's project will consider pretreating oysters to reduce health risks of consuming raw oysters. • As fishing is a major part of coastal communities, researchers will explore what matters most about the industry to producers and consumers. • Researchers set up a nutrient addition bioassay on the Neuse River to analyze the effects of increased levels of dissolved organic forms of nitrogen.

As the demand for oysters continues to rise in North Carolina, risks associated with consumption also are increasing. This project will test a new probiotic treatment, such as is currently used in human health practices.

Instead of treating oysters after they are harvested — a process that can alter the taste or even kill the oysters — the researchers propose a technique that will introduce non-harmful bacteria into young oysters. These added bacteria would prevent harmful bacteria from living inside the oysters. The technique could reduce oyster-related food-borne illness. Given the implications for your health, this study has the potential to shape global shellfish aquaculture, the team notes.

“While there is some risk of eating any raw animal product, through research we can ensure that raw oysters can be enjoyed with safety,” says Brett Froelich, a shellfish expert at the UNC-CH Institute of Marine Sciences. “Thank you to Sea Grant for providing this opportunity, through which we can hopefully provide a nutritious, delicious and safe product.”

STUDYING ATTITUDES ABOUT FISH

The Value of Fishing, Farming and Eating: New Approaches to Understanding Coastal Community Well-Being in a Changing World; Grant Murray, Lisa Campbell, and

Luke Fairbanks of Duke; Linda D’Anna of the UNC Coastal Studies Institute; Joshua Stoll, University of Maine.

The integral role of commercial fishing in coastal communities, as well as the increase of aquaculture production in North Carolina, combine for varied impacts. A multi-campus team suggests that in order to make informed decisions about seafood production, citizens should understand economic impacts, as well as the values and attitudes associated with consuming seafood.

The researchers will implement a mixed-methods approach in the Down East area of Carteret County. By conducting interviews and surveys and analyzing documents, the team will be able to consider decisions of different audiences, such as managers, communities and academics.

“Producing and eating seafood is an important part of life in many coastal communities,” says Grant Murray, who focuses on marine policy at Duke. “But where our seafood is coming from is changing, and we’re working with local partners to better understand that change, and what it means for the well-being of North Carolina’s coastal communities.”

INSPECTING ESTUARINE WATERS

The Missing Link? The Role Dissolved

Organic Nitrogen Plays in Controlling Phytoplankton and Eutrophication Dynamics in the Neuse River Estuary, NC; Hans Paerl of UNC-CH; with Christopher Osburn of NC State.

The Neuse River Estuary is the largest tributary of the Albemarle-Pamlico Sound, a vital fisheries nursery and habitat, as well as an important recreational and tourism resource and the site of increasing residential properties in North Carolina.

Agricultural and urban expansion have led to an increase in nitrogen loading to this estuary, promoting eutrophication, or excessive nutrients in a body of water. Associated negative impacts on water quality can include increases in harmful algal blooms and low-oxygen conditions, known as hypoxia, that threaten shellfish and finfish habitats. While improved wastewater treatment, the construction of riparian buffers and better fertilizer management have led to a decrease in inorganic nitrogen inputs, dissolved organic forms of nitrogen (DON) have increased.

“The observed increase in DON represents a new dimension and challenge to our understanding of how watershed-based nitrogen sources impact estuarine and coastal eutrophication,” says Hans Paerl, an environmental scientist at the UNC-CH Institute for Marine Sciences.



• **LEFT:** Antonio Rodriguez (left) and Carson Miller (right), collect cores from a salt marsh in the Newport River Estuary. It is one of several study sites where the team is assessing marsh resilience to sea level rise. • **RIGHT:** Researchers anticipate beach cleanups can encourage environmental literacy not only for students, but also for their parents and eventually local officials.

Utilizing Christopher Osburn’s ability to identify land-based sources of DON, Paerl’s group will focus on how this increase in DON loading affects the growth and composition of phytoplankton, the base of the Neuse River Estuary’s food web. The results will offer insight into how increased nitrogen in the Neuse River Estuary impacts the ecosystem and overall water quality. These results can then be applied to other similarly impacted estuarine and coastal ecosystems.

REVIEWING SALTMARSH RESILIENCE

Improving Saltmarsh Conservation by Examining Transgression Across a Range of Upland Gradients and Saltmarsh Widths at Decadal to Millennial Time Scales; Antonio Rodriguez of UNC-CH.

Saltmarshes work as buffers protecting inland developments from sea waves, but due to sea level rise, saltmarshes are diminishing globally. Antonio Rodriguez, a coastal geologist at the UNC-CH Institute of Marine Sciences, aims to determine rates of saltmarsh expansion into the forested upland, known as transgression. The research will focus on areas that reflect conditions related to increased storminess and accelerated sea level rise.

“Some of the best records of sea level rise and changes in storminess over the last 1,000

years are based on data from North Carolina,” Rodriguez says. “We’re complementing that previous work with contemporaneous records of saltmarsh landward expansion.”

By reconstructing transgression rates at 40 different N.C. coastal sites, the team will gain a better understanding of how to predict the phenomenon, and how to increase saltmarsh resistance to erosion.

Study results will be shared with scientists, coastal managers and restoration practitioners. In addition, the team will develop educational materials including lesson plans and a virtual field trip for grades 6 to 12.

EVALUATING ENVIRONMENTAL LITERACY

Improving Environmental Decision Making in Coastal Communities through Children: Building Science Literacy, Civic Engagement, and Coastal Resilience with K-12 Citizen Science; Kathryn Stevenson of NC State; with Howard Bondell, Sarah Carrier, M. Nils Peterson, K.C. Busch and Renee Strnad, all also of NC State; along with Elizabeth DeMattia of Duke.

Environmental literacy is vital to understanding and implementing scientific recommendations regarding coastal and estuarine ecosystems. Based on the team’s earlier research, K-12 students may not only improve

environmental literacy in each other, but also in their parents. Additionally, environmental literacy may extend from parents to local officials and larger communities.

