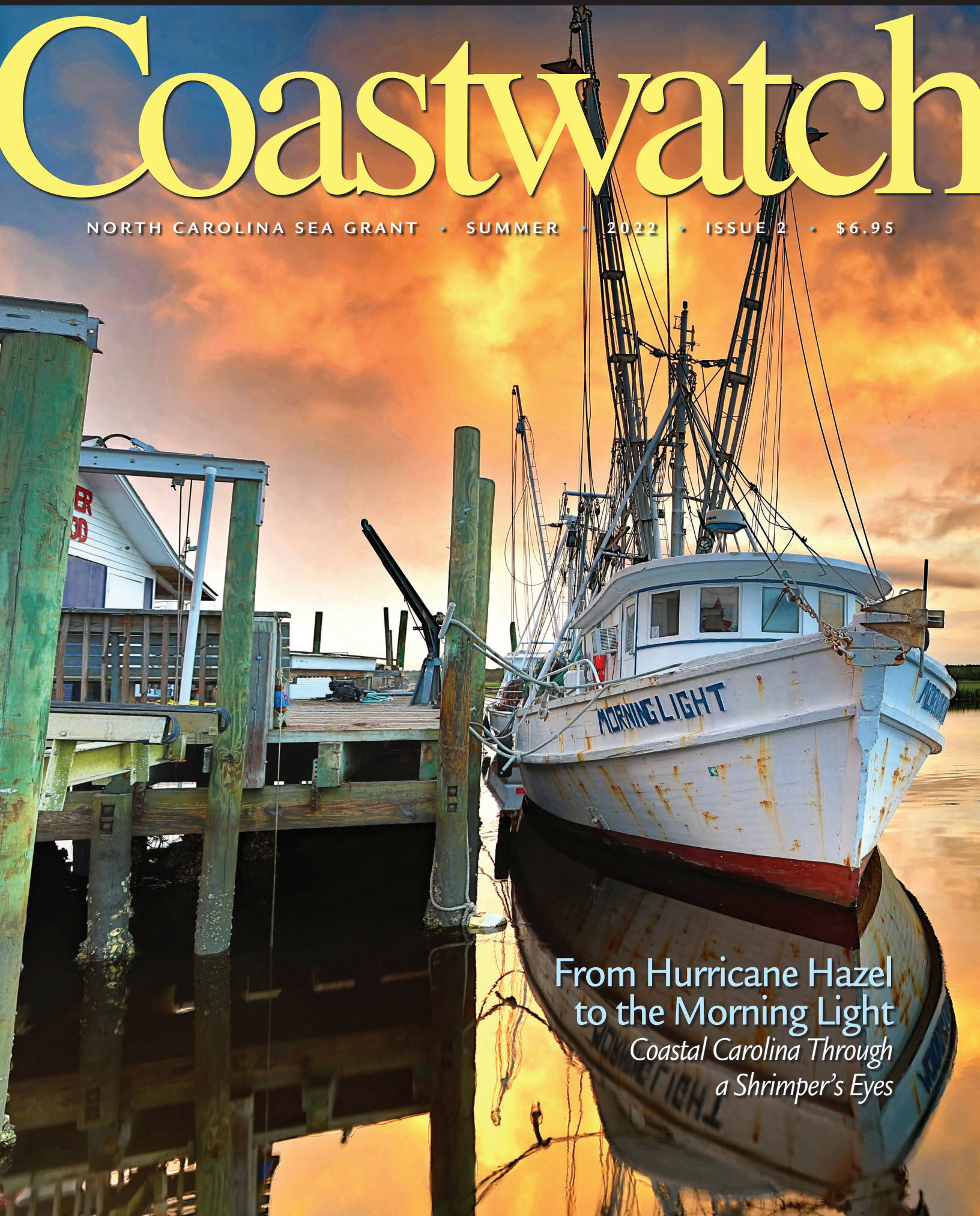
Climate Change & Antibiotic Resistance • Sea Level Rise vs. Septic Systems • Global Warming & Northern Migration

Coastwatch

NORTH CAROLINA SEA GRANT • SUMMER • 2022 • ISSUE 2 • $6.95



From Hurricane Hazel to the Morning Light

Coastal Carolina Through a Shrimper's Eyes

Summer 2022: New Horizons

North Carolina Sea Grant brings research findings and extension programming to bear on the pressing community and environmental challenges and opportunities our coast faces today and tomorrow. In close collaboration with a broad range of academic institutions, state and federal agencies, and critically important coastal community leaders, our program provides needed resources and on-the-ground capacity to understand impacts and implement solutions.

This issue of *Coastwatch* provides a diverse set of stories that fully captures the breadth of Sea Grant's programs and partners. From the first page to the last page, *Coastwatch* highlights research, extension, and education — the pillars of the program — through stories addressing a breadth of topics relevant now and in the future.

You'll find stories in this issue about research that has identified local climate change impacts, as well as new solutions and initiatives to understand how to support human health and well-being, to improve habitats and the animals that depend on them, and to address infrastructure challenges.

On page 6, you'll also find "From Hurricane Hazel to the Morning Light: Coastal Carolina Through a Shrimper's Eyes," an interview with Harry Bryant, who built his own shrimp boat and made a living on open waters for 32 years. We can all learn from others' experiences as we continue to frame and reframe our understandings of our coast — and Harry Bryant's story shows how the changing conditions we observe over time impact the perspectives and priorities of each of us.

The cycle of research-extension-education is continuous. As our state's coastal challenges and opportunities evolve, so must our programs and partners to maintain effectiveness and relevance. We highlight our new research projects in this issue on page 2, providing a preview of what's to come, what we all will be learning, and how we may all work together moving forward in these areas of investment.

The breadth of research topics ranges from identifying drivers of chronic coastal flooding to understanding environmental justice during disaster recovery, from studying shellfish aquaculture and fisheries recruitment to engaging youth in research and extension — among many other areas of interest.

We also support early career scientists through research fellowships in partnership with the Albemarle-Pamlico National Estuary Partnership and with the NC Water Resources Research Institute. (See pages 3 and 4.) These opportunities provide students with leadership and research experience in addressing our state's needs. I'm excited to learn with you as all these projects advance. We look forward to sharing these works and their impacts with you in the coming years.

In the nearer term, hurricane season is upon us. Time to review and prepare with information available in this issue on page 5 and at *go.ncsu.edu/hurricane-resources*.

And we're looking forward to hosting the NC Coastal Conference on November 7 and 8 on NC State's campus in Raleigh. We've heard from our partners about how important this conference is for information sharing, strengthening collaborations across the state, and providing important opportunities for student presentations and networking. Please mark your calendars and join us.

Conference information is available at *go.ncsu.edu/Coastal-Conference*. You'll find details about submitting abstracts (due September 2) for presentations and poster sessions. Later this summer, you'll also find instructions for registration. I look forward to seeing you there.

If you have any suggestions for conference topics or sessions — or if you have any other input for North Carolina Sea Grant as we continue our strategic planning this year — please email me at *snwhite3@ncsu.edu*.

— Susan White, Executive Director, North Carolina Sea Grant

IN THIS ISSUE

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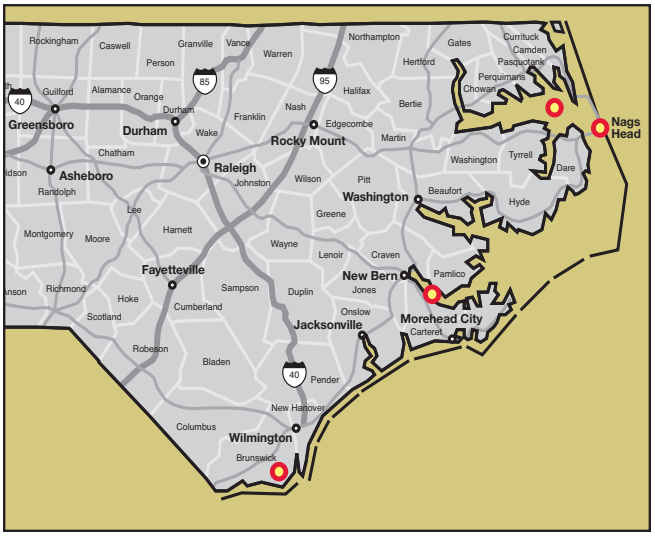
The stories in this issue cover many locations, including these settings from north to south on the map: Albemarle Sound, Nags Head, the Neuse River, and the little town of Supply, North Carolina.



Coastwatch

FEATURES

- *Front Cover: Photograph by Terrah Hewett:* fineartamerica.com/profiles/terrah-hewett/shop
- *Table of Contents: Photograph courtesy of NC State University.*

Coastwatch

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Since 1970, North Carolina Sea Grant has aligned our goals with the National Sea Grant College Program. We provide research, education, and outreach to serve our state's coast and its communities.

Under executive director Susan White, our primary areas of emphasis include healthy coastal ecosystems, resilient communities and economies, sustainable fisheries and aquaculture, and environmental literacy and workforce development.

NOAA and the State of North Carolina fund our work. By forging enduring collaborations that bridge North Carolina's public and private universities with critical coastal needs, our program fuels discovery, learning, and real-world solutions.

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Principal investigators on new core projects include Antonio Rodriguez, who wrote about migrating salt marshes for the Fall 2021 issue.

NC Sea Grant Announces 2022–2024 Core Research Projects

Research teams across the state recently have begun work on North Carolina Sea Grant's new core projects. Scientists are applying innovative approaches to coastal resilience, climate change, flooding, disaster recovery, sustainable fisheries and aquaculture, environmental literacy, and more.

"Our core research examines real-world needs of our coastal communities and ecosystems," says Susan White, executive director of North Carolina Sea Grant. "We are pleased to have so many multidisciplinary collaborations that address our program's strategic focus areas."

The projects include lead researchers from NC State University, the University of North Carolina at Chapel Hill, East Carolina University, and the University of North Carolina Wilmington. In addition, Chowan University, Duke University, Rural Forward NC, Audubon NC, and state agency partners play key roles. Most projects provide student support and training opportunities.

The following studies will run through early 2024:

- *Assessing Long-Term Water Temperature Patterns in North Carolina Estuaries: A Key for Gauging and Predicting Ecosystem Health in an Era of Global Change* — Joel Fodrie, University of North Carolina at Chapel Hill, principal investigator
- *Trickle-Down Effects of Increasing Coastal Sediment Loads on Tidal-Creek Levee Morphology, Salt-Marsh Platform Accretion, and Resilience to Sea-Level Rise Since AD 1900* — Antonio Rodriguez, University of North Carolina at Chapel Hill, principal investigator
- *Identifying the Drivers of Chronic Coastal Flooding: A Community-Centric Approach* — Katherine Anarde, North Carolina State University, principal investigator
- *JustWater: Policy Leadership and Environmental Justice During Disaster Recovery* — Bethany Cutts, North Carolina State University, principal investigator
- *Assessing Spatial and Temporal Controls on Sediment Transport in Currituck Sound* — David Lagomasino, East Carolina University, principal investigator
- *Understanding the Effects of a Newly Discovered Trematode Parasite on Wild and Cultured Bay Scallop Production* — Julia Buck, University of North Carolina Wilmington, principal investigator
- *Potential Impacts of Marine Dredging on Key Commercial and Recreational Fish and Shellfish: Informing Decisions Regarding Mitigation and Seasonal Closures of Dredging to Maintain North Carolina's State Ports* — David Eggleston, North Carolina State University, principal investigator
- *Assessing Influence of Sea-Level Rise Induced Salt Intrusion and Associated Circulation Change on Southern Flounder Recruitment Processes in Albemarle-Pamlico Sound* — Qianqian Liu, University of North Carolina Wilmington, principal investigator
- *Multi-Trophic Waste Management for Finfish Mariculture in Land-Based Recirculating Aquaculture Systems Using the Salt-Tolerant Halophyte* Salicornia virginica — Wade Watanabe, University of North Carolina Wilmington, principal investigator
- *Developing a Model for Supporting Coastal Resilience through Youth-Led Coproduction* — Kathryn Stevenson, North Carolina State University, principal investigator

For updates, follow North Carolina Sea Grant's Twitter and Facebook feeds, and check back here.

- **funding opportunities at North Carolina Sea Grant:** *ncseagrant.ncsu.edu/funding-opps*

NC Coastal Conference Set for November

North Carolina Sea Grant will host the North Carolina Coastal Conference on November 7 and 8 this year at NC State University in Raleigh.

"We're looking forward to gathering researchers, agency and business experts, community leaders, students, and all who are interested in coastal topics for these engaging presentations and discussions," says Susan White, executive director of North Carolina Sea Grant.

Members of the Sea Grant team, its advisory board, and various partners are planning the event. The University of North Carolina System already has signed on as a sponsor.

The conference will include in-person and hybrid sessions, featuring presentations on a wide range of issues related to coastal communities and ecosystems, including the watersheds that feed coastal waters.

"We will have invited speakers, as well as an abstract submission process for presentations, lightning talks, and a student poster competition," adds John Fear, North Carolina Sea Grant's deputy director. Sea Grant is accepting abstracts for talks and posters until September 2.

For updates, watch for the hashtag *#NCCoastConf* on social media, and check the conference website for information about registration, submitting proposals for posters and presentations, becoming a sponsor, and other details. *— Carrie Clower*

- **NC Coastal Conference:** *go.ncsu.edu/coastal-conference*

Joshua Himmelstein

NC Sea Grant and APNEP Name New Joint Fellow

Joshua Himmelstein, a Ph.D. student in the University of North Carolina at Chapel Hill's Institute of Marine Sciences, is the recipient of the 2022 joint fellowship from North Carolina Sea Grant and the Albemarle-Pamlico National Estuary Partnership. Himmelstein will install sensors across coastal North Carolina marshes to study sediment delivery.

"This project will provide novel information on how sediment is distributed across saltmarshes, helping us to better understand the vulnerability of this important coastal habitat to sea-level rise," says Tim Ellis, APNEP's quantitative ecologist.

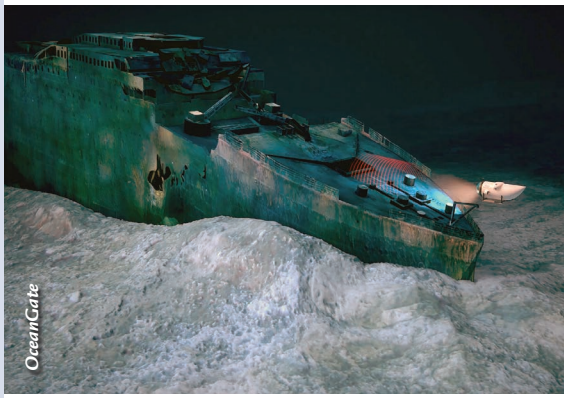
Himmelstein works with Antonio Rodriguez, coastal geologist at IMS. Rodriguez says that tidal creeks across coastal North Carolina are "filling in with sediment" at a time when many of the adjacent marshes are losing elevation relative to sea level.

John Fear, deputy director of North Carolina Sea Grant and the North Carolina Water Resources Research Institute, says Himmelstein's project helps address an ongoing mystery in marsh dynamics.

"Coastal marshes are an important nursery area for estuarine species and an extremely productive ecosystem," Fear adds.

