

# Coastwatch

NORTH CAROLINA SEA GRANT • SUMMER • 2019 • ISSUE 2 • \$3.75

**Testing the Waters**  
*Ensuring Shellfish  
Are Safe to Eat*



## Summer Fun in North Carolina

It's time to hit the water! Our ocean, sounds and lakes are beckoning families and friends during precious breaks from school and work. Time slows down on the water, offering opportunities to sit and fish, or eat, or just be with one another to catch our collective breath.

Summer is a great time to explore — and to enjoy this edition of *Coastwatch* that provides a breadth of topics for your reading pleasure. You can learn of post-Hurricane Florence efforts to support community recovery and future preparedness, or you can check out fishing tips. But relax and read from the comfort of your hammock, beach chair or rocking chair. I'm right there with you.

If you — or your family and friends — head to the coast this summer, please take time to review beach and surf safety details wherever you stay. Know if that beach uses warning flags, and if so, what those colors mean for swimming conditions. Many communities offer surf zone safety classes and provide updates on social media.

Take note of where lifeguard stations are located. It's always best to swim at a protected beach during hours when guards are on duty. Rip currents can be a problem any time of day on any beach — tragic lessons learned already this year.

Check out the poster inside our back cover of this issue. It provides tips to avoid rip currents, and how to escape if you get caught. Go ahead: Tear it out. Then share with friends and family.

These signs are up and down the coast. The National Park Service has added more than 200 new signs in recent years. So, too, have many beach towns and community partners who realize that preparedness and knowledge increase everyone's awareness, safety and ability to relax at the beach.

North Carolina Sea Grant team members have spent decades as part of a national beach safety task force. In fact, local and national efforts by Spencer Rogers, our coastal construction and erosion specialist, recently were noted as he received an award for employee excellence in NC State's Office of Research and Innovation.

As a Sea Grant extension specialist for over 40 years, Rogers gives his all to provide research-based information to coastal property owners, government agencies, designers and building professionals. His expertise also includes constructing more resilient coastal homes and buildings.

We also are proud of Jessica Whitehead. In early June, she starts as chief resilience officer for the N.C. Office of Recovery and Resiliency in the N.C. Department of Public Safety. Jess brings 11 years of service experience in working with Sea Grant — here in North Carolina and nationally, and earlier in a joint role serving both Carolinas.

Her new team has impressive goals to bring varied partners together to develop solutions that enhance the resilience of communities and the natural environment, while creating safe and affordable housing solutions. We look forward to working with, and learning from, Jess in her new role.

We are in the midst of planning for the 2019 North Carolina Coastal Conference on Nov. 19 and 20 in Wilmington. Save the date and join this discussion. Drawing upon the success of previous events, sessions will include partners from academia, state and local government, industry, non-profit entities, and local community members. Speakers will discuss research and outreach that address current and expected needs on topics such as storms and climate; community and ecosystem health; fisheries and aquaculture; and planning and economics.

To propose a conference presentation or poster, visit [ncseagrant.ncsu.edu/nc-coastal-conference](http://ncseagrant.ncsu.edu/nc-coastal-conference). For broader program suggestions or to join us as a cosponsor, contact me at [snwhite3@ncsu.edu](mailto:snwhite3@ncsu.edu).

Thank you for being a part of our Sea Grant family this summer and all year as we, together, explore and learn about North Carolina's natural resources and the great diversity of communities where we live, work and play.

— Susan White, Executive Director, North Carolina Sea Grant

### IN THIS ISSUE

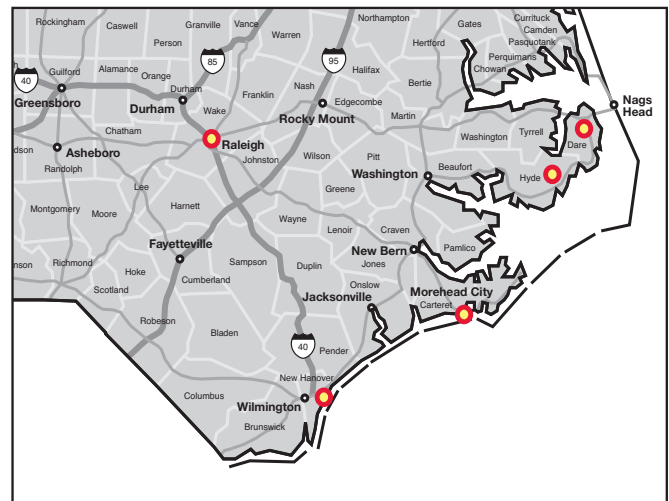
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North Carolina's diverse coast and inland terrain offer countless interesting subjects. The map indicates some of the story settings in this issue — including Carteret, Dare, Hyde, New Hanover and Wake counties.



# Coastwatch

## FEATURES

**COASTAL TIDINGS** ..... 2

### TESTING THE WATERS

How does the state ensure that shellfish are safe to eat? ..... 6

### DON'T CUT DOWN THAT TREE!

#### Preserving a Protective Buffer Against High-Speed Winds

Keeping certain strategic trees can reduce the risk of roof damage. .... 16

### LAND VERSUS SEA

An epic battle is taking shape on our coast, where incremental changes will have enormous impacts. .... 22

### YOUNG MINDS ENJOY NEW GREEN INFRASTRUCTURE

#### Stewardship Begins Early and Upstream

What happens when students, teachers, parents and others come together to care for a modest but beloved urban stream? ..... 28

### PEOPLE AND PLACES

#### Rising Stars: New Fellows Fuel Scientific Discovery

A new group of talented movers and shakers will advance several fields for years to come. .... 33

### HOOK, LINE & SCIENCE

#### Tuna, Toadfish and More

Our fisheries specialists break down research on everything from life jackets to noise-sensitive toadfish. .... 36

### SEA SCIENCE

#### Which Wetlands Will Survive?

New research suggests all marshes have tipping points. .... 40

### COASTAL CURRENTS

#### Gone Crabbin'

Recreational crabbers play a role in responsibly harvesting crabs and managing gear. .... 41

### COASTAL CONNECTIONS

#### Public Events Enhance Research and Dialogue

North Carolina Sea Grant and partners host important and popular events to share new science and foster collaborations. .... 43

### LAST WORD

#### Your Free Rip Currents Safety Poster

Tear it out. Put it up. Save a life. .... 45

*FRONT COVER: Photograph by Vanda Lewis. TABLE OF CONTENTS: Graphic based on photo of Taylor's Creek in Beaufort, North Carolina, courtesy of VisitNC.com.*

# 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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## COASTAL TIDINGS



Barbara Doll

### HURRICANES THREATEN ROADS AND BRIDGES

The 2019 North Carolina Transportation Summit brought together policymakers and others to discuss topics that included 2018's Hurricane Florence and potentially similar disasters to come.

At the event, WNCN-TV interviewed Barbara Doll, North Carolina Sea Grant's water protection and restoration specialist, about possible modifications to major roads and highways. She explained that in some areas elevation was a clear concern.

"Simply, the road is too low," Doll said. "And, in other areas, it's going to have to be bridging. So, they are looking at these options, the costs of these options, and that's a real high priority."

Citizen safety is also a main concern, Doll added. "If there is a warning that has been issued not to drive, heed it, because that's where a lot of deaths occur, where people are trying to get out on the roads."

Watch the WNCN-TV interview: [go.ncsu.edu/Doll-interview](http://go.ncsu.edu/Doll-interview).

— Katelyn Vause

### HANS PAERL RECEIVES BEST PAPER HONOR

The *Environmental Science & Technology* journal has recognized "Mitigating the Expansion of Harmful Algal Blooms across the Freshwater-to-Marine Continuum" as one of the "Best Papers of 2018."

Hans W. Paerl, an aquatic ecologist at the University of North Carolina at Chapel Hill's Institute of Marine Sciences, led a team of authors who shared expertise on groundbreaking research on nutrient over-enrichment and its negative effects on coastal ecosystems. The paper cites a North Carolina Sea Grant project, along with international research.

Excess nutrients in water bodies and resulting harmful algal blooms, known as HABS, have increased across Europe and North America, with negative effects on fisheries, tourism and property values. Paerl and his co-authors have conducted innovative work on the proliferation of excess nutrients, called "eutrophication," and HABS in North Carolina's waters and beyond.

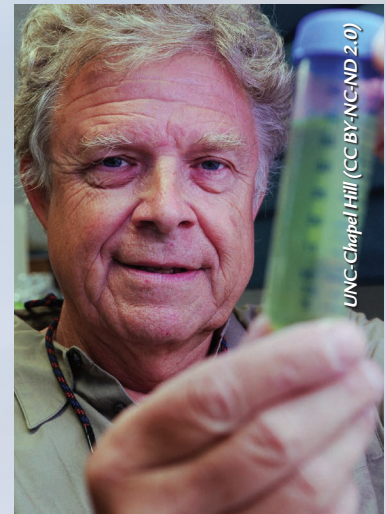
"Our North Carolina Sea Grant projects are addressing causes and consequences of expanding algal blooms in the estuaries, especially their impacts on low oxygen conditions and food web alterations," Paerl says.

Large-scale agriculture, industrialization and urbanization, as well as rising temperatures and extreme weather events, all contribute to harmful algal blooms. Paerl's research explored a new strategy that focused on reducing both phosphorous and nitrogen levels upstream in order to control HABS long-term. The team's award-winning article also explains approaches that can prevent the spread of HABS worldwide.

The North Carolina Water Resources Research Institute also has funded research by Paerl and his IMS lab on water quality.

Read the full article in *Environmental Science & Technology*: [go.ncsu.edu/Best-Paper](http://go.ncsu.edu/Best-Paper).

— Summer Walls



Hans Paerl

UNC-Chapel Hill (CC BY-NC-ND 2.0)



## RISING EXHIBIT CONTINUES CONVERSATIONS

The RISING exhibit recently brought to Raleigh its ongoing community conversations about North Carolina's changing coast.

The NC State College of Humanities and Social Sciences, in partnership with the Southeast Climate Adaptation Science Center and the university's African American Cultural Center, hosted the exhibition from late March to late May.

RISING is a multimedia collection of artistic and oral history accounts, paired with scientific information to present how the North Carolina coastal region has transformed over time. North Carolina Sea Grant originally funded the project through its Community Collaborative Research Grant Program, a partnership with NC State's William R. Kenan Jr. Institute for Engineering, Technology and Science.

A team of creators, scientists and local leaders developed RISING with an emphasis on working across disciplines to reach wide audiences. The exhibit now travels throughout the state, helping residents and visitors better perceive changes occurring along the coastline.

In Raleigh, a discussion on the "Human Impacts of Sea Level Rise" featured Baxter Miller, RISING's co-leader and fine art photographer. Another project partner, Karen Willis Ampacher, director of the Core Sound Waterfowl Museum and Heritage Center and co-author of *Living at the Water's Edge*, also spoke.

Additional panelists provided southeast regional perspective for diverse communities facing coastal change. Watch a video of the full panel discussion: [go.ncsu.edu/sea-grant-rising](http://go.ncsu.edu/sea-grant-rising)  
— Katie Mosher



Guillette, Polera & Balcher

## WHAT'S IN OUR FISH — AND OUR GATORS?

A new collaborative team of researchers and community members have established that wildlife in some areas of North Carolina face exposure to perfluoroalkyl and polyfluoroalkyl substances, known as "PFAS."

Chronic exposure to two types of PFAS found within the Cape Fear River's watershed, perfluorooctane sulfonate and perfluorooctanoic acid, have known adverse health effects in mice and are associated with negative health effects in humans.

With support from a Community Collaborative Research Grant, NC State University toxicologist Scott Belcher and his partners found that striped bass along the Cape Fear have over 40 times higher blood concentrations of PFAS compared to striped bass at an aquaculture facility with low levels of PFAS in the water. In addition, striped bass along the river have higher blood concentrations of perfluorooctane sulfonate, a type of PFAS associated with liver and immune dysfunction.

The team also examined PFAS in the local American alligator population of coastal North Carolina. They determined that gators in Greenfield Lake have 10 times higher concentrations of PFAS in their blood.

Belcher's team encourages Cape Fear River communities and others to offer feedback so they can prioritize their study of PFAS to best serve both scientific inquiry and the broader public's needs.

North Carolina Sea Grant and NC State's William R. Kenan Jr. Institute for Engineering, Technology and Science co-sponsor the Community Collaborative Research Grant program.

Read more: [go.ncsu.edu/fish-and-gators](http://go.ncsu.edu/fish-and-gators).

— Dave Shaw



## NCLocalFoodCouncil.org GOES LIVE

A new website showcases the North Carolina Local Food Council, a network of organizations and state agencies working to improve North Carolina's local food systems.

North Carolina Sea Grant is among the primary partners on the council, known as NCLFC, which collaborates with community and regional food councils, food producers, retailers and state agencies.

Barry Nash, North Carolina Sea Grant's seafood technology and marketing specialist, says the NCLFC helps to foster successful

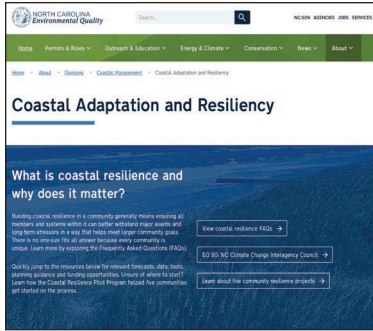
farms and fisheries, healthy eating, thriving local-food economies and resilient ecosystems.

"This council will address the pressing concerns of local and regional food councils across the state to make locally produced foods more available to North Carolina consumers," Nash says. "By creating a space for diverse stakeholders to collaborate on building local-food systems, we can join forces to promote North Carolina products, including local seafood."

Rising consumer demand for local foods — and for healthy eating options — offers tremendous opportunities to community and regional producers and retailers, Nash adds.

Visit [NCLocalFoodCouncil.org](http://NCLocalFoodCouncil.org).

— Danielle Costantini



## NEW WEB PORTAL OFFERS INFO ON COASTAL ADAPTATION AND RESILIENCY

To help coastal communities plan for resilience, the N.C. Division of Coastal Management has launched a new website for local government officials and staff in the 20 counties designated by the N.C. Coastal Area Management Act.

The online portal helps foster collaboration and lesson-sharing across jurisdictions and sectors.

Users will find resources on floodplain management, living shoreline installation and reducing flood insurance rates. They also will find case studies in mitigation and adaptation practices from local communities, including Nags Head, Oriental, Edenton, Duck, Pine Knoll Shores and Hatteras Village.

Tools from partner organizations, such as NOAA and the Nature Conservancy, will help officials, their staff and residents explore risks that include storm surge, high tides and sea level rise.

This new resource also supports *Executive Order 80*, signed by N.C. Governor Roy Cooper in October 2018, which calls for the development of a State Climate Risk and Resilience Plan by 2020.

Coastal managers are seeking user feedback about the website from local governments and other stakeholders.

Visit the portal: [deq.nc.gov/about/divisions/coastal-management/coastal-adaptation-and-resiliency](http://deq.nc.gov/about/divisions/coastal-management/coastal-adaptation-and-resiliency).