Researchers from NC State will work with the Duke University Marine Lab to expand citizen science-based environmental education projects to 32 middle-school classrooms across the 20 counties included in the state’s Coastal Area Management Act.

The results will shed light on how this educational experience affects students’ understanding of the environmental challenges, as well as their awareness of career options. The data also will indicate how the knowledge gained by students ultimately affects decisions made by parents, local officials and community members.

“Environmental education typically focuses on training the next generation so we are prepared for the future,” says Kathryn Stevenson, who focuses on environmental education in her faculty position at NC State’s College of Natural Resources. “We also think that kids can take an active role in helping us respond to environmental challenges right now.”

As these projects unfold, watch North Carolina Sea Grant’s social media feeds on Twitter and Facebook, as well as the Coastwatch Currents blog at ncseagrant.org, and Coastwatch magazine in print and at nccoastwatch.org.



Perspectives of Change

“They’re just stories,” he says.
Or are they?

My dad and I have a Buxton ritual. Oil lamp in hand, he meets me on the screened porch at dark, where we settle into whitewashed rockers. He’ll crank the lamp’s knob to lengthen the wick and strike a match. As reflections of the Cape Hatteras Lighthouse’s beam wash across his face, those stories mingle with the scent of burning oil.

His Hatteras is a different place than the Hatteras I’ve grown to know. His Hatteras is a vivid memory of a place in the past — 25, 50 and 75 years ago. He describes thick, sandy roads and his family’s two-wheel drive Model A Ford that seemingly could handle any terrain.

He mentions the cattle that roamed free and the bull that forced him up a tree for the night. He waxes poetic about the lives claimed by the Graveyard of the Atlantic, and about those rescued by my great-grandfather’s Lifesaving Service heroics.

He also remembers pulling the floor plugs in his grandmother’s house to let in hurricane flood waters so the house wouldn’t float away, and he recalls sweeping out the sand and fish in the aftermath.

He talks about undeveloped land, unadulterated marshes, and abundant fish and wildlife.

He’ll mention that he was one of the first lifeguards hired by the National Park Service at Cape Hatteras. He’ll talk about how far the shorebreak was from the lighthouse then — 1,000 yards, at least — and we’ll marvel at how quickly the beach has retreated westward over his lifetime and at various unsuccessful attempts to slow that process.

We’ll get to the part where, as a summer lifeguard in the ’50s, he spent the night in the top of the lighthouse during Hurricane Donna...or was it Hazel?

“It must’ve been Donna,” he’ll conclude. *Continued*



A breach in Core Banks.

RISING

on the North Carolina Coast

PHOTOGRAPHS AND INTRODUCTION
BY BAXTER MILLER

ORAL HISTORIES COLLECTED
BY RYAN STENCIL AND
BARBARA GARRITY-BLAKE

WITH SCIENTIFIC PERSPECTIVES
FROM JESSICA WHITEHEAD

He'll tell me about the ocean overwash lapping up at the base of the lighthouse, how it swayed back and forth with the wind all night long, and how he clutched his pocketknife as if it could protect him.

For the most part, his stories are about the way things used to be. And while they're just anecdotes to him, they are a living record of time, place and change.

Change is constant across the sounds and along the banks of coastal North Carolina. Perpetually shifting sands, the tides and unpredictable weather patterns have battered and blessed these resilient communities at the water's edge. For generations, natural forces have shaped where people live, how they build homes, what foods they eat, and how they earn an income.

Advances in technology, engineering and construction, along with evolving economic demands, have shaped how people adapt to environmental change. We make bigger dunes and more jetties. We dredge inlets and renourish eroded beaches.

We build our houses higher but closer to the water. We pave land and depend on dikes to protect agricultural fields from saltwater. We face decisions about fisheries as waters warm and populations potentially shift.

We brace for storms and hope that infrastructure survives. As each new hurricane season unfolds, we cope with uncertainty.

What are the experiences and adaptation strategies of people living on the front lines of coastal change? How might the stories of residents, business owners, commercial fishermen, farmers and community leaders offer insight into the manifold threats facing coastal communities? Can they transcend political discourse and offer a new perspective — one that captures the natural, cultural and economic consequences of change? How do their experiences affect perceptions of the future?

These are the questions that *RISING* — an ongoing multidisciplinary research project combining oral history, photography and science — explores.

CHRONICLING CHANGE

The *RISING* project is made possible by the Community Collaborative Research Grant, a program of North Carolina Sea Grant in partnership with the William R. Kenan Jr. Institute for Engineering, Technology and Science at NC State.

Additional support comes from the Center for the Study of the American South at the University of North Carolina at Chapel Hill and *Southern Cultures* journal, along with Food for All, the UNC-CH Department of American Studies, and the Coastal Resilience Center.

The project team includes Karen Willis Amspacher, executive director of the Core Sound Waterfowl Museum & Heritage Center; author Alton Ballance; Ben Cahoon, mayor of the Town of Nags Head; photojournalist Margaret Cheatham Williams; Barbara Garrity-Blake, a cultural anthropologist at Duke University; documentary photographer Baxter Miller; Stanley Riggs, a coastal and marine geologist at East Carolina University; content creator and communications strategist Ryan Stancil; journalist Susan West; and Jessica Whitehead, Sea Grant's coastal communities hazards adaptation specialist.

For more information on the Community Collaborative Research Grant, visit go.ncsu.edu/CCRGprogram.

ON DISPLAY

RISING is on view at the Core Sound Waterfowl Museum & Heritage Center now through September, and will travel next to the Outer Banks. For updates, go to risingnc.com/updates. Those interested in hosting the exhibit can fill out a contact form on risingnc.com, or email project manager Ryan Stancil at adamryanstancil@gmail.com.

On Aug. 14, the Core Sound Waterfowl Museum & Heritage Center will host a conversation, open to the public, about how communities in Carteret County and other coastal areas are experiencing change. Featured guests will include Tom Horton, author of *Island Out of Time*, who will lead a discussion about flux in the Chesapeake Bay. For more details, visit coresound.com.



Patterns form in the main ditch from Juniper Bay to the canal, Hyde County.