The joint fellowship, now in its sixth year, supports graduate students from institutions based in North Carolina who conduct applied research within the North Carolina portion of the Albemarle-Pamlico National Estuary Partnership region. *— Lauren D. Pharr*

- **funding opportunities :** *ncseagrant.ncsu.edu/funding-opps*
- **Albemarle-Pamlico National Estuary Partnership :** *apnep.org*



OceanGate's Titan scans the Titanic.

Expedition Explores the Titanic's Deep-Sea Ecosystem

Steve W. Ross will lead an international team of scientists this summer in a first-of-its-kind survey of marine life at the *Titanic* shipwreck.

"We are seeking to compile a list of every living creature we can identify inhabiting the *Titanic* wreck site to understand this unique deep-sea ecosystem," says Ross, who specializes in corals, fish, and submarine canyons for the University of North Carolina Wilmington's Center for Marine Science.

OceanGate Expeditions of Nassau, Bahamas, is commissioning the 2022 *Titanic* Survey Expedition. The British luxury passenger ship sank during its maiden voyage in 1912 and rests over two miles deep off the coast of Newfoundland. Today, the ship serves as a refuge for corals, squat lobsters, brittle stars, and rattail fish.

Ross, whose previous research has included support from North Carolina Sea Grant and NOAA, will collect HD video and photography, conduct environmental DNA analysis, and gather other data. His team will descend to the site in OceanGate's *Titan*, the world's only five-person submersible capable of withstanding such depths.

"Every time we do a deep-sea mission, we discover something new that is unexpected," says Ross. "Anticipating new discoveries is very exciting. Will we discover a new species or new predatory behaviors? A whole range of things is possible."

— adapted from a news release from UNCW

Lori Sanderlin (left) and Katy Menne (second from right) receive the Maritime Museum's award from Council awards chair LeRae Umfleet and former president Scott Warren.

Southport's Maritime Museum Wins Inclusion Award

North Carolina Museums Council has named the N.C. Maritime Museum at Southport the recipient of the 2022 Diversity, Equity, Accessibility, and Inclusion Award for its work last year to make the museum more accessible for patrons of all ages and abilities.

In particular, the museum's director Lori Sanderlin and curator of education Katy Menne introduced a semi-guided, multi-lingual tour, as well as tactile maps, to accommodate deaf visitors and people with low vision or total blindness.

"Having the museum selected for this award is indescribable," Menne says. "This award is all thanks to the support of the Southport Lions Club and N.C. Department of Health and Human Services."

The N.C. Maritime Museum at Southport tells the story of the Cape Fear region and its people. The museum shares tales of pirates and pillage, blockade running and riverfront archaeology, and other nautical adventures.

"I am so pleased with the changes at the museum over the past four years," Sanderlin adds. "We really want the museum to be a place in the community where visitors and locals see it as a welcoming space for all people to learn and enjoy maritime history."

— from a story by the North Carolina Department of Natural and Cultural Resources

- **N.C. Maritime Museum at Southport:** *NCMaritimeMuseumSouthport.com*

New Fellows Investigate Flooding, PFAS, and More

NC State's Emine Fidan (here) joins four other graduate students as new coastal and water resource fellows: NC State's Tiffany VanDerwerker, UNC-Chapel Hill's Lauren Grimley, East Carolina University's Georgette Tso, and UNC-Chapel Hill's Holly Haflich

Five North Carolina graduate students recently began new coastal and water resource fellowships. North Carolina Sea Grant and the North Carolina Water Resources Research Institute are supporting four students' research projects, and the state's Urban Water Consortium is funding a fifth.

Topics include PFAS removal, flooding, a potential new source of drinking water, and oyster reef breakwater designs.

"This group of projects will provide much-needed insight for several grand challenges facing our state," says John Fear, deputy director for North Carolina Sea Grant and North Carolina Water Resources Research Institute (WRRI). "The quality of proposals and projects generated by our state's universities continues to impress me."

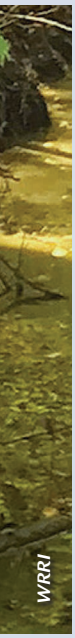
This year's fellows currently study at four North Carolina universities:

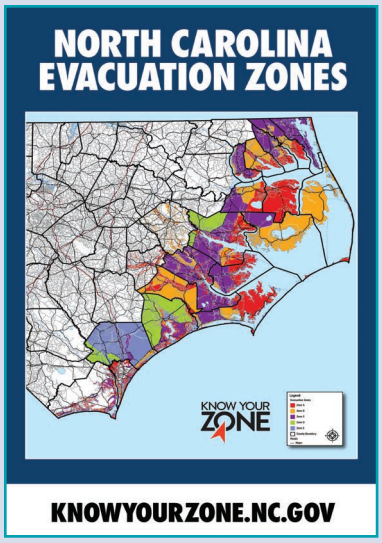
- **Emine Fidan** is a doctoral student in biological and agricultural engineering at NC State University. Her advisor is Natalie Nelson, and her project is "Advancing Understanding of Flood Water Quality Distributions and Drivers through Statistical Modeling."
- **Tiffany VanDerwerker** is a doctoral student in marine, earth, and atmospheric sciences at NC State. Her advisor is David Genereux, and her project is "Assessing Water Quality in the Upper Cape Fear Aquifer, a Potential Alternate Drinking Water Source for Chemours-Area Residents."
- **Lauren Grimley** is a doctoral student in earth, marine, and environmental sciences at University of North Carolina at Chapel Hill. Her advisor is Antonia Sebastian, and her project is "Determining the Relative Contribution of Nuisance Flooding to the Risk Profiles of Estuarine Communities Under Current and Future Climate Conditions."
- **Georgette Tso** is a doctoral student in coastal studies at East Carolina University. Her advisor is Siddharth Narayan, and her project is "Integrating Hydrodynamic and Ecological Modeling to Optimize Oyster Reef Breakwater Designs for Ecological Success and Coastal Resilience Benefits."
- The Urban Water Consortium, which WRRI facilitates, is supporting a fellowship for **Holly Haflich**, a doctoral student in environmental sciences and engineering at University of North Carolina at Chapel Hill. Her advisor is Orlando Coronell, and she will be researching "PFAS Removal from Natural Water through Electrodeionization Equipped with Novel PFAS Selective Resins."

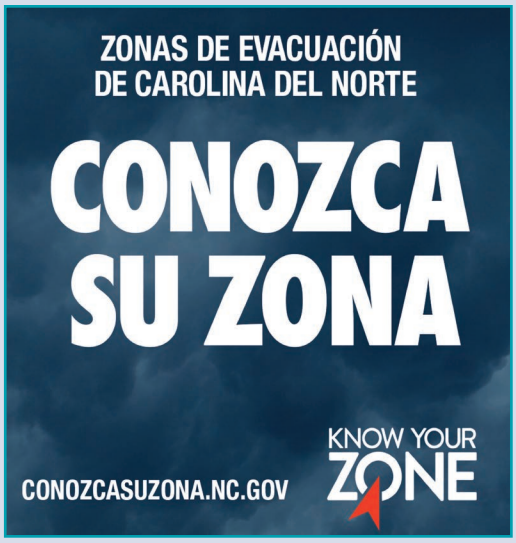
Past recipients of the joint fellowship from North Carolina Sea Grant and the North Carolina Water Resources Research Institute have included several noted researchers, such as Austin Gray, whose latest study we highlight on page 45 of this issue.

— Justin Lindemann

- **North Carolina Sea Grant's funding opportunities:** *ncseagrant.ncsu.edu/funding-opps*
- **WRRI's funding opportunities:** *wrri.ncsu.edu/funding*
- **about the Urban Water Consortium:** *wrri.ncsu.edu/partnerships/uwc*







Hurricane Season Is Here: Know Your Zone

The Atlantic hurricane season runs from June 1 to November 30 and includes an area covering the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. NOAA reports that for the last 30 years, the Atlantic season has averaged 14 named storms, seven hurricanes, and three major hurricanes.

The first named storm usually forms in mid to late June, the first hurricane in early to mid-August, and the first major hurricane in late August or early September.

Residents and visitors to North Carolina's coast can refamiliarize themselves with evacuation zones and routes by consulting the resources below.

- **Know Your Zone:** *KnowYourZone.NC.gov*
- **Conozca Su Zona:** *ConozcaSuZona.NC.gov*

Online Guide Offers Resources in Spanish for Hurricane Season

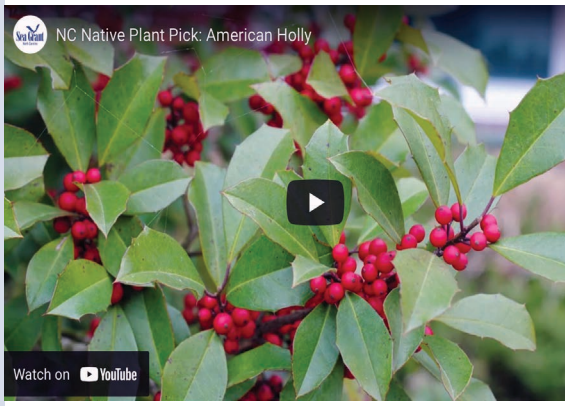
In conversation with members of the Enlace Latino NC team, people in the Latino and Latina community who were affected by hurricanes reported that language barriers and the lack of accessible information hampered prevention and recovery efforts. After listening to their needs, Enlace Latino NC has launched *Prepárate NC*, an online guide with resources for the hurricane season in Spanish.

Prepárate NC provides practical and educational tools to help mitigate the great risks that the Latino and Latina community faces from the impact of hurricanes. The online guide provides resources designed to be useful before, during, and after hurricanes hit, including practical recommendations about how to reduce damage to the home, the most convenient evacuation routes, and how to purchase insurance that will save thousands of dollars on repairs.

In addition, *Prepárate NC* includes directions to shelters, instructions on what to do in a power outage, and how to respond if the streets are flooded. The site also includes post-storm tips on returning home safely, doing repairs, collecting flood insurance, accessing temporary housing, and seeking assistance from both the state and non-governmental organizations.

— adapted from a press release from Enlace Latino NC

- **Prepárate NC:** *preparateNC.com*



New "Native Plant Picks" videos are available from the Coastal Landscapes Initiative.

Demand Rises for Native Plants

Demand for native plants has increased as more people plan for nature-enhancing landscapes. But is the industry poised to deliver?

At a presentation at the Green & Growin' education conference in Greensboro, North Carolina Sea Grant's Jane Harrison pointed to findings from a survey of the state's plant nurseries. Sea Grant's Coastal Landscapes Initiative (CLI) sponsored the survey.

A mix of different-sized commercial plant growers in North Carolina responded, says Harrison, coastal economics specialist for Sea Grant. The majority of growers reported offering a mix of both native and non-native species. Most (67%) said demand for native plants has increased over the last five years, while less than one-third reported demand stayed the same.

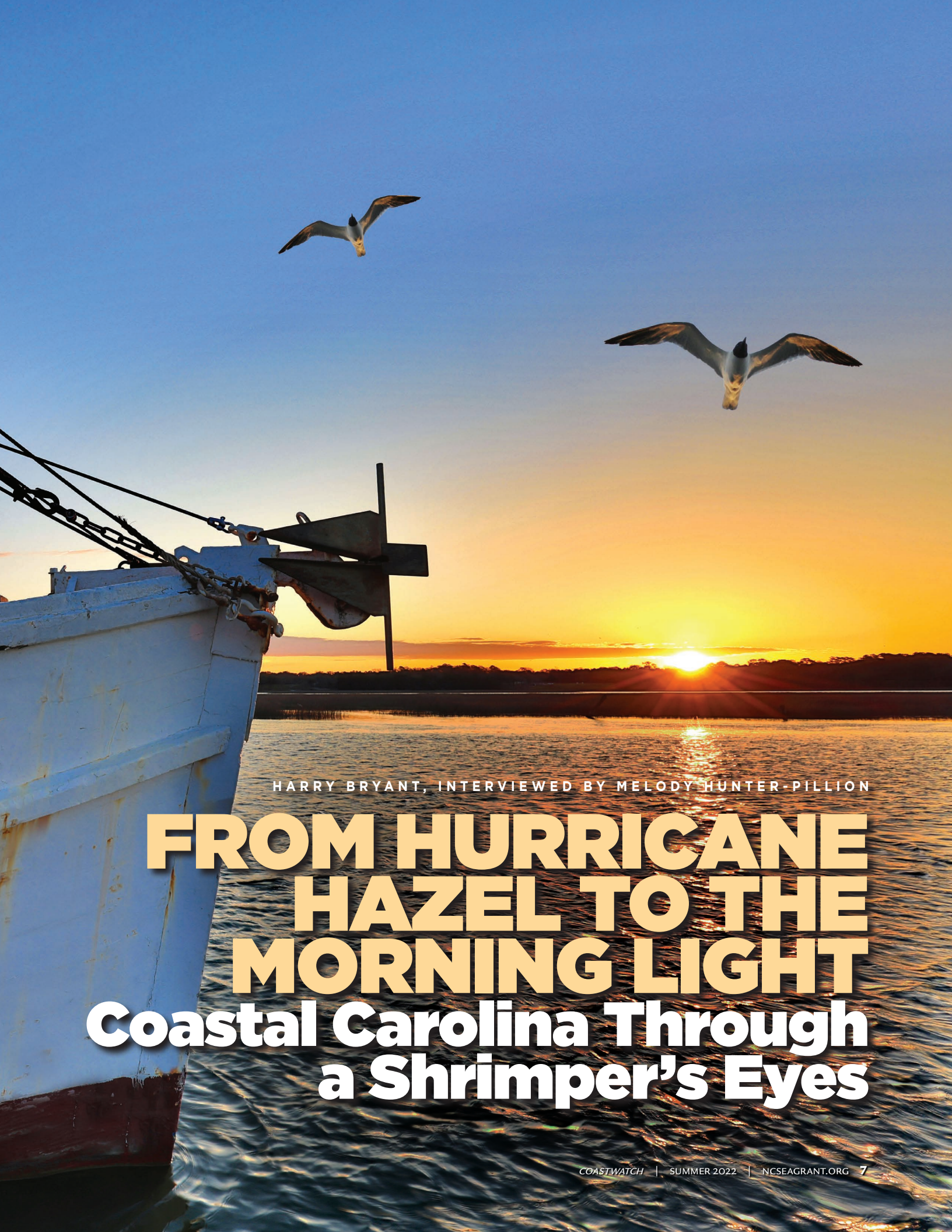
Growers also named their top five native plants, based on sales. Southern wax myrtle, native hollies, and oaks topped their lists. Virginia sweetspire, pink muhly grass, milkweed, river birch, dogwood, and Joe Pye weed also were common.

In addition to Harrison, the team that developed the survey and analyzed results included North Carolina Sea Grant's Gloria Putnam, N.C. Cooperative Extension's Tanya Lamo and Lloyd Singleton, and Kathy Mitchell of Coastal Roots Garden Design.