Send questions and comments to coastal resilience specialist Christian Kamrath: [Christian.Kamrath@ncdenr.gov](mailto:Christian.Kamrath@ncdenr.gov) or 252-808-2808, ext. 230.

— Sarah Spiegler

## COASTAL TIDINGS

### WARMER WATERS LINKED TO MORE MALE FLOUNDER

If southern flounder live in warmer water during a critical window of early development, a higher percentage become male — more than 90% in some cases — according to new research that North Carolina Sea Grant and several other partners supported.

Having a high proportion of adult males over the long term could threaten both wild populations and the commercial fishing industry, the research team from NC State University notes.

Field research and lab experiments showed that a four-degree Celsius increase in average water temperature during juvenile development shifted the male-female ratio from about 50-50 to as much as 94-6, says Jamie Honeycutt, who worked on the study with project lead Russell Borski. That difference is within the range of expected ocean temperature increases under climate change models.

Environmental factors influence sex determination in southern flounder, as well as in other fish and reptiles, Honeycutt explains. Flounder stick to shallow waters that serve as nurseries until after they become male or female, eventually returning to the ocean to spawn at about age 2.



NC State News

Male flounder in early development

“In flounder, if an individual is a genetic male, it is destined to be male,” Honeycutt says. “However, if a genetic female is exposed to temperature extremes, then it can develop as a functioning male.”

If the male bias persists in adult flounder, that could be bad news for wild populations and commercial and recreational fishing. “Flounder fisheries are really totally dependent on females because males rarely make it to catch and market sizes,” Honeycutt says.

Read the full study in *Scientific Reports*: [go.ncsu.edu/male-flounder](http://go.ncsu.edu/male-flounder). — D’Lyn Ford

### WAVE GAUGES PROVIDE FLORENCE FLOOD MODELING DATA

The United States Geological Survey recently publicly posted a flood map model of Hurricane Florence, using data from a variety of gauges, including measurements provided by Spencer Rogers, North Carolina Sea Grant’s coastal erosion and construction specialist.

Rogers partnered with the University of Notre Dame’s Andrew Kennedy, who sent gauges to deploy before Florence. Working with a graduate student, Rogers set up the instruments on Wrightsville Beach, Topsail Beach and North Topsail Beach. One gauge in North Topsail recorded 5 feet of erosion and significant wave hits, he notes.

“Beginning with Hurricane Rita in 2005, USGS has installed wave gauges for storms,” explains Rogers. “Before then, USGS had river gauges, but nobody in the country was in charge of collecting water levels after coastal storms and hurricanes.”

Researchers strap the gauges to stable structures. Once secure, the instruments collect data on storm surge and wave conditions when waves hit. In addition to using the information for flood map modeling, scientists can determine how waves evolve over the duration of a storm.

Watch the Flood Event Viewer for Hurricane Florence: [go.ncsu.edu/wave\\_gauge](http://go.ncsu.edu/wave_gauge).

— Katelyn Vause



Spencer Rogers sets up wave gauges at N.C. sites.

## OCRACOKE SEEKS SUSTAINABLE TOURISM



Ocracoke Lighthouse

To ensure Ocracoke Island can continue to accommodate visitors and support a sustainable workforce, researchers have worked with community leaders and residents to consider needs — and opportunities.

North Carolina State University's Whitney Knollenberg and North Carolina Sea Grant's Jane Harrison have worked with David Tweedie of Ocracoke Alive!, a nonprofit organization on the island. Through interviews and focus groups, they evaluated assets critical to the labor force, and also identified resources that require greater investments.

Preliminary findings reveal that islanders have especially strong social ties and experience a culture of community support. Even with significant changes in demographics — such as an increase in the Latino population from 2% to 19% between 2000 and 2010 — the island retained a sense of social cohesion.

However, the team also identified needs, in particular to support essential services for

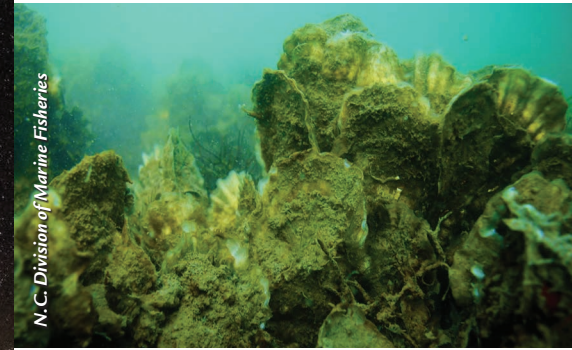
workforce groups, including Latino residents, college students, high school students and retirees seeking part-time work.

“High-amenity coastal towns attract large influxes of visitors each summer,” Harrison says. “Tourism demand can only be met if the local workforce has sufficient housing options and the year-round services needed for all aspects of life — childcare, doctors offices and high-quality K-12 education, for example.”

The team has presented results to island residents and will discuss findings with similar communities. Data and conclusions also have been shared at regional and national tourism meetings and are slated for an international conference.

This research started through a Community Collaborative Research Grant, a program funded by North Carolina Sea Grant and the Kenan Institute for Engineering, Technology and Science at NC State University.

— Marisa Incremona



N.C. Division of Marine Fisheries

Oyster reefs provide valuable ecosystem services.

## MAPPING IDENTIFIES SITES FOR OYSTER REEFS

Researchers from NC State University have developed a mapping tool that identifies sites for re-establishing oyster reefs in order to maximize their ecological benefits.

Oyster reefs, salt marshes and seagrass beds provide valuable ecosystem services, such as water filtration, shoreline protection and wave buffering during storms. When these habitats suffer damage, restoration efforts are critical to the overall health of coastal ecosystems.

“This work focused on identifying key areas for oyster reef restoration that would provide water filtration benefits in the Pamlico Sound,” says Seth Theuerkauf, now a scientist with The Nature Conservancy and National Oceanic and Atmospheric Administration. “Globally, less than 15% of the historic distribution of oyster reefs remain, so restoration efforts have to focus on efficiency.”

The researchers developed three versions of their model: one that identified where restoration yielded maximum benefits; another that identified areas that would best sustain the oyster population; and one that identified areas with a balance between water filtration and population enhancement.

North Carolina Sea Grant, North Carolina Space Grant, the National Defense Science and Engineering Graduate Fellowship and the National Science Foundation provided funding for this research.

Read more: [go.ncsu.edu/mapping](http://go.ncsu.edu/mapping)

Read the full study in *PLoS ONE*: [go.ncsu.edu/reefs](http://go.ncsu.edu/reefs).

— Tracey Peake and Summer Walls

## FISHERIES SCIENCE COURSE LAUNCHES

Scott Baker and Sara Mirabilio, fisheries specialists at North Carolina Sea Grant, recently offered a new course on fisheries science that focused on topics related to management.

“Scott and Sara continue to seek opportunities to engage and educate fishers and interested community members regarding commercial and recreational fishing efforts in North Carolina,” says Susan White, executive director of North Carolina Sea Grant.

Baker and Mirabilio developed “Introductory Fisheries Science for Fishermen” in partnership with experts from across the state.

Participants could attend weekly in February and March at NC State’s Center for Marine Sciences and Technology in Morehead City or take the course as a webinar online.

Baker and Mirabilio have declared the initial course series a success — and will use the evaluations to help shape ongoing education and outreach on fisheries topics.

— Katie Mosher



Sara Mirabilio

UNCW's Fred Scharf leads a course session.

# TESTIN

Baxter Miller





JULIE LEIBACH

Contamination from large rain events like Hurricane Florence can severely affect water quality. How does the state ensure that shellfish are safe to eat?

# THE WATERS

*Continued*

“The first question they had when they sat down was, ‘Is it okay for us to eat the seafood here?’”

— CHEF CRAIG LOVE

**A**s Hurricane Florence bore down on North Carolina last September, Chef Craig Love was concerned foremost about the safety of his family and coastal community, Carolina Beach. But as the founder of Surf House Oyster Bar and Surf Camp — located about 12 miles southwest of Wrightsville Beach, where the storm’s eye made landfall — he also was anxious about the potential impacts on the state’s seafood supply.

Love’s restaurant, which celebrates its 10th anniversary this August, locally sources the majority of its seafood. After Surf House reopened to guests post-Florence, “the first question they had when they sat down was, ‘Is it okay for us to eat the seafood here?’” Love recalls.

Diners inquired about various seafood products. Among them were “oysters, for sure,” Love says.

It’s understandable that consumers would be concerned about the hurricane’s potential effects on their shellfish. Oysters, clams and mussels are rooted to their environment, so they can’t simply swim out of polluted waters. They’re also filter feeders, meaning that they strain food from the surrounding water through their gills. With that nourishment, however, they also can take in bacteria and viruses, as well as pollutants.

What’s more, “they concentrate any contaminants that might have been in the water, sometimes 10, 100, even 1,000-fold,” says Rachel Noble, an environmental microbiologist with the University of North Carolina at Chapel Hill’s Institute of Marine Sciences (IMS) in Morehead City. Consuming raw shellfish

that contain high concentrations of certain bacteria or viruses can lead to gastrointestinal illness such as diarrhea, vomiting, nausea — and worse.

With Florence’s torrential rain came massive flooding carrying a concoction of sewage and animal waste, among other contaminants.

“You could visibly see that there was contamination in the system, and — I’ll be honest with you — in a lot of areas, you could smell it,” says Noble, describing the odor as an acrid, “awful stink” reminiscent of strong organic compost, fecal waste and chemicals.

#### WASHING DOWNSTREAM

During the month following the hurricane, the state’s Division of Water Resources (DWR), part of the N.C. Department of Environmental Quality (DEQ), received notifications of 80 wastewater bypasses at 61 treatment facilities across the state. Those breaches released nearly 62 million gallons of partially treated and untreated wastewater to surface waters.

In addition, DWR learned of 516 sewer overflows at 149 systems, resulting in nearly 55 million gallons of untreated wastewater coursing into surface waters.

Did that sewage reach shellfish harvest areas? It’s highly likely, according to DWR.

The division also received reports from swine farmers that 33 waste lagoons brimmed and ran over the top of the dike wall. There was evidence, too, that some poultry farms were inundated.

*Continued*

*The North Carolina Shellfish Sanitation Program is responsible for monitoring and classifying waters for the state’s bivalve mollusks.*







“You could visibly see that there was contamination in the system, and — I’ll be honest with you — in a lot of areas, you could smell it.”

— RACHEL NOBLE

Joshua Stevens/NASA Earth Observatory, using USGS data

It's possible that hog and poultry waste traveled to shellfish harvest areas. But the most heavily affected areas primarily were in inland counties or in places that don't drain directly to shellfish waters, according to DWR.

While DWR did not investigate or receive reports of harmful algal blooms associated with Florence, "it is too early to tell what the runoff following Hurricane Florence has in store," according to Hans Paerl, a marine and environmental scientist at IMS. "Stay tuned for what might happen this summer, as the sediments that entered our estuaries from last fall's storm are still releasing nutrients that could fuel algal blooms in those estuaries as well as Pamlico Sound."

*(The N.C. Division of Water Resources recently published a water quality report related to Hurricane Florence. Go to [deq.nc.gov/may-8-2019-wqc-agenda](http://deq.nc.gov/may-8-2019-wqc-agenda) and select "Report: Survey of Surface Water Quality Associated with Hurricane Florence, September 2018.")*

## SAFETY FIRST

To ensure that North Carolina shellfish reaching the market are safe to eat, the state's Division of Marine Fisheries (DMF), part of DEQ, oversees the North Carolina Shellfish Sanitation Program.

This program, which follows federal guidelines, is responsible for monitoring and classifying waters for the state's bivalve mollusks, which primarily consist of oysters and clams, but also include mussels and scallops. There are four major types of classifications, explains Shannon Jenkins, DEQ's Shellfish Sanitation and Recreational Water Quality Section chief.

"Approved waters are the waters that are open most all the time," he says. They're "the least impacted by any kind

of pollution, and generally only close under emergency conditions, like a hurricane."

Next are conditionally approved waters, which have two sub-categories. Conditionally approved-open waters stay open almost all the time, he says, but rainfall and other periodic events can warrant temporary closings. Meanwhile, conditionally approved-closed waters are generally closed, except during certain periods when they're deemed safe for harvesting — say, during a drought, when stormwater runoff, and hence contamination, is low.

Restricted waters, meanwhile, are closed to shellfish harvested for direct consumption, Jenkins says. However, their pollution levels are low enough that shellfish removed from those areas and placed into approved waters will eventually be safe to eat. Indeed, over time, shellfish are able to rid themselves of contaminants. "They self-cleanse," Jenkins says.

The last classification is prohibited waters. "At this time, no shellfish are allowed to be harvested from waters classified as prohibited," Jenkins says.

The state uses a set of stringent protocols to classify shellfish harvest areas.

For starters, over the course of a year, the shellfish sanitation team collects water samples from hundreds of locations throughout the areas open to shellfish harvest, as well as in some closed areas. They do this at least six times, randomly, at each location. Two state labs then test those water samples for fecal coliform bacteria — that is, bacteria that are characteristically found in the gut and feces of animals and humans.

Most fecal coliform bacteria are not disease-causing, or pathogenic. We all have "good" *E. coli* residing in our

bodies, for example. But where good fecal bacteria reside, "bad" bacteria or viruses also might be lurking. The presence of fecal coliforms in a water sample can thus serve as indirect evidence of pathogens in the source water.

In addition to water sampling, at least every three years the shellfish sanitation team conducts shoreline surveys that offer further insight into water quality. "We have a number of shoreline surveyors who go along waterfront properties and up in the watersheds and visit businesses and homes to identify potential and actual sources of pollution" that could affect shellfish harvest areas, Jenkins explains. Such sources could be farms, marinas or septic systems, for instance. Surveyors work with DWR to evaluate wastewater treatment plants and collections systems as well, Jenkins adds.

The program also periodically examines meteorological and hydrographic factors — the physical features of water bodies, such as tides and currents — to understand how they influence water quality. Those investigations include studies of point-source discharges, such as from industrial plants or wastewater treatment plants, to determine if buffer zones are adequate in the event of a malfunction or other potentially contaminating event.

Data collected from water sampling, shoreline surveying and weather and water studies form the basis of a comprehensive report known as a sanitary survey. "That's what we use to classify the waters for shellfish harvest," Jenkins says. The Shellfish Sanitation Program produces a report at least every three years for each of 55 designated "growing areas" where shellfish are harvested.

*Continued*

• **LEFT:** This Landsat satellite image shows how flooding from Hurricane Florence affected water quality in the White Oak River, the New River, Adams Creek, and their outflows along the N.C. coast near Cape Lookout on Sept. 20, 2018. It reveals how soils, sediments, decaying leaves, pollution and other debris have discolored the water in swollen rivers, bays, estuaries and the nearshore ocean.

If you're wondering about chemical contaminants such as per- and polyfluoroalkyl substances, or PFAS, the Shellfish Sanitation Program does not regularly test for those. It instead relies on its classification system to limit harvest from areas prone to chemical contamination, Jenkins says. For instance, most of the Cape Fear River is permanently closed to shellfish harvesting.