A view of ever-changing Hatteras Island.

ON THE BRINK

"We came in at about 10,000 feet over the Gulf Stream. Coming into Elizabeth City. . . we already started descending off Hatteras, 90 miles away. When I looked down, tears came right out of my eyes. When I looked down, I saw the entire Outer Banks. . . I always felt like I was seeing the Outer Banks the way God sees it. . . then I watched that shrink over the years, little by little by little by little." — DWIGHT BURRUS, HATTERAS VILLAGE, RETIRED COAST GUARD PILOT AND PREACHER

Change is a constant along North Carolina's coast. Natural processes, like erosion, wind, weather events and tide shape our shoreline's appearance as sand moves from one place to another — sometimes opening and filling inlets, widening or narrowing beachfront, and altering the tideline of soundside creeks and marshes.

Change also comes from people, whether through land management or coastal development, ranging from building living shorelines to installing bulkheads to dredging. While the shoreline moves and changes, it is more difficult for people and the structures we build to do the same.

Continued

FRAGMENT (facing)

"I remember my grandmother's yard in particular because I lived there for a lot of years. She has a big piece of land. When I was a little girl, I would run in that side yard and play all the time. And my daughter can't do it now because it's basically a swamp where Jarrett Bay is pretty much intruding inward. That ground has just become spongy marsh. I don't think anybody would think to build on it now the way they did if they went there and looked at it."

— LAUREN SALTER, WILLISTON

Marshes are important habitat for juvenile fish species. They also filter water from land, ensuring clean water in our sounds. But will our marshes survive accelerated rising water?

The answer depends on how fast marshes can trap and build up sediment. If a marsh can do this faster than the land sinks and the water rises, then the marsh may survive, albeit changed. Where water rises faster than marshes can build up, erosion will fragment the marsh, transforming once continuous expanses of habitat into smaller segments.

ROAD WORK AHEAD (below)

"Tides have been high here before and they've been extremely high. But the bottom line is the drainage systems are horrible. We've made everything concrete. . . Development has its negative side, and part of it is in stormwater and in water runoff and what takes place. When I was growing up, there was a two-lane road through there, little bit of parking out here, but most of it was rocks so water soaked in. It was all a different environment, totally. Now, every house has got big driveways. And it's not porous. You have lots of problems with that. . . Development has caused a lot of it, there's just no way around saying it hasn't."

— ALLEN BURRUS, HATTERAS VILLAGE, FORMER DARE COUNTY COMMISSIONER

You may be able to raise a home higher above floodwaters — but what about the road leading to it?

As water levels rise, roads that did not previously flood regularly may flood more often — first during storms, then during higher than normal tides. More frequent flood events also can increase wear and tear on roadway ditch drainage systems.

In fact, roads can be raised. Across the United States, many communities, including those in neighboring states such as Norfolk, Virginia, and Charleston, South Carolina, are beginning to plan to raise roads.

Continued



The approach to the North River Bridge, the gateway to Down East, Carteret County.



A changing marsh habitat in Carteret County.



In certain areas, a living shoreline can be more effective than a bulkhead.



A ghost forest in Hyde County.

RESTORATION (facing)

"I remember reading one time about sea level rise that a lot of times, if it's fair weather, it's not real noticeable. But if you have a hurricane, nor'easter, or a whole lot of rain, that's when you can really tell the water's up. ... I think I agree with that statement — that you don't notice [changes] until you have a storm."

— HOWARD BENNING, OCRACOE BUSINESS OWNER, RETIRED TEACHER AND NATIONAL PARK SERVICE RANGER

Erosion is a natural process that can happen over long periods of time — what's known as chronic erosion — or it can be episodic, occurring quickly during storms like hurricanes and nor'easters.

People also can hasten this natural process. For example, boat wakes contribute to erosion, as do hard structures like sea walls, which deflect energy from waves to surrounding areas.

As land sinks and sea levels rise, erosion will happen faster where marshes cannot trap sediment fast enough to keep up. Research suggests that in certain areas a living shoreline may be a more effective solution to erosion than bulkheads or retaining walls.

Living shorelines use natural materials like oyster shells, rocks and native marsh grasses to protect estuarine shorelines, and come with smaller repair and maintenance costs than their manmade counterparts.

INUNDATED (above)

Long before rising seas inundate land, habitats at the edges of our sounds will change. Ghost forests — carcasses of trees that once filled maritime forests — are becoming more common as saltwater penetrates farther inland and remains longer.

Trees sequester more carbon than other types of vegetation, so carbon storage is a good indicator of vegetation type. New research has measured increasing losses in carbon storage between 2001 and 2014 along the edges of the Albemarle and Pamlico sounds.

The results indicate that forests are changing to marshes or being lost altogether. Sea level rise and wind tides may be factors, but fires, which dry out peat and wick salt water from the sounds into land, may also play a part.

"One of the biggest changes I've noticed is probably the dead pine trees on points of land from rising salt water. I noticed how they were declining recently. The pine trees are dying, and it's not just erosion of the land from storms. It's saltwater intrusion. I've counted those trees. Three years ago there were 58 live pines. Last year there were 30 live pines. There are about 13 live pines right now."

—PENNY HOOPER, SMYRNA, RETIRED BIOLOGIST

Continued

THE DIKE SYSTEM

"If it wasn't for the dike in here, and there's probably 11,000 acres inside that dike, I dare say of that 11,000 acres you wouldn't have but 500 or 600 of it that would be farmable now. Twenty years ago, I coon hunted back of this dike. . . some 200 yards out, at least. Beautiful woods. Dead marshland now. You can still see the snags out there, where pine trees were on it."


— J.W. SPENCER,
SWAN QUARTER
FARMER AND HYDE
COUNTY SOIL AND
WATER CONSERVATION
DISTRICT BOARD
MEMBER

A dike is a long wall, made of earth or materials like steel or concrete, built to keep out water. A system of canals, pumps and tide gates ensures that water inside a dike can still get out, and that creeks can still flow in during normal conditions.

