

Stepping Up After Storms • Chasing Algal Blooms • Breaking Barriers • Measuring Megalodons

Coastwatch

NORTH CAROLINA SEA GRANT • SPRING • 2021 • ISSUE 1 • \$6.95



MAGIC AT 64.4 DEGREES
Science, Serendipity, and Farmed Striped Bass

Signs of Spring

Here's to hoping that you have enjoyed some sights and sounds of spring already, maybe even some examples very close to home.

The arrival of spring last year came just as the impacts of a global pandemic moved from theory to reality. Within a matter of days, it seemed, our lives focused on remote work and schooling, face coverings in public, and social distancing. For many, the impacts were much more dramatic life disruptions and illness. Our hearts especially go out to those who have felt deep loss in the past year.

While many of these societal changes are with us into 2021, our team at North Carolina Sea Grant has continued our work on many fronts. For a quick two-page snapshot of some of our recent accomplishments, visit go.ncsu.edu/yearly-snapshot.

Not surprisingly, women drive much of our work. March is Women's History Month, and you can celebrate women at all stages of their careers simply by acknowledging the authors of many stories in this issue of *Coastwatch*.

Graduate students Haley Plaas and Erin Voigt are sharing their own research on algal blooms and crab habitats respectively. Also, Susan West, a journalist and longtime partner for Sea Grant research and outreach, explains results of a Community Collaborative Research Grant focusing on resiliency in the seafood industry, a project led by cultural anthropologist Barbara Garrity-Blake.

Lauren D. Pharr, a science communicator with North Carolina Sea Grant — and a scientist in her own right — provides profiles of women and men facing challenges of being Black researchers in the aquatic sciences.

You will find other important contributions from women in this



Susan White

issue as well: Jane Harrison in her role as a Sea Grant economist and mentor; Allison Fisk explaining fisheries science in *Hook, Line & Science*; and Vanda Lewis helping consumers enjoy N.C. seafood with *Mariner's Menu*. Linnea Andersen is a key collaborator on groundbreaking research from NC State scientists about farm-fresh striped bass, which we cover in "Magic at 64.4 Degrees." Of course, science editor Julie Leibach often writes for *Coastwatch* and plays an important role in every issue.

By the time you read this, we will have completed our spring meeting for the Sea Grant Association. In my role as SGA president, I am proud to lead this organization, which represents the nearly three dozen Sea Grant programs in our national network that runs from Maine to Guam. While

each program focuses on needs in respective communities, we can share impacts and consider critical challenges together.

Looking ahead, applications again have impressed us for the National Sea Grant program's next class of Knauss Fellowships and for the second year of our NC STEM Policy Fellowship. This year, the N.C. Department of Natural and Cultural Resources will partner with us and host a STEM Policy Fellow, joining ongoing partners at the state Department of Commerce and Department of Environmental Quality. Read *Currents* (ncseagrant.ncsu.edu/currents) for updates on the state and national fellows and other students in our programs. These fellows are the next generation of state and national leaders.

Enjoy the spring sunshine and plan-making for the months to come. In the meantime, if you have topics of interest, please drop me a note: snwhite3@ncsu.edu.

— Susan White, Executive Director, North Carolina Sea Grant

IN THIS ISSUE

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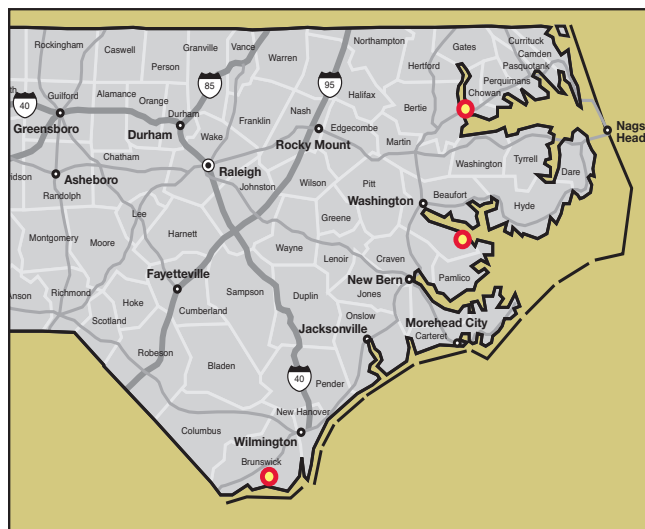
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Settings for the stories in this issue cover numerous locales in North Carolina, including Hendersonville in western N.C., as well as these places (north to south on the map): the Chowan River, the town of Aurora, and Brunswick County.





Coastwatch

FEATURES

COASTAL TIDINGS.....2

IN THE WAKE OF STORMS

Even as our state's capacity for seafood processing declines, wholesalers and distributors have built a network that rapidly deploys initial aid to coastal communities after hurricanes.6

MAGIC AT 64.4 DEGREES

Science, Serendipity, and Farmed Striped Bass

Diligence and hard-earned expertise contributed to a recent breakthrough that has positioned farmed striped bass for commercial success. And scientists behind the innovation say they couldn't have done it without another key ingredient: luck.14

BREAKING SYSTEMIC BARRIERS

Being Black in the Aquatic Sciences and Related Fields

"I can't walk around with a sign on my back that says, 'I'm not a threat. Don't shoot me.'"19

IN FULL BLOOM

Algae, Air Quality, and New Research on the Impacts of Cyanotoxins

"Some days, we even operated like a band of storm chasers: When the CEEG's network reported bloom sightings, we would all jump in our vehicles and speed toward those locations."26

HOOK, LINE & SCIENCE

Illegal Angling, Measuring the Megalodon, and More

Video footage revealed that illegal fishing occurred regularly within the areas under observation.31

MARINER'S MENU

Spring Succulence

Recipes for Tex-Mex shrimp, stuffed soft-shell crabs, and monkfish bisque tantalize chefs and DIYers alike.36

BLUE ECONOMY

Comparing Apples to Oysters

Farmers and fishers have much in common in the way of obstacles and opportunities.38

SEA SCIENCE

Crabtat: Juvenile Blue Crab Habitats in Pamlico Sound

Blue crabs go through drastic changes in body shape and location as they age.42

RIP CURRENTS: KNOW YOUR OPTIONS (Poster)

Tear it out, put it up, and save a life.45

▣ *Front Cover:* Courtesy of Benjamin Reading

▣ *Table of Contents:* Courtesy of Barbara Garrity-Blake

Coastwatch

North Carolina Sea Grant • Spring • 2021 • Issue 1

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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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Baxter Miller

NEW PROJECTS STUDY BLACK SEA BASS AND SHELLFISH ECONOMICS

Two new North Carolina research projects on black sea bass and shellfish are among only 12 selected nationally to advance understanding of the economics of aquaculture and to provide businesses with critical market information.