— adapted from the North Carolina Native Plant Society's story

- **Coastal Landscapes Initiative:** *go.ncsu.edu/CoastalLandscapes*
- **new *Native Plant Picks* videos:** *go.ncsu.edu/plant-picks*

Terrah Hewett, fineartamerica.com/profiles/terrah-hewett/shop



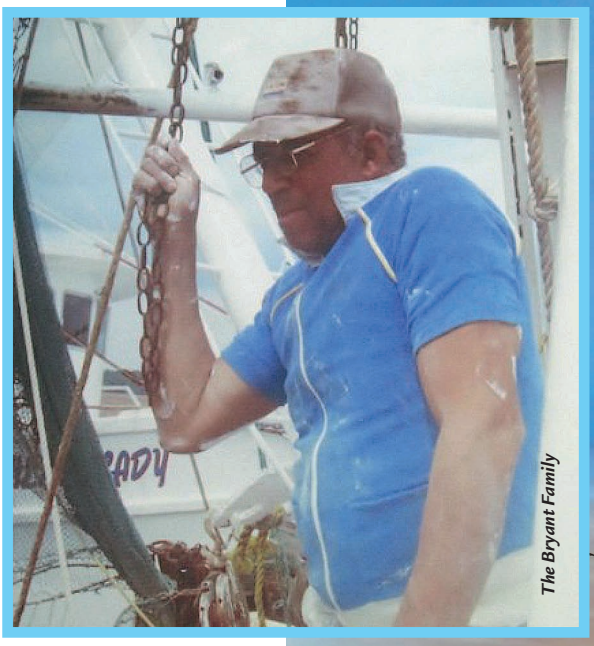
HARRY BRYANT, INTERVIEWED BY MELODY HUNTER-PILLION

FROM HURRICANE HAZEL TO THE MORNING LIGHT

Coastal Carolina Through a Shrimper's Eyes

Harry Bryant began farming with his father in Supply, North Carolina, before becoming a licensed plumber and then launching a 32-year career as a shrimper. After using scrap metal to build his own 56-foot boat, he would escape waterspouts and a lightning strike, witness the effects of climate change firsthand, and successfully earn a living on the open waters pulling two 60-foot nets.

Here, we include excerpts of Melody Hunter-Pillion's interview with him on his 84th birthday. They opened their talk by discussing the Bryant family's roots.


The Bryant Family

Harry Bryant: My ancestors arrived in Brunswick County in 1863 with the man — with the slave owner. And whenever that slavery broke, he had not changed their name, so they remained to be Bryants right on, and they refused. He tried to get them to change their names to Lancaster, because that was a homage to those slaveholders. They refused to change their name, and so we remained to be Bryants right on.

Melody Hunter-Pillion: ***When emancipation happened and the family became free, do you know what kind of work your family started doing? Was it farming right off?***

Harry Bryant: Yes, because they farmed for the Lancaster man. And then, my dad stayed in the farming business the rest of his life.

How long did you farm with your father, and what made you change?

Well, the farming business outgrowed me. You had to have so much more equipment, and we had about 35 acres of not too productive

Continued

Harry Bryant (inset) says he first became a shrimper because he "always wanted a steady job. Something I could depend on."

Terrah Hewett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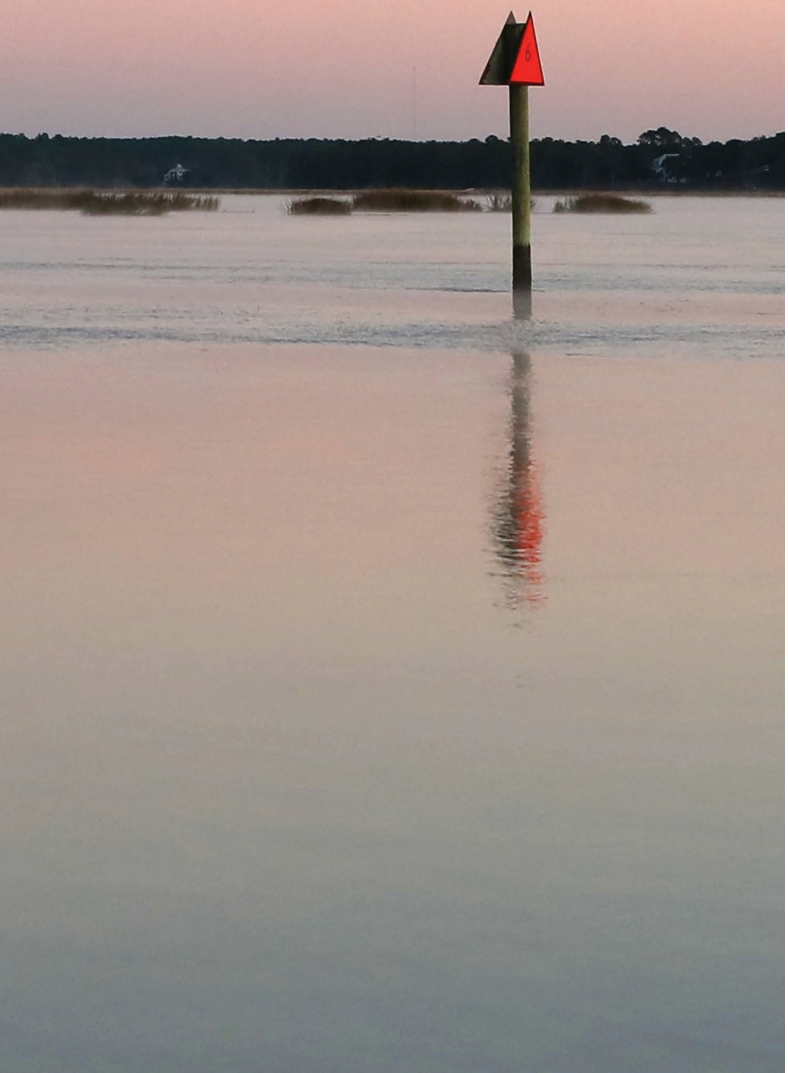
Terrah Hewett

In 1972, "We worked night and day," Harry Bryant says, "for six months building that boat." Fifty years after its construction (inset), the Morning Light is still heading out onto open waters.



land. And so, we just couldn't make a living.

See, long as we had tobacco, we could, we could make a living. We go out, and we had an allotment ourself of about three or four acres.

And so, then after a while you had to have a lot equipment, and then finally tobacco just went out of existence, you know, except in Brunswick County. Now, I think there are two tobacco farmers, and they plant 100 acres.

Was your family always in this part of Brunswick County?

Yes. This was some of the slave owner's land right here where we're sitting on now. Unless I has to go to a nursing home, I would never sell none of it.

Where would I go without some land? I don't know where to go. You know?

When your grandfather and dad were adults, having land was, even now, is meaningful, but it was difficult sometimes for African Americans to acquire land.

Well, back in that day, it was very important for them, because that was like you having money in the bank. You know, if you didn't have no land, you didn't, you didn't have no money. But if you had land, you had value.

WATER AND GOLF

Is it harder to keep land now?

Yes. A lot of people sell it because they can't pay the taxes. You see, we're getting so many goods and services in the county that the tax value, the tax has to go up. A lot of people just cannot pay the taxes, and they had to sell this land.

See. . . we get drinking water from Cape Fear River, and people who voted for County water they say, "Well, this is going to be great. We go get clean water."

What did they do? Run it all the way down to Calabash, to the ends of the county. And the people on the North side of the road is barely beginning to get a spare from water now. Barely. Just a very few people. They voted for water, but they don't get no water. It's Holden Beach got plenty of water. I mean, I got water because they were trying to get it to Holden Beach. They didn't run it by here for me.

Continued

Terrah Hewett

In its heyday, the Morning Light *carried 3,600 pounds of shrimp, 10,000 pounds of ice, 1,600 gallons of fuel, and 500 gallons of water. After Harry Bryant retired from shrimping, the boat's new owner often parked it at Varnamtown.*

Terrah Hewett

So tourism and development have changed things.

Everything. Everything. The inshore fishermens and the offshore fishermens would have been better off to have never sold a foot of land to tourists. Because that's the end of fishing. Because now the earth cannot absorb all the waste and pollution. It's killing the shrimp and the oyster beds, all that. It's not as plentiful as it was.

We just got just a few acres in the Lockwood Folly estuaries we can get oysters anymore, or clams. Just a few acres. We could fish the whole bay [Lockwood Folly] for clams and oysters. Now they've got a golf course down there. And of course, whenever you fertilize the golf course with all the nitrogen to keep to keep the grass green, that's bad for the estuary.

BUILDING A BOAT AND BECOMING A SHRIMPER

Tell me about your boat.

I always wanted a steady job. Something I could depend on. And that's when I started the boat.

While I was unemployed, I'd go by the scrap yard and buy scrap iron and bring it home, because I know that's going to be on the boat. I built all that stuff out of scrap. If you look halfway up the mast you see two different sizes of pipe… They had about 20 foot of one piece and 20 foot of another piece. So, I married them together and made it as tall as it's supposed to be.

And that was during 1971. Every week, whenever I go to sign up for unemployment, I'd stop by and get scrap shackles and iron. Angle iron. And all kinds of stuff.

And we worked night and day from then for six months building that boat. *The Morning Light*. That's what we named it in. *The Morning Light*.

You worked all day, nine hours a day. You were ready to go to bed whenever you got home, but I couldn't go. Because when I got home, my wife had supper cooked. And I'd come in, I'd leave, I'd eat and go out there, start welding.

We had to borrow some money. And I'll use the word luck — I don't use that word too many times — that I had a good bank that stood up for me with the board, that I could get the money I needed to build this boat.

I had all the confidence that I could make it work. At that time there was a lot of shrimp around. There was three or four, about four different people down there building boats, selling them as fast as they could build them. They sold before they could even get it built. If I failed on the ocean, I could always sell it. Yeah, so, I wasn't really worried about it.

We'd add a 8V 71 Detroit engine into it on the four and a half year.

Continued


The Bryant Family

Harry Bryant says in all his years on the water, he always had "no problem with selling the shrimp. Nowhere you went." Not in Key West or up the coast. "And we got same thing to Pamlico Sound. No problem at all. Never."

When you started, were you shrimping? Is that what you did first?

No, I did the menhaden first. I could stand the ocean. So, that didn't worry me.

See, some people can't deal good with the water. My brother, he could not stay on the water. He just couldn't keep his food down.

I wasn't worried about that. But then after I got started, it was a challenge. But I liked it, because I could take care of my family. That was my main goal. I was my own boss.

They sell these sport boats for 5 or $600,000 just to go out and have fun fishing. Now, believe it or not, it's as tough as life is on the water. It's a hard life. When I dumped shrimp on the deck, I was just as happy as them guys pulling, that's pulling big fish, you know? I got just as much pleasure out of dumping them shrimp on there when I had a good trip. And come back home and know everything's okay.

And so, it took me four or five years to learn. I shrimped from Pamlico Sound to Saint Augustine, Florida, the first four years. And I was back where I started. So, then I started to go to Key West in the wintertime. And I'd stay in Key West. I'd shrimp three weeks and take one week home. And we'd leave the boat down there, you know?

We started off with a CB radio. That's about it. In 1972 that was all there was. They did have big marine radios, but we didn't need that. We started off with a CB radio in him that come with a VHF.

You got this little 12-foot "try net." You pull that and determine what you're catching and when you should take it up and when you shouldn't take it up. When I first started, if I was dragging down, and I pulled my try net and had a good try of shrimp, I'd look on my depth record and I'd say, "I'm in 32 foot of water, so I'm going to turn around and go back." Same trek. Well, whenever we got radar, we found out then it might be 32 foot over here, too. So we might be way off where we're saying.

They tell me now you can hook this chart plotter up to your GPS. It'll automatically take you down in the same trail where I used to have to steer it back down that same track. Now we had an autopilot. Even if I was dragging the boat, I could put it on autopilot... Sometimes the current would drag you out a little bit. But now they got it where it's automatic.

A SHRIMPER'S LIFE

Was it easy selling your catch?

No problem. See, back then there was plenty of shrimp. They were small shrimp, but there was plenty of shrimp. I was in Georgia one time — this comes to mind right now — yes, off the coast of Georgia, and I didn't know where to go to sell my shrimp. And I was talking on the CB radio, said, "I got to go find somewhere to go in to sell my shrimp."

And before I could finish, then somebody called me back, said, "Takes 66 to channel into Georgia. We'd be happy to sell it, take the shrimp, unload the shrimp." So, there was never no problem with selling the shrimp. Nowhere you went. And we got same thing to Pamlico Sound. No problem at all. Never.

So, you made a good living. You were able to take care of your family.

I was able to take care of my family. My main goal was in life is to take care of my family, have a decent place to live. Or listen, let's use the word "comfortable" place. I don't know whether I got a decent place, but I hope it's comfortable. I didn't need a Cadillac, you know.

Ed. Note: *Harry Bryant's son Conrad, who was present for the interview, added: "He would just get up on Sunday mornings at 3 o'clock, and he had to get the boat out there to make a drag before daylight. And then we stayed out there and worked all the way up until 11 o'clock that night, and then you would go to sleep and get up at 3 o'clock again the next morning and go start back over.*

He had four bins, and each bin was 900 pounds. So that was 3,600 pounds [of shrimp]. And when it was completely loaded, you couldn't hardly read the name on the boat. So, it would be weighted."

Harry Bryant: In Pamlico Sound, we put 38 boxes in 3.5 bins. And we carried 10,000 pounds of ice. And we carried 1,600 gallon of fuel, 500 gallon of water on a trip with us.

At that time, we was getting a pretty good price out of them.

CLIMATE CHANGE AND BAD WEATHER ESCAPES

I want to ask you about changes in the weather and the climate.

I gave [Conrad] a piece of property down at Havana on Lockwood's Folly River, and he can tell you right now the tide stays higher all the time

Harry Bryant's son Conrad (left) says his father (right) "would just get up on Sunday mornings at 3 o'clock, and he had to get the boat out there to make a drag before daylight."

than it did whenever I built this boat. It's higher all the time. Whenever we have storms, we have storms higher. The water table rises higher. We gets more rain in the storms.

Hurricane Floyd came by. It went up past. It went up Carolina Beach, turned around, and then come back and went across the land. And what we would do if a storm was coming, we would take the boats up [NC highway] 211 to Supply and tie them up two-abreast, and tie them off to trees, and we would come home and stay with our families until the storm went over. The trees would knock the wind off of us if we was down low enough.

Well, the next day, after the storm was over, we'd come back down the river, but the river is real crooked. We had to stay up there about four or five days, because we couldn't find the channel to come back down the river, you know?

Continued

Melody Hunter-Pillion

The water went high enough it went on 211. We went out on 211 with the 40-horse fiberglass boat. It was 18 foot. Whenever the Hurricane Floyd came, it went over the top of the rail of the bridge to 211.

In the creeks down there now, like where we go get oysters at, it don't fall as low. Where I had the boat tied up at Beacon One fish house, he said if it keeps rising, he probably will eventually need to raise his fish house up, because you can just see visible with your eyes that the average tide is higher than what it used to be. So it's different and it's more severe.

Normal rain in this area is 54 inches. The record that we knew of, up until this year, was 84. That was just one year. The record. This year it was over 100 inches of rain. So definitely — you know, I don't argue with people about what caused it. I don't know because I'm not the scientist. But I can definitely tell you something is happening.

Let me ask you, if you can remember from your father and your grandfather, were there things that they taught you about weather?