The 17.7-mile dike surrounding Swan Quarter took 46 years to complete. The \$13-million dike was first proposed to protect valuable farmland from wind-driven saltwater intrusion.

When Hurricane Irene struck in 2011, the dike protected the village of Swan Quarter from soundside tidal surge.

During tropical storm events in 2015 and 2016, however, farmers had to pump the village because winds kept the Pamlico Sound levels high for days. High sound levels also kept tide gates closed, trapping floodwaters from heavy rain inside the dike.

In 2009, the Natural Resources Conservation Service estimated the dike provides over \$700,000 in annual economic benefit by reducing damages to homes, cropland, roads and bridges. 



*Within the Swan Quarter dike,
a network of flood gates,
drainage canals and water pumps
helps protect agricultural land.*

CAPITAL ACHIEVEMENTS: Knauss Finalists Named

BY DANIELLE COSTANTINI, MARISA INCREMONA AND DAVE SHAW

THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION'S NATIONAL SEA GRANT OFFICE HAS NAMED FOUR NORTH CAROLINA GRADUATE STUDENTS FROM THREE DIFFERENT UNIVERSITIES AS FINALISTS FOR THE 2019 JOHN A. KNAUSS MARINE POLICY FELLOWSHIP.

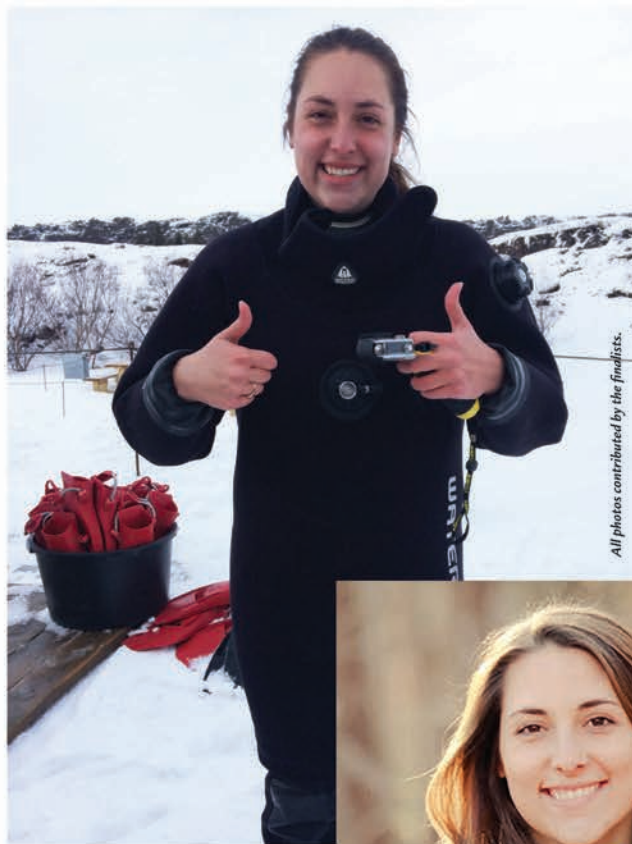
Alicia M. Cheripka, Jill Hamilton, Chrissy Hayes and William Thaxton are among the state's Knauss finalists. Following placement in federal and congressional offices, they will begin the fellowships in February 2019.

This year marks the 40th anniversary for the esteemed program. More than 75 graduate students from North Carolina have served as Knauss fellows since 1979.

"One of the most remarkable successes of the Knauss program has been the long-sustaining network, with personal and professional relationships that benefit these individuals throughout their careers," says Susan White, executive director of North Carolina Sea Grant.

"Individuals I've been lucky enough to know — including N.C. fellows, as well as others from across the Sea Grant network over the past decade with whom I've worked — bring a level of professionalism and situational awareness to their work that makes them stand out in their fields."

This year's finalists from North Carolina already have accumulated a wealth of experience. Their collective educational background and service have supported residents and ecosystems from Indonesia to Oahu and from Peru to Sierra Leone.



All photos contributed by the finalists.



ALICIA M. CHERIPKA

Alicia M. Cheripka graduates in August from the University of North Carolina Wilmington with a master's degree in marine biology. Her thesis project included creating a model to determine how various marine protected area network configurations affect species. She currently works as a research assistant with J. Will White at the Quantitative Marine Ecology Lab at UNCW.

During Cheripka's work in Indonesia as a research assistant for Operation Wallacea, a United Kingdom-based research organization, she witnessed the struggles of conservationists and managers as they tried to develop a fishery-based economy. In collaboration with scientists and students from around the globe, she conducted biodiversity studies, monitored coral habitats and educated fishermen on the importance of preserving fishery habitats.

The project in Indonesia caused a local shift to habitat conservation for ecotourism, as well as diversification of the local economy through

Continued

• **ABOVE:** Alicia M. Cheripka graduates in August from the University of North Carolina Wilmington with a master's degree in marine biology.

help aquaculture and the inclusion of new low-impact fishing techniques. It was Cheripka's first experience with the translation of primary science into real-world solutions.

Cheripka plans to continue to explore the relationship between scientific research management and decision-making in order to strengthen her insights into North Carolina fisheries.



CHRISSY HAYES

Chrissy Hayes is a recent graduate of Duke University, where she earned a master's of environmental

management with a concentration in coastal environmental management. Her studies focused on the performance of small-scale fisheries development.

Previously, she was a graduate student researcher at the Southeast Fisheries Science Center, as well as an oceans intern at the

• **TOP AND MIDDLE LEFT:**

Chrissy Hayes graduated from Duke University with a master's in environmental management and a concentration in coastal environmental management.

• **MIDDLE RIGHT AND BOTTOM:**

Jill Hamilton also earned a master's degree in environmental management from Duke.



Environmental Defense Fund.

Before graduate study, Hayes worked with Tulane University as a research associate on the island of Oahu, Hawaii. While there, she hosted lectures for elementary school teachers and state employees about her group's research and its implications for stream conservation. The experience motivated her to address similar issues while in graduate school.