"We are pleased to see these projects move forward to expand finfish and shellfish aquaculture opportunities in our state, and to share our lessons regionally and nationally," says Susan White, executive director of North Carolina Sea Grant.

Both of the new projects are based at the University of North Carolina Wilmington.

Wade Watanabe will head a production economic analysis of market stage black sea bass in a recirculating aquaculture system, along with his fellow UNCW colleagues Christopher Dumas, Md Shah Alam, and Patrick Carroll, as well as North Carolina Sea Grant's Frank López.

The team will look at the impacts of improved fingerling prices, more sustainable feeds, and faster growth from selective breeding.

"We will develop an economic model of a commercial land-based recirculating aquaculture facility that can be adapted for varied locations and scales of production," Watanabe says.

Industry partners include Ted M. Davis of Aqua Plantations LLC, Leo Chen of Shogun Japanese Restaurant, Lorenzo Juarez of Sea Products Development LLC, April Harper of Golden Island International, and John Graham of Graham Bass Fish Farm.

"The potential impacts of faster fish

growth resulting from selective breeding over five generations will also be analyzed," Watanabe explains. "Such information is critical to identify economic constraints and opportunities, to aid researchers, investors, and policymakers, and to accelerate commercial production of marine finfish in the United States."

UNCW's Troy Alphin heads the new shellfish project to develop farm and market tools for mariculture, with UNCW's Martin Posey and Diane Durance. López joins this team, too, as well as North Carolina Sea Grant's Eric Herbst.

"Our new project will support North Carolina's blue economy by providing a business incubator, as well as marketing and economics tools for the shellfish cultivation industry," Alphin says. "These tools will help growers address and respond to volatile conditions, uncertain markets, and varying demands."

The incubator will offer mentorship for new and current farmers, Alphin adds, along with online tools for business management.

In addition to North Carolina Sea Grant's aquaculture extension team, project partners include the UNCW Center for Innovation and Entrepreneurship, the UNCW Center for Marine Science, the N.C. Division of Marine Fisheries, the N.C. Coastal Federation, The Nature Conservancy, and the N.C. Coastal Reserve and National Estuarine Research Reserve.

• funding opportunities

go.ncsu.edu/sea-grant-funding

— Katie Mosher

NEARLY 20 MILLION PACK NC PARKS IN 2020

Jockey's Ridge led all N.C. state parks with 1.9 million visitors in 2020.

State parks and recreation areas welcomed 19.8 million visitors last year — 400,000 more than any other year on record and 1.2 million more visitors than in 2019.

“As we came together to face the pandemic, our state parks became a comfort in a time of isolation,” Gov. Roy Cooper says. “The records set in park visitation show that our outdoor spaces hold even greater value than we could have imagined before the challenges of the last year.”

Among 41 state parks and recreation areas, 28 reported increases in visitation in 2020, even though the majority of parks were closed for weeks at the outset of the pandemic.

Jockey's Ridge State Park in Dare County reported the highest visitation at 1.9 million, and was among seven state park units that welcomed more than a million visitors. The others were Carolina Beach, Pilot Mountain, William B. Umstead, Fort Macon, and Eno River state parks, as well as Falls Lake State Recreation Area.

Several parks experienced increases in visitors in excess of 25% compared to 2019, including Carolina Beach, Mayo River, Raven Rock, and Grandfather Mountain.

According to the Division of Parks and Recreation, visitors can help to reduce negative impacts in the parks by carrying a bag for their own litter, wearing a mask when they approach other visitors, and staying on trails to avoid damaging natural resources.

• **read more:** www.ncdcr.gov

— adapted from a news release from the N.C. Department of Natural and Cultural Resources

NC FRESHWATER FISH ATLAS AVAILABLE ONLINE

An Annotated Atlas of the Freshwater Fishes of North Carolina is now available online at no cost. Bryn H. Tracy and Gabriela M. Hogue of the North Carolina Museum of Natural Sciences, with NOAA's Fred C. Rohde, have provided the first comprehensive resource since 1991's *The Freshwater Fishes of North Carolina*.

The authors of the annotated atlas say that the last two decades brought new access to historical records, collections available through federal and state resource agencies, and other sources, all of which provided the opportunity to chronicle the state's freshwater fish species even more comprehensively.

The atlas includes 257 species within

North Carolina. Entries for each fish include a distributional map, descriptions addressing records and previous misidentifications, and much more.

With *An Annotated Atlas of the Freshwater Fishes of North Carolina*, Tracy, Hogue, and Rohde have continued a long history of cataloguing fish in the state. In 1709, John Lawson published the first checklist of North Carolina's freshwater fish species.

• **An Annotated Atlas of the Freshwater Fishes of North Carolina**
go.ncsu.edu/nc-fish

— Dave Shaw



PINE KNOLL SHORES AQUARIUM CERTIFIED AS SENSORY INCLUSIVE

KultureCity, a nonprofit organization devoted to sensory accessibility and acceptance, has certified the North Carolina Aquarium at Pine Knoll Shores as a sensory inclusive facility.

“We are very excited to partner with KultureCity to meet the sensory needs of any guest with sensory issues,” says Liz Baird, director of the North Carolina Aquarium. “We’ve added signs to identify areas that might be a bit overwhelming and areas that are quieter.”

Sensory sensitivities or challenges with sensory regulation are often experienced by people with autism, dementia, PTSD, or other conditions.

In addition to adding signage, aquarium staff attended training about how to recognize guests with sensory needs and how to handle a sensory overload situation. Sensory bags, equipped with noise-canceling headphones, fidget tools, verbal cue cards, and weighted lap pads will be available to all guests at the aquarium. Also, dedicated quiet areas are now open to anyone who may need a quieter and more secure environment.

“We are so excited to have begun creating an inclusive environment at the aquarium with KultureCity,” says aquarium educator Ellie Fallaize. “Inclusion is a mindset, and we are all so much better when every voice is heard.”

• **read more**
ncaquariums.com/pine-knoll-shores

— adapted from a news release from
North Carolina Aquariums



“NO CREDIBLE EVIDENCE” SEAFOOD TRANSMITS COVID-19

The U.S. Department of Agriculture, the U.S. Food and Drug Administration, and the Centers for Disease Control and Prevention have issued a rare joint statement, emphasizing there is “no credible evidence” that food and food packing are sources of COVID-19 transmission.

The statement highlighted the safety of the U.S. food supply, noting findings based on “overwhelming international scientific consensus.”