Well, my dad didn't recognize much extreme weather. They had moderate rains about the same time, the same thing every year. Whenever they planted their crops, their beans, I hear him say, "Well, I sure would love to see rain come."

But we didn't have much extreme weather at that time, and he passed on in this area here. I don't recall very much at all.

Hurricane Hazel — nobody had seen anything like it, before or after for a long time.

I didn't even. That was 1954.

That Friday morning we went to work. And I was working on the railroad at that time, and we all went down. The whole party went. And I got down there. I think I had a radio in the car, but I had it on the music station from Tennessee or somewhere. And we got out there, and one guy said, "This is going to take Southport off the map."

The boss said, "Everybody wait." You know, he was going to get the checks and bring them back to us. And he brought the checks back and passed them out.

We headed back the way we came. We got down to the Desmond Creek and the wind had not started blowing, but water was coming across the road. I thought it was just boiling out the earth it was coming so fast.

We saw a car going up the hill over the other side. We should be good to cross that creek. It was about a quarter of a mile long. So my brother — we was riding with my brother — he says to them, "We'd better not try that. We'd get washed away." So, we turn around and come back, had to go out by Winnabow and then come down to get here and my mom's house down there. You cross, trees start falling.

And then it tore everything up on the beach. Nobody had seen that. Everybody talks about they'd seen storms before, but some of them got their ribs broke.

The people on Ocean Isle — a whole family got lost there. One man went across Long Beach on a foam mattress. He flew cross on a foam mattress. And from then on, we had storms.

But see, that was 18, 19 years of my life I'd never seen a storm. I'd never seen storm in 19 years.

So, how do you cope with this change?

Well, it's hard to say. I always says that I would never leave my home here, but I did leave it in this last storm. I went to Durham. Wished that I had never went.

And I've been in some pretty rough weather. I've been in waterspouts in the ocean. Hit by lightning while I was out there on the boat. That isn't much fun. Lightning hit us in off of Georgetown in a waterspout. And then I was in another waterspout in Charleston one time. When it come by, we were catching shrimp.

You do a lot of crazy things when you're catching shrimp. Because it gets in your head, you know. And we didn't want to quit. But anyway, whenever we seen it coming, we knew we didn't have enough time to go to another safe harbor or nothing at that time. So whenever we picked up the nets, we picked them up and said, "We've got to pick up the nets and move offshore."

Well, we picked up the nets. And we had no idea that there was a waterspout coming. We knew that bad weather was implied once we picked them up, and the wind got to blowing hard enough that it was carrying us backwards. So I told the guys, I said, "We've got to pick them up a little higher, so it won't blow our boat over the nets and get net in the wheel under the boat."

We went back and picked up, got one more whip on them, and tied them off. By the time we got back to the wheelhouse, our boots — white boots about this high — water was running out of my boots. That's how fast the water was. It just poured down.

When I pulled the door shut, at that moment, the lightning hit the CB antenna. And just fire was all over the room. And knocked out all my electronics on the boat. I had more than CB on there, but you could just see fire fly all around us.

You couldn't see nothing on the radar. And it was just so much water it was just dark. The fathometer wouldn't work, because there was so much rain hitting the water that it was too much noise that it wouldn't receive it back.

We was in Key West one time, and we got in some bad weather there. They give out a good forecast. Like Southeast winds are getting rougher and rougher and rougher, and afterwhile the seas were building and building. And we dropped down the anchor when we worked down that night. And afterwhile we couldn't sleep. And we pulled up the anchor and started in.

On the end of these outriggers, we got something called stabilizers. When the boat rolls over, they dive and they flatten out and slow the boat down going the other way. Well, after a while the ocean took one of them. Then the swells was coming fast enough it felt like it was going to turn over.

But anyway we put ahead in sea and decided we just had to rough it out. After a while we couldn't keep the cabinet door shut on the boat. We brought cooking along in a gallon jug. It flew out the cabinet and fell all over the floor. My helper — he was back there, and he didn't go

to church very much. After a while I heard him back there praying: "Oh, Lord! If you let me get back home to Shallotte, I'll go to church." But it was rough. I mean, you could barely hang onto the wheel up there. Just it was rolling so vicious, you know.

THE CATCH — AND THE FUTURE OF SHRIMPING

Before you retired, did you see a decrease in how many shrimp were available?

The last two years. I believe 2002 we had a good year. Not everybody did, but we did. Just by luck, being in the right place at the right time.

2003 and 2004 things just got bad. The price went bad on shrimp. They got a lot of shipping in shrimp from China and South America. And the catch got lesser. So that made it very hard. Even in 2004, I had to sell my boat, because I had to come home and take care of my wife.

And a lot of boats at that time just went to pieces. People just couldn't keep them up because of the price. See, the shipping in shrimp here from China — they could ship them in much cheaper than we could catch them, because the price of fuel went up, see. And the price of equipment just went up tremendously. Tremendous.

And then for the next 5 or 6 years, people's boats just — they just couldn't keep them up. They just let them go to pieces. And I said at that time, anybody who would be able to maintain during them hard times would be able to make a good living, because a lot of people would be out of business, you know.

And so far, that's been right for the last five years. I almost wanted to cry because I wasn't able to go shrimping. My whole 32 years of shrimping, the year Hurricane Floyd come by we caught 21-count shrimp [jumbo shrimp, 21 of which on average make a pound] off of North Carolina. Now, don't get me wrong, we caught some 21-count shrimp in Pamlico Sound every year. But not off the coast, except that one year.

And guess what, in the last five years, they is catching 21-count shrimp by the boatloads off of North Carolina. That makes you want to go shrimping.

We've been talking about climate change. Evidently, the ocean temperature has changed, and they're raising these shrimp in Chesapeake Bay. Which is a huge bay. And when the cold weather come they come out and come down to North Carolina coast.

We caught 21 counts of shrimp off of Florida back when I was shrimping. But now they're coming out of Chesapeake, which — you cannot drag a net in Chesapeake Bay. So, they get fully grown before they even come out. So, now, if you're working off the North Carolina coast, they're working here now in the wintertime.

Your son Conrad doesn't go out there catching. Do you kind of wish he was out there doing it?

Well, everybody can't shrimp. It's something you either love it or you hate it. You have to learn how to live with it. When you go out here shrimping, you got to put all your might in the shrimping. You have to have confidence in your boat, you have to have confidence you can shrimp.

My wife could take care of what she needed to take care of while I'm out there. I didn't have to worry about home. I didn't have to worry about her grocery bill, or what she spent, or whatever. I had it fixed. She could spend the house money. She could write a check out of my boat money, but she understood that's boat money. I could calculate in my head, if I need to buy a PTO [power take-off] to go on the boat, how many thousands of dollars it cost. It was there. So I didn't have to worry about that.

Now, like I told you, when I was in Key West, when I come home, then I spent that week with my family. I focused on them. I didn't worry about the boat.

We excerpted and edited Harry Bryant's interview for length. A recording of Melody Hunter-Pillion's full talk with him is available here:

- ***go.ncsu.edu/Harry-Bryant***

This interview is part of "Masters of Our Own Domain: North Carolina's African American Farmers and Fishermen," courtesy of the Southern Oral History Program at the UNC Center for the Study of the American South.

- ***SOHP.org***

Special thanks to the Bryant family for the vintage photos of the *Morning Light*.

The contemporary photographs of the *Morning Light* are courtesy of Terrah Hewett, who generously has allowed us to publish them here.

- ***https://fineartamerica.com/profiles/terrah-hewett/shop***

Melody Hunter-Pillion is a Global Change Fellow with the Southeast Climate Adaptation Science Center, a broadcast correspondent for ncIMPACT and PBS North Carolina, and a Ph.D. student in public history at NC State University.

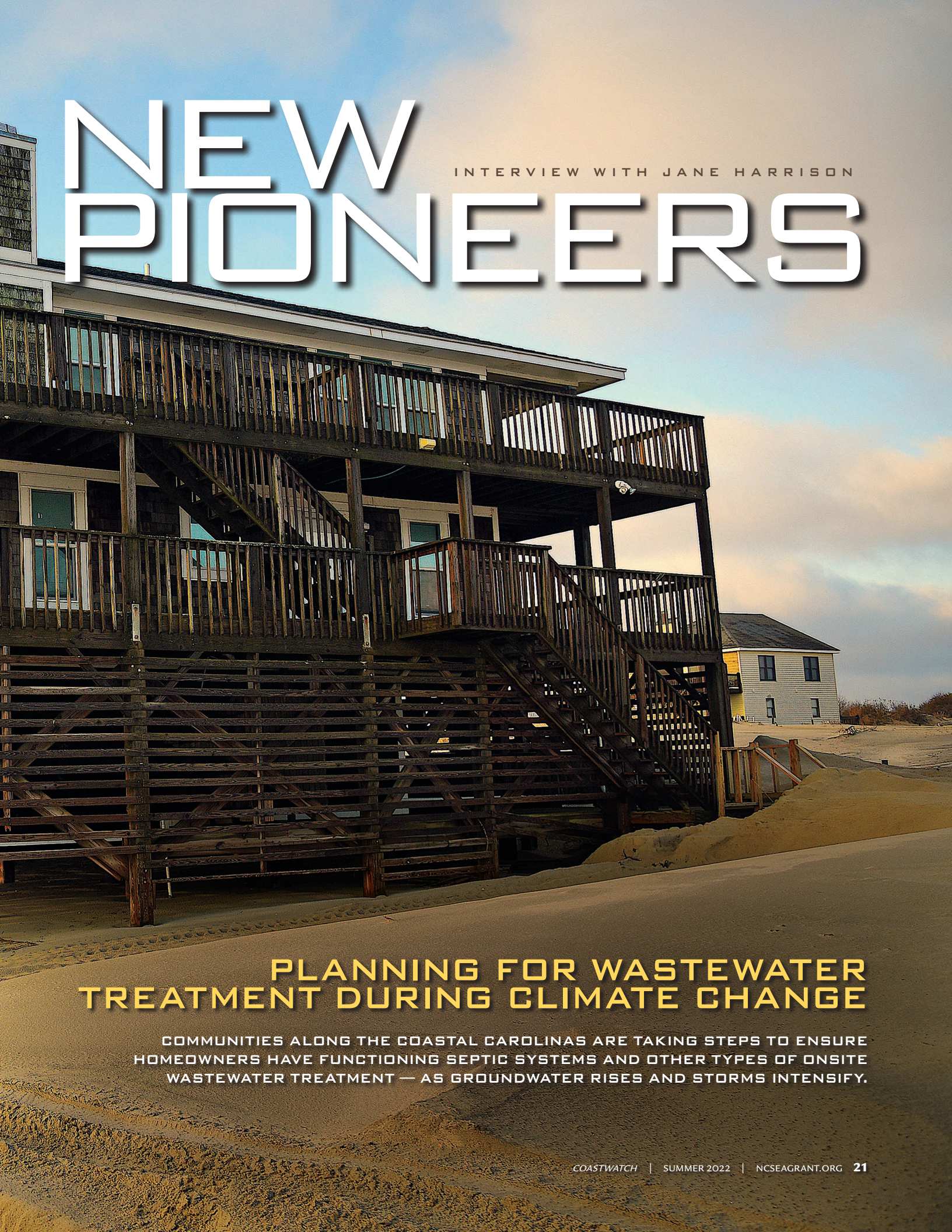
THE

NC State University

North of Nags Head in Currituck County

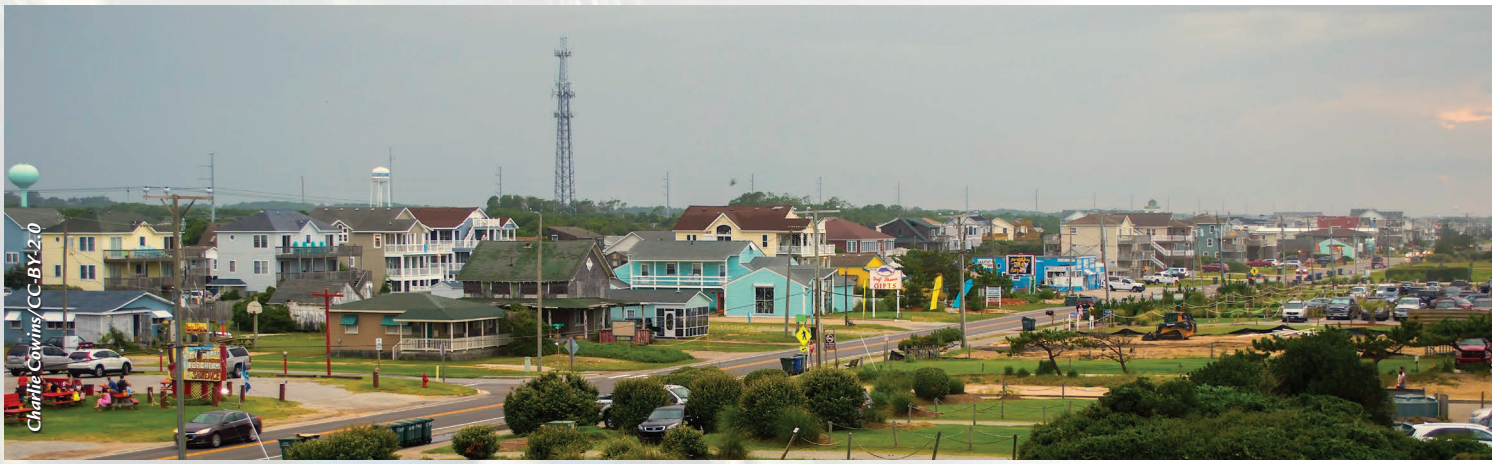
NEW PIONEERS

INTERVIEW WITH JANE HARRISON



PLANNING FOR WASTEWATER TREATMENT DURING CLIMATE CHANGE

COMMUNITIES ALONG THE COASTAL CAROLINAS ARE TAKING STEPS TO ENSURE HOMEOWNERS HAVE FUNCTIONING SEPTIC SYSTEMS AND OTHER TYPES OF ONSITE WASTEWATER TREATMENT — AS GROUNDWATER RISES AND STORMS INTENSIFY.