What about toxins associated with algae? Harmful algal blooms (HABS) affecting shellfish are rare occurrences in North Carolina, according to Jenkins. "The last issue we had regarding HABS and shellfish was in 1987 due to the red tide event," he says. When necessary, the Shellfish Sanitation team works collaboratively with state and federal agencies and local academic researchers to screen for harmful algal species and test for toxins.

Jenkins and his team remain vigilant on a day-to-day basis, too. After certain amounts of rain, for example, they close affected conditionally approved areas for a short time period until they can complete bacteriological testing. "We know that if it rains a lot, it's going to wash sediment and bacteria from the land directly into the water," Jenkins says, "and temporarily, those waters will be not safe for shellfish harvest because of all the bacteria and other potential pathogens in the water that the shellfish are taking up."

In the case of Hurricane Florence, the program consulted with the state health director and preemptively closed all shellfish harvest areas on Sept. 13, a day before the storm made landfall. The state anticipated impacts to those areas, Jenkins says, and "we knew that we would have to assess issues after the storm."

During the closure, Jenkins' team worked with DWR and other agencies

and municipalities to monitor rainfall totals, flood reports and wastewater treatment problems.

They used that information to evaluate which harvest areas could be reopened and when. Some northeastern areas were spared major water quality impacts and reopened quickly, Jenkins says. Others in the central and southern parts of the state took longer, as drainage from ditches and rivers, failing wastewater infrastructure and sewage discharges were addressed.

In addition, the shellfish sanitation team contacted as many shellfish dealers as possible, either by phone or in person, to ensure that no product was sold at dealer locations that had been affected by floodwaters or power outages.

By sunrise on Oct. 27, about six weeks after Florence made landfall, all areas typically open to shellfish harvest were back in business. As Jenkins puts it, when it comes to shellfish monitoring, there's a lot of work "that goes behind the scenes."

Effects from Florence were particularly problematic for N.C. shellfish farmers. The state's up-and-coming shellfish aquaculture industry lost around \$8 million in product, according to Chuck Weirich, North Carolina Sea Grant's marine aquaculture specialist.

"Not only did many producers lose a lot of product from the storm, the inability to harvest and supply product to their markets for an extended period of time definitely hurt their businesses," he says.

"However, the industry as a whole understands the closures and strives to make sure that the shellfish harvested from their farms is safe to enjoy."

#### WHAT ABOUT VIBRIO?

If you've ever eaten raw shellfish, you might be aware of the concern over

bacteria known as *Vibrio*. Certain strains of *Vibrio* are pathogenic, and can cause maladies ranging from gastrointestinal upset to bloodstream infections and skin lesions, according to the Centers for Disease Control.

Unlike fecal coliform bacteria, *Vibrio* are naturally found in the environment. Nearly 100 species of *Vibrio* bacteria have been described, and they exist in a wide array of aquatic niches.

In North Carolina, the two pathogenic species of concern are *Vibrio vulnificus* and *Vibrio parahaemolyticus*, according to Noble of IMS. "They don't like fresh water, but they don't like full salt ocean water, either," she says. They're found in estuaries — as many bivalves are — and thrive in warm, stagnant water.

When *Vibrio* encounter an accommodating environment, Noble says, they're "going to be extremely happy and capable of reproducing very, very rapidly. In fact, they can double every 10 to 20 minutes, she says.

In July 2018, Noble co-authored a study appearing in *Applied and Environmental Microbiology*, funded by the National Science Foundation and the UNC Research Opportunities Initiative, that used genetic sequencing to characterize *Vibrio* communities in the Neuse River Estuary, near Pamlico Sound. (The estuary is closed off to shellfish harvesting). They found dramatic changes in the overall *Vibrio* population following Hurricane Matthew, which struck the East Coast in 2016.

Notably, *V. vulnificus* became "much more prolific" post-Matthew, the authors write, likely for two primary reasons. For one, freshwater discharge diluted the salinity of the estuary to levels at which *V. vulnificus* can

*Continued*

- **RIGHT:** Matthew Stokley of the N.C. Division of Marine Fisheries' Shellfish Sanitation and Recreational Water Quality Section collects routine bacteriological water quality samples in the Topsail Sound area.
- **INSET:** The state preemptively closed all shellfish harvest areas ahead of Hurricane Florence.

“Not only did many producers lose a lot of product from the storm, the inability to harvest and supply product to their markets for an extended period of time definitely hurt their businesses.”

— CHUCK WEIRICH



Baxter Miller

Andy Haines/DMF

"Florence definitely made us all appreciate just the fragility of this environment on a lot of levels."

— CHEF CRAIG LOVE



Cassidy Klos

Cassidy Klos



survive, but which may have negatively affected its competitors. And two, the species might have exploited an influx of nutrients in the organic runoff.

Noble and her team have continued to monitor *Vibrio* in the Neuse River Estuary and are currently analyzing samples taken before and after Hurricane Florence.

She notes that the storm's drenching rains followed a summer that already had been "incredibly, incredibly wet." After the hurricane, a hot period ensued. During that time, "we saw some very interesting dynamics in the *Vibrio* populations that we were following," says Noble, who has received N.C. Sea Grant funding in the past. Genetic results will reveal more about the pathogenic nature of those bacteria — and help shellfish growers protect their product, she adds.

But one thing already is clear: "We need to understand more about the effects of storms on *Vibrios*, and therefore understand more about the effects of those *Vibrios* on shellfish," she says.

The state does not regularly test for *Vibrio*, because it's a naturally occurring pathogen. But Jenkins says that measures are in place to counteract the post-harvest growth of bacteria. For example, certified shellfish dealers are required to receive and adequately refrigerate any shellfish obtained from licensed harvesters within a certain time frame from the start of harvest. "So, after harvest, we're looking at sanitation practices related to shellfish as well," he says.

## MOVING FORWARD

Are North Carolina shellfish safe for consumption post-Florence? As Jenkins said during a March interview, "we're talking over six months since that event, and shellfish are safe."

Noble agrees. "Certainly, by the time 2019 rolled around, I would venture to say that the majority of microbial contaminants that had been

concentrated during Hurricane Florence would have disappeared."

The state is not aware of any illnesses from shellfish consumption linked to Florence, according to Jenkins. It did investigate two restaurant-related cases of illness caused by *Vibrio*, reported last October, but could not trace the product to a specific location, either in or out of North Carolina, he says.

Noble says that North Carolina has "an excellent reputation" when it comes to monitoring shellfish. "We have protected North Carolinians from these kinds of outbreaks using this fecal coliform system for decades," she says. She adds, however, that "our systems are designed for normal conditions." Major storms like Florence "pose a dramatic scenario."

Sampling water isn't a perfect proxy for sampling shellfish meat. They don't "magically just spit all that contamination out. As a filter feeder, they filter it, and they keep it basically in their tissue until it really falls apart," Noble says. "There may be additional measures that can be put in place following a major event like this to ensure that the product is safe for consumption."

Noble's lab currently is developing a kit that could be used to rapidly detect *Vibrio* species in shellfish, thanks to support from the National Science Foundation and the UNC Research Opportunities Initiative. The kit is based on an earlier product that her team developed that tests for *E. coli* and *Enterococcus* bacteria. One company already licenses that kit for use in testing produce wash water and the quality of recreational beach water.

Noble envisions that larger farms and food distributors might be interested in using the *Vibrio* test, and a private corporation has shown interest in licensing it. If licensing comes to pass, she says, then she and the company could work to get the test validated for

use in testing of shellfish harvest waters.

For DEQ's part, "we can't in general take something that hasn't been vetted and approved by the National Interstate Shellfish Sanitation Conference and incorporated into the National Shellfish Sanitation Program for shellfish regulatory purposes," Jenkins says. "But all this research [into *Vibrios*] is very important."

Consumers also can take measures to protect themselves against pathogens.

"Any raw food can potentially contain bacteria or viruses that can make people ill, particularly individuals with weakened immune systems from chronic health problems," says Barry Nash, Sea Grant's seafood technology and marketing specialist. "Those with chronic health issues should avoid eating raw or undercooked shellfish."

"It's always a good idea to cook your shellfish," Noble says. That way, "you're generally going to break down most of the viruses and most of the *Vibrios* or other bacteria that could be inside the oysters that could make you sick."

She adds that other contaminants, such as heavy metals or chemicals, generally "are not removed by cooking."

## COMING TOGETHER

Surf House Oyster Bar and Surf Camp closed for 10 days after Florence to regroup and support the community. Upon reopening, they did serve oysters — Chef Love had stockpiled them ahead of the storm. "But we definitely did not have access to the mussels for about three weeks after the storm," nor to clams, he says.

Fortunately, the restaurant suffered no structural damage. Says Love of Florence, "it definitely made us all appreciate just the fragility of this environment on a lot of levels." 🍷

*Stay tuned for future stories about seafood consumption safety.*

- **LEFT:** Craig Love is chef and founder of Surf House Oyster Bar and Surf Camp.
- **INSET:** Surf House locally sources most of its seafood, such as the clams and mussels in this dish.



# Don't Cut Down

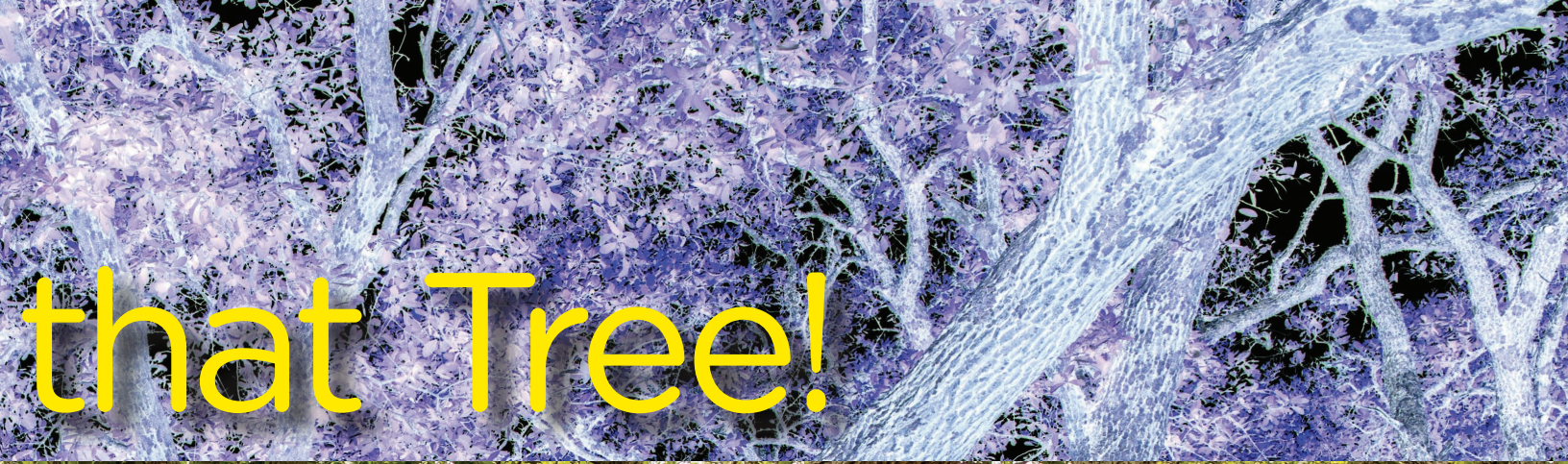
## Preserving a Protective High-Speed Winds

DEBBI SYKES BRASWELL

CONTINUED



*Taylor's Creek in Beaufort, N.C.*



that Tree!

Buffer Against



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**P**aul Hosier listens sympathetically when he hears people vowing to cut down all of their trees after Hurricane Florence. After all, he felt the pain himself — the pain of cleaning up and the pain of writing large checks to cover the cost of removing downed trees.

“They really do love trees,” the Wilmington plant ecologist says of coastal homeowners. “They just don’t love the ones that hit their house and cost them \$5,000 to fix their roof. That’s why they say: ‘Cut them all down. I’m not going to take any chances.’”

Fortunately, science has some answers about saving trees. Keeping and maintaining certain strategic trees on your property can save money by reducing the risk of roof damage, while also providing beauty, shade, and habitat and food for wildlife.

### Structural Significance

“In hurricane category 3 winds or lower, most trees don’t fall,” says Spencer Rogers, North Carolina Sea Grant’s coastal construction and erosion specialist. In any case, Rogers says, some trees actually help to protect a house by being the first barrier the wind encounters.

Wind speeds are typically measured at airports, where nothing blocks the wind.

“Significant wind speed reduction begins at the top of the first surface features the wind strikes,” Rogers says. “At the airport, that’s grass and pavement. At your house it’s the treetops or — if you don’t have trees — it’s your roof.”

According to Rogers, recent studies from Florida have found surprisingly large reductions in wind speed in locations where trees were even widely spaced. “Anyone planning to protect their house by cutting their trees should ask themselves, ‘How will higher wind speeds affect my home?’”

In the 1990s, Rogers explains, coastal



• **Top:** Hurricane Fran, September 4, 1996. • **Bottom:** Wind speed measurements typically occur at airports, where open spaces allow for unhindered velocities.

North Carolina did not experience much structural wind damage in the two higher windstorms, hurricanes Fran and Floyd. “A lot of nice trees surrounded many of our houses.”

The protective benefit of a tree boundary layer varies with the height and density of the trees.

“If your neighbor clears all his trees, the added open space can put more stress on your roof, and on your trees,” Rogers says. “A couple of my neighbors cleared most of their trees for various reasons, including the hurricanes of the 1990s, except for a large oak and a cedar near my property line. Both trees ended up across my driveway, fortunately missing my house.”

### Minimizing Damage

Hosier, whose recent and seminal guide *Seacoast Plants of the Carolinas* profiles over 200 species, recommends regular maintenance. Overly mature trees should go. Viable trees should be kept pruned and healthy.

“Just manage it all year long,” he says,

“and when a storm comes, you’ve got confidence the tree is going to survive.”

He has a personal story to tell about a grand old oak taken out by Hurricane Bertha in 1996. It was huge and still growing, but it had a rotten place at the base of its trunk — damage that might have been caught on an earlier inspection.

“It just nicked our deck when it fell, and the railing still bears the scar,” Hosier says, noting the damage could have been far worse if it had landed on his roof. “That was a good learning lesson.”

For those making a fresh start on a property, Hosier highly recommends hiring a landscape architect to help choose trees to fit their lot’s individual conditions. Is it sunny? What times of the day

and year? Is the soil dry, moist or wet?


He also urges landowners to shop for trees based on suitability rather than price.

“It always hurts,” he adds. “You say, ‘Oh no, that’s going to cost me a lot of money.’ Well, it is. But it’s actually going to save you money in the long run because you’ll get the right trees in the right place — and 5, 10, 15, 20 years down the road, you’ll be happier.”

In *Seacoast Plants*, Hosier cites research showing which plants are most suitable in hurricane-prone environments. Native plants typically fare better. They are suited to an environment that periodically includes these punishing storms, which bring wind, salt aerosols and flooding.

Hosier belongs to a public-private collaboration called the Coastal Landscapes Initiative, or CLI. With leadership from North Carolina Sea Grant, CLI aims to enhance the environment through landscaping. One way CLI does so is by recommending plant species

*Continued on page 21*



Southern red oak acorns at maturity.