“From epidemiologists to biologists, authorities are confident in the safety of the seafood supply and, what’s more, health experts cite seafood’s role in supporting a healthy immune system,” says Lisa Weddig, vice president for regulatory and technical affairs at the National Fisheries Institute.

“People are understandably nervous about contracting COVID-19, given the spike in infections, hospitalizations, and deaths since the start of the holiday season,” says Barry Nash, seafood technology and marketing specialist for North Carolina Sea Grant. “This announcement from federal public health agencies should assure consumers that the U.S. food system is not a source of COVID-19 transmission.”

- **seafood consumer tips**
go.ncsu.edu/seafood-tips
- **Mariner’s Menu seafood recipes**
MarinersMenu.org

— adapted from a news release from the
National Fisheries Institute

IS CLIMATE CHANGE AFFECTING FISH IN NC WATERS?

Fish larvae are entering Beaufort Inlet earlier in the year than ever before, according to a recent study from researchers at East Carolina University and NOAA.

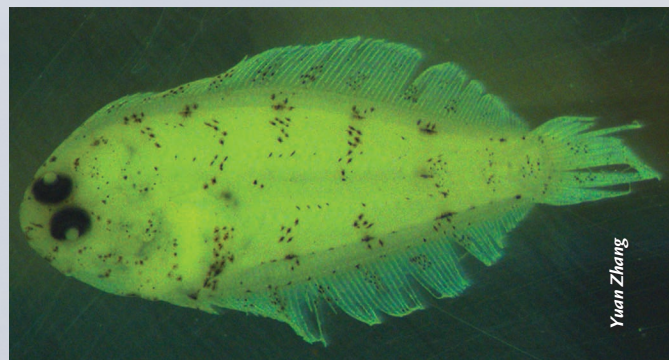
There also has been an increase in the length of the season when larvae enter the inlet, according to ECU’s Rebecca Asch in a guest piece for *Hook, Line & Science* earlier this year. “These changes were related to variations in temperature, the timing and strength of local and regional wind patterns, and basin-wide climate indices.”

As climate has warmed, Asch explains, seasons are changing in many ecosystems. “Spring is arriving earlier, summer is lasting longer, and winters are shorter,” she writes. “This has changed when fish and other marine organisms use different habitats.”

Asch and her colleagues found that the species that showed particularly large changes in their seasonality included summer flounder, Atlantic croaker, and pinfish.

Such changes could impact fisheries management in North Carolina, Asch says, including the timing both for closing seasons to conserve stocks and for conducting fisheries surveys to estimate stock size and set catch limits.

- **read more:** go.ncsu.edu/larvae



Flounder larvae show great sensitivity to changing environmental variables.

Yuan Zhang

ARE WE CATCHING THE SAME SPORT FISH?

After catch-and-release, several species of sport fish are more likely to be recaptured, according to a new study that NOAA and North Carolina Sea Grant supported. The findings raise some interesting questions for policymakers hoping to preserve sustainable fisheries.

“Fisheries researchers who work in tagging programs have long noticed that certain fish seem to get caught repeatedly, and we set out to determine the implications of this phenomenon,” says Jeff Buckel, coauthor of the study and a fisheries biologist at North Carolina State University’s Center for Marine Sciences and Technology.

The finding could have a significant impact on stock assessments, which inform fishery policies.

“Reliable estimates of how many unique fish are released are critical to accurately assessing the health of the population,” says Kyle Shertzer, a coauthor of the study and a stock assessment scientist at NOAA Fisheries.



Brendan Runde, lead author of the study

Owain Mulvey-McFarlane

“It’s exciting to have scientific data showing that catch-and-release works in letting fish live for another day,” says Sara Mirabilio, fisheries specialist with North Carolina Sea Grant and coauthor of the *Hook, Line & Science* blog series.

Mirabilio adds that the new findings also present some challenges to traditional population modeling. “It’s great to have research, such as this study, to begin to resolve those data challenges.”

- **the full study**
go.ncsu.edu/recatch

— adapted from a news release from NC State News

HOOK, LINE & SCIENCE TURNS TWO

North Carolina Sea Grant's *Hook, Line & Science* celebrated its second birthday in December by publishing its 100th post.

Scott Baker and Sara Mirabilio, fisheries specialists with North Carolina Sea Grant, curate content for the popular series on the latest science for anglers. New pieces appear every Monday on *HookLineScience.com* and quarterly in *Coastwatch* magazine.

Thousands of readers in North Carolina, across the country, and around the globe have accessed *Hook, Line & Science* since Baker and Mirabilio launched it in 2018. Baker says posts on flounder identification, changes in shrimp abundance, and fish tagging have been the most popular.

"Our goal, as scientists who specialize in marine fisheries, has been to provide saltwater anglers in particular, and a broader audience in general, with easy access to science-based information related to fishing and fisheries," says Baker. "After all, science really isn't that useful unless we all have a chance to learn about it."

Baker and Mirabilio each have summarized dozens of studies for *Hook, Line & Science*, and they also have recruited 29 guest authors to discuss their own work, including 14 students.

- **The Top 20 Most Popular Posts from *Hook, Line & Science*:** go.ncsu.edu/top-20 — Dave Shaw



NC STAR PARTY LAUNCHES IN APRIL

Friday, April 16, and Saturday, April 17, mark the ninth annual North Carolina Statewide Star Party, a signature event of the NC Science Festival. This year's theme is "Moon and Mars."

NC Space Grant joins the NC Science Festival in supporting the annual Star Party. Organizers call this year's night-sky viewing a "pandemic-proof event, following a hybrid model that can pivot to all-virtual offerings as needed."

- **read more**
ncsciencefestival.org/starparty
- **downloadable Star Party Kits**
go.ncsu.edu/party-kit
- **NC Space Grant**
ncsspacegrant.ncsu.edu
- **North Carolina's famous night skies**
go.ncsu.edu/sky



Barry Nash

SEA GRANT PUBLISHES A GUIDE TO COMMERCIAL SEAFOOD

Barry Nash, North Carolina Sea Grant's seafood marketing specialist, has compiled *A Primer on North Carolina Seafood*, a free online resource for anyone interested in the commercial seafood industry.

"People are paying much greater attention to where, how, and from whom their seafood is sourced," Nash says. "To better address this need for information, we created an online overview of the state's commercial fishing."

The primer describes North Carolina fisheries, provides harvest statistics, and explains how the seafood supply chain impacts the state's economy. Other sections also explain how the seafood industry has shaped the history and cultural heritage of North Carolina.

In addition, consumers can access information about seafood's health benefits, as well as safety tips, including how best to handle and prepare seafood at home.