Hayes now works to identify opportunities to bridge gaps between science and communities. For example, she developed a policy analysis that has guided EDF's upcoming Pacific fisheries work.

In addition,

Hayes worked on projects that ranged from evaluating socioeconomic health of communities to identifying illegal fishing. The latter included analyzing proprietary electronic vessel monitoring data from Sierra Leone, which required learning and using complex

quantitative software to identify illegal, unreported and unregulated fishing.

JILL HAMILTON

Jill Hamilton graduated with a master's degree in environmental management from Duke University. Her thesis focused on aid for small-scale fisheries, analyzing the extent to which aid organizations have improved ecosystems and livelihoods in coastal fisheries.



She currently volunteers with the Environmental Law Institute on the Gulf of Mexico Policy Team.

Last summer, Hamilton served as a policy intern with the Environmental Defense Fund's Cuba Oceans Program, developing and implementing strategies to promote stronger fisheries management. She worked closely with Cuban government officials, nongovernment organizations and fishing communities to strengthen community-based fisheries initiatives. She also helped to organize and conduct trainings on multi-species fisheries management.

Additionally, she completed a research project



WILLIAM THAXTON

Paddling, hiking and fishing around North Carolina's Outer Banks first sparked William Thaxton's love for nature and the ocean. He will complete his master's in biology at East Carolina University this fall, where he has explored the effects of climate variability on several commercially important marine fishes in Beaufort Inlet. At ECU, he also has served as vice president of the university chapter of the American Fisheries Society.

During his time as a National Oceanic and Atmospheric Administration Hollings intern in Santa Cruz, California, Thaxton received a merit award and worked on a project involving the distribution and diet of juvenile salmon.

Throughout his work on different projects,

on fisheries learning networks, producing a report that today guides the EDF fisheries strategy in 10 Cuban communities and other locations globally.

Thaxton has surmounted challenges of many varieties, including equipment malfunction, navigation error, inclement weather and even personal injury. In the Amazonian rainforest, with limited resources, he improvised field techniques to collect frogs and survey insect communities under extremely harsh and often dangerous conditions.

Thaxton anticipates working in the legislative branch on coastal sustainability topics, helping to bridge science and policy. 📍



Inspired by the collaborative marine policy initiatives between the United States and Cuba, Hamilton helped to organize a panel for the 2018 Tulane Environmental Law & Policy Summit, "Gulf Marine Sanctuaries: Cuba, Mexico, and the U.S." This year, she also helped organize a policy workshop in Mérida, Mexico, to explore policy and regulatory reforms for expanding collaborative marine conservation initiatives among the United States, Mexico and Cuba.

• **ABOVE:** William Thaxton will complete his master's in biology at East Carolina University this fall.

THE KNAUSS NETWORK

North Carolina's finalists for the 2019 Knauss Fellowship will join 1,200 professionals who have received hands-on experiences bringing science to policy and management through one-year appointments with federal government offices in Washington, D.C.

Read more about the 2019 Knauss finalists: seagrant.noaa.gov/Knauss.

Read about current Knauss fellows from North Carolina, Elizabeth Clark and Brianna Elliott: go.ncsu.edu/ElizabethClark and go.ncsu.edu/BriannaElliott.

Returning to Shore



Matthew Godfrey/N.C. Wildlife Resources Commission

BY DANIELLE COSTANTINI

• **ABOVE:** In 2005, two leatherback nests were found on Pine Knoll Shores. • **FACING PAGE, TOP:** Terri Kirby Hathaway, Sea Grant education specialist, included leatherbacks in North Carolina's Amazing Coast. "The leatherback is my personal favorite, because of the hooks in its mouth for eating jellies!" Hathaway shares. • **FACING PAGE, BOTTOM:** Sea turtle nests are marked off when they're discovered, like this leatherback nest found at Fort Fisher earlier this summer.

AFTER SIX YEARS, GENTLE GIANTS HAVE RETURNED TO NEST ON NORTH CAROLINA BEACHES.

Theirs was a long journey. Leatherback sea turtles undertake migrations of up to 3,700 miles from their feeding grounds to where they breed and nest. In total, they can travel up to 10,000 miles a year.

"Leatherbacks are typically tropical beach nesters," says Jon Altman, a biologist for the National Park Service at Cape Lookout.

They often choose sites in the Virgin Islands or Costa Rica. In the past few decades, they have started to nest on Atlantic Florida beaches in large numbers — and occasionally they make it to North Carolina.

This summer, Fort Fisher State Recreation Area and Cape Lookout National Seashore each are home to a leatherback sea turtle nest.

At the end of May, a few lucky beachgoers spotted the nests. Rangers with North Carolina State Parks and the National Park Service

quickly marked the areas to protect them.

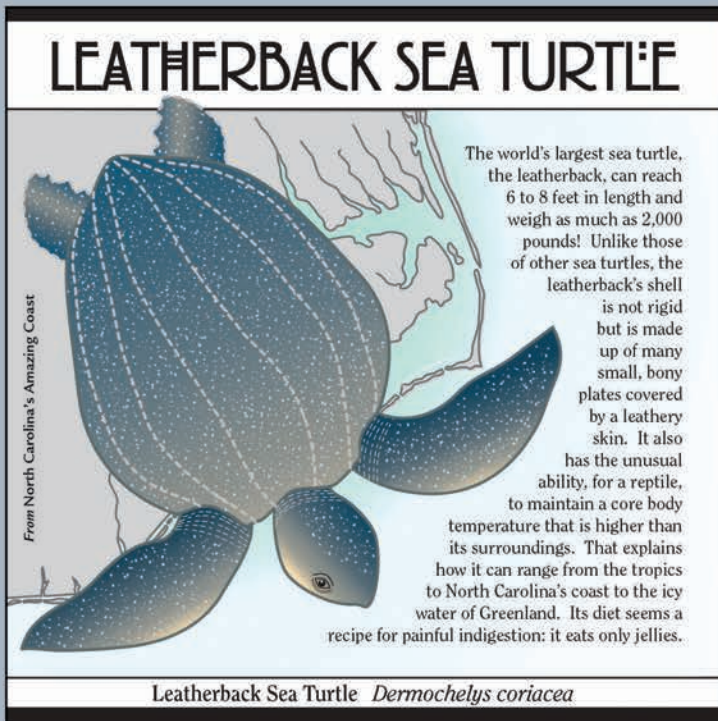
Altman suggests the same female turtle may have laid the two nests. Female leatherbacks lay multiple clutches a year, and the time between when the two nests were laid corresponds to the amount of time a female needs between clutches. Later, DNA analysis from egg samples will determine the parentage.