# Southern red oak

*Quercus falcata*

- **Family:** Fagaceae (Beech)
- **Other Common Names:** Spanish oak, red oak
- **Range:** New Jersey west to Missouri and south to Oklahoma, Texas and Florida
- **Habitat:** Maritime forests; also upland forests
- **Habit:** Tree
- **Flowering/Fruiting Period:** FL April–May; FR September–October (2nd year)
- **Wetland Status:** FACU
- **Origin:** Native

Paul E. Hosier

Southern red oak is a common, easily recognized tree in the maritime forest along the Carolinas coast. Capable of growing to 90 feet tall under the best environmental conditions, the tree rarely exceeds 30 or 40 feet in areas influenced by salt aerosols. Not a self-pruning tree species, mature specimens often have branches and leaves that nearly touch the ground. Long, droopy leaves are a simple but distinctive characteristic used to identify this tree in the field.

Young trees have smooth, light gray bark; the bark of mature trees is dark gray with deep, narrow ridges and furrows. Leaves are variable in shape, simple, bristle-tipped, and alternately arranged on the stems. They range from 5 to 9 inches long and 4 to 6 inches wide. Some leaves have 3 lobes, while others, especially those on the upper branches, have 5 or 7 lobes. Each leaf lobe has 1 to 3 bristles and deep sinuses. They are shiny green above and glaucous green

below, with reddish-brown hairs along the major veins. The leaf blades are U-shaped at the base and noticeably lopsided on either side of the petiole. The terminal lobe is much longer than the other lobes. Leaves are late deciduous, gradually falling from the tree over the winter and before new leaves expand in the spring.

The tree is monoecious, with male flowers developing on 3- to 5-inch-long, drooping, yellowish-green catkins that mature at the same time the leaves appear. The wind-pollinated female flowers are borne on short spikes, each with 2 flowers. The fruit is an orange-brown acorn 1/2- to 5/8-inch long. Reddish-brown hairy scales cover the cap, which extends over less than one-third of the nut. The acorns, either solitary or paired, mature in the fall of the second year after pollination. Acorn production begins when the tree reaches about 25 years old.


Southern red oak prefers full sun or light shade and well-drained, sandy

soils. Trees are highly drought tolerant at maturity and tolerate moderate salt aerosols.

Propagation is by seeds (acorns) only; planting seeds in the fall assures the best germination.

Acorns are a significant wildlife food for white-tailed deer and squirrels. Small mammals are important agents for dispersing the seeds. Oak trees, including southern red oak, are hosts for larvae of hairstreak butterflies and many moths.

While intolerant of root disturbance, southern red oak is a long-lived and fast-growing shade tree. The long taproot of southern red oak diminishes transplant success. Best used as a specimen tree in native garden settings, southern red oak has branches that are resistant to breakage and can withstand hurricane-force winds.

Southern red oak wood is hard, making it useful for lumber, furniture, flooring and firewood. The bark is used as an antiseptic, astringent and tonic. 



Live oak's male flowers, borne on catkins.

# Live oak

*Quercus virginiana*

- **Family:** Fagaceae (Beech)
- **Other Common Names:** Southern live oak, Virginia live oak, coastal live oak
- **Range:** Virginia south to Florida and west to Texas
- **Habitat:** Maritime forests and maritime shrub thickets, edges of coastal marshes, and dunes
- **Habit:** Tree
- **Flowering/Fruiting Period:** FL March–April; FR September–November
- **Wetland Status:** FACU
- **Origin:** Native

Paul E. Hosier

In addition to serving as home to Spanish moss, resurrection fern, and occasionally American mistletoe, live oak is one of the best-known plants in the southern United States; in fact, it has become an icon of southern coastal living. Its instantly recognized profile graces many coastal business logos ranging from landscapers' and law firms' to restaurants' and banks'.

When growing in ideal conditions, live oak produces a short, thick trunk often between 2 and 4 feet in diameter and reaches a height of 50 to 70 feet with a crown spread sometimes twice its height. Live oak is evergreen or semideciduous; it always appears green, shedding last year's leaves within a few weeks of developing new leaves in the spring. Large branches close to the ground grow nearly horizontally, sometimes dipping toward the ground before ascending to the edge of the crown. Live oak leaves are alternately arranged, elliptical, and leathery with entire edges that are slightly rolled under, a key to identification of this species.

The dark green leaves range from 1 1/2 to 3 1/2 inches long, 1/2 to 1 1/2

inches wide, and occasionally possess bristle-tipped teeth, especially at the apex. The upper surface is shiny, and the lower surface is light green with some pubescence.

Live oak is monoecious, with male flowers borne on catkins 1 to 3 inches long and wind-pollinated female flowers borne on spikes arising in the axils of leaves. Acorns are chestnut brown, about 1 inch long, and 1/2- to 5/8-inch wide with the cap covering one-third to one-half of the acorn. They occur singly or in clusters of 2 to 5. In contrast to the acorns of sand laurel oak and water oak, live oak acorns mature in 1 year and germinate shortly after falling from the tree.

Acorns serve as a food source for birds, squirrels and white-tailed deer.

Live oak is the climax tree of the maritime forest in the Carolinas due to its adaptation to salt aerosols, soil salinity and wind. Live oak tolerates salt aerosols well, but it takes on a characteristic wedge-shaped profile where and when salt-laden winds kill the buds and leaves on the windward side of the tree. Live oak grows well

in full sun or shade, and it tolerates moderate drought, occasional flooding with salt water, and nutrient-poor soils as long as the soil remains unsaturated.

During severe hurricanes, the tree's broad, squat profile reduces the possibility that it will topple. Hurricane-force winds strip the leaves and small branches from live oak; however, the tree sprouts new branches and leaves within a few weeks.

Live oaks are fast-growing trees, especially when they are young. They often live 200 to 300 years or longer. Propagate live oak from seed, or plant sapling live oaks that are available commercially. Trees larger than saplings do not transplant well. With adequate space, live oaks develop into spectacular ornamental and shade trees.

*The plant profiles of both oaks come from Seacoast Plants of the Carolinas: A New Guide for Plant Identification and Use in the Coastal Landscape by Paul E. Hosier. Copyright © 2018 by North Carolina State University. Used by permission of the University of North Carolina Press. [www.uncpress.org](http://www.uncpress.org).*

for coastal homeowners to consider for their property and for any common areas in their neighborhoods.

“Some pines are better than others, but if you have a choice between pines and hardwoods, I’d choose hardwoods,” Hosier says. He especially recommends oaks — live oak for the southern coast of North Carolina, southern red oak for the northern coast —as well as American holly and black gum throughout the coast.

To minimize the chance of structural damage from storms, it pays to keep an eye to the future.

“You can avoid damage by the selective placement of the trees or by being judicious in cutting when you start developing your house,” Hosier says. “That allows the trees to fall without falling on your house, yet, gives you the shade that you want and the view that you want.”

He also wants property owners to be realistic in their expectations. “The overall approach is *minimizing* damage,” he says.

“You want to plan a yard that utilizes the research that tells you the plants that have the highest probability of surviving based on their structure and shape, their root systems, etc. But you’re not going to get a silver bullet and plant things in your yard so that you look over at your neighbor’s yard after a hurricane and they have no trees left and you have all your trees left.”

*North Carolina Sea Grant and the University of North Carolina Press published Seacoast Plants of the Carolinas, which includes sections on how some trees and shrubs survive storms, how to minimize damage, and how to recover after a storm. In particular, a useful table ranks 39 trees and large shrubs from high to low suitability for hurricane-prone environments. These conclusions came from coastal scientists who studied plants immediately after storms and noted that damage was species specific. For more: [go.ncsu.edu/SeacoastPlants](http://go.ncsu.edu/SeacoastPlants).*

*Also check out the Coastal Landscapes Initiative. Products available for download include a brochure and booklet that highlight 34 species, including trees and shrubs, along with grasses and other categories, recommended by the initiative’s team members. Go online to: [go.ncsu.edu/CoastalLandscapes](http://go.ncsu.edu/CoastalLandscapes).*



Volunteers from the UNCW Women’s Studies and Resource Center participate in Habitat for Humanity homebuilding projects that include steps to increase resilience for roofs.

## ROOF RETROFITS ARE WISE INVESTMENTS

North Carolina learned the hard way about construction standards when seven major hurricanes struck the state in the 1950s.

Spencer Rogers, coastal construction and erosion specialist for North Carolina Sea Grant, notes that the destruction those storms spawned led the N.C. Building Code Council to require inexpensive metal straps to improve the roof-to-wall connection capacity tenfold or more.

Those codes applied to new construction on the barrier islands beginning in the mid 1960s, but similar standards did not apply to houses on the mainland until about 1995. As a result, many houses in coastal North Carolina have wind-sensitive roofs.

“If you have an older house, and cannot see metal straps in your attic that attach each of your rafters to the exterior walls, you probably have a wind-sensitive roof,” he says. “With some effort, houses can be retrofitted for high winds. It’s usually easiest when doing other renovations.”

Lots of factors affect a building’s outcome during a storm, including the roof slope, shape and wind alignment. Roof failures are usually associated with vertical lift, and the common, moderately sloped roof has the highest lift compared to steeper or flatter pitches. In most houses, the connections that attach the roof to the walls work great against gravity and lateral forces. However, the

connections of most roofs built with common construction practices begin to fail when the wind speed on the roof increases above 85 mph.

Rogers has been working with a group of engineers through a National Science Foundation grant to evaluate the coastal storm damage to buildings. In general, wind speed, storm surge, wave and erosion damage was much lower along the oceanfront with Hurricane Florence than it was with Hurricanes Fran in 1996 and Floyd in 1999.

In the coastal communities between Carteret County’s Bogue Banks and New Hanover County, the group found relatively little structural wind damage to buildings. However, minor to major roof covering damage was widespread. In many cases, water had penetrated the damaged roofing and caused much extensive damage to interior finishing, such as drywall and flooring, and belongings. 🏠

### Reroofing?

You can take relatively inexpensive steps to be better prepared for the next wind storm. There are also several new insurance provisions that can lower your wind insurance premiums and in some cases may help pay for installing better roofing.

### Read More:

- [go.ncsu.edu/WindInsuranceIncentives](http://go.ncsu.edu/WindInsuranceIncentives)
- [DisasterSafety.org/fortified/fortified-home/](http://DisasterSafety.org/fortified/fortified-home/)

— DEBBI SYKES BRASWELL



# LAND



AS SEA LEVELS RISE, AN EPIC BATTLE TAKES SHAPE ON OUR COAST, WHERE INCREMENTAL CHANGES WILL HAVE ENORMOUS IMPACTS. A NEW PROJECT IS COORDINATING INVALUABLE MEASUREMENTS OF MARSHLAND ELEVATIONS TO REVEAL THE STORY AS IT UNFOLDS.

SARAH SPIEGLER

*NORTH CAROLINA SEA GRANT'S SARAH SPIEGLER, COORDINATOR FOR THE NORTH CAROLINA SENTINEL SITE COOPERATIVE, IS FACILITATING AN INNOVATIVE NEW GROUP AT WORK ON PART OF THE CLIMATE CHANGE EQUATION THAT WE DON'T NORMALLY THINK ABOUT WHEN WE TALK ABOUT SEA LEVEL RISE. BY CAPITALIZING ON SURFACE ELEVATION TABLES (SETs), THE NC SET COMMUNITY OF PRACTICE WILL CREATE A MORE COMPLETE PICTURE OF THE EFFECTS OF CLIMATE CHANGE.*

# VERSUS SEA

*Continued*



N.C. Coastal Reserve

STAFF FROM THE N.C. COASTAL RESERVE AND NATIONAL ESTUARINE RESEARCH RESERVE  
MONITOR A SURFACE ELEVATION TABLE.

A few years ago, Galen Scott of NOAA's National Geodetic Survey used a simple exercise to illustrate how to think about coastal changes due to sea level rise. He raised his hands next to each other, palms facing downward. His left hand signified the water level, and his right hand signified the marsh edge. He then started moving his left hand up slightly and his right hand down slightly. In essence, he said, "If the water levels are higher than the marsh, that's when we're in trouble."

But he then moved his right hand slightly above his left, depicting what can happen when marshes gain elevation, building through sediment deposits and plant root production — potentially how marshes might "keep up with or outpace rising water levels." He then started moving both his hands up and down next to each other, explaining that understanding dynamic changes in water levels and

in marsh elevation is crucial for coastal managers when making decisions about how to manage coastal resources in the face of climate change.

#### • SEA LEVEL RISE

Scientists predict that climate change will impact coastal habitats and communities in the coming years, including an increase in average water levels along coasts worldwide. Sea levels are rising on the scale of millimeters annually, due both to the melting of glaciers and ice caps and the expansion of water as it warms. However, as millimeters add up over the coming years and decades, big changes and immense challenges will result for coastal ecosystems and communities.

Although sea level rise occurs on a global scale, the effects and rates are regional and local in nature. "Relative" rates of sea level rise can differ from the global rate due

to local factors. These include upstream flood control, erosion and regional ocean currents — and even land movement, in continuation of a centuries-long response to the weight of Ice Age glaciers.

In Beaufort, North Carolina, the current relative sea level rise is 3.1 millimeters annually, based on data from 1953 to 2018 at a National Oceanic and Atmospheric Administration tide gauge. This yearly increase is a little more than the thickness of two pennies. In Wilmington, the sea level rises 2.39 mm per year, according to data from 1935 to 2018 at a NOAA tide gauge. On the Outer Banks, over 40 years of data from the Oregon Inlet NOAA tide gauge shows an annual increase of 4.69 mm.

But why worry about sea level rise that's only two or three pennies thick?

The global rate of sea level rise is accelerating, and those pennies will add up even more quickly. In fact, the NOAA "low"

## THE CEDAR ISLAND STORY

### HERE'S HOW SURFACE ELEVATION TABLES WORK — AND WHAT THE FIRST ONE INSTALLED IN NORTH AMERICA TELLS US.

IN 1992, SCIENTIST DON CAHOON INSTALLED THE FIRST SURFACE ELEVATION TABLE (OR “SET”) IN NORTH AMERICA ON CEDAR ISLAND, NORTH CAROLINA. SETS CAN MEASURE CHANGES IN THE MARSH SURFACE ELEVATION TO WITHIN 1.5 MILLIMETERS.

EACH SET REQUIRES A METAL ROD, WHICH RESEARCHERS MUST DRIVE 3 TO 25 METERS INTO THE GROUND. THE ROD REMAINS PERMANENTLY INSTALLED IN THE MARSH, PROVIDING A REFERENCE POINT — OR BENCHMARK — IN A MARSH ENVIRONMENT THAT CONSTANTLY CHANGES WITH TIDES, WIND, STORMS AND EROSION. THIS BENCHMARK ALLOWS SCIENTISTS TO MEASURE AND DETERMINE IF THE MARSH IS BUILDING

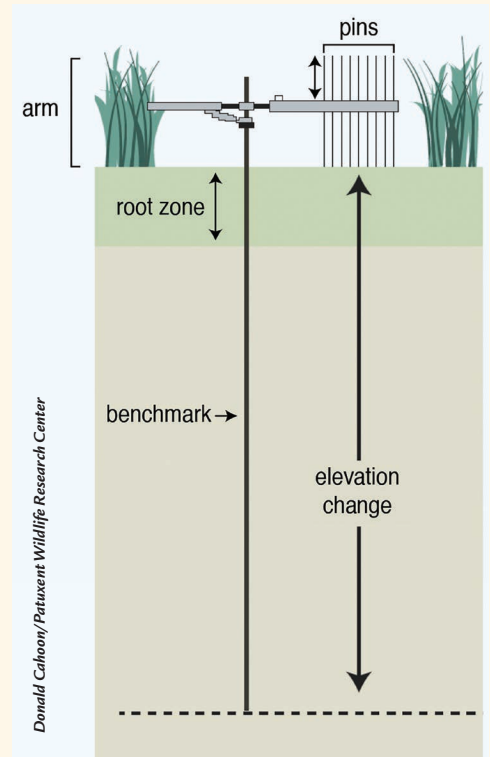
OR SINKING OVER TIME.