A Primer on North Carolina Seafood also serves as a hub for a wide array of related resources, including links to videos, festivals, recipes, dietary guidelines, and more.

Nash says the new online resource complements background information Sea Grant previously developed on the state's shellfish mariculture industry.

- ***A Primer on North Carolina Seafood***
go.ncsu.edu/seafood-primer
- **about N.C.'s shellfish mariculture industry**
go.ncsu.edu/shellfish-mariculture

— Dave Shaw

BY SUSAN WEST

IN THE WAKE OF STORMS

EVEN AS OUR STATE'S CAPACITY FOR SEAFOOD PROCESSING DECLINES,
WHOLESALERS AND DISTRIBUTORS HAVE BUILT A NETWORK THAT
RAPIDLY DEPLOYS INITIAL AID TO COASTAL COMMUNITIES AFTER HURRICANES.

Continued

Brunswick County, North Carolina



1 SEAFOOD
42-2203

NO FISHING
ON DOCK
DUE TO INSURANCE
POLICY
BEACON 1 SEAFOOD
Since 1961



Scott Baker

Active seafood wholesalers, such as Garland's Seafood in Brunswick County (above and right), are becoming a rarity in North Carolina. The state has 76 active seafood wholesalers, a 41.5% reduction since 2000.

In partnership with the William R. Kenan Jr. Institute for Engineering, Technology, and Science, North Carolina Sea Grant's Community Collaborative Research Grant Program supported "In the Wake of the Storms: Working Waterfronts and Access in Coastal North Carolina." Susan West, journalist and project co-director, served with Barbara Garrity-Blake, project director, alongside Scott Baker and Sara Mirabilio, fisheries specialists with North Carolina Sea Grant. Their team conducted interviews in the aftermath of Hurricane Florence.

North Carolina fish houses tend to be small, rural businesses nestled off the beaten path in the nooks and crannies of the state's meandering shoreline. But even the most remote and isolated are connected by an impressive

communications network that kicks in when hurricanes strike the coast. Word-of-mouth news travels fast on the seafood industry pipeline, and seafood wholesalers are often the conduits for getting resources to disaster areas quickly.

A Cedar Island fish house, for instance, served as the staging ground for local fishing boats hauling bottled water, cleaning supplies, and other donated goods from the Down East area of Carteret County to Ocracoke Island where homes and businesses were severely damaged by Hurricane Dorian in 2019. Watermen and other volunteers from Ocracoke and Hatteras — armed with everything from mops to chainsaws — had rushed to Carteret County communities hit hard by Hurricane Florence the previous year.

"If something affects any coastal community, it affects us," reported a seafood distributor in Chowan County.

Barbara Garrity-Blake, project director for "In the Wake of Storms" and a cultural anthropologist at Duke University Marine Laboratory, says working waterfronts serve



Scott Baker



Barbara Garrity-Blake

On hurricanes: "It's a roll of the dice," said one fish buyer. "You prepare for the worst and hope for the best."

as gathering places and information hubs in many communities.

"So, it makes sense that fish houses continue to play a role for the community in storm recovery," she explains. "They have their pulse on where needs are greatest and have access to boats that can reach hard-hit areas before roads and bridges have been cleared and repaired."

The Decline of Seafood Processing

"In the Wake of Storms" assessed changes in seafood wholesaling capacity in North Carolina, updating fish house inventories completed in 2007 and in 2012. We asked seafood packers and distributors questions about profitability, business model adjustments, domestic product trends, and market challenges

and opportunities. We also sought information on how the seafood industry prepares for and recovers from hurricanes.

Our research found that North Carolina continues to lose seafood processing capacity. The state currently has 76 active seafood wholesalers, a 41.5% reduction since 2000.

This trend is consistent with information on commercial fishing from the North Carolina Division of Marine Fisheries that shows a 40% decrease in the pounds of seafood harvested annually and a 48% drop in the number of active commercial fishing license holders during the same time period.

Wholesalers pointed to the decline in the availability of North Carolina wild-caught seafood as the main challenge facing their businesses and identified over-regulation, fewer fishermen, and degrading water quality as contributing factors.

"Attrition is a problem for the seafood industry," said a dealer, noting that the number of fishermen selling shrimp, crabs, and fish to his fish house had sharply declined over the last two decades, as fewer young people turn to commercial fishing careers. Almost as dramatic as the immediate market fallout are the long-term consequences for sustaining social networks as young fishermen find a shrinking community of peers at the local fishing docks to help them grow their businesses, learn how to engage in the fisheries management process, or fend off threats to their livelihoods. To help bridge that gap, North Carolina Sea Grant has sponsored leadership retreats where young fishermen network with fisheries managers, scientists, and their peers from other counties.

"Seafood is a highly competitive market, and it is hard to establish consistency," said a seafood distributor in Pender County. "There is not enough local product, not enough watermen. To get product to our customers, we buy imported seafood if it is not available in North Carolina."

Despite heightened concern over the loss of market share to seafood from other countries, wholesalers differed on the general health of their businesses. "It's always been an ebb and flow of good and bad," said a Dare County dealer.

Fish house owners reporting positive change credited the addition of retail outlets or value-added products to business models.

"The retail market makes the profit and pays the bills," said a fish house manager in Hyde County.

Continued

Some mentioned the influence of consumer education campaigns by NC Catch and other local seafood organizations. “Groups have done a great job branding local products,” said a Pamlico County seafood packer. “Now we have the public wanting fresh local seafood, but we might not always be able to provide that product.”

Even though some businesses had not fully recovered from Hurricane Florence at the time of our interviews, fish house owners did not perceive storms as a nail-in-the-coffin threat.

“I’m not afraid of hurricanes,” a seafood distributor said. “I’m afraid of uninformed politicians.”

In the Aftermath of Hurricane Florence

In September 2018, slow-moving Florence made landfall near Wrightsville Beach and battered North Carolina for days with storm surge flooding and record-breaking rainfall, resulting in statewide losses totaling \$22 billion. Damage to fish houses ran the gamut from power outages to the destruction of docks, buildings, and equipment. In some communities, boats sank or were tossed unimaginable distances. Falling trees smashed crab pots, and nets were ripped to shreds by debris floating through yards or buried in a sloppy mix of mud and marsh grass. Floodwaters also swept away fish houses, industrial coolers, and docks.

The National Oceanic and Atmospheric Administration, working with North Carolina Sea Grant and the North Carolina Division of Marine Fisheries, found that 65% of seafood dealers in the state reported damage. Estimated losses were \$12.9 million to facilities and \$20.0 million in revenue.