A LONG WAIT

Leatherback sea turtles nesting in North Carolina are rare, says Matthew Godfrey, a biologist with the N.C. Wildlife Resources Commission. "There have only been 39 total confirmed nests by leatherbacks on North Carolina beaches since 1966," he notes.

By comparison, loggerhead sea turtles are more common in our coastal waters.





By early July just under 400 loggerhead nests had been found. In 2017, there were over 1,000 total loggerhead nests on N.C. beaches, according to the state's Sea Turtle Nest Monitoring System, which is hosted by the Wildlife Commission's Sea Turtle Project.

Leatherbacks are uncommon on our beaches and are wondrous sights. They are the largest sea turtles on Earth, weighing up to 2,000 pounds and reaching up to 8 feet long. Instead of a hard shell, they have a flexible and rubbery carapace, which inspired their name.

The carapace isn't a single structure, but instead a mosaic of small bones, characterized by seven prominent ridges. These ridges, and the

turtle's size, make them easily distinguishable from the more common loggerhead turtles.

Leatherbacks also have a far larger range than other species. Once prevalent in every ocean except the Arctic and Antarctic, leatherbacks are now endangered in the United States and vulnerable worldwide.

Population trends vary per region, however. "In the North Atlantic, it appears that leatherback nesting populations have been stable or increasing for the past few decades," Godfrey says. "In recent decades in the East Pacific, nesting populations have shown decline."

PRECIOUS CARGO

To protect the fragile eggs found on Fort Fisher and Cape Lookout, staff members and volunteers have marked the sites and erected barriers to prevent the eggs from being trampled.

The eggs are expected to hatch after about 60 to 80 days of incubation. When the hatching date nears for each site, the section of the beach around each nest will be closed off. This way, the grooves that cars leave in the sand will smooth out, giving the small hatchlings a higher chance of making it to the ocean, Altman explains.

Anyone who spots a turtle or nest on the beach should report it to a park ranger or local sea turtle group. Park officials also ask that visitors don't disturb the animals.

Pictures can help rangers with identification, but rangers tell beachgoers to avoid using a flash. When used at night, even a quick camera flash can startle mothers during nesting and also can confuse hatchlings when they're trying to find their way to the water.

Where the hatchlings go after reaching the waves is a mystery. "Little is known about leatherback turtles between the time they enter the ocean as hatchlings and are seen again foraging or nesting as adults," Godfrey says.

Mothers, meanwhile, will follow their own course. This time of year, "typically leatherbacks migrate up the Atlantic coast following jellyfish," Altman says. "They can go as far up as Canada."

Check N.C. State Parks and Recreation and Cape Lookout National Seashore social media for updates on the nests.

For more facts on leatherback sea turtles, go to the National Oceanic and Atmospheric Administration's website at [fisheries.noaa.gov/species/leatherback-turtle](https://www.fisheries.noaa.gov/species/leatherback-turtle). For recent data from the N.C. Wildlife Resources Commission, visit [seaturtle.org](https://www.seaturtle.org), go to "Sea Turtle Nesting" and then select "North Carolina."

North Carolina's Amazing Coast: Natural Wonders from Alligators to Zoës, is available online at go.ncsu.edu/amazingcoast, or ask your local bookstore. 📖



Scott Taylor

Snapper with Tropical Fruit Salsa



Vanda Lewis

Seafood Stuffed Avocado

Summer's Spread

BY DANIELLE COSTANTINI • RECIPES FROM MARINER'S MENU

JUST LIKE THE COAST ITSELF, RECIPES HAVE A WAY OF CHANGING. SOME REMAIN CLASSICS. OTHERS BRING SURPRISES THROUGH NEW COMBINATIONS AND COOKING TRICKS.

This can easily be seen in the pages of *Mariner's Menu*, North Carolina Sea Grant's seafood resource book that offers traditional and innovative recipes.

For a modern take on seafood, look no further than **seafood stuffed avocado**. This recipe brings together the season's best flavors of crab, shrimp and avocado for a refreshing bite.

If you have some fresh fruit, **snapper with tropical fruit salsa** makes for a juicy plate. Sauté the snapper and then add the mango, pineapple, orange and pepper salsa on top and enjoy.

Grill-masters out there, take note. Throw on some **scallop kabobs** with pineapple chunks, mushrooms and peppers for a guaranteed fan pleaser.

Finally, a classic Southern recipe: a **Carolina shrimp boil** has long been my favorite to serve family style while on vacation at the beach. Passing around the pot, each person can grab a hearty handful of shrimp, corn and potatoes. You can even add Andouille sausage, like my family does, for a kick at the end.

Enjoying seafood during the summertime is the perfect way to end a long day in the heat. Whether you're hosting friends and family or simply enjoying a homemade meal, these recipes are sure to delight and inspire you to take your next trip to the coast.

For more ideas and recipes, order a copy of *Mariner's Menu: 30 Years of Fresh Seafood Ideas* at ncseagrant.ncsu.edu/bookstore. Or check your local bookstore.

Also, visit the blog at marinersmenu.org and follow North Carolina Sea Grant on social media. Information on seasonal seafood also can be found at ncseagrant.ncsu.edu/seafood.

SNAPPER WITH TROPICAL FRUIT SALSA

- 1 1/2 pounds snapper fillets
- salt
- freshly ground white pepper
- flour
- 2 tablespoons canola oil
- 2 tablespoons margarine or butter

Prepare fruit salsa and chill. Lightly salt and pepper fish. Dredge in flour. Heat oil in large skillet. Add margarine and heat. Lightly sauté fillets, top side down, until golden brown, about 4 to 5 minutes. Turn and repeat on other side. Drain on paper towels.