ONCE THE BENCHMARK IS IN PLACE, RESEARCHERS ATTACH A PORTABLE SET INSTRUMENT TO THE PERMANENT ROD AND THEN CAN TAKE HIGH-PRECISION MEASUREMENTS OF THE MARSH SURFACE ELEVATION. THIS PORTABLE DEVICE INCLUDES MOVABLE PINS TO MEASURE THE CHANGE IN HEIGHT OF THE SURFACE OF THE MARSH OVER TIME.

WITH RESEARCHERS JENNY DAVIS AND CAROLYN CURRIN FROM THE NOAA BEAUFORT LAB, CAHOON REVISITED THE CEDAR ISLAND SET 23 YEARS LATER. THE DATA SHOWED THAT FROM 1992 TO 2015, ON CEDAR ISLAND THE BATTLE OF LAND VS. SEA WAS A DRAW. DURING THAT TIME PERIOD, THE ISLAND'S MARSH KEPT PACE WITH THE LOCAL RATE OF SEA LEVEL RISE.

**FOR MORE ON SETS, LISTEN TO NOAA'S PODCAST ON “MAKING WAVES: MEASURING CHANGE IN AN ESTUARY.”**

[GO.NCSU.EDU/WAVES](http://GO.NCSU.EDU/WAVES)



SURFACE ELEVATION TABLES MEASURE CHANGES IN MARSH SURFACE ELEVATION.

global sea level rise scenario for Beaufort, for instance, predicts seas a full foot higher in the next 40 years. However, if rates continue

to accelerate, NOAA forecasts say Beaufort could experience sea level rise of 2 to 4 feet over the same time.

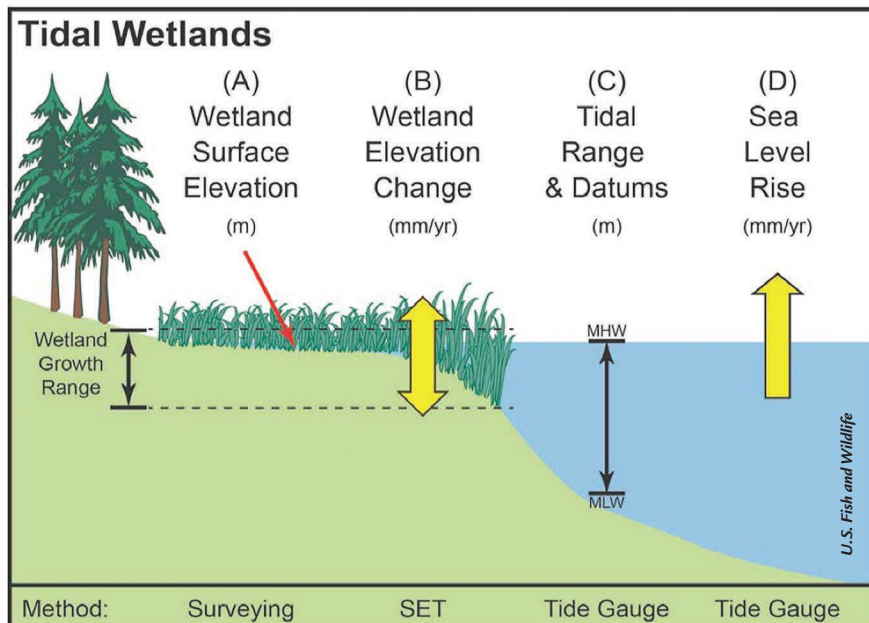
### • MARSH ELEVATIONS

Marshes are potentially resilient, but if they cannot build elevation quickly enough through deposited sediments to keep up with rising water levels, eventually marsh plants will drown and die. In this case, the marsh will become open water habitat. Understanding the dynamics of change at the marsh edge in elevation and water levels, therefore, can help coastal managers make better decisions about how to plan, prepare and adapt to sea level rise at our coasts.

Just as scientists measure changes in water levels in millimeters per year — quite a tiny change when you stand on the beach looking out into the waves, contemplating the immense amount of water present — researchers also record changes in marsh surface elevations at a very fine scale. In 1992, Don Cahoon, an internationally

*Continued*

CHANGES AT THE MARSH EDGE IN ELEVATION AND WATER LEVELS AFFECT WETLAND SURVIVAL.



recognized expert in tidal wetland elevation dynamics, installed what likely was the first surface elevation table (or “SET”) in North America, which he placed on Cedar Island.

SETs measure changes in the marsh surface elevation with 1.5 millimeters of precision. Although these instruments have provided data about coastal marshes in the United States for less than 30 years, NOAA’s Center for Operational Oceanographic Products and Services has been measuring sea levels for over 150 years. Tide stations operating along the coasts measure water levels locally by comparing them to specific points on land. Only more recently have researchers become interested in monitoring the changes in marsh elevation specifically for a better understanding of how marshes respond to sea level rise.

Often, scientists install SETs to find

answers to specific research questions. For example, Jenny Davis and Carolyn Currin at the NOAA Beaufort Lab examined how the use of nutrient fertilizers affects marsh elevation. Their results, published in the journal *Estuaries and Coasts* in 2017, revealed that nutrient fertilization may be an effective adaptive management strategy for helping marshes keep pace with sea level rise.

#### • UNTAPPED RESOURCES TO ADDRESS KEY QUESTIONS

SETs are vital to understanding changes in marshes and can help us answer important questions, such as:

- 1) How is the surface elevation of the marsh changing?
- 2) Is the elevation of the marshes we

study in North Carolina keeping up with local sea level rise?

SETs are relatively inexpensive to install and maintain, but they do require staff training and time to collect data on a consistent basis. Because researchers often install SETs for specific purposes, after funding ends some researchers may not have the resources or staff time available to keep taking SET measurements. However, SETs require relatively little maintenance. Even if months or years pass without measurements, a SET remains ready until the person-power is available again to collect data.

In North Carolina, we formed the “NC SET Community of Practice” in a collaborative effort among academic, governmental and private organizations that have installed SETs in order to measure

## COLLABORATION AND EDUCATION THE CITY OF JACKSONVILLE INSTALLS SETS

THE CITY OF JACKSONVILLE IN NORTH CAROLINA WAS INTERESTED IN LEARNING WHETHER ITS MARSHES WERE KEEPING PACE WITH SEA LEVEL RISE. IN THE SUMMER OF 2016, PAT DONOVAN-BRANDENBURG, THE CITY’S STORMWATER MANAGER, TEAMED WITH NOAA RESEARCHER CAROLYN CURRIN AND FORMER N.C. SENTINEL SITE COOPERATIVE COORDINATOR JENNIFER DORTON TO INSTALL SIX SETS IN RESTORED AND NATURAL MARSHES IN WILSON BAY. THEIR WORK WAS PART OF A MULTIDISCIPLINARY COMMUNITY COLLABORATIVE RESEARCH GRANT (CCRG) PROJECT TO STUDY THE EFFECTIVENESS OF RESTORATION IN THE BAY.

AFTER INSTALLATION, CURRIN TRAINED CITY STAFF TO READ AND COLLECT DATA FROM THE SETS — INFORMATION THE STORMWATER MANAGER HAS CONTINUED TO COLLECT AFTER THE CCRG STUDY ENDED. DONOVAN-BRANDENBURG ALSO

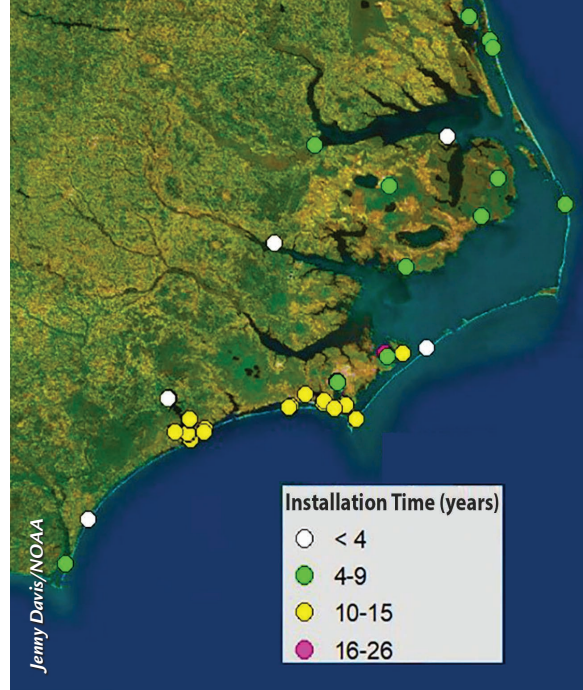


SET ROD INSTALLATION.

CURRENTLY PARTICIPATES IN THE NC SET COMMUNITY OF PRACTICE.

TODAY, STURGEON CITY, THE CITY’S ENVIRONMENTAL EDUCATION CENTER ON WILSON BAY, USES THE SETS IN ITS EDUCATIONAL PROGRAMMING, WHICH INCLUDES LESSONS AND RESOURCES DEVELOPED DURING THE CCRG PROJECT.

THE WILLIAM R. KENAN JR. INSTITUTE FOR ENGINEERING, TECHNOLOGY AND SCIENCE AT NC STATE UNIVERSITY AND NORTH CAROLINA SEA GRANT SUPPORT THE COMMUNITY COLLABORATIVE RESEARCH GRANT PROGRAM: [GO.NCSU.EDU/CCRG](http://GO.NCSU.EDU/CCRG).



**LEFT:** NC SET Community of Practice member Lisa Baron at Cape Lookout National Seashore. **RIGHT:** SET installation times and locations on the N.C. coast.

and monitor how our marsh habitats are changing. This network includes scientists, resource managers and town staff invested in understanding the trends of elevation change in our marshes.

The group began working together last year to map the locations of all North Carolina SETs, increase collaboration among SET users, and support efforts to identify regional trends in North Carolina salt marsh response to sea level rise.

Most scientists who work with SETs agree they need to be installed for at least five years before the data can be used to start making predictions about the trends at a specific marsh site. And the longer the dataset, the better. The NC SET Community of Practice's initial inventory, which Jenny Davis conducted at the NOAA Beaufort Lab, found 143 SETs in the state, with 107 now installed long enough to meet the five-year criteria.

As a result, the NC SET Community of Practice has recently created an interactive map tool and database of the SETs in our state, modeled on a similar effort from the Chesapeake Bay Sentinel Site Cooperative.

The map also capitalizes on technical expertise available from the NOAA Beaufort Lab and NOAA Sentinel Site Program, providing researchers and resource managers with metadata from all the inventoried SETs in North Carolina and allowing them to view preliminary trends of land accretion (building) or subsidence (sinking) at marsh sites where researchers record SET data.

It is important to understand that marsh elevation is a useful measure in comparison to water level. If an increasing rise in water level outpaces an increasing rise in marsh elevation, that marsh is still drowning. As our NC SET Community of Practice analyzes and shares data, we will learn more about the trends in our marshes, how sea level rise will affect our coasts, and which side is prevailing in the battle of land versus sea. 🌊

**USE THE NC SET INTERACTIVE MAP: [GO.NCSU.EDU/SETS](http://GO.NCSU.EDU/SETS)**  
**FOR MORE ON SEA LEVEL TRENDS, VISIT NOAA'S "TIDES & CURRENTS": [TIDESANDCURRENTS.NOAA.GOV/SLTRENDS/](http://TIDESANDCURRENTS.NOAA.GOV/SLTRENDS/)**

## MEMBERS OF THE NC SET COMMUNITY OF PRACTICE

THE NC SET COMMUNITY OF PRACTICE IS A COLLABORATIVE EFFORT AMONG SCIENTISTS, RESOURCE MANAGERS AND TOWN STAFF WHO HAVE INSTALLED SETS AND WHO ARE INVESTED IN UNDERSTANDING THE TRENDS OF ELEVATION CHANGES IN OUR MARSHES.

THE NETWORK INCLUDES MEMBERS AND AFFILIATES OF ACADEMIC, GOVERNMENTAL AND PRIVATE ORGANIZATIONS:

- AUDUBON NORTH CAROLINA
- CAROLINA WETLANDS ASSOCIATION
- CHOWAN UNIVERSITY
- CITY OF JACKSONVILLE
- EAST CAROLINA UNIVERSITY
- THE NATURE CONSERVANCY IN NORTH CAROLINA
- NC STATE UNIVERSITY
- NOAA NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE
- N.C. COASTAL RESERVE AND NATIONAL ESTUARINE RESEARCH RESERVE
- NORTH CAROLINA SEA GRANT
- U.S. FISH AND WILDLIFE SERVICE
- U.S. NATIONAL PARK SERVICE
- UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL'S INSTITUTE OF MARINE SCIENCES



*Students play with a watershed model at Kingswood Elementary School.*

# YO NEW GREEN



## Stewardship Begins Early and Upstream

CHRISTY PERRIN

*Christy Perrin serves as sustainable waters and communities coordinator for North Carolina Sea Grant and the Water Resources Research Institute. Here, she tells the story of Kingswood Elementary School and the Black Creek Watershed Association, a collaboration she facilitated for students, teachers, parents and other community members to care for a beloved urban stream. Black Creek flows from downtown Cary into the Crabtree Creek system and ultimately drains to the Neuse River Estuary and the Atlantic Ocean.*

*Continued*

# YOUNG MINDS ENJOY INFRASTRUCTURE

Christy Perrin



On a warm autumn morning, four young boys excitedly reach for irises in small pots and a chance to push their hands into soft dirt. One of the fourth graders laments his buddy is late and will miss out on planting the rain garden. “This is so much better than sitting in class!” he exclaims.

As these young Kingswood Elementary School students have learned over the past two school years, this new rain garden on the school grounds does more than soak up rain water, reduce pollutants and improve the health of downstream Black Creek. It provides plants for our butterfly and bee pollinator friends, birds and amphibians. It provides a touchable, smellable and dynamic outdoor learning environment for growing minds. Also, as we unexpectedly learned through conversations with teachers, tranquil planted spaces like these provide brief moments of respite for stressed teachers and other school staff.

The impetus for the Kingswood Elementary School rain garden, cistern and native planting areas came from Black Creek, a modest but beloved urban stream in Cary. Black Creek flows from the historic downtown into the Crabtree Creek system and ultimately drains to the Neuse River Estuary and the Atlantic Ocean.