Businesses in central and southern counties sustained the most infrastructure damage, but disruption of the seafood supply chain affected fish houses everywhere. “We had no physical damage, but we lost income,” a fish buyer on Hatteras Island explained. “There was diminished effort for five days preparing for Florence, and for at least five days afterwards, due to rough seas.”

Most wholesalers, however, experienced much longer disruptions. Nearly a year after Florence, a Pamlico County seafood dealer reported that his business had not fully recovered. Florence had torn apart his fish house, scattering remnants downriver for miles, and

fishermen who had sold their catches to him had to find alternative unloading docks and markets.

“They all can’t run back to me, turning their backs on those who took them in,” he said. “So even now, I do not have the fishermen or the product I once had.”

All fish houses had a storm preparation protocol, and some dealers had taken innovative steps to lessen storm damage. Electrical outlets in one Carteret County fish house were installed four feet off the floor, and a Pamlico County fish house was being rebuilt with mobility in mind so that equipment could be rolled to higher ground.

“It’s a roll of the dice,” said an Outer Banks fish buyer. “You prepare for the worst and hope for the best.”

Wholesalers also noted limitations on how much insurance and loans had helped with recovery. “Nobody insures fish house docks,” a distributor said.

At the time of our interviews, no federal or state disaster relief was available for seafood wholesalers with infrastructure damage from Hurricane Florence.

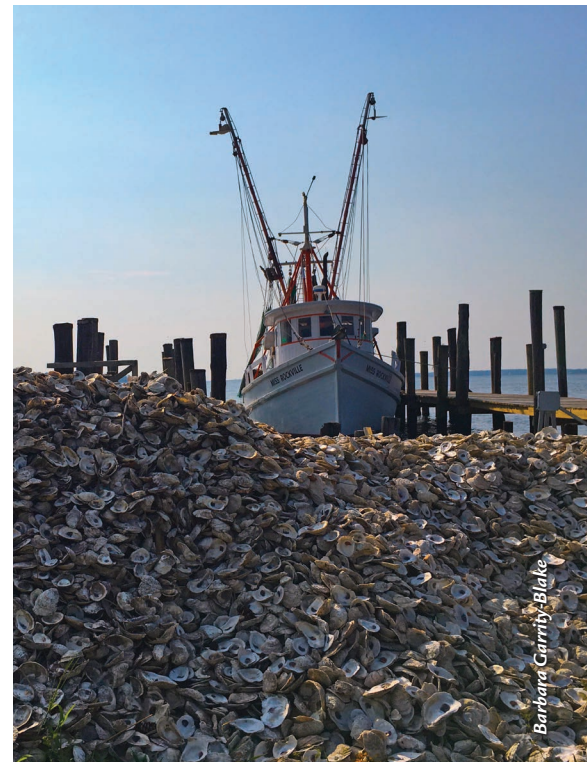
“If you live here, you kind of have to be self-sufficient, and most people will be able to take care of themselves,” explained a Carteret County dealer. “But if there is a major problem, then everybody contributes.”

A Hyde County wholesaler sends out heavy equipment to help clear roads after storms, and fish houses routinely stockpile ice, a coveted item during major power outages, in the days leading up to a hurricane.

“After Florence,” a dealer explained, “we left the door unlocked and told people to come get what ice they needed.”

North Carolina fish houses also assist with recovery efforts in other states. A North Carolina seafood industry nonprofit sent bulk ice and pallets of donated seafood to feed storm victims and relief workers after a hurricane tore through Louisiana in 2020.

The Pamlico County fish dealer who lost his facility to Florence acknowledged that in the first hours after the storm, rebuilding seemed too



Barbara Garrity-Blake



Barbara Garrity-Blake

Despite heightened concern over the loss of market share to seafood from other countries, wholesalers differed on the general health of their businesses.

daunting — until friends and neighbors and even people he did not know showed up to help him salvage bits and pieces of his fish house. Other seafood dealers in the county donated building supplies to kickstart rebuilding of his fish house.

“People just showed up and helped,” he



Barbara Garrity-Blake



Barbara Garrity-Blake

Hurricane Florence's disruption of the seafood supply chain affected fish houses everywhere in coastal N.C., and in 2020 the COVID-19 pandemic erased a major source of seafood sales when restaurants curtailed indoor dining or closed altogether.

recalled. "The support from this community made the decision for me. I had to rebuild." When he later heard about damage to the Ocracoke fish house from Hurricane Dorian in 2019, he organized a fundraiser on his docks. "I don't know them, but I know what they're going through firsthand. The fundraiser made me feel like I could finally give back."

New Challenges

We heard similar descriptions of the network of relationships fueled by reciprocity that assist with hurricane recovery. After we had conducted our interviews for "In the Wake of Storms," the COVID-19 pandemic swept through the United States, erasing a major source of seafood sales, as restaurants curtailed indoor dining or closed altogether. Again, social networks came into play, this time with new open-air retail markets, home-delivery services, and food bank partnerships.

What we saw in the response to the pandemic confirmed that the commercial fishing industry is adaptive, innovative, and

quick to assist and feed its communities. How well the industry adapts to future challenges may hinge on its ability to sustain the vibrant social networks that have seen it through hurricanes and other natural disasters. 📍

- **Susan West's "Charting the Course" on the aging fleet of commercial fishers**

go.ncsu.edu/charting

- **Sara Mirabilio on North Carolina Sea Grant's "fish camp" leadership retreats**