Fruit Salsa:

- 1/2 diced mango (about 1/4 inch dice)
- 1/2 cup cubed pineapple (about 1/4 inch dice)
- 1/2 cup halved orange segments
- 1/4 cup chopped chili peppers
- 1/4 cup finely chopped red onion
- 1 teaspoon minced garlic
- 1 tablespoon balsamic vinegar
- 1 tablespoon chopped fresh cilantro
- 1/4 teaspoon salt



Grilled Scallop Kabobs

- 1/8 teaspoon cayenne pepper
- 1 tablespoon chopped fresh basil
- 1 tablespoon chopped fresh parsley

Combine mango, pineapple, orange, chili peppers, onion and garlic and mix well. Add vinegar, cilantro, basil, parsley, salt and pepper. Chill until ready to use.

SEAFOOD STUFFED AVOCADO

Fresh seafood is essential when preparing recipes from *Mariner's Menu*. For this dish, the avocados are equally as important. For exceptional flavor, select ones that are dark green and slightly soft when gently squeezed.

- 1/2 pound backfin crabmeat
- 1/2 pound cooked small shrimp, peeled and deveined
- 3 tablespoons mayonnaise
- 3 tablespoons sour cream
- 1/4 teaspoon salt
- 1/4 teaspoon freshly ground white pepper
- 3 avocados, chilled
- paprika
- lettuce leaves

Carefully remove any shell or cartilage from crabmeat. In medium bowl, lightly toss crabmeat and shrimp. In small bowl, combine mayonnaise, sour cream, salt and pepper. Add to crab and shrimp. Mix gently but thoroughly. Chill for several hours.

When ready to serve, peel avocados and

cut in half lengthwise. Pile centers with salad. Sprinkle with paprika. Place on lettuce leaves. Serves 6.

GRILLED SCALLOP KABOBS

- 1 1/2 pounds bay scallops (or sea scallops, halved)
- 1 can (13 1/2 ounces) pineapple chunks, drained
- 1/2 pound button mushrooms
- 1 sweet red pepper, cut into 1/2-inch squares
- 1/4 cup vegetable oil
- 1/4 cup fresh lemon juice
- 1/4 cup chopped fresh parsley
- 1/4 cup soy sauce
- 1/4 teaspoon salt
- 1/8 teaspoon freshly ground black pepper

Place scallops, pineapple, mushrooms and red pepper in medium bowl.

In separate small bowl, combine oil, lemon juice, parsley, soy sauce, salt and pepper. Reserve 1/3 cup. Pour remainder over scallop mixture and marinate in refrigerator 30 minutes, stirring occasionally.

Alternate scallops, pineapple, mushrooms and red pepper on skewers. Grill about 4 inches from moderately hot coals until one side is golden, about 4 to 5 minutes. Baste with reserved sauce. Turn and cook until other side is golden and scallops are tender. Serves 6 to 8.




Carolina Shrimp Boil

CAROLINA SHRIMP BOIL

Fresh shrimp smell like seawater. There should be no off-odors, mustiness or chemical smells. Occasionally shrimp will smell and taste like iodine. This is not related to spoilage and is not harmful, but makes them unacceptable for eating. Certain organisms on which shrimp sometimes feed can cause this iodine effect. If you buy shrimp that smell this way, return them to your market for a refund or replacement.

- 8 pounds large unpeeled shrimp
- 8 quarts water
- 8 rounded tablespoons Old Bay Seasoning (more to taste)
- 30 small new potatoes (or larger ones, halved or quartered)
- 5 large onions, halved
- 15 ears corn, shucked and cut into thirds

In large cooker, bring water to rolling boil. Add seasoning. Add potatoes and onions. Continue to boil until potatoes are almost done, about 10 minutes. Add corn and cook until done, about 3 minutes. Add shrimp and cook until done, about 3 to 5 minutes. Drain and serve. Serves 12 to 15.

NOTE: Many people like to shake additional Old Bay over the food after draining it. Also, you can add smoked sausage to the pot. Cut into pieces about 1 1/2 inches long and add after the potatoes. Other seafood seasonings can be used for flavor. Follow package instructions for amounts and cooking methods. 

ADVANCING COMMUNITY



THREE NEW PARTNERSHIPS ARE GROWING, THANKS TO FUNDING FROM THE NORTH CAROLINA COMMUNITY COLLABORATIVE RESEARCH GRANT PROGRAM, OR CCRG. TOPICS INCLUDE FLOOD RISKS AND EMERGING CONTAMINANTS, AS WELL AS NEW TOURISM OPPORTUNITIES THAT CAPITALIZE ON DARK SKIES.

In its third year, the CCRG leverages support from the William R. Kenan Jr. Institute for Engineering, Technology and Science, or KIETS, at NC State University with funding from North Carolina Sea Grant.

“We are excited to continue to bring together new sets of researchers and community partners,” says Susan White,

Sea Grant’s executive director.

Project teams include at least one science expert, as well as one local-knowledge expert. This partnership encourages creative problem solving for environmental issues and other challenges that N.C. communities face. The multidisciplinary program increases the likelihood that resource managers and industry leaders will accept recommendations, White explains.

Raj Narayan, KIETS associate director, notes that the projects address priorities of both programs.

“Projects selected for CCRG support in 2018 continue to connect and bring together experts from higher education institutions, local community stakeholders, businesses, nonprofits and government organizations to work collaboratively for the benefit of North Carolina — and to reflect the innovative and

COLLABORATIONS

BY MARISA INCREMONA

- *Researchers will assess the environmental consequences of flooding on Pender County, which is still struggling to rebound from Hurricane Matthew.*

impactful partnerships and collaborations enabled and leveraged through the CCRG program,” he says.