The Black Creek Watershed Association (BCWA) has been working to reduce stormwater runoff impacts to the creek through green stormwater infrastructure — projects that use nature to reduce runoff and pollution while benefiting people’s health and well being. Think of the difference between a stormwater pipe hidden underground that sends untreated stormwater directly to a creek, on one hand, and a below-grade rain garden that uses plants and soil to soak up water and pollution, on the other.

A U.S. Environmental Protection Agency grant allowed partners to design, install and provide educational opportunities for students around green infrastructure at the school as part of a larger initiative to improve the health of Black Creek.

## Experts and Students-Turned-Experts

Knowing that teachers are pressed for time to meet educational standards and ready students for tests, the BCWA asked how we could meaningfully engage teachers and



*ABOVE: Christy Perrin (left) and community leaders spoke at the green infrastructure celebration at Kingswood Elementary.*

students so they would be comfortable using outdoor spaces. Kingswood Elementary principal Sherry Schliesser and assistant principal Barbara Fair already knew the benefits of outdoor learning spaces. The student Garden Club was growing edible plants in raised beds and in a greenhouse built on the school grounds by a local Rotary Club, and school leaders already had some ideas and suggestions. They recommended involving Randy Senzig of the education nonprofit Center for Human and Earth Restoration (CHER).

Senzig brought teachers and their classes outdoors throughout 2017 and 2018, guiding students through activities to explore the natural features of the school campus and to choose a location for a possible rain garden. After learning how rainwater flows across their campus, students chose the grassy area downhill of the basketball court as an ideal spot.

Unbeknownst to them, the adult professionals had selected that very spot as our priority area, too. Shortly after receiving the grant, the BCWA team had held two meetings to explore opportunities and needs on the campus. These meetings brought together school administration and teachers, Wake County Public School System Facilities staff



and Town of Cary stormwater staff.

They joined a team including engineering expert Sarah Waickowski of North Carolina State University’s Department of Biological and Agricultural Engineering, landscape architecture and early childhood development expert Carla DeCambre from the Natural Learning Initiative in NC State’s College of





Christy Perrin



Christy Perrin

**ABOVE:** North Carolina Sea Grant's Jane Harrison (left) and Anna Martin (right) volunteered to tend native plants at Kingswood. **LEFT:** After six months, the rain garden plants offered a haven for students and teachers.

Design, along with Senzig and the Kingswood community. The team chose two spaces: the highly visible location suggested by students for a bioretention area — a large, engineered rain garden — and the area next to the media center and greenhouse for a rainwater-harvesting cistern and a few rows of native plants.

DeCambre assigned graduate students

to create designs for the two areas. To kick off the process, the students visited the school and chatted with children about what they did outside and how they felt about the outdoors. DeCambre and her team heard their voice fears about touching things outdoors. Would the children hurt something, or themselves?

In a time when screens command attention from all sides, many kids have few opportunities to interact with nature. Thus, engaging youth with natural spaces requires an intentional approach, which includes addressing their fears and inviting them into structured activities outside.

### Parents and Teachers Pipe Up

The students' plans were beautiful and innovative, running the gamut from ready-to-implement to ahead-of-their-time. The BCWA team displayed the six most viable plans at a teachers' meeting and at the annual spring STEM Fair. Older students and parents wrote what they liked about the designs on sticky notes, while DeCambre's interactive kinetic-sand watershed model engaged the younger

children. Parents wanted as many native plants as possible. The concept of decorative grasses was very popular with all, as was the idea of incorporating art.

DeCambre took the students' and parents' feedback into account and created a beautiful planting plan that almost exclusively utilized native plants. The strip of land where the cistern was planned was already landscaped with the non-native shrub inaptly named "heavenly bamboo," or nandina, which is not so heavenly to birds that eat its toxic berries. To fuel their migration, cedar waxwings tend to descend in large groups and gorge on the berries, which are deadly for them.

The nandina had to go.

### Construction Kicks Off

The preparation work for the bioretention construction and cistern area, including nandina removal and disposal, was put out for bids from contractors. We selected Vortex Drainage Systems, which had the experience and reasonable price we needed.

We were ready to go, with a goal to do the excavation and move heavy equipment offsite before school started in August 2017. A moment of panic ensued when the first day of school saw the rain garden still undergoing construction, complete with a giant pile of bioretention sand next to the car pool lane.

But Kingswood staff were not deterred. Yellow tape went up and Principal Schliesser stood nearby, directing parents around it. The contractor's staff stood on the sidewalk watching out for students migrating between buildings, stopping their equipment to let them pass.

That fall, Mitch Woodward, the area natural resources agent for NC State Extension, installed a 2,100-gallon cistern, after several of us on the team put our backs into rolling it across campus to get it into place. He installed a top-of-the-line submersible pump, to minimize chances of malfunction, and a yard spigot for attaching a hose or filling watering cans we provided.

An electrician recommended by Wake County Public Schools installed an outdoor outlet for the pump. To ensure that the cistern functions as a stormwater-reduction device, Woodward installed an overflow valve that will slowly drip the top third of the tank through the landscaped area into an existing storm drain. Even if the

*Continued*



Christy Perrin

A Kingswood Elementary student and parent were among the volunteers who installed native plants in the school's rain garden.

school forgets to use the cistern, it will slowly drain, making space for more rain.

### Planting Energizes Everyone

With the heavy lifting done, the fun part began. With over 250 plants – 84% of them native – to install, we needed many hands.

Our 4th grade Kingswood Elementary friends kicked off the planting in the fall of 2017 with help from the CHER staff. They installed plants in the bed of the rain garden, where the bioretention soil mix was soft and sandy. They planted irises, milkweed, black-eyed Susans and ajuga, the one non-native ground cover.

Parents and BCWA volunteers planted during the school's STEM Saturday. NC State graduate students relished a sunny afternoon away from their computers, and WRI and North Carolina Sea Grant staff members pitched in to help. People love to dig in the dirt and experience plants, though we tested their resolve with the difficult task of planting on the upward slopes and nearby areas of the rain garden. The soil there was mostly compacted clay with some gravel left over from school construction.

To encourage students to get close to the rain garden, while protecting the soil

from compaction, we visited a stone supplier and ordered a pallet of small boulders. One afternoon in December, graduate students and BCWA volunteers moved boulders into place with a wheelbarrow, shovels and muscle power. Our resident BCWA horticulture expert and long-time volunteer with the JC Raulston Arboretum, Carol Lawrence, guided us in installing boulders with the important advice to carefully dig holes for them, so they remain stable when small feet step on them. Deliberate placement also prevented the boulders from looking as though they dropped from space. Finally, the student Garden Club helped to install plant markers and the BCWA team provided simple, educational signs for both the cistern and rain garden.

We extended the grant into the 2018-2019 school year to provide plenty of time after installation to ensure proper initial functioning and plant survival, and to engage a second year of classes in outdoor educational activities. We held a celebration and dedication last fall for what we called Kingswood Elementary School's "Outdoor Learning and Stream Protection Areas." Danielle Scheren's 5th grade class performed a skit at the rain garden that shared what the rain garden provided: habitat for

wildlife, beauty for the school, absorption of stormwater and many more benefits.

In the audience were 65 4th and 5th graders, and adult guests who included Wake County commissioner Greg Ford, Wake County School Board member Bill Fletcher, Cary Town Council member Don Frantz and Wake County School System's superintendent Cathy Moore. Our guest dignitaries also spoke with students about the benefits of green infrastructure and the process of collaboration and making ideas come to life. They stressed that any person can have an idea, find partners and make it happen together. WUNC Radio and *Cary Magazine* reported on the event.

### Green Infrastructure and Schools – A Hopeful Future

The benefits to teachers' and students' well-being and development, in addition to the reduced pollutant and flooding impacts on the ecosystem and downstream communities, can outweigh the modest costs to maintain green infrastructure and keep it functioning as the school amenity it should be.

Hopefully, the high involvement of Kingswood Elementary has planted the seeds for long-term care. The school's staff members have demonstrated their willingness and ability to keep up their green infrastructure, already adding mulch when needed and engaging the custodian in watering and care.

However, support and oversight from the school system or an outside third party could ensure maintenance continues over time, particularly when school administration changes in the future. This modest investment may be the key to long-term success for green infrastructure at schools.

*For tips and strategies for anyone interested in planning and building green school projects, read "Lessons for Working with Schools on Outdoor Learning and Green-Infrastructure Areas" at [go.ncsu.edu/green-infrastructure](http://go.ncsu.edu/green-infrastructure).* 🌱

# RISING STARS

## New Fellows Fuel Scientific Discovery

BY LEE CANNON, MARISA INCREMONA, KATELYN VAUSE, SUMMER WALLS AND DAVE SHAW

*North Carolina Sea Grant helps to develop a cadre of educated, innovative and technologically advanced professionals through a variety of fellowships for talented graduate students. These rising movers and shakers will advance the field for years to come.*



• Sarah Donaher



• Melinda Martinez



• Emily Ury

### CLAMS MAY FACILITATE SEAGRASS RECOVERY

• **Sarah Donaher** will study the resilience and restoration of seagrass beds as the recipient of the 2019 North Carolina Coastal Research Fellowship. North Carolina Sea Grant and the N.C. Coastal Reserve and National Estuarine Research Reserve Program sponsor the fellowship, which supports work in the state's reserve system.

"Understanding how ecosystems such as seagrasses respond to disturbance is a fundamental ecological question," says Brandon Puckett, research coordinator at the Coastal Reserve. "By testing the potential for dams to facilitate the recovery of seagrasses from disturbance, Sarah's research also will provide insights that can be applied

in restoration and resource management contexts."

Donaher, a marine sciences doctoral student at the University of North Carolina at Chapel Hill, will focus in part on the erosional effect on seagrass beds from high wave energy caused by storms and boat wakes.

### DRONE DATA AIDS "GHOST FORESTS" RESEARCH

The 2019 North Carolina Sea Grant – North Carolina Space Grant Graduate Research Fellows will identify early warning signs of "ghost forests" using drones and remote sensing technology.

• **Melinda Martinez**, a doctoral student in forestry and remote sensing in the Department of Forestry and Natural Resources at North

Carolina State University, and **Emily Ury**, a doctoral student in ecology from Duke University, will determine when saltwater has begun killing healthy wetlands, a process that leaves behind ghostly stands of dead trees.

"It is interesting this year that both fellows proposed to use drones in their research," says Susan White, executive director of North Carolina Sea Grant and North Carolina Space Grant. "We hope their work will encourage others to utilize cutting-edge technologies."

Martinez will use remote-sensing technologies to study coastal forested wetlands. She will measure the volume of greenhouse gases released by standing dead trees and compare that to amounts released by soils in forested wetlands near the coast.

*Continued*



• Erin Voigt



• Olivia Vila



• Lise Montefiore



• Riley Mulhern

Ury will examine how marine salts present due to sea level rise affect plants that are accustomed to growing in freshwater, and if signs of stress from salt exposure can be distinguished from other stressors, such as flooding.

**SHORELINE EROSION RELATES TO NURSERIES**

• Erin Voigt, a doctoral student at North Carolina State University, is the recipient of the 2019 joint fellowship from North Carolina Sea Grant and the Albemarle-Pamlico National Estuary Partnership (APNEP).

Voigt will study how native and invasive species distribution and wave exposure affect shoreline erosion and the availability of nursery habitats. She anticipates this work will identify factors that affect marsh shoreline erosion and

growth along the Currituck, Albemarle and Pamlico sound system. The study also will use a drone to map marsh habitat change over time.

“The resulting insights — into the interacting effects of invasive marsh grasses and wave energy on shoreline erosion and fish habitat at landscape scale — will help to inform APNEP’s approach to invasive species management and fish habitat conservation,” says Dean Carpenter, APNEP program scientist.

**SEA GRANT/WRRI FELLOWS FOCUS ON DIVERSITY**

Six graduate students across North Carolina are beginning new coastal and water resource research projects. North Carolina Sea Grant and the Water Resources Research Institute of the University of North Carolina system are funding four fellows. Research

consortia facilitated by WRRI — the Urban Water Consortium and the Stormwater Consortium — are supporting the other two projects.

“We are pleased to have our funding partners join us again this year in support of research fellowships that focus on diverse communities,” says John Fear, deputy director for the state’s Sea Grant and WRRI programs. “We have a broad range of projects that consider topics of immediate and long-term needs for a variety of North Carolina communities.”

North Carolina Sea Grant and WRRI are supporting these four fellows:

• Olivia Vila is a doctoral student in parks, recreation and tourism management at NC State. She will discuss disaster-related experiences with people who live in Wilmington



• *Yener Ulus*

in order to reveal recovery priorities. She will focus particularly on engaging Hispanic/Latinx community members. Her project uses a citizen-science framework to understand how this particular approach can assist with communities' recovery from natural disasters.

- **Lise Montefiore** is studying for her Ph.D. in biological and agricultural engineering in the Biosystems Analytics Lab at NC State. Her research examines how land-use change can affect water quality. She is using satellite images to map the growth of swine concentrated animal feeding operations (CAFOs) waste lagoons across North Carolina's coastal plain in order to investigate potential connections between CAFO growth and changes in water quality.

- **Riley Mulhern** is studying for his doctorate in environmental science and engineering at UNC-Chapel Hill. He is partnering with UNC-Pembroke and American Indian Mothers for this project, which complements a larger National Science Foundation project, "Water Health and Infrastructure Resilience and Learning." His research focuses on mitigating risks of drinking water contamination among vulnerable and marginalized communities, particularly in Wake and Robeson counties. He is developing predictive tools to respond to water quality risks.

- **Yener Ulus** is a doctoral student in environmental health science at UNC-Greensboro. Ulus seeks to understand how

salinization changes toxic mercury levels in North Carolina's coastal wetlands. He will travel to Dare County and Tyrell County with a team of undergraduate students to collect water and sediment samples for analysis.

- The Urban Water Consortium is funding **Arpit Sardana**, a Ph.D. student in environmental engineering at NC State. Sardana's research aims to improve water quality using natural processes. By conducting tests on water samples from wetlands across North Carolina, he will examine how sunlight can degrade pharmaceuticals in wastewater.

- The Stormwater Consortium is funding **Zhenzhen Zhang**, a doctoral student studying interdisciplinary sustainable science at NC State. Her research focuses on helping communities be aware of and be prepared for issues related to climate change, such as increased flooding and stormwater management challenges. For this project, she will research the benefits to teachers, students and ecosystems when implementing green infrastructure in elementary schools across the city of Raleigh. 🌱



• *Arpit Sardana*



• *Zhenzhen Zhang*

*More information about these and other funding opportunities is available at:*

- [ncseagrant.ncsu.edu/funding-opps/](https://ncseagrant.ncsu.edu/funding-opps/)
- [wri.ncsu.edu/research/funding/](https://wri.ncsu.edu/research/funding/)
- [ncspacegrant.ncsu.edu/higher-ed-opportunities/](https://ncspacegrant.ncsu.edu/higher-ed-opportunities/)

# Tuna, Toadfish and More

SCOTT BAKER AND  
SARA MIRABILIO



Bill Russ/VistiNC.com

*Scott Baker and Sara Mirabilio, fisheries specialists with more than 40 years of combined experience, have launched the Hook, Line & Science blog series for North Carolina Sea Grant. The following blog posts, along with many others, are available at [HookLineScience.com](http://HookLineScience.com).*

## WHAT ARE THE BARRIERS TO LIFE JACKET USE?

### *Here's Why Many Recreational Boaters Don't Wear Preservers*

The annual number of drownings that occur in the United States during recreational boating has changed little over the past decade. Approximately 3.56 people drown per 100,000 registered boats, even though the law requires all recreational boats to carry life jackets.