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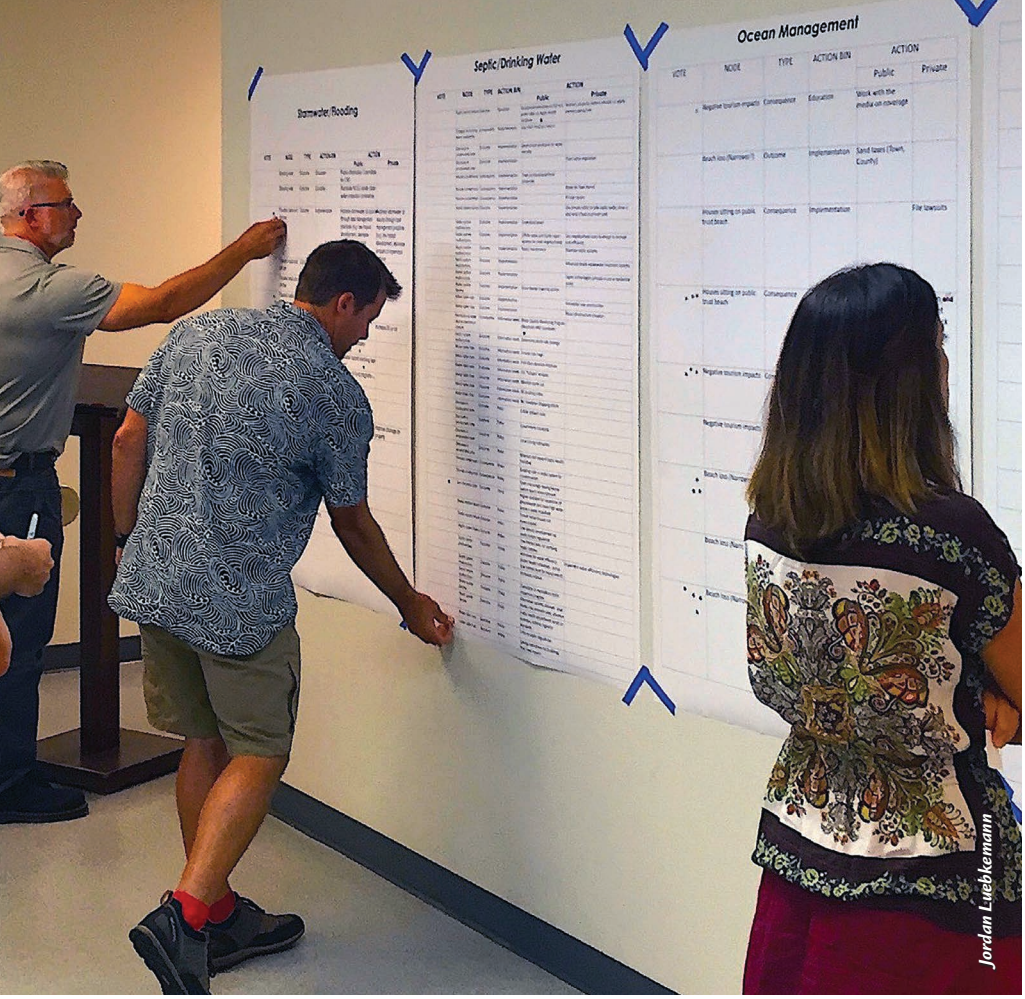
The communities of Nags Head (above) and Folly Beach (below) are partnering on a Sea Grant project that addresses the challenges that rising seas pose for wastewater treatment.

JANE HARRISON

is North Carolina Sea Grant's coastal economics specialist. In collaboration with university and community partners, she heads a team looking at climate change and onsite wastewater treatment systems. The project will help coastal communities to implement climate adaptation plans. She recently sat down with Coastwatch*'s Julie Leibach to discuss the threats that climate change poses and how some wastewater managers are addressing current and future challenges.*

WHAT DO WE KNOW ABOUT HOW ONSITE WASTEWATER TREATMENT SYSTEMS ARE WORKING ALONG THE COAST?

It's difficult to assess. Unless you have an obvious bad smell, visual evidence of sewage, or water rising up in your yard, you don't necessarily know that your system isn't working. System owners are likely to assume everything's okay. But it's not necessarily okay.



The Town of Nags Head has a long history of preparing for climate change, including "Vulnerability, Consequences, and Adaptation Planning" (here), which North Carolina Sea Grant facilitated.

A research team I work with monitors water quality near septic systems along the coast. Charlie Humphrey and Mike O'Driscoll at East Carolina University evaluate inland coastal systems and systems on the barrier islands for treatment efficiency — and now our project allows them to monitor more sites in the town of Nags Head and, in South Carolina, the city of Folly Beach.

We can't monitor every septic system in Nags Head and Folly Beach, so we've chosen different kinds of septic systems and other types of onsite wastewater treatment — like packaged plants, which are cluster systems built to serve multiple households or a small housing development. We're also evaluating treatment efficiency at centralized wastewater treatment facilities.

Our intent is to gain a better understanding of how on-site and centralized methods impact water quality: in particular, how different types of wastewater treatment systems reduce concentrations of potentially harmful nutrients, including nitrogen, phosphorus, and fecal coliform.

WHAT MAKES NAGS HEAD AND FOLLY BEACH GOOD PARTNERS FOR THE PROJECT?

The Town of Nags Head has a long history of working on climate change adaptation. They've been a partner with North Carolina Sea Grant for years and were involved in a process called "Vulnerability, Consequences, and Adaptation Planning" that we facilitated.

Holly White was a planner with Nags Head and our main collaborator there. She had a passionate interest in climate change adaptation for the town.

Similarly, the City of Folly Beach worked on a vulnerability assessment with South Carolina Sea Grant some years ago, and they wanted to take the next steps and look specifically at septic systems and decentralized wastewater treatment adaptation.

WHY DO COMMUNITIES IN THE COASTAL CAROLINAS OFTEN RELY ON ONSITE TREATMENT SYSTEMS?

For the most part, our coast is less densely populated than the urban areas that can afford centralized wastewater treatment. We need a certain population density to make centralized wastewater treatment plants economically feasible. It's just not a treatment option in less populated areas.

WHAT ARE THE CLIMATE IMPLICATIONS OF RELYING ON SEPTIC SYSTEMS ALONG OUR COAST TO TREAT WASTEWATER?

You need dry soil to process contaminants from wastewater. You have groundwater underneath your topsoil layer, and if the groundwater is rising — which is what's been happening on our coasts because of sea level rise — any untreated wastewater is going to hit that groundwater. Then, it mixes and goes wherever that groundwater goes. Into creeks and streams and lakes and the ocean.

Not surprisingly, contaminants from improperly treated wastewater can cause human illness and damage to ecosystems, and may, ultimately, diminish the quality of life in affected coastal towns and cities.

The vertical separation distance — that's the distance between the top of your soil layer and the groundwater level — should be between a minimum of 12 to 18 inches for conventional septic systems to function properly. Advanced onsite systems are another option when site conditions aren't ideal for conventional septic. These more robust systems, though, would have to be required for them to become widespread, because they're costlier.

A conventional septic system has a tank, drainage line, and soil treatment area. An advanced system often adds pretreatment to the process, some type of additional filtration. Advanced systems cost twice as much as conventional septic — $30,000 to $40,000 vs. $10,000 to 20,000 per property. *Continued*

YOU INTERVIEWED A LOT OF PEOPLE WHO MANAGE SEPTIC SYSTEMS AT THE COAST. HOW ARE THEY REACTING TO THE CHANGING CLIMATE? ARE THEY ALTERING THEIR APPROACHES?

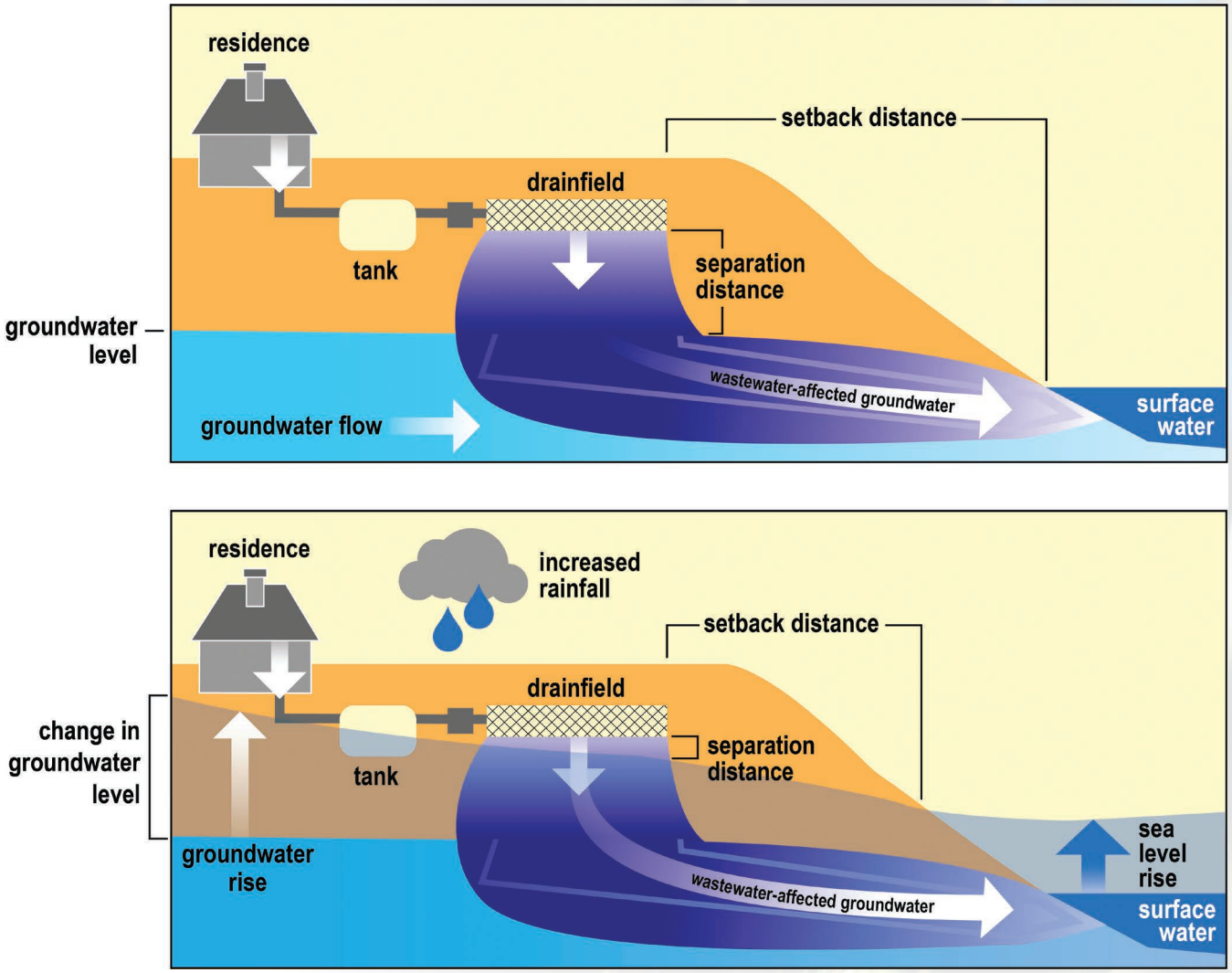
I'm encouraged that septic operators and installers are already adapting to climate change. Now, they wouldn't necessarily describe their actions in terms of climate change. They're preparing for *current* climate. They've experienced intense storms, flooding events, hurricanes. They're not preparing for the future. They're preparing for what they see year in, year out.

Septic operators and installers are recommending advanced systems to property owners, as well as more conservative installations. For example, they will raise up the soil layer, building in extra soil prior to system installation to create a larger treatment area.

The installers are obviously doing some good things, and that's important. But if you want to see future-oriented systemic change, we need to see regulatory shifts as well.

We interviewed state and county health department personnel who are responsible for permitting septic systems. The regulatory changes that the health departments need to make — those can account for *continued* climate change and govern what things look like *into the future* and on a bigger scale.

And statewide changes don't happen quickly. Whereas, if a community takes more local ownership of solutions, it can possibly move faster and do what's needed for its particular area.



Melissa D. Smith

NORMAL MOVEMENT OF WASTEWATER THROUGH A CONVENTIONAL SYSTEM FOR PROPER TREATMENT (ABOVE) SUFFERS WHEN RISING GROUNDWATER TABLES IMPACT WASTEWATER SOIL TREATMENT AREAS (BELOW).

Nags Head is moving ahead with a pioneering wastewater management plan, which includes a suite of recommendations that incorporate research from Jane Harrison's Sea Grant team, as well as from other sources.

AND NAGS HEAD IS EXHIBIT A.

Yes, I'm excited to see that Nags Head is going forward with a decentralized wastewater management plan. The town is developing a suite of recommendations, in fact, incorporating our research and other work. They are investing in public education on septic use, free septic system inspections, and discounts on pumping out septic tanks, continuing their proactive track record when it comes to climate change.

To see a town get to this kind of granularity on onsite wastewater treatment, on septic systems, is really cool. It's one of the first examples of a community doing that kind of climate adaptation in a sector that so few communities have figured out how to tackle.

WHAT ABOUT HOMEOWNERS ON THE COAST WHO CURRENTLY ARE RELYING ON AGING ONSITE SYSTEMS? HOW CAN THEY PREPARE FOR A STORM, FOR INSTANCE?

Basically, you need to prepare to not use your system. The main thing that you can do is let it rest after a storm event, because you need to be aware it's probably not working correctly, especially if it's older or not well maintained.

Typically, how well an onsite system will respond to disruptive weather depends on the drainage. Rainfall can saturate the soil and stress the system. The experts we interviewed agreed, though, that onsite systems are generally able to recover on their own *if* the soil in the drainfield has time to dry out.

Our interviewees also told us that communication to property owners about onsite systems is fractured and inconsistent, which contributes to system failures. Something like the impact-based warnings the National Weather Service uses during severe storm events would be useful for homeowners. For example, with damaging tornadoes, they say "Mobile homes will be destroyed" to motivate people to find shelter. Similarly, severe storm warnings could say "Septic systems may not function properly" and "Wait 48 hours before flushing your toilet."

HOW CAN WE BEST PROTECT OUR COAST'S ONSITE WASTEWATER TREATMENT SYSTEMS AS THE CLIMATE CONTINUES TO CHANGE?

We know that older systems often fall through the cracks. An ongoing program that tracks system inspections could ensure systems remain well-maintained and compliant.