go.ncsu.edu/fish-camp

- **Julie Leibach on Florence: "A Slow-Motion Emergency"**

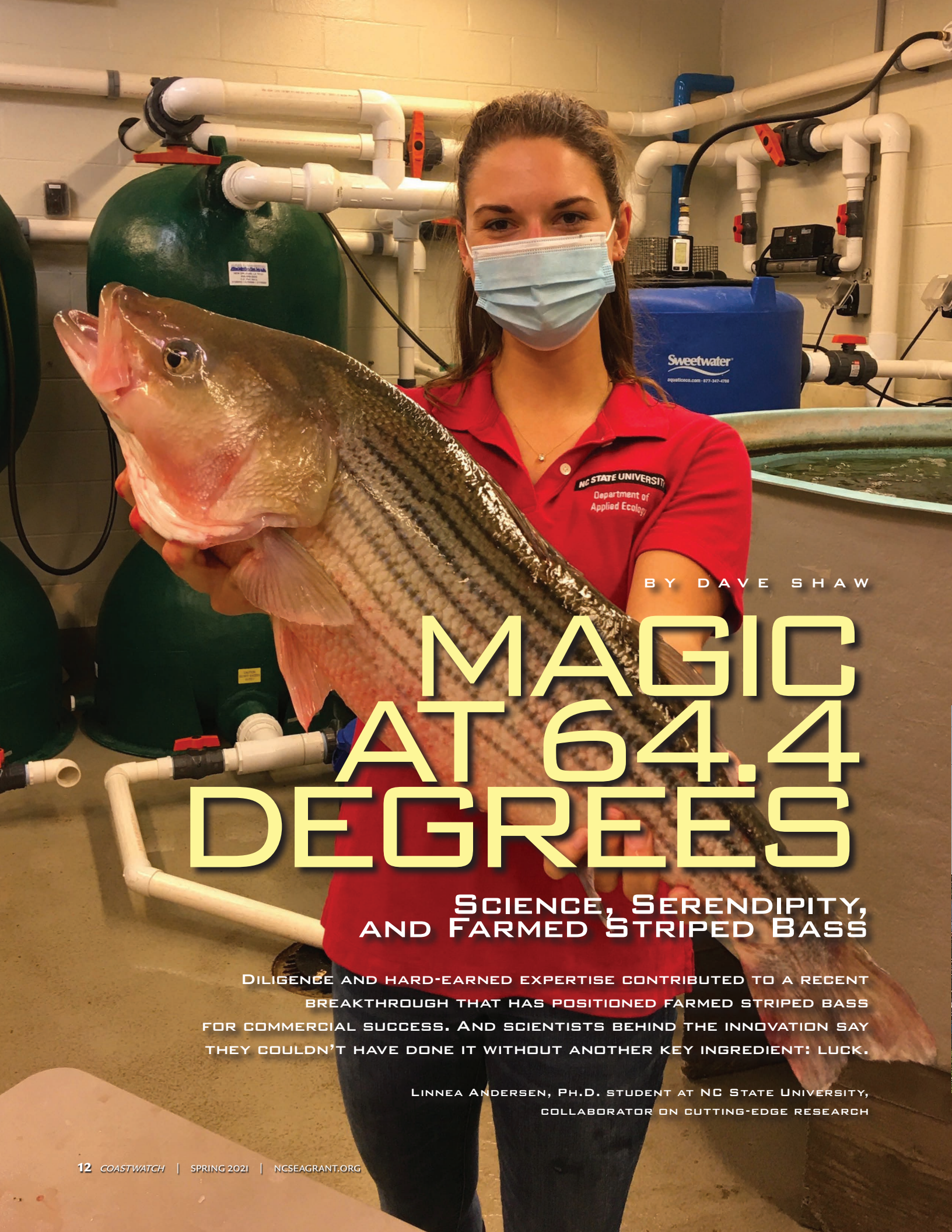
go.ncsu.edu/slow-mo

- **Coastwatch on Hurricanes**

go.ncsu.edu/Coastwatch-hurricanes

- **Community Collaborative Research Grants**

go.ncsu.edu/CCRGprogram



BY DAVE SHAW

MAGIC AT 64.4 DEGREES

SCIENCE, SERENDIPITY,
AND FARMED STRIPED BASS

DILIGENCE AND HARD-EARNED EXPERTISE CONTRIBUTED TO A RECENT
BREAKTHROUGH THAT HAS POSITIONED FARMED STRIPED BASS
FOR COMMERCIAL SUCCESS. AND SCIENTISTS BEHIND THE INNOVATION SAY
THEY COULDN'T HAVE DONE IT WITHOUT ANOTHER KEY INGREDIENT: LUCK.

LINNEA ANDERSEN, PH.D. STUDENT AT NC STATE UNIVERSITY,
COLLABORATOR ON CUTTING-EDGE RESEARCH

WHEN HE WAS 34, THE SWISS ENGINEER GEORGE DE MESTRAL SET OFF WITH HIS DOG INTO THE ALPINE COUNTRYSIDE ON A HUNTING TRIP. AFTER CROSSING FLOWERING FIELDS IN THE CRISP, GLACIAL AIR ON HIS RETURN, HE DISCOVERED THAT BURDOCK BURS THOROUGHLY COVERED HIS DOG'S COAT. AT HOME, HE PICKED THE PERSISTENT CLINGERS FROM HIS PET'S FUR, ONE BY ONE, MARVELING AT THEIR TENACITY, SO MUCH SO THAT HE HAD TO EXAMINE THEM UNDER A MICROSCOPE.

What he saw under the lens would impact the aerospace and apparel industries, as astronauts, scuba divers, skiers — even toddlers too young to tie their own shoes — would come to use his invention. His microscope revealed hooks by the hundreds covering each bur. Thanks to that hunting trip with his dog, George de Mestral had discovered the mechanism for what he would call “Velcro.”

The worlds of invention and discovery have long relied on chance, even on sheer, dumb luck. From the detection of X-rays to

that first accidental culture of penicillin, from Silly Putty to the Big Bang's cosmic signature, from insulin to Vulcanized rubber to Vaseline — benevolent happenstance has led to groundbreaking advances of all sorts.

The expectation that such twists of fate will lead to great discoveries has long made its way into pop culture — to such an extent that an old marketing campaign sold Reese's Peanut Butter Cups on the notion of invention by collision between two lovestruck moviegoers. One held a broken candy bar, the other a jar of peanut butter with a chunk of chocolate lodged in it. Anyone with a sweet tooth was left to believe the rest was history.

So why shouldn't we have expected fate to intervene when NC State University scientists tried to get farmed striped bass to reproduce?

THE PRIZE

Since the 1980s, in a Beaufort County town of 520 residents, known for its phosphate mine and fossil museum, scientists have been breeding hybrid striped bass. The epicenter for their research, the Pamlico Aquaculture Field Laboratory, sits in Aurora, North Carolina, not far from the southern terminal on the Pamlico River ferry route.

The lab has access to numerous sources of freshwater and seawater. It also includes 16 ponds, a hatchery with recirculating water systems, a 300-foot pier, and a boat ramp. There's even a dorm for the diehards who want to sleep overnight where they work.

NC State scientist Benjamin Reading, who began working at the field lab nearly two decades ago, says the research in Aurora has been essential in supporting an industry flooded with fish from abroad.

“Nine out of 10 seafood products that Americans consume are imported,” says Reading, who also serves as program coordinator for StriperHub, a National Sea Grant initiative to advance the commercialization of marine striped bass. “But there's a significant untapped demand for striped bass — and we can help to satisfy those consumers.”

Hybrid striped bass, a cross between striped bass and white bass, already is a successful freshwater farmed fish, grossing \$50 million annually, pre-pandemic. Both striped bass and its hybrids find eager consumers at markets, restaurants, and sushi bars.

Unlike the hybrid striped bass, however, the striped bass also thrives in saltwater and grows to a larger size.