- **Research Need**

Do you always wear your life jacket? Why or why not? Researchers wanted to understand the reasons why adults might not

wear life jackets while recreational boating. The results can inform intervention strategies and boating safety campaigns.

- **What did they study?**

Researchers in the state of Washington conducted a survey with 675 boaters one year during late summer and early fall at multiple boat ramps. Some boaters participated as they were leaving the dock after being out on the water. The researchers analyzed the data by separating the boaters into groups based on life jacket usage rates and compared usage to such factors as age, gender, weather, boating experience, type of vessel and several other factors.

- **What did the results show?**

Scientists found several reasons associated with not wearing a life jacket, including discomfort with the life jacket, alcohol consumption, warm weather, and swimming experience in open water. The restriction or limited range of motion that typical life jackets provide was a prominent factor. Study participants were more likely to use inflatable life vests, because the boaters considered them more comfortable. Also, because the law requires children to wear life jackets, researchers observed that parents were more likely to wear life jackets, perhaps in order to set a good example. Scientists also found that boaters who attended a boating safety class were more likely to wear a life jacket.

- *What else did they find?*

The researchers found that only 1 in 10 boaters in the study wore a life jacket during the entire recreational boating trip.

Coast Guard approved life vests and other important info: [go.ncsu.edu/life-vests](http://go.ncsu.edu/life-vests)

Information on boating safety: [www.ncwildlife.org/Boating/Laws-Safety](http://www.ncwildlife.org/Boating/Laws-Safety)

The full study in *Injury Prevention*: [go.ncsu.edu/life-jackets-save](http://go.ncsu.edu/life-jackets-save)

— Summary compiled by  
Anna Greene and Scott Baker

## WHY DO SOME ANGLERS TARGET BLUEFIN TUNA WHILE OTHERS DO NOT?

### *The Answer Partially Depends on Annual Income*

- *Research Need*

The Atlantic bluefin tuna (*Thunnus thynnus*) supports a popular private and for-hire recreational fishery along the East Coast, from Maine to North Carolina. Some people believed that the thirst for large trophy bluefin tuna was the reason recreational landings have exceeded the annual sub-quota in recent years.

Researchers wondered, though, if there were other factors at play in landings exceeding the sub-quota, such as changes in fish availability and difficulties in real-time monitoring of catch. Because recreational bluefin tuna anglers are allocated about 20% of the total U.S. bluefin tuna quota, it is important for managers to understand how regulations, trip costs and other factors affect fishing behavior.

- *What did they study?*

From spring to early summer 2016, researchers surveyed private recreational anglers from Maine to North Carolina with permits to target Atlantic bluefin tuna. The study evaluated preferences and policy options by offering respondents choices for a range of management strategies (e.g., keeper size, bag limits, seasons), catch-related outcomes (e.g., size and number of fish caught) and trip costs. The survey also had a series of direct questions regarding angling behavior, attitudes and demographics.

- *What did the results show?*

Anglers with higher levels of income who had fished for bluefin within the last 5 years

valued more catch-and-release fishing. Anglers with annual incomes less than \$150,000 did not target bluefins with any regularity, given both the high trip costs and relatively restrictive harvest regulations (only 1 to 3 fish allowed per vessel per day, since the mid-2000s). However, anglers in the under-\$150,000 income range highly value harvest over catch-and-release fishing. These anglers could reenter the fishery if conditions — fish availability, regulations and costs — made doing so a worthwhile endeavor. This could complicate fishery management if such angler behavior was not predictable.

- *What else did they find?*

The study determined that the recreational Atlantic bluefin tuna fishery resulted in an aggregate consumer surplus of over \$14 million for 2015. This estimate reflects the total net benefits that anglers derived above and beyond their trip expenditures — a figure analogous to profit a commercial fishery might obtain.

The full study in *North American Journal of Fisheries Management*: [go.ncsu.edu/bluefin-study](http://go.ncsu.edu/bluefin-study)

— Summary compiled by Sara Mirabilio

## CAN FISH COMPETE WITH MAN-MADE NOISE?

### *For the Oyster Toadfish, Boat Noise Impacts Communication*

- *Research Need*

Lots of things, both natural and man-made, create noise underwater: waves, marine life, shipping traffic and, yes, sport-fishing boats. All these things can make it tough for a fish to perceive predators or prey, communicate, and interpret the surrounding environment,



*An Atlantic bluefin tuna on the hunt*

*Continued*

particularly at a distance. As man-made underwater sound increases in many places, it is important to understand the potential impacts of such sounds on marine and freshwater fishes at the individual and population level — and on their acoustic habitat.

• *What did they study?*

Researchers conducted nighttime field playback experiments to test for the ability of oyster toadfish (*Opsanus tau*) to respond to and overcome man-made and natural sounds. Fish “dens” — cement block shelters — were established so toadfish would take up residence at a noisy site (Newport River) and quiet site (Jarret Bay), locations where researchers then could record fish vocalizations. The noisy site had high levels of observed boat activity (over 100 vessels per day), while the quiet site had low levels of boat activity (fewer than 25 vessels per day).

The research team also observed responses from fish after the team played recordings of six types of sound (snapping shrimp, inboard vessel motor, outboard vessel motor, low- and high-frequency bottlenose dolphin sounds, and inboard vessel motor noise in combination with low-frequency dolphin sounds). Hydrophones — underwater microphones — measured fish vocalizations.

Researchers repeatedly compared the average strength of the vocalizations before, during and after the playback periods to ensure their findings were scientifically rigorous.

• *What did the results show?*

Fish may compensate for a noisy underwater environment by amplifying their vocalizations (what researchers call “the Lombard effect”) and by altered call rates. When experiencing vessel noise alone, oyster toadfish increased vocalizations by an average of 8.5 decibels (dB); however, most vessels passing the dens increased peak ambient noise levels by 14.6 dB. In a busy vessel channel, oyster toadfish may be unable to effectively



Sara Mirabilio

Sara Mirabilio, North Carolina Sea Grant fisheries extension specialist, with oyster toadfish in hand.

compensate for the increased noise. When researchers introduced the sound of dolphins — a natural predator — oyster toadfish decreased their calling rates, and they stopped calling altogether when the dolphin sounds accompanied vessel noises.

• *What else did they find?*

Oyster toadfish near a busy boat channel have lower reproductive success, producing fewer embryos than toadfish with nesting sites in quiet areas.

The full study in *Proceedings of Meetings on Acoustics*: [go.ncsu.edu/toadfish-study](http://go.ncsu.edu/toadfish-study)

— Summary by Sara Mirabilio

## CAN EDUCATION CORRECT UNLAWFUL BEHAVIOR?

### *A Class for Anglers with Fishing Citations Pays Off*

• *Research Need*

Fisheries managers use a host of rules and regulations to manage fisheries — like size limits, bag limits and seasonal harvest restrictions. Of course, successful management relies on the principle that stakeholders understand or, at least, follow the rules. In south Florida, the Biscayne and Everglades National Parks established a 3.5-hour Fisheries Education Class to enhance compliance with fishing regulations



and improve stakeholders' understandings of the need for management. Open to the community and available to anglers cited with a fishing violation, the program has educated 1,242 people between 2007 and 2015. Anglers participate in order to strike a citation from their record, which includes a \$50 course fee.

But are these types of programs effective at changing angler behavior? How can managers evaluate the success of such a program?

• *What did they study?*

To determine the effectiveness of this type of intervention, program evaluators surveyed

200 class attendees from 2012 to 2015 about their own behavior changes and understandings of management needs before and after class completion.

• *What did the results show?*

Despite the low sample size, results confirm that attendees felt better equipped to understand and adhere to fisheries regulations after taking the class. Also, the class improved the attitudes of the participants toward fishing regulations.

In addition, a review of park records showed that of the 803 people who were issued citations and then took the class, only four

received another citation within the period of this study.

• *What else did they find?*

Most class participants were aware that fisheries regulations exist, but many were confused about how to interpret the regulations and how to apply them when fishing. In addition, most anglers were not aware of the scientific basis for regulations.

The full study in *Fisheries Magazine*: [go.ncsu.edu/no-tickets](http://go.ncsu.edu/no-tickets)

— Summary by Scott Baker 📄

Visit [HookLineScience.com](http://HookLineScience.com)



National Park Service

Many anglers are unaware of the scientific basis for regulations.

# Which Wetlands Will Survive?

*New research suggests all marshes have tipping points.*

BY SUMMER WALLS

Jarek Tuszynski (CC-BY-SA-3.0)

Core Banks, North Carolina.

**S**EA LEVEL RISE. HUMAN DEVELOPMENT. SEDIMENT DEPOSITS. WAVE ENERGY. All affect coastal wetlands, but to what extent? Is it possible to forecast which wetlands will thrive — or which, instead, will respond catastrophically to coastal change?

Coastal salt marshes offer numerous benefits — protecting shorelines, providing habitats for fish, filtering pollution and even preventing floods. Wetlands also remove carbon dioxide from the atmosphere, and, by doing so, help to slow global warming.

Because of the essential role wetlands play, scientists Anna Braswell and James Heffernan, both based at Duke at the time, examined the characteristics of hundreds of estuaries using geospatial analyses that spanned the Atlantic and Gulf coasts from Maine to Mexico.

Estuaries — areas where freshwater meets saltwater — are critical when considering what causes marshland to thrive or die. Marshes have special ecological relationships with their water sources, which supply nutrients. River-deposited sediment, for instance, delivers nutrients with greater potential to build wetlands.

Saltwater affects marshes as well. For example, in places that experience higher tidal ranges, marshes usually are more resilient to sea level rise, because vegetation provides a buffer zone for higher water levels.

With support from North Carolina Sea

Grant and the National Science Foundation, Braswell and Heffernan focused on estuary water depth, land use, vegetation, erosion and other factors, exploring interactions and impacts on ecosystems both locally and more broadly.

Braswell, now at the University of Colorado at Boulder, says her work with Heffernan revealed that the health of marshes depends on such factors as erosion, nutrient deposits and vegetation.

“But at broader spatial scales,” she says, “other key drivers emerged, too.” Geographic features, such as coastline and tidal ranges, control wetlands when considered on a wider level, and these forces influence the effects of local ecological processes, or “feedbacks.”

“These larger coastal and watershed characteristics accentuated or limited the stabilizing impacts of the local feedbacks,” Braswell explains. “But they weren’t really evident until we took a few steps back and viewed the estuaries from broader perspectives.”

Heffernan says their study indicates that all salt marshes likely have tipping points.

“Knowing what causes these tipping points to vary from location to location is an important step in identifying where we should expect marshes to be especially vulnerable to future change,” Heffernan explains. “It also provides a framework for understanding where wetland restoration is likely or not likely to succeed.”

According to the researchers, some

marshes exist in favorable conditions but without the expected wetland growth. Such cases could be prime candidates for restoration.

“This research supports North Carolina Sea Grant’s aim to meet the needs of coastal communities and answer complex questions by combining a respect for the importance of marsh and wetland habitat and the need to maximize the use of restoration dollars to maintain those habitats,” says John Fear, deputy director of North Carolina Sea Grant and the state’s Water Resources Research Institute.

“The work demonstrates a connection between our state’s inland population centers and the coastal region through the state’s expansive watersheds,” he adds.

Braswell and Heffernan determined that a lack of deposited sediment negatively affects marsh development and maintenance. This is especially noteworthy, because inland reforestation and use of dams have caused the delivery of sediment to coastal wetlands to decrease by 20%.

To better inform restoration efforts and sustainability in the face of future sea level rise and other environmental changes, Braswell and Heffernan call for continued forecasts of wetland health that incorporate both local processes and broader estuarine and watershed drivers.

[Read the full study results published in \*Ecosystems\*:  
go.ncsu.edu/marsh.](https://go.ncsu.edu/marsh) 



• LEFT: A blue crab, *Callinectes sapidus*. • RIGHT: Recreational crab pots require a pink buoy.

# GONE CRABBIN'

Recreational crabbers play a role in responsibly harvesting crabs and managing gear.

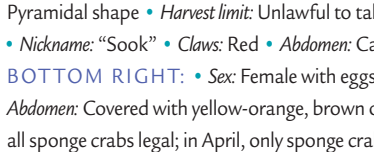
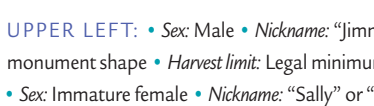
BY JULIE LEIBACH

Detach this page and save for crab identification.

**B**LUE-CRABBING WITH FAMILY AND FRIENDS IS A POPULAR COASTAL NORTH CAROLINA PASTIME. And there's more than one way to catch a crab. So-called "chicken-neckers," for instance, tie a weighted string around — you guessed it — a chicken neck (or other bony part) and drop it in the water. Others sneak up on their catch with a dip net. But many people set a pot and check back later for the goods. If you prefer the pot, read on for more information on harvesting and gear management.

## KNOW YOUR CRAB

Before harvesting blue crabs (*Callinectes sapidus*), know which ones are legal to keep. A crab's sex and general age can be determined by



**UPPER LEFT:** • Sex: Male • Nickname: "Jimmy" • Claws: Blue • Abdomen: Washington monument shape • Harvest limit: Legal minimum size is five inches  
**UPPER RIGHT:** • Sex: Immature female • Nickname: "Sally" or "she-crab" • Claws: Red tips • Abdomen: Pyramidal shape • Harvest limit: Unlawful to take  
**BOTTOM LEFT:** • Sex: Mature female • Nickname: "Sook" • Claws: Red • Abdomen: Capitol dome shape • Harvest limit: No size limit  
**BOTTOM RIGHT:** • Sex: Female with eggs • Nickname: "Sponge crab" • Claws: Red • Abdomen: Covered with yellow-orange, brown or black egg mass • Harvest limit: Outside of April, all sponge crabs legal; in April, only sponge crabs with a yellow-orange egg mass are legal.

**HARVEST LIMITS ABOVE APPLY TO HARD-SHELL CRABS.**

the color of its claws and the shape of its abdomen, or apron. Crabs are measured from point to point across the widest part of their shell, or carapace.

## TENDING YOUR POT

As a recreational crabber, you can set one pot without a license. You can set up to five with a license.

Based on data from coastal recreational fishing license holders, recreational crabbers brought in an average of nearly 31,400 pounds of crab a year from 2011 to 2017, according to the N.C. Division of Marine Fisheries. The amount doesn't account for crabbers fishing without licenses, however.

While that number is hard to pin down, a 2002 survey by researchers at East

*Continued*

Carolina University and supported by North Carolina Sea Grant indicated that about 5,500 recreational crabbers who were legally fishing without licenses hauled in close to 280,000 pounds.

By comparison, the commercial blue crab harvest averaged over 27 million pounds annually from 2008 to 2017.