We also know that regulatory requirements for onsite systems currently do not take into account resiliency to future climate change. Low-lying areas, such as North Carolina's Outer Banks and South Carolina's Low Country, are already experiencing the impacts

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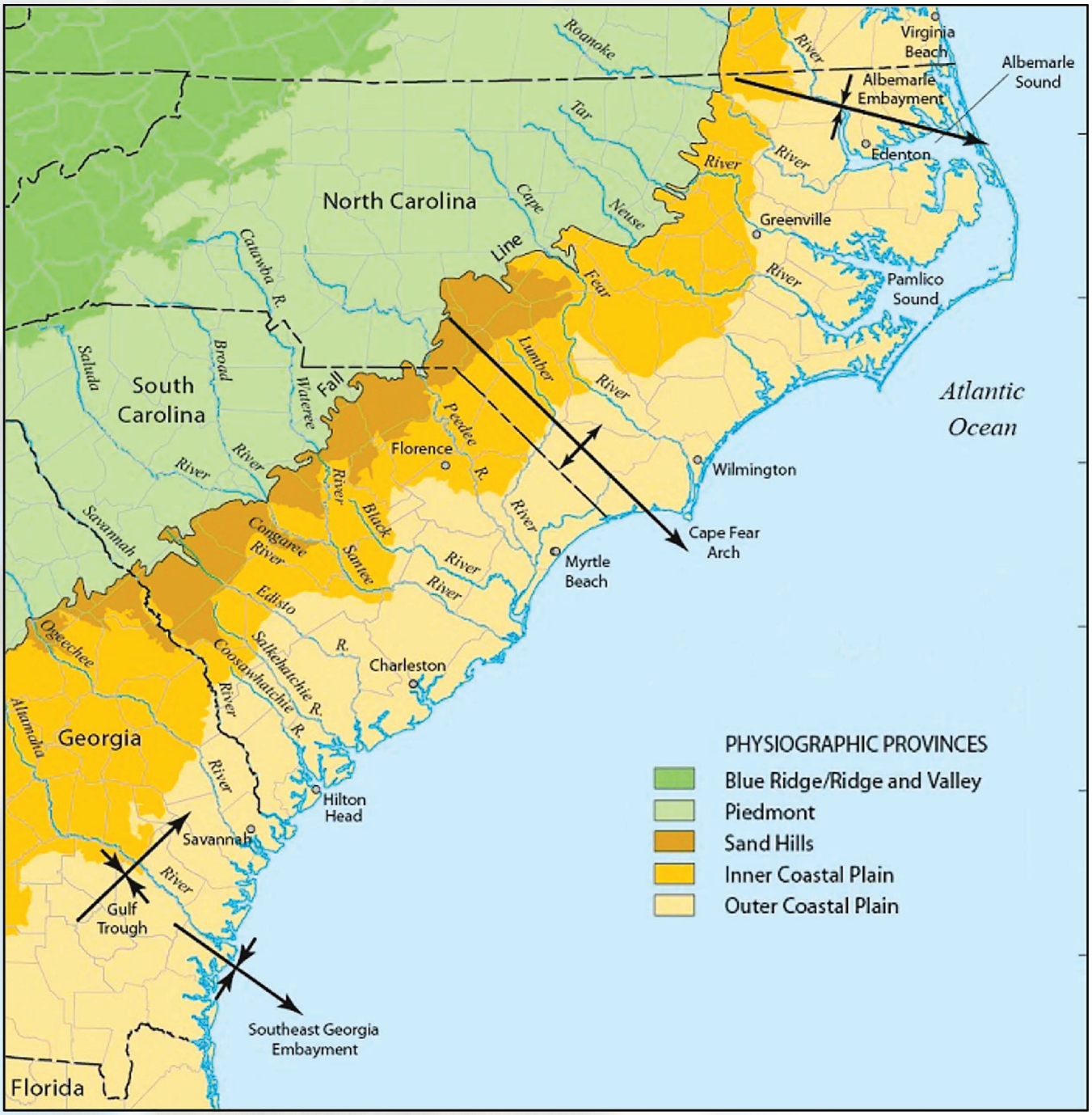

USGS

Low-lying areas, such as North Carolina's Outer Banks and South Carolina's Low Country, are already experiencing the impacts of sea level rise, and inland areas in the coastal plain are experiencing increases in groundwater table heights. Both areas are particularly vulnerable to extreme precipitation events, which places stress on onsite treatment systems.

of sea level rise, and inland areas in the coastal plain are experiencing increases in groundwater table heights. Both areas are particularly vulnerable to extreme precipitation events, which places stress on onsite treatment systems.

Current regulations are inadequate to deal with future climate risks, and this is where state government has a role to play. A next step for our project is taking the results and sharing them with the regulatory community, the State Health Departments, and to hopefully inform their planning and decision-making processes.

We also think that our findings will be useful at the community level for other municipalities as they plan ahead.

NCDOT

Current regulations don't account for future climate risks — and this is where state policymakers and planners have a role to play.

North Carolina Sea Grant is leading this project on climate change and onsite wastewater systems, in collaboration with university and community partners and with funding from the NOAA Climate Program Office.

The research team includes:

- Jane Harrison, coastal economics specialist, North Carolina Sea Grant
- Lauren Vorhees, research assistant, North Carolina Sea Grant
- Jared Bowden, senior research scholar, Department of Applied Ecology, North Carolina State University
- Michael O'Driscoll, associate professor of coastal studies, East Carolina University
- Charles Humphrey, Jr., professor of environmental health sciences, East Carolina University
- Eric Edwards, assistant professor of agricultural and resource economics, North Carolina State University
- Katie Hill, J.D., research professional, Carl Vinson Institute of Government, University of Georgia

Community partners have included Holly White, former principal planner for the Town of Nags Head, and Aaron Pope, city administrator for the City of Folly Beach.

MORE

The team's final report (available this summer), project updates, and more information

- *go.ncsu.edu/wastewater*

About Nags Head and the town's climate adaptation planning

- *go.ncsu.edu/TheLongView*

Coastwatch on sea level rise and climate change

- *go.ncsu.edu/coastwatch-climate*

Coastwatch on resilience

- *go.ncsu.edu/coastwatch-resilience*

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By Maya Hoon

CLIMATE CHANGE AND RESISTANCE TO ANTIBIOTICS

Hotter Waters, Heavy Metals, and a Growing Public Health Concern

Maya Hoon investigated how heavy metals and environmental factors affect antibiotic resistance, drawing her study samples at four sites in the Neuse River basin, including the Eno River (here).

A Rising Threat

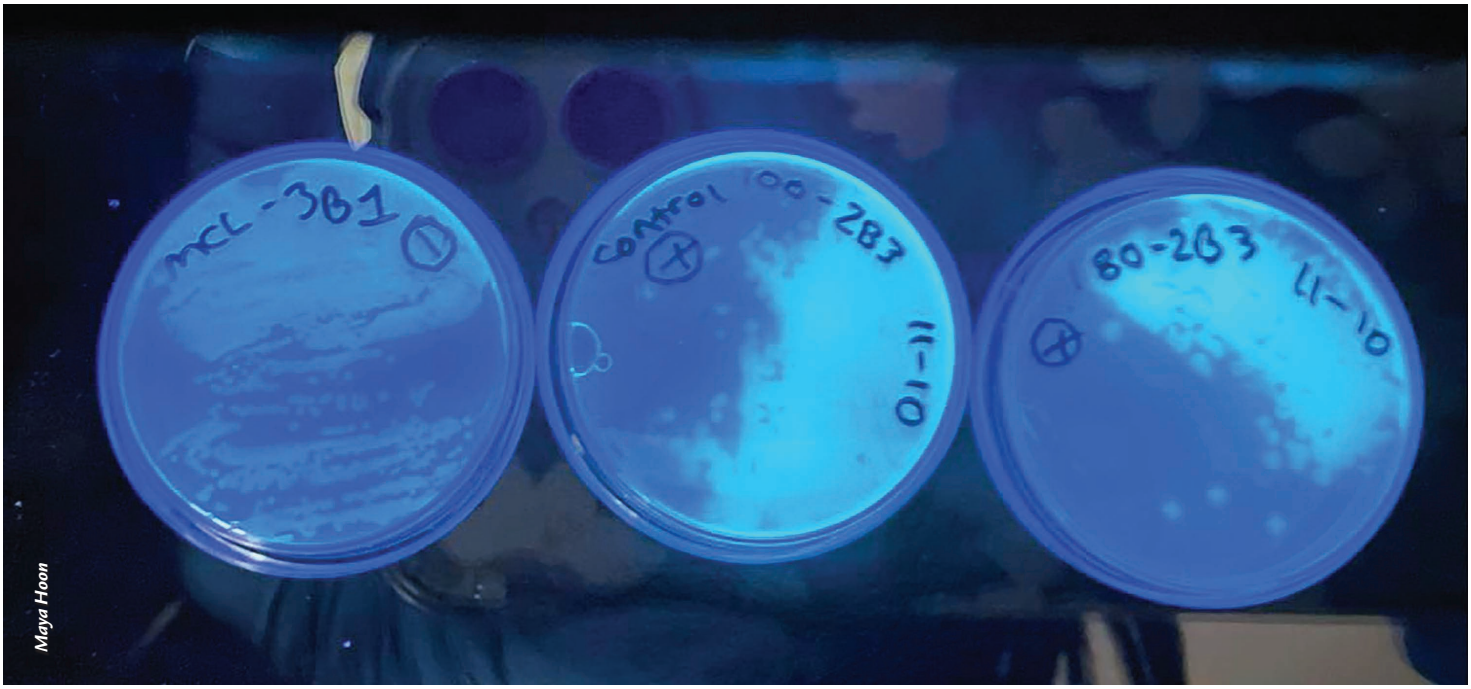
Antibiotic use is an important life-saving practice to treat infections caused by bacteria, fungi, or viruses. As far back as 2600 B.C.E., ancient Egyptians used heavy metals like copper to treat ailments that even included headaches. Over time, Greeks, Romans, Aztecs — and other major civilizations — used heavy metals as antimicrobials for ailments and to sterilize water, until commercially-available synthetic antibiotics replaced heavy metals in the 20th century.

Although widespread use of heavy metals as antimicrobials has diminished, frequent exposure to heavy metals in the environment, such as in surface waters, has caused bacteria to evolve and adapt. These adaptations also help bacteria resist widely available synthetic antibiotics, contributing to an urgent, emerging public health issue: antimicrobial resistance. Some of today's life-threatening bacteria, fungi, and viruses are surviving and growing in the presence of the very medicines designed to stop them.

As more resistant bacteria spread in surface waters, people are at higher risk of exposure, through recreational activities, to these dangerous bacteria. In fact, at the current rate of spread, related deaths from annual antimicrobial resistance could reach 10 million by 2050, even exceeding annual cancer-related deaths (8.2 million), according to the 2016 Review on Antimicrobial Resistance. Among those affected, immunocompromised groups (e.g., people who undergo chemotherapies, burn-wound victims, and people with diabetes) are most at risk of dying from life-threatening infections.

Additionally, antimicrobial resistance and its impacts on animal health are a potential risk to economic stability. Animals inhabiting these waters also face exposure, raising concerns for the aquaculture industry and anyone who consumes fish or other animals that carry resistant bacteria. Infections in finfish and shellfish from aquaculture farms also could reduce harvests, weakening the capital that the aquaculture industry generates. In fact, according to the same 2016 Review on Antimicrobial Resistance, global GDP could fall by an estimated 2% to 3.5% due to all impacts associated with antimicrobial resistance, costing the world up to $100 trillion.

Overall, antimicrobial resistance poses worldwide health and economic threats, with some vulnerable populations likely to face disproportionately difficult impacts. Therefore, we have to better understand what influences antimicrobial resistance, which is what my team and I set out to do. *Continued*



Maya Hoon

From grown bacterial colonies, tests revealed which bacteria are resistant to heavy metals and which bacteria are resistant to certain antibiotics in the Neuse River basin.

Heavy Metals in Surface Waters — and How Environmental Factors Complicate Matters

Heavy metals are present much more than antibiotics in surface water environments. Past research shows heavy metal concentrations have an influence on antibiotic resistance, typically involving a process called "co-occurrence," in which heavy metal resistance and antibiotic resistance occur in the same microorganism. Heavy metals can be toxic to bacteria at high concentrations, which, in turn, may lead bacteria to acquire and be genetically selected for traits that allow them to resist these metals. These traits also help to fight against antibiotics.

Among the most common metals in surface waters are zinc and copper, which were the metals we used for this investigation. Copper and zinc are additives in agricultural animal feeds and often wash from farms into surface waters through runoff. As the second-ranked hog producing state in the country, North Carolina serves as an interesting setting to examine the associations between copper, zinc, and antibiotic resistance.

Furthermore, metals-based pesticides are another notable source of heavy metals in surface waters. Copper sulfate, for instance, is commonly used as an algicide in our state, especially in wastewater treatment plants.

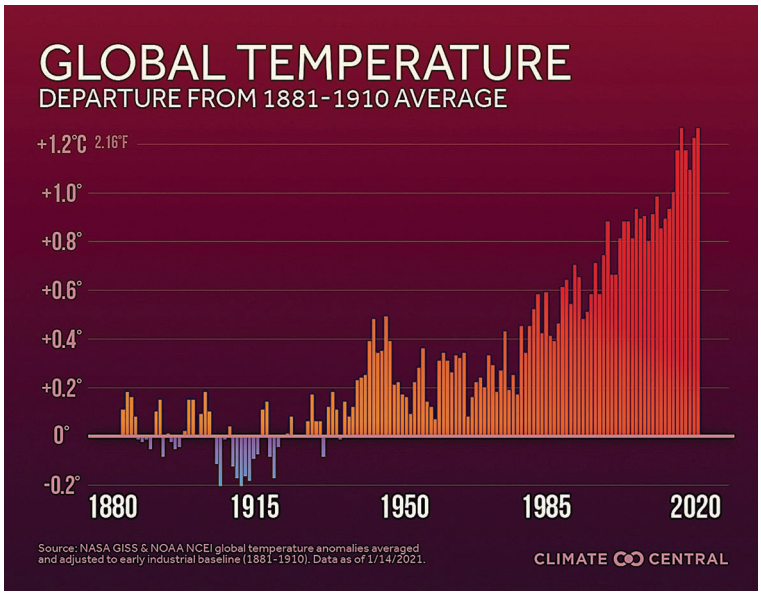
In addition to studying heavy metal associations with antibiotic resistance, I looked into the associations of several different environmental factors, including salinity and temperature. Previous studies investigating these factors have noted their potential correlations with antibiotic resistance. However, few have looked into environmental factors and metals and antibiotic resistance in surface water environments.

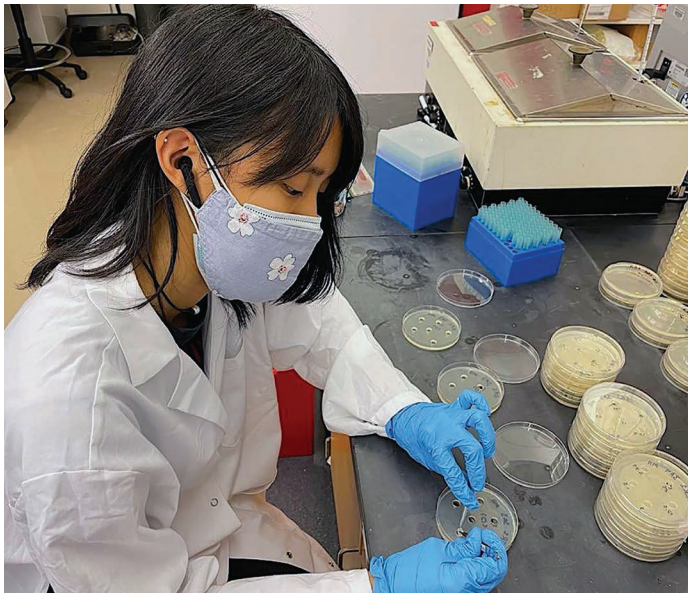
Investigating the Neuse River Basin

Flowing from the Triangle region to the Pamlico Sound, the Neuse River hosts many major recreational areas, especially within the Neuse River Estuary — and heavy metals have affected the area over the past couple decades.

Ultimately, I wanted to address two questions. First, is heavy metal resistance associated with antibiotic resistance in the Neuse River Basin? Second, what environmental factors, if any, are associated with antibiotic resistance in surface waters?