Continued



SINCE THE 1980S, SCIENTISTS HAVE BEEN DOMESTICATING HYBRID STRIPED BASS AND STRIPED BASS AT THE PAMLICO AQUACULTURE FIELD LABORATORY IN AURORA, NORTH CAROLINA.



NC State CALS

IN ADDITION TO SERVING AS PROGRAM COORDINATOR FOR STRIPERHUB, NC STATE'S BEN READING (ABOVE) DIRECTS THE NATIONAL PROGRAM FOR GENETIC IMPROVEMENT AND SELECTIVE BREEDING FOR THE US HYBRID STRIPED BASS INDUSTRY. READING AND HIS TEAM ARE THE LATEST IN A LONG LINE OF PIONEERS AT THE PAMLICO AQUACULTURE FIELD LABORATORY. EARLIER GROUNDBREAKERS (RIGHT) INCLUDED CRAIG SULLIVAN (BACK ROW, LEFT), FORMER NORTH CAROLINA SEA GRANT DIRECTOR RON HODSON (BACK ROW, MIDDLE), ANDY MCGINTY (BACK ROW, RIGHT), AND MIKE HOPPER (KNEELING).

"We're building on NC State's research and development of six generations of striped bass that have been bred in captivity," Reading explains. "And the early reception from consumers and servers of traditionally wild-caught striped bass shows they love the farm-fresh taste, too."

NC State's Russell Borski, StriperHub's southeast regional coordinator, says taste, in fact, is part of what makes striped bass a prized species for aquaculture — and a rarity.

"A candidate species has a premium price, high consumer demand, and adapts well to localized production," Borski says. "Among white-fleshed marine fishes in the U.S., there aren't many of these. But striped bass meets all the criteria."

Which is why, Reading says, researchers probably would have raised striped bass from

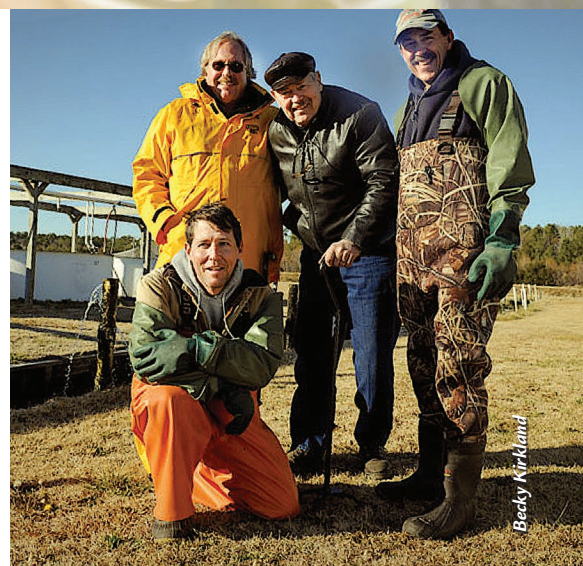
the start, instead of hybrid striped bass — if they had possessed the knowhow.

THE WORK

Ernest Hemingway, who knew something about fish, once famously told his son, "You make your own luck."

Frank López, North Carolina Sea Grant's extension director, says scientific breakthroughs similarly often require a long-term commitment. "For years, North Carolina Sea Grant has been supporting striped bass aquaculture research and extension, including hybrids," says López.

"Farming striped bass provides an opportunity to develop and sustain the population of these fish," Reading says. When scientists at the Pamlico Aquaculture Field Laboratory first began breeding captive striped



Becky Kirkland

bass without hybrids, though, they had to rely on hormones to induce spawning. The process was expensive and complicated, requiring technical expertise.

Persistence, dedication, educated guesses, and trial and error propelled their research. Of course, the "error" in "trial and error" is never as glamorous as the trial or the overall pursuit. After telling his son to make his own luck, the rest of Hemingway's advice was more cynical:

"You know what makes a good loser?" he asked. "Practice."

But *The Old Man and the Sea* author had forgotten to add that practice was also the foundation for breakthroughs on spawning farmed striped bass. In collaboration with David Berlinsky at the University of New Hampshire, Reading and his colleagues hypothesized about the effects of injecting only half a sample of striped bass with hormones, and then they found that doing so prompted the others to spawn.

In addition to discovering a method that saved half the money and hassle, the team learned critical new information: that hormone-free fish could spawn in captivity.

"We realized we were in new territory," Reading says.

THE MISHAP

"I always tell people this story is about serendipity," Reading says.

First, he explains how when scientists at the Pamlico Aquaculture Field Laboratory want their striped bass to spawn, they carefully set the environmental conditions in their 30,000-liter tanks to fool the fish into thinking they've gone upriver.

"Striped bass typically migrate from cold,

salty estuary waters in winter and head upstream into warmer and fresher waters in springtime, when they spawn," he says. "We try to emulate those conditions in the tanks."

As a matter of practice, they also hold males and females in different tanks for the sake of tracking the precise ratios of each when they then bring them together. The proportion of male to female striped bass can affect how efficiently they spawn, which is why Reading's team always took special care to keep them separate.

Until they didn't.

"One day we came in, and we had accidentally mixed some males and females without any hormones," Reading says, laughing. "From the standpoint of running a rigorous scientific experiment, at first we thought it was a catastrophe. But the striped bass had spawned. And then we thought, well, why the heck would they do that?"

The team quickly switched from "Oh, no, what are we going to do?" to "Let's sit down and write down everything we know about what just happened and see if we can recreate it." Then they spent several months trying to emulate environmental conditions for the accident, studying how it worked, and refining the process.

"Sure enough," Reading says. "We showed

you could replicate it. Dial up the temperature and drop the salt. Then boom."

Magic at 18° C, or 64.4° F, with no salt — and, most importantly, no hormones — all with a single species. It was a feat no one ever before had reported achieving with captive striped bass.

"Our new method simplifies the whole spawning process," Reading says. "Now, you don't need two species on site. You also don't need the hormones, which are expensive, require a prescription from a veterinarian, and are much more technically difficult to work with. Compare all that to just putting fish in a tank now and letting nature go to work."

THE MARKET

López, who also serves as StriperHub's principal investigator, likens the surprise behind the Reading team's discovery to "that Alexander Graham Bell moment," when the inventor startled his assistant with the line from the famous first phone call: "Mr. Watson, come here."

The Reading team's new method had been born from the "error" in "trial and error," but it was also, of course, the product of decades of research and hard work. Reading and his colleagues soon could produce 5 million larvae from a single spawning event with captive striped bass.