“Recreational crabbers represent only a tiny fraction of the harvest and pots in the water, when you compare it with commercial enterprises,” says Gloria Putnam,

North Carolina Sea Grant’s coastal resources and communities specialist. “But each of us — every angler, crabber — has the opportunity to contribute to resource and seafood conservation through attentive gear practices.”

The beauty of a crab pot is that you can walk away from it for a while. But don’t set it and forget it. Instead:

- In addition to your buoy, mark your pot with your name.
- Use enough line so the pot stays submerged at high tide.
- Check pots daily, if possible, but at a minimum of every 5 days during daytime hours.
- Bring in gear before a big storm and before you leave the property.
- Remove your pot during the blue crab fishery closure, which in 2020 is Jan. 15 through Feb. 7, unless otherwise indicated. Note that in some areas, pots may not be set from June 1 through Nov. 30. See designated pot areas: [portal.ncdenr.org/web/mf/designated-pot-areas](http://portal.ncdenr.org/web/mf/designated-pot-areas).

For a full list of recreational crabbing regulations, check the N.C. Division of Marine Fisheries’ website. Go to [portal.ncdenr.org/web/mf/recreationalfishing](http://portal.ncdenr.org/web/mf/recreationalfishing), look for the Recreational Crabbing tab, and select Regulations and Requirements. Regulations can change, so check back periodically.

### VANQUISHING GHOSTS

Ever heard of derelict fishing gear? The term refers to gear such as pots, nets and lines



Chris Hamant

A commercial fisherman recovers a crab pot during the N.C. Coastal Federation’s Lost Fishing Gear Recovery Project cleanup.

that have become lost or otherwise discarded. Globally, derelict gear appears to be the main type of submerged marine debris, according to several surveys on the subject.

Various causes lead to rogue crab pots, such as storms; rope and buoys in poor condition; entanglement with boats; and inappropriate disposal. Once lost, those pots can pose navigational hazards, as well as damage sensitive habitats such as seagrasses and marshes.

Derelict pots also can continue trapping crabs, potentially luring them away from pots that crabbers regularly check. They can attract other species, too. For example, during a 2018 crab pot cleanup effort in N.C. coastal waters, participants found more than 2,400 blue crabs and more than 760 finfish enmeshed as bycatch in nearly 3,000 pots. Retrieval efforts elsewhere have documented organisms including birds, river otter and diamondback terrapin, among others.

Diamondback terrapins are small turtles native to estuarine environments along the Atlantic and Gulf coasts from Cape Cod, Massachusetts, to Texas. In North Carolina, they’re a species of special concern. Both active and derelict pots can capture and drown these reptiles, which in the summer can only hold their breath for 45 minutes.

Creatures that have succumbed to derelict crab pots can become bait for other organisms, fueling a cycle known as “ghost fishing.”

Preventing gear loss is the best way to

minimize the impacts of ghost fishing. But once gear has disappeared, then what? There are various ways to improve retrieval, including using sonar to detect derelict gear, as well as organized cleanups.

Inspired by crab pot recovery efforts by the N.C. Division of Marine Fisheries’ Marine Patrol, in 2014 the North Carolina Coastal Federation launched the Lost Fishing Gear Recovery Project, hiring local commercial fishermen to retrieve derelict

pots during the annual fishery closure. Initial funding came from North Carolina Sea Grant and the National Oceanic and Atmospheric Administration’s Marine Debris Program.

The project expanded statewide in 2017, thanks to funding from the N.C. General Assembly, administered by North Carolina Sea Grant. The state directly funded the 2018 and 2019 cleanups.

In 2019, nearly 80 participants removed more than 3,000 crab pots from coastal N.C. waters.

### SEAFOOD SAFETY

Once you’ve got your blue crab haul, what next?

Store live crabs at 40 to 50°F until ready to cook. If you’re using a cooler, place three to four inches of ice at the bottom and cover with a barrier, such as plastic foam or waxed cardboard with holes punched in it, or a burlap sack.

Place your crabs belly-down on the barrier and loosely cover them with damp burlap or a cheesecloth. Leave the cooler lid ajar for air circulation.

Cook crabs the same day they’re caught. Never eat dead crabs — bacteria can quickly accumulate. Live crabs will show leg movement even at cool temperatures.

For blue crab recipes, check out [marinersmenu.org](http://marinersmenu.org). Janna Sasser and Gloria Putnam contributed research. 📷

Detach this page and save for crab identification.



WRI

# Public Events Enhance Research and Dialogue

*North Carolina Sea Grant and partners host important and popular events to share research results and encourage networking on critical topics.*

COMPILED BY KATELYN VAUSE

## **SAVE THE DATE: NORTH CAROLINA COASTAL CONFERENCE SET FOR NOVEMBER**

North Carolina Sea Grant again will host the North Carolina Coastal Conference Nov. 19 and 20, 2019, at the Hotel Ballast in downtown Wilmington.

Susan White, executive director of North Carolina Sea Grant, anticipates the event will draw a sizeable crowd from a diverse array of groups.

“By funding research and supporting outreach, our program provides information and resources to assist state efforts to respond to, recover from and anticipate urgent and long-term coastal challenges,” White says.

Drawing upon the success of similar conferences in 2015 and 2017, sessions will include a variety of important topics, such as weather, storms and climate; community and ecosystem health; fisheries and aquaculture; and planning and economics. Experts will lead interdisciplinary sessions designed to bring together a wide range of perspectives.

Based on response from past conferences, this year the event has moved from Raleigh in the spring to the coast in the late autumn. North Carolina Sea Grant also recently issued a call for presentation proposals.

Information is available to submit abstracts or to check on registration and other details.

[ncseagrant.org](http://ncseagrant.org)

## **WRI CONFERENCE DRAWS RECORD CROWD**

Nearly 400 attendees gathered recently to explore research and engage in timely discussions about one of the world’s most valuable resources at the 21st North Carolina Water Resources Research Institute Annual Conference.

Sessions ranged from water utility management and contamination concerns to algae and nutrients in water bodies. Poster presentations included such topics as the impact of vegetation removal on dry detention basins and cyanotoxins in North Carolina’s lakes.

A variety of organizations had a presence at the conference, including universities, local government bodies, federal and state government agencies, private businesses and nonprofits. Nearly 20 organizations and agencies – including North Carolina Sea Grant – also hosted exhibits.

The state’s WRI and Sea Grant programs work together closely, sharing key management personnel, fellowships opportunities for students and other funding. The 22nd Annual Conference in 2020 will take place March 18 and 19, again at NC State University in Raleigh.

[wri.ncsu.edu](http://wri.ncsu.edu)

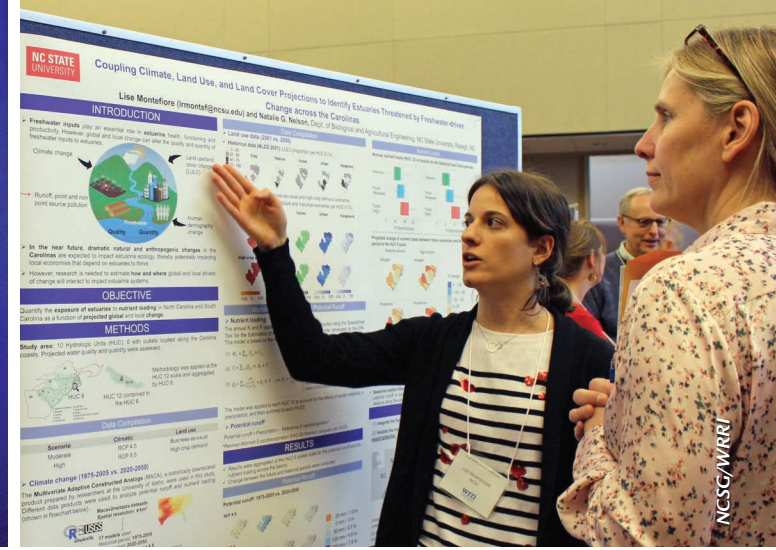
## **AQUACULTURE CONFERENCE FEATURES SHELLFISH TOPICS**

North Carolina Sea Grant specialists and a variety of other experts led sessions on freshwater aquaculture and mariculture for people with

*Continued*



NC Space Grant



NCSG/WRII



NCSG/WRII



NCSG/WRII



NCSG/WRII

- **TOP LEFT:** The inaugural SPACE Symposium featured a keynote address from Gerald D. Griffin, former director of the NASA Lyndon B. Johnson Space Center.
- **TOP RIGHT and BOTTOM ROW:** The WRII Conference drew nearly 400 attendees.

an interest in finfish or shellfish farming at this year's North Carolina Aquaculture Development Conference at Carteret Community College in Morehead City.

Chuck Weirich, marine aquaculture specialist for North Carolina Sea Grant, opened the conference's mariculture morning sessions for prospective and new shellfish growers. Weirich, along with Carteret Community College's Dave Cerino, led a session on farming methods and business planning for newcomers.

A partner on several Sea Grant initiatives, Cerino also led a session on learning opportunities. The mariculture sessions concluded with a market trends panel, featuring Barry Nash, Sea Grant's seafood technology and marketing specialist, and Tres Hundertmark, a champion oyster shucker with N.C. Oyster 365.

Freshwater aquaculture sessions included an update from Ben Reading of NC State University, whose research has included striped bass aquaculture projects funded by Sea Grant.

[ncaquaculture.org](http://ncaquaculture.org)

**OYSTER SUMMIT HIGHLIGHTS STRATEGIC MARICULTURE PLAN**

Oyster growers, fishermen, government officials, lawmakers, academics and conservation interests gathered to learn more about the state's oysters and other shellfish at the 2019 North Carolina Oyster Summit.

The meeting revealed North Carolina's progress in advancing shellfish efforts. The state has addressed habitat creation and water quality protection, developed a strategic shellfish mariculture plan and conducted the policy, research and planning that help to make such progress possible.

A series of panel presentations also explored the recommendations

in the recently completed state *Strategic Mariculture Plan*. The summit also covered the value of clean water to ensure the continued success of all restoration, rehabilitation and mariculture efforts.

The North Carolina Coastal Federation and partners — including North Carolina Sea Grant, the National Oceanic and Atmospheric Administration, the N.C. Department of Environmental Quality, and the N.C. Division of Marine Fisheries — organized the forum. Michael Regan, NC DEQ secretary, provided opening remarks.

[ncoysters.org](http://ncoysters.org)

**NC SPACE GRANT LAUNCHES SPACE SYMPOSIUM**

North Carolina Space Grant recently hosted its inaugural SPACE Symposium in Raleigh. Turnout more than doubled initial expectations, as nearly 200 attendees packed the conference area of the new Stateview Hotel in Raleigh.

Gerald D. Griffin, the former director of the NASA Lyndon B. Johnson Space Center in Houston, delivered the keynote. Griffin has held many positions in both industry and government programs during his career, including serving as a flight director during NASA's Apollo Program. Christopher Chung, the CEO of the Economic Development Partnership of North Carolina, delivered the plenary talk.

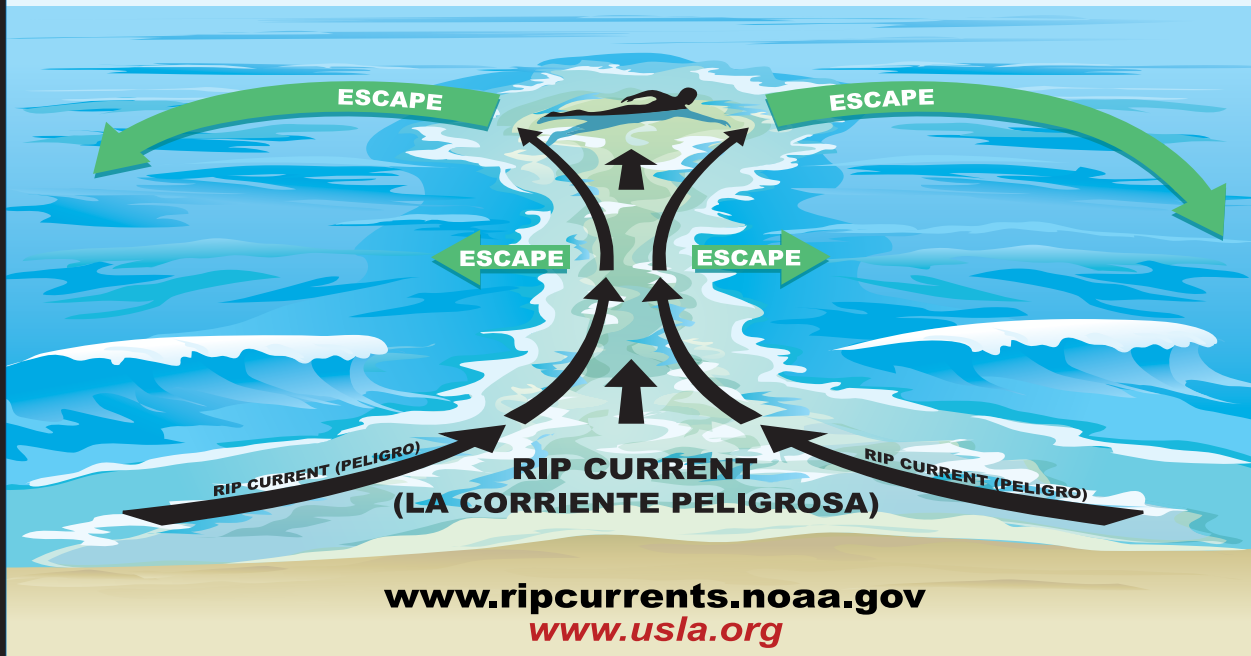
The symposium offered sessions on science, technology, future flight and careers. Each included experts from industry, government and academia, as well as a student Space Grant scholar. Undergraduate and graduate students also presented research at poster sessions throughout the day, including presentations from North Carolina Sea Grant—North Carolina Space Grant Fellows Melinda Martinez and Emily Ury.

[ncspacegrant.ncsu.edu](http://ncspacegrant.ncsu.edu)

Detach this page and stick it to your refrigerator at the beach house, post it on the back door of your coastal rental cottage, pack it in your beach bag, use it as a bookmark, or stow it with the suntan lotion and umbrellas. Break the Grip of the Rip!

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*No luche contra la corriente*
- ◆ **Swim even with the shore, until current weakens, then swim to shore**  
*Nada al nivel de la orilla hasta que la resaca se debilite*
- ◆ **If you can't escape, float or tread water**  
*Si no logra escapar, mantengase a flote pedaleando*
- ◆ **If you need help, call or wave for assistance**  
*Si necesita auxilio, grite o agite los brazos*

More information about rip currents can be found at the following web sites:  
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[www.ripcurrents.noaa.gov](http://www.ripcurrents.noaa.gov)  
[www.usla.org](http://www.usla.org)



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North Carolina Sea Grant joins the National Weather Service, oceanfront communities and other partners to highlight surf-zone safety throughout beach season. • Order English, Spanish or bilingual metal signs at [ncseagrant.ncsu.edu/bookstore](http://ncseagrant.ncsu.edu/bookstore).



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— King Nobuyoshi Godwin, author of *The Artist Is Having a Very Good Day*

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