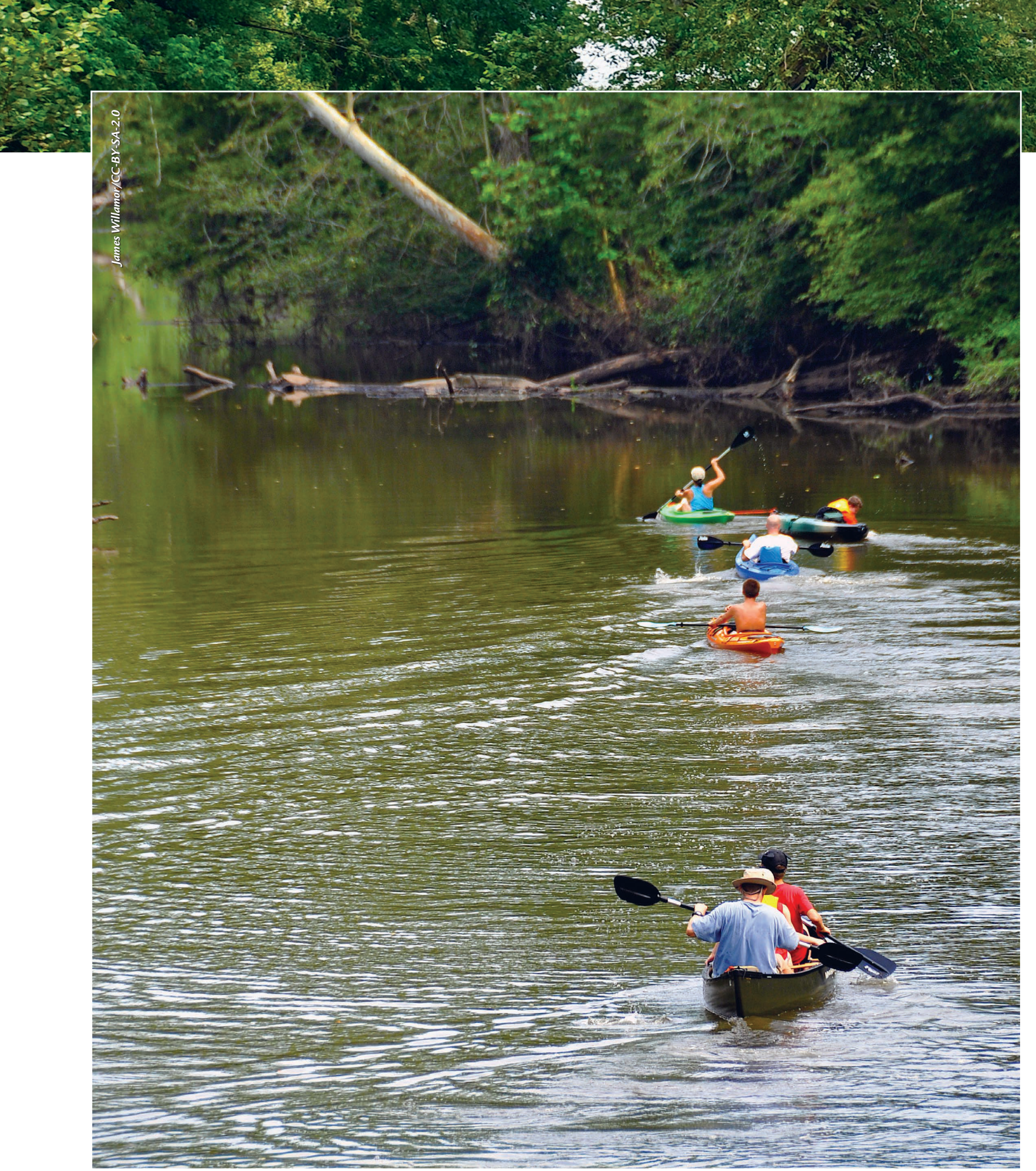
Continued





The significant association of high temperature with antibiotic resistance is troubling, because climate change continues to warm the planet. Maya Hoon (here) also determined that the presence of zinc in water samples coincided with antibiotic resistance.

Sea level rise increases salinity in surface waters, not only causing ghosts forests like this along the Alligator River — but also contributing to the spread of antibiotic resistance.



James Willamor/CC-BY-SA-2.0

As more resistant bacteria spread in the Neuse River (here) or in other surface waters, people face higher risk of exposure, even through recreational activities.

I took water samples and water quality measurements from four surface water sites in the Neuse River Basin: the Eno River, Morgan Creek, the Neuse River in Raleigh, and the Neuse River Estuary.

"Maya brought together a very interesting set of disciplines to examine antibiotic resistance from the Neuse headwaters in the Piedmont down to the estuary. This robust design greatly increased our understanding of this issue and could lead to better management options to protect public health."

— JOHN FEAR, DEPUTY DIRECTOR OF NORTH CAROLINA SEA GRANT AND THE NC WATER RESOURCES RESEARCH INSTITUTE

In the lab, I immediately captured bacteria on membrane filters and grew them overnight on agar plates, focusing on Gram-negative bacteria. Among the most concerning bacteria, Gram-negative bacteria have a unique cellular structure that reduces the effects of antibiotics. These bacteria also are responsible for many serious diseases relevant to human and animal health and rapidly have become more resistant to multiple drugs over the past decade.

From grown bacterial colonies I could test which bacteria are resistant to copper, zinc, or both and which bacteria are resistant to certain antibiotics.

What We Found

There are indeed associations between where antibiotic resistance occurs and heavy metals occur, especially **zinc**. This is cause for concern because of zinc's abundance in surface waters. More zinc will continue to come into our waterways through animal feeding operations in North Carolina and even from wastewater treatment plant effluent, increasing possibilities for co-occurring zinc and antibiotic resistance in our state.

Furthermore, **temperature** is associated with both antibiotic resistance and heavy metal resistance. In other studies, higher temperatures appeared to enhance antibiotic resistance mechanisms in Gram-negative bacteria — and the significant association between antibiotic resistance and metal resistance at higher temperatures that we found suggests the potential for even more widespread antimicrobial resistance in warmer waters.

In addition, **high salinity** appeared to have an association with resistance to at least three antibiotics in a single Gram-negative bacteria. Multi-drug-resistant bacteria is a serious public health concern, because this type of resistance further limits effective options to treat life-threatening infections.

The significant associations of high temperature and salinity with antibiotic resistance is troubling because climate change continues to exacerbate each of these factors. As temperatures increase, sea levels rise and occurrences of saltwater intrusion increase.

Our team also determined that **higher pH levels** were associated with multi-drug-resistance. Different pollutants and chemicals, as well as bedrock composition, can cause higher pH.

Looking ahead, understanding how heavy metals and environmental factors influence antimicrobial resistance in Gram-negative bacteria in North Carolina's surface waters can help inform efforts to monitor and manage associated hazards in our state. Ultimately, this could help reduce the spread of antimicrobial resistance, protecting public health and our state's economy.

Maya Hoon was the 2021-2022 joint fellow with North Carolina Sea Grant and NC Space Grant. She recently completed her M.S. in environmental sciences and engineering from the University of North Carolina at Chapel Hill.

- **North Carolina Sea Grant and NC Space Grant Graduate Research Fellowship:** *go.ncsu.edu/sea-space-fellowship*
- ***Coastwatch* on climate change:** *go.ncsu.edu/coastwatch-climate*

NC State University

Shark Thievery, American Shad in the Albemarle Sound, and How We Fished 12,000 Years Ago

The Latest Science for Anglers

CURATED BY SCOTT BAKER AND SARA MIRABILIO,
FISHERIES SPECIALISTS WITH NORTH CAROLINA SEA GRANT

HOW OFTEN DO SHARKS SWIPE THE CATCH?

A new study reveals that avid anglers are no strangers to opportunistic sharks — and this could impact shark conservation.

Many species of shark are found year-round off the North Carolina coast, but several open-ocean species will venture closer to shore come early spring. This can either provide the thrill of a big fight for these catch-and-release species or cause dismay over the loss of bait and gear — or, even worse, cause dismay over losing prize fish catches to hungry sharks.

- *Research Need*

"Shark depredation" — when a shark takes part or all of a hooked fish before an angler or commercial fisher lands it — is increasing in the United States, according to anecdotal reports.

Most research on perceptions of sharks has focused on people whose livelihoods depend on the fish they catch (or don't catch, thanks to the sharks). But do anglers' experiences with sharks impact their support for shark conservation? Is the rise in recreational shark fishing in any way correlated to personal experiences and second-hand accounts from friends and family?

- *What did they study?*

A research team set out to study the impact of sharks on recreational fishing experiences, using an online survey of saltwater anglers in North America.

The team gathered information about anglers' emotional and behavioral responses to

shark depredation, as well as basic information about the survey participants, including how often they fish, where they fish, and species they target. The surveys also collected information about anglers' motivations for fishing (such as for food or catch-and-release), whether they have experienced depredation, their perceptions of sharks and shark conservation, and whether they served as a fishing guide.

Anglers who had experienced depredation in the last five years also received specific questions about those events.

• *What did they find?*

Most of the anglers who took the survey were male (89%), between the ages of 25 and 44 (51%), and considered themselves avid anglers (68%) who fish more than 30 times a year. Of the 541 people who responded, 77% had experienced depredation in the last five years, more commonly in the Southeast than other areas.

Of those anglers who experienced shark depredation, 90.3% had experienced it more than once, and over half experienced 20 or more depredation events in the last five years.

The most frequently depredated fish included various tuna species, king mackerel, and various snappers, though these numbers primarily are due to the large number of respondents from the southeastern U.S., particularly Florida.

In the northeast, the most frequently depredated species were striped bass, black sea bass, and pollock, and, on the West Coast, anglers most frequently reported that sharks took tunas.

• *Anything else?*

The team determined significant differences in emotional responses to depredation between fishing guides and anglers. Guides felt negative emotions — including sadness, distress, and anger — much more extremely than anglers. Additionally, guides reported feeling excitement or awe less than anglers.

All told, 87% of guides experienced depredation when fishing with clients and overwhelmingly reported that depredation has a negative effect on their livelihood.

• *So what?*

While many anglers reported that they would not change their behavior after experiencing depredation, guides said they were much more likely to target and harvest sharks in the future, as well as much less likely to fish in the same area again.

Such behavior change — to target and harvest sharks recreationally — results in the potential for shark depredation to have lasting management implications both for the species anglers target and for shark populations.

— by Sara Mirabilio

HOW DID PEOPLE CATCH FISH 12,000 YEARS AGO?

An archaeological site has revealed an enormous collection of early hooks, lines, and sinkers — and even evidence of artificial lures.

• *Research Need*

Catching fish on a regular basis — notice I said catching, not just fishing — can require significant skill and attention to the craft.

In short, anglers can gain a lot of information by studying other successful fishers, the tackle they prefer, and how they use it. In a way, archaeologists are like anglers in that both groups attempt to gain new knowledge from people who came before them.

Over the last 10 years, archeologists have discovered many well-preserved bone fishhooks, smooth grooved stones (thought to be early sinkers), artificial lures, and evidence of plant-based fishing line, all in the Hula Valley of modern-day Israel. The site represents one of the largest collections of early hook and line fishing tackle.

So, what can we learn about early fishing practices?

• *What did they study?*

With access to the largest and most complete gathering of early fishing tackle remains, investigators sought to better

Continued

Bob Talbot/NOAA

Avid anglers are no strangers to opportunistic sharks.

understand how people made the items and fished with them. The team conducted archaeological, technological, and microscopic examinations to explore original uses for the fishing tackle.

• *What did they find?*

Hooks shaped from bone came in assorted sizes, with many including an outward facing barb. These hooks did not have eyes to attach line. Instead, the barbs, in combination with single and double knobs kept the line secure on the hook. The line also could have wrapped around a large portion of the hook shank. In some instances, adhesive was used to attach lines to hooks.

Several pebbles with grooves created by hand tools were found in the same area as the hooks. Thought to be sinkers, all pebbles were of comparable size and still had small remnants of early fishing line attached.

Fishing line was not discovered intact but in small fragments attached to hooks and grooved pebbles. Composed of unidentified vegetative material, the line would have been strong enough to retrieve at least a 2-pound fish, according to the research team.

The presence of deep grooves, adhesive, and animal hair on two hooks from the site also confirm that artificial lures were in use 12,000 years ago. The researchers think that early fishers may have attached small pieces of shell — which displayed a mother of pearl color pattern — to attract fish as the lure fluttered in the water.

• *Anything else?*

The study site indicates that fishing occurred in shallow water close to the lakeshore. People most likely left hooks near the water's edge accidentally or when the hooks broke during use.

In addition, the fish remains found at the site indicate that catch was composed of at least three fish: Cyprinidae (the same family as carps and minnows), Cichlidae (the family that includes tilapia), and probably Salmonidae (which today includes salmon and trout).

• *So what?*

Fishers 12,000 years ago were more sophisticated than we previously thought. The skill required to manufacture and assemble hooks, line, and sinkers in combination confirms that fishers had a deep understanding of fish behavior, including feeding, and that they developed strategies for capture.

I assume they shared their personal tips and tricks with others…

— by Scott Baker

Hooks, lines, and sinker — from 12,000 years ago.

PLoS One/CC-BY-4.0

WHERE DO AMERICAN SHAD LIKE TO SPAWN?

When these fish return to the Albemarle Sound to reproduce, they prefer one river basin — by far.

From late February through early April each year, American shad, often called "white shad," return to North Carolina coastal waterways, headed for obscure backwaters where they complete their mating rituals and lay eggs before returning to sea. This fish population may be making a comeback — due to activities like state stocking of recently hatched shad — but not to the extent managers hoped.

• *Research Need*

American shad once supported one of the largest commercial fisheries along the Atlantic Coast. Dams and other man-made impediments that block spawning habitat in rivers, combined with habitat degradation and overfishing, severely depleted American shad populations. In 2005, fishery managers closed commercial ocean fishing for this species, yet the most recent coastwide stock assessment found that most American shad stocks remain at all-time lows.

It is believed the fish generally return to their birthplace to spawn. For example, fish entering the Albemarle Sound to spawn primarily swim upstream on the Roanoke River or the Chowan River. Determining the current primary spawning river for American shad in the Albemarle Sound would help inform research efforts and resource management decisions to improve stocks.

• *What did they study?*

For much of the time period from 2013 to 2019, state biologists tagged and released a total of 266 adult American shad from various locations within Albemarle Sound. A

small sound-emitting "acoustic tag" allows the detection and remote tracking of organisms in aquatic ecosystems. An array of acoustic receivers at ocean inlets and throughout the Albemarle Sound, the Chowan and Roanoke rivers, and their smaller tributary rivers detected fish as they migrated.

- *What did they find?*

Of the 266 tagged fish, receivers subsequently detected 212. The 56 other fish presumably died not long after tagging. In over half of the detected fish (114 of the 212), tagging resulted in the fish aborting their spawning runs and moving back downstream; 28 of those fish did resume a spawning run later (on average, after 11 days), but 86 fish left the system entirely.

Of the fish that completed upstream migrations, there were 56 runs up the Chowan River, 5 up the Roanoke River, and 1 each up the Alligator and Pasquotank rivers. Of the Chowan River migrations, 39 remained in the upper Chowan River, 8 entered the Meherrin River, and 9 entered the Nottoway River. None of the fish used the Blackwater River.

Because migrating adult fish typically return to the rivers where they were born, these results suggest that American shad entering the Albemarle Sound are disproportionately spawning in the Chowan River basin and that the Chowan River basin may host a larger population.

- *What else did they find?*

The observed higher use of the Chowan River over the Roanoke River (56 runs, compared to only 5) for spring spawning migrations could partially be the result of differences between the two river basins. The Chowan River and its tributaries offer significantly more unimpeded miles of river: 610 miles, compared to 214 miles.