"That yield is the equivalent of what used to take the time and resources of an entire season's effort for our team," says Reading. "It's a revolutionary change, and it suggests high potential for scaling up to commercial levels."

At this point, Reading's team has optimized the process, determining that bringing together 25 males and 25 females maximizes efficiency. Two recent research articles in the journal *Aquaculture* describe their findings.

"The process has come a long way," says coauthor Linnea Andersen, a Ph.D. student at NC State. "It's become so standard for us, but when I first started on the project in 2017, we were developing this brand new approach."

Because the hybrid striped bass industry reaps tens of millions of dollars annually, the implications of a simpler, cheaper, and more efficient means of producing striped bass larvae are significant. Reading says the new, hormone-free method could seed the whole industry with as few as six or seven spawning events annually.

Continued



Becky Kirkland

A PENNY DWARFS STRIPED BASS EGGS.



Vanda Lewis

GRILLED STRIPED BASS WITH HERB BUTTER

A RECIPE FROM *MARINER'S MENU*

BY VANDA LEWIS AND JOYCE TAYLOR

- 1 ½ POUNDS STRIPED BASS FILLETS, SKINLESS, CUT INTO SERVING-SIZE PIECES
- 4 TABLESPOONS BUTTER, MELTED
- SALT
- BLACK PEPPER, FRESHLY GROUND

PREPARE THE HERB BUTTER (BELOW) ONE HOUR AHEAD AND SET ASIDE. PREHEAT THE GRILL TO MEDIUM-HIGH. BRUSH THE FISH ON BOTH SIDES WITH MELTED BUTTER. LIGHTLY SALT AND PEPPER.

PLACE THE FISH ON A WELL-OILED GRILL AND COOK FOR 6 TO 8 MINUTES. TURN THE FISH OVER AND REPEAT, COOKING UNTIL DONE.

HERB BUTTER

- ½ CUP BUTTER, SOFTENED
- 2 TABLESPOONS GREEN ONIONS, MINCED, INCLUDING TOPS
- 2 TABLESPOONS PARSLEY, MINCED
- 2 TABLESPOONS TARRAGON, MINCED
- ½ TEASPOON SALT
- ½ TEASPOON WHITE PEPPER, FRESHLY GROUND

IN A SMALL BOWL, CREAM TOGETHER BUTTER, ONION, PARSLEY, TARRAGON, SALT, AND PEPPER. SPREAD OVER HOT FISH.

VISIT MARINERSMENU.ORG

Not only does the new production method cut costs and reduce challenges, he adds, farm-raised striped bass can weigh in at 3 pounds apiece, roughly twice the size of domesticated hybrid striped bass.

According to López, the StriperHub project will help streamline commercialization of the species.

“Through StriperHub, we’re disseminating new findings like these about state-of-the-art production techniques and tips,” López explains. “We’re also developing education and training programs, clarifying permitting and licensing procedures, and promoting outreach and visibility among producers and consumers of striped bass.”

Researchers at North Carolina Sea Grant and NC State are collaborating with experts along the Atlantic Seaboard on the project, which also includes other Sea Grant programs, industry partners, government researchers, policymakers, and university scientists. Barry Nash, North Carolina Sea Grant’s seafood technology and marketing specialist, also will play a key role on the project as StriperHub helps make the farmed striped bass increasingly available to consumers.

Reading believes many farmers will see the value of diversifying their crop by also raising striped bass.

“Our production of larvae at this level positions us well to supply producers of fingerlings” (finger-sized juvenile fish). “Producers can use the larvae to create fingerlings for distribution,” he says. “Last year, we also grew 150,000 fingerlings ourselves that we sent out to farmers in our state.”

In 2019 and 2020, Reading says, StriperHub supported bringing roughly 8,500 pounds of farm-raised striped bass to North Carolina markets — and the project continues to distribute 200 to 400 pounds every month during the pandemic.

THE FUTURE

Eric Herbst, North Carolina Sea Grant’s coastal aquaculture specialist, says having the Pamlico Aquaculture Field Laboratory as ground zero for cutting-edge research and practice also provides unique educational opportunities for college students.

“Students in aquaculture programs at Carteret Community College and Brunswick



NC State's Department of Applied Ecology



Erin Ducharme/NC State News

OVER THE YEARS, READING (TOP, RIGHT) AND HIS TEAM REFINED THEIR METHODS, DETERMINING THAT BRINGING TOGETHER 25 MALE AND 25 FEMALE STRIPED BASS MAXIMIZES EFFICIENCY. "THE PROCESS HAS COME A LONG WAY," SAYS ANDERSEN (BOTTOM).

Community College can observe and get valuable hands-on experience at the facility," says Herbst. "Some of the field's most innovative work is happening in our own backyard, and the next generation of fish farmers gets to see it first-hand."

David Cerino, chair of the Aquaculture Department at Carteret Community College, also collaborates on the StriperHub project. Herbst says the facility provides students in the program invaluable experience in applied research, growing striped bass from fingerlings to market size in aquaculture systems at commercial densities.

"There's nothing like working with the actual fish," Reading adds.

As the field lab provides a training ground for new scientists and fish farmers, more questions remain.

"Can we speed up the spawning process and make it even more efficient?" he says. "And what about wild striped bass? Can we do this with them?"

Meanwhile, the rest of us already can feast on such delicacies as Southwest striped bass with black bean salsa, striped bass chowder,

Continued



A WIDE VARIETY OF RESTAURANTS AND OTHER RETAILERS HAVE CARRIED FARM-FRESH STRIPED BASS, INCLUDING RALEIGH'S "DEATH & TAXES" (ABOVE, PRE-PANDEMIC).

WHERE TO FIND FARM-FRESH STRIPED BASS

THE RALEIGH AND DURHAM LOCATIONS OF LOCALS OYSTER BAR CARRY FARM-FRESH STRIPED BASS, AND LOCALS SEAFOOD ALSO OFFERS

IT AT THE RALEIGH STATE, CHAPEL HILL, AND WESTERN WAKE FARMER'S MARKETS.

IN ADDITION, LOCALS SEAFOOD DISTRIBUTES FARM-FRESH STRIPED BASS TO NORTH CAROLINA RESTAURANTS, ONLINE RETAILERS, AND GROCERY STORES (RIGHT). VISIT: LOCALSSEAFOOD.COM.

RESTAURANTS

- CAPITAL CLUB 16 (RALEIGH)
- CAROLINA COUNTRY CLUB (RALEIGH)
- THE CORTEZ (RALEIGH)
- DEATH & TAXES (RALEIGH)
- FORESTRY CAMP (ASHEVILLE)
- MANDOLIN (RALEIGH)
- THE MAYTON INN (CARY)