• FOCUSING ON FLOOD RISK

Joanne N. Halls of the University of North Carolina Wilmington; with Wesley MacLeod of Cape Fear Council of Governments; and Pat O’Mahony of Pender County

“Residents of Pender County are no strangers to the impacts of flooding, especially in and around our most susceptible areas,” says Pat O’Mahony, senior planner with Pender County Planning and Community Development. “This study serves as an opportunity to understand how environmental changes may impact current and future residents in a rapidly growing area that is vulnerable to flooding and poor

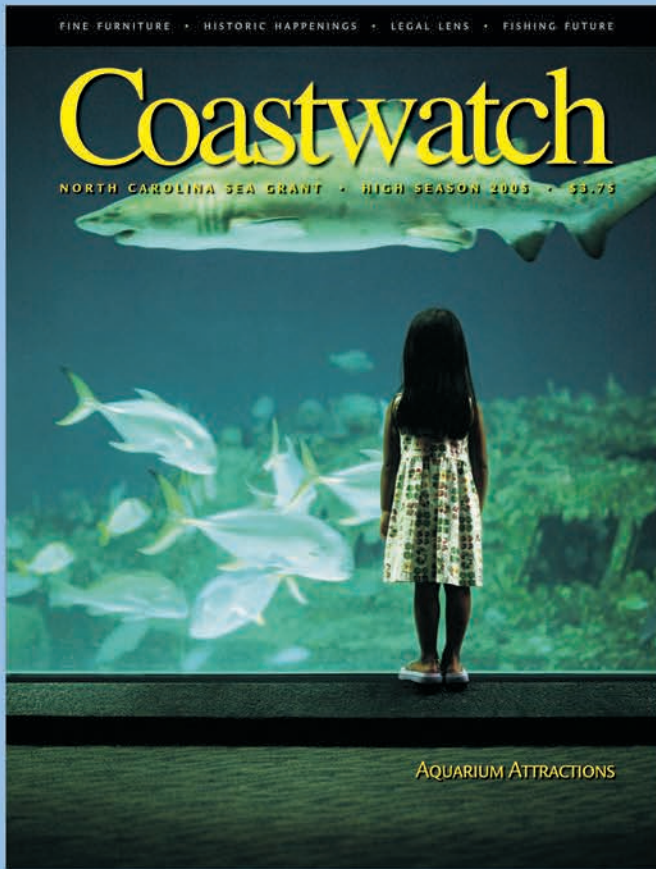
drainage, while providing a framework for future planning efforts.”

Pender County is one of many coastal communities that traditionally has relied on wetlands to mitigate some flooding effects. The “Assessment of Flood Risk and Simulations of Wetland Change in Pender County, N.C.” project will look at how flooding affects freshwater and saltwater wetlands.

Joanne Halls, of the UNCW Department of Earth and Ocean Sciences, says she and graduate student Jessica Magolan are excited to work with the Cape Fear Council of Governments and Pender County. “Through this collaborative effort we will use a variety of existing geospatial data, expert knowledge and simulations to identify flood risk,” says Halls, who also directs the UNCW Spatial Analysis Lab.

Continued

Courtesy Kyle Breuer



Dear Coastwatch Readers,

As I embark on this new voyage as managing editor of *Coastwatch*, I'd like to ask for your help.

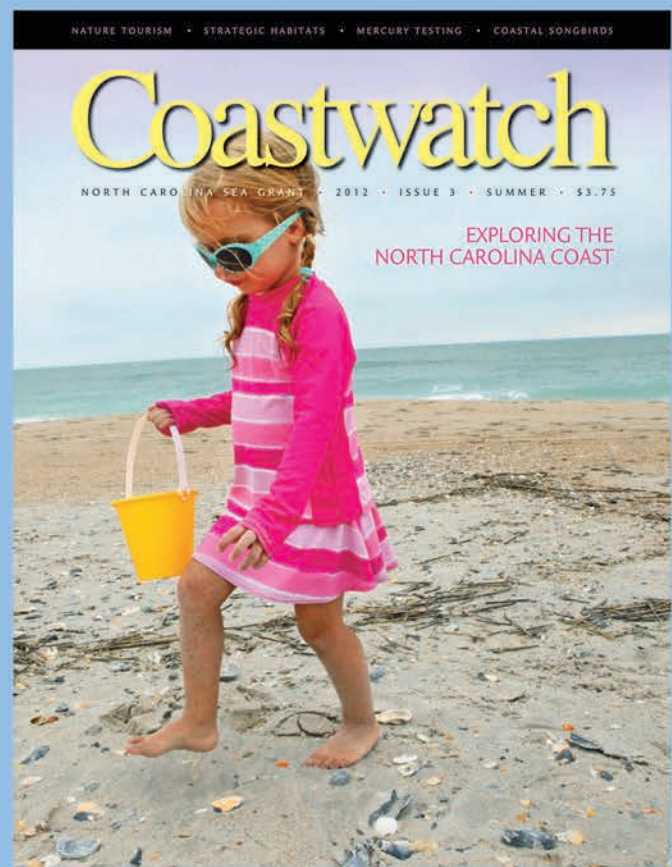
For over four decades, *Coastwatch* has been publishing news about North Carolina Sea Grant's research, outreach and educational initiatives — all of which have shaped critical discussions about our coast. Of course, such a long and distinguished record is only possible with the support of readers like you.

That's why our editorial team soon will survey you to learn more about what we're doing right and what we need to change.

I've been fortunate to work for the past two decades on behalf of highly respected publications. It's rare that such opportunities come around, though, and I couldn't pass up the chance to join *Coastwatch*.

Joining a publication with such a history of success is a little like encountering a shark on the other side of the glass. It's awe-inspiring — with a little fear mixed in. But I know that with feedback from readers like you, we'll continue to build on *Coastwatch's* strong legacy.

With gratitude, **Dave Shaw**





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NIGHTLIGHT

Brightness in the dark,
Illuminating the night
Guiding Mariners.

— Brooksie Pollack, volunteer, Cape Hatteras National Seashore

*Pollack's poem and artwork first appeared on the Cape Hatteras National Seashore Twitter feed.
Share your creative work with @SeaGrantNC.*

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