These findings suggest that over many years the Roanoke River population of American shad may become depleted, compared to the population that is homing to the Chowan River.

- *Anything else?*

Despite American shad in the Albemarle Sound system typically experiencing multiple reproductive cycles over the course of a lifetime, the research team detected only a single fish that made a repeat migration, and that was into the Chowan River in 2013 and 2014. This might be because of the relatively low sample size of the study and the high rate of mortality from tagging (presumably about 20%).

— by Sara Mirabilio

read more and access the full studies
HookLineScience.com

American shad have a favorite river for spawning.

USFWS

Crab Imperial

Freshly Grilled Striped Bass

CRAB IMPERIAL, GRILLED STRIPED BASS, AND MORE

BY VANDA LEWIS AND JOYCE TAYLOR

MARINER'S MENU, NORTH CAROLINA SEA GRANT'S POPULAR ONLINE SEAFOOD GUIDE, FEATURES BLOGGER AND PHOTOGRAPHER VANDA LEWIS'S PICTURES WITH HUNDREDS OF RECIPES THAT JOYCE TAYLOR DEVELOPED. ENJOY THESE SUMMERTIME TREATS — AND VISIT *MARINERSMENU.ORG* FOR MORE.

CRAB IMPERIAL

- 1 pound of backfin crabmeat
- 1 egg, beaten
- 1/4 cup of mayonnaise
- 3/4 teaspoon of Worcestershire sauce
- 1/4 teaspoon of salt
- 1/16 teaspoon of dried thyme
- 1/16 teaspoon of dried oregano
- 1/16 teaspoon of ground mustard
- 1/4 teaspoon of Tabasco sauce
- 1 teaspoon of dried parsley flakes
- paprika

Remove any shell and cartilage from the crabmeat. In a large bowl, mix the egg, mayonnaise, Worcestershire sauce, salt, thyme, oregano, mustard, and Tabasco. Gently mix in the crabmeat.

Place in a lightly greased 1-quart casserole. Sprinkle with parsley and paprika. Bake at 350° F until the mixture is lightly browned and bubbly, about 25 minutes.

FRESHLY GRILLED STRIPED BASS

- 1 1/2 pounds of striped bass fillets, skinless, cut into serving-size pieces
- 1/4 cup of butter, melted
- 1 tablespoon of Worcestershire sauce
- 1 1/2 teaspoons of smoked paprika
- 1/2 teaspoon of garlic
- 1/2 teaspoon of salt
- 1/2 teaspoon of black pepper, freshly ground

Preheat the grill to medium-high.

In a small bowl, combine butter, Worcestershire, paprika, garlic, salt, and pepper.


Vanda Lewis

Triggerfish with Pineapple Salsa

Brush fish on both sides with the mixture. Cover and marinate in the refrigerator for 20 minutes.

Place fish on the grill and cook for about 5 minutes. Flip over and repeat, cooking until done.

TRIGGERFISH WITH PINEAPPLE SALSA

- 4 triggerfish fillets, skinless
- 1/2 cup of fresh orange juice
- 2 tablespoons of fresh lime juice
- 2 tablespoons of honey
- 1/4 teaspoon of salt
- 1/4 teaspoon of white pepper, freshly ground
- 1/4 teaspoon of garlic, pressed
- 3 tablespoons of butter, melted

Place the rack in the top third of the oven and preheat the broiler. Prepare the Pineapple Salsa (below) and chill.

For the fish marinade, in a small bowl combine the orange juice, lime juice, honey, salt, pepper, and garlic.

Place the fish in a dish, cover with the marinade, and refrigerate for 20 minutes. Then remove it from the marinade.

Brush the fish with melted butter. Place the fish on a broiler pan coated with cooking spray. Broil until golden brown and the fish flakes easily when tested with a fork, about 8 minutes. Serve with Pineapple Salsa.

Pineapple Salsa

- 1 cup of fresh pineapple, finely chopped
- 3 tablespoons of green onion, very thinly sliced


Vanda Lewis

Shrimp with Fennel

- 3 tablespoons of red pepper, diced
- 1 tablespoon of fresh lime juice
- 3 tablespoons of fresh basil, chopped
- 1/4 teaspoon of salt
- 1/8 teaspoon of white pepper, freshly ground
- 1/2 teaspoon of balsamic vinegar

In a medium bowl, combine the pineapple, onion, red pepper, lime juice, basil, salt, pepper, and balsamic vinegar. Chill until ready to serve.

SHRIMP WITH FENNEL

- 1 pound of shrimp
- 1 cup of water
- 3/4 teaspoon of ground fennel seed
- black pepper, freshly ground
- 4 tablespoons of unsalted butter
- 1 tablespoon of fresh lemon juice

Peel and devein the shrimp. Reserve the shells. In a small saucepan, bring the water, 1/2 teaspoon of fennel, pepper, and shells to boil. Simmer uncovered until the liquid is reduced to 1/2 cup. Strain and reserve the liquid.

In a medium skillet, sauté the shrimp in 3 tablespoons of butter, sprinkling with the remaining 1/4 teaspoon of fennel. Remove the shrimp to a serving dish.

Make a sauce by whisking together in a skillet the reserved shell liquid, lemon juice, and remaining butter. Pour it over the shrimp.

For hundreds of free seafood recipes, visit:
MarinersMenu.org

Keith Ramos/USFWS & NOAA

Climate Change and the Northern Migration

More animals — including sea turtles, manatees, sharks, and hundreds of other fish species — will be on the move.

BY SARA MIRABILIO

IN NORTH AMERICA, CHANGES IN THE FREQUENCY, INTENSITY, AND DURATION OF COLD TEMPERATURE EXTREMES WILL GREATLY INFLUENCE THE DISTRIBUTIONS AND MIGRATIONS OF FISH AND OTHER SPECIES. DECREASES IN THE FREQUENCY AND INTENSITY OF THE COLDEST EVENTS COULD ALLOW WARM-WATER MARINE ORGANISMS TO EXPAND THEIR HOME RANGE NORTHWARD. AND FOR COLD-WATER SPECIES, IT COULD MEAN THEY LEAVE AREAS THEY ONCE INHABITED AS WARMER WATERS BECOME INHOSPITABLE TO THEM.

In particular, changing distributions of many popular fish species would impact local fishing communities, and, quite possibly, major fishing ports. As a result, natural resource managers want to better understand the ecological impacts of changes in the frequency and intensity of extreme climatic events.

The U.S. Geological Survey's Michael J. Osland and a team of researchers examined several scientific studies in order to understand the influence of extreme cold events on the northern limits of the ranges of a diverse group of tropical and subtropical organisms in North American waters, including coastal fishes, sea turtles, and others. They considered the frequency, intervals, and physiological effects of extreme cold events, as well as recent winter warming trends.

To evaluate winter trends over recent decades, the research team analyzed temperature data from several locations in the U.S. between tropical and polar regions. Such "transition zones," between areas of much hotter and much colder climates, generally experience wider temperature ranges throughout the year.

Transition zones also undergo more distinct seasonal changes compared to tropical and polar climates, where such variations often are small. North Carolina reefs, for example, lie within such a transition zone, and both subtropical and tropical marine species live comingled, each at the limits of their respective ranges. As water temperatures in the zone are becoming more tropical, this area is becoming an important place to detect climate change and its impacts.

Recent decades have included warmer winters with fewer extreme cold events. Historically, such events acted in a similar manner as other ecologically important but infrequent disturbances, such as hurricanes, fires, or floods — all of which can cause mass mortality and even large-scale changes in the structure and function of ecosystems.

With warmer winters — and fewer extreme cold events — in the northern hemisphere, scientists now expect many species to expand their ranges to the north. These species include the goliath grouper, gray snapper, cobia, bull shark, and manatee, as well as loggerhead and Kemp's ridley sea turtles.

In taking a closer look at the manatee in particular, the research team found there have been large numbers of manatee sightings, including annual sightings of previously identified manatees, on coastlines in Alabama, Georgia, South Carolina, and North Carolina. These reports suggest that the species is expanding its summer foraging range. In addition, due to exploratory migrations, manatee sightings are also increasing even farther north — including the Chesapeake Bay.

Manatee sightings are increasing farther north — including reports from the Chesapeake Bay.

the full study in *Global Change Biology*

Tropicalization of Temperate Ecosystems in North America: The Northward Range Expansion of Tropical Organisms in Response to Warming Winter Temperatures

- ***go.ncsu.edu/migration***

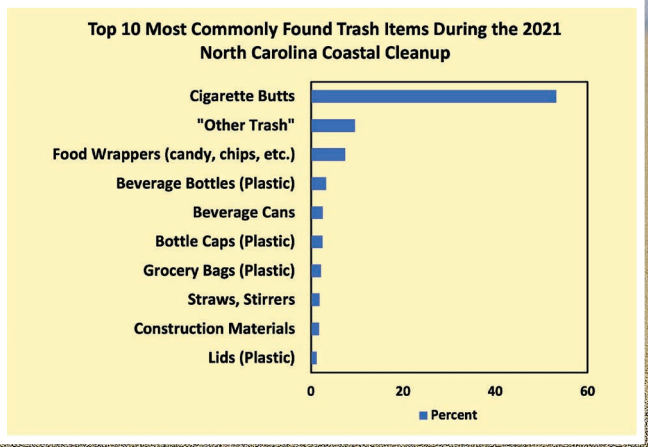
Coastwatch *on climate change*

- ***go.ncsu.edu/coastwatch-climate***

Sara Mirabilio is a fisheries extension specialist with North Carolina Sea Grant and co-curator with Sea Grant's Scott Baker of the popular "Hook, Line & Science" series, which originally published this story.

- ***HookLineScience.com***

LEFT: Manatees are headed north.



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The Top 10 Most Common Types of Trash on the North Carolina Coast

And How to Join the International Coastal Cleanup

LAST YEAR'S COASTAL TRASH INCLUDED A GARTER BELT AND A WINDSHIELD — BUT YOU CAN HELP REDUCE DEBRIS.

BY SCOTT BAKER

SUMMER IS HERE, AND NORTH CAROLINA IS POISED TO HAVE ANOTHER RECORD-SETTING SEASON IN TERMS OF SHEER NUMBERS OF BEACHGOERS.

Unfortunately, people bring more than just sunglasses, beach chairs, and towels to the beach. Most people generate trash, and most dispose of it properly. But it only takes a little trash to be an eyesore — and to be a detriment to coastal wildlife and habitat.

Have you ever wondered about what might be the most common trash item found along the North Carolina coast? How about the most unusual item found on a beach last year?

More importantly: How can we all help remove trash from the beach, join a global initiative, and document our own trash cleanup?

The Ocean Conservancy has been organizing the International Coastal Cleanup for more than 35 years. This global initiative includes beach cleanups and all cleanups inland that intercept litter before it travels downriver to oceans. In 2020, over 220,000 volunteers from across the globe collected 5.2 million pounds of trash from 49,635 miles of shoreline.

The International Coastal Cleanup tallies results each year by country, state, county, and even the individual or group leading each particular cleanup. The latest data for North Carolina, collected in 2021, is easily accessible at *CoastalCleanupdata.org*.

The cigarette butt continues to be the most commonly collected trash item along North Carolina shorelines. In 2021, it accounted for 53% of the 112,645 pieces collected. The cigarette butt was also the most common item for all countries combined in the global cleanup effort, which you can read about at *go.ncsu.edu/global-cleanup*.

All told, 4,028 volunteers cleaned up 53,815 pounds of trash along 562 miles of North Carolina coastline in 2021. Fishing gear, such as monofilament line, rope, nets, pots, and buoys made up less than 1% of total items collected. There were definitely some unusual items — such as a windshield, a garter belt, and a lottery ticket.

Anyone with access to a body of freshwater or saltwater can contribute information to this great cause. You'll need to first sign up for an account before you can document your trash haul, or you can download the "Clean Swell" app that links to the same trash database.

the Clean Swell app

- ***go.ncsu.edu/clean-swell***

Scott Baker is a fisheries extension specialist with North Carolina Sea Grant and co-curator with Sea Grant's Sara Mirabilio of the popular "Hook, Line & Science" series, which originally published this story.

- ***HookLineScience.com***

The Effects of Antibiotics Vary on Urban Stream Ecology

BY LAUREN D. PHARR

SOME EMERGING CONTAMINANTS IN WASTEWATER MIGHT NOT POSE IMMEDIATE ECOLOGICAL DANGERS, ACCORDING TO NEW RESEARCH FROM AUSTIN GRAY, A BIOLOGIST AT VIRGINIA TECH AND A FORMER JOINT FELLOW WITH NORTH CAROLINA SEA GRANT AND THE NC WATER RESOURCES RESEARCH INSTITUTE. HIS STUDY FOCUSED ON THE POTENTIAL IMPACTS OF THREE COMMON ANTIBIOTICS ON URBAN STREAMS IN PIEDMONT NORTH CAROLINA.

"Increases in atmospheric carbon dioxide concentrations, nutrient pollution, habitat destruction, and biodiversity loss are drivers of global change and get a lot of attention and resources to understand their impact," says Gray. "Rarely do we see emerging contaminants incorporated into these studies, even though their presence is ubiquitous in global water supplies."

Urban wastewater exposes organisms in streams to low levels of pharmaceuticals, Gray explains. These emerging pollutants are widespread, hard to remove, and carry unknown ecological consequences when they interact with other pollutants.

Gray (above) says antibiotics belong to the class of most commonly used pharmaceuticals that appear in aquatic environments. With a joint North Carolina Sea Grant and Water Resources Research Institute Graduate Student Research Fellowship, he previously studied antibiotic pollution in streams and well water. His latest research builds on that work, with new support from Sea Grant, to determine how sulfamethoxazole, danofloxacin, and erythromycin impact ecosystem processes in urban streams.

Under the direction of Emily Bernhardt, ecosystem ecologist and biogeochemist at Duke University, Gray conducted his study at Duke's River Center with Brooke Hassett, the center's lab manager. To observe the impacts of antibiotics, Gray added antibiotics to stream sediment that had contained none, and for seven days he then measured the effects on key ecological processes that stream microbes control.

"We determined that these antibiotics, at levels comparable to what we find in the environment, do not currently pose a critical risk within the context of the study," says Gray, now an assistant professor at Virginia Tech.

In fact, he adds, a mixture of the antibiotics, which best reflects how they occur in urban streams, reduced "nitrification" — a microbial process that can lead to adverse effects on water quality. The mixture also enhanced the breakdown of chemicals into a form more easily accessible to plants.

"The findings from the study are limited," Gray cautions. "There are so many chemicals out there. It would be interesting to conduct more studies using different types of contaminants to see how they impact these ecosystem processes. I plan to expand upon this research, using other contaminants and discerning between the impacts of single exposures and mixtures."

the full study in *PLOS One*

Are Nitrogen and Carbon Cycle Processes Impacted by Common Stream Antibiotics? A Comparative Assessment of Single vs. Mixture Exposures

- ***go.ncsu.edu/antibiotics***

Austin Gray on his work

Research Explores the Implications of Antibiotic Pollution

- ***go.ncsu.edu/Gray-in-Coastwatch***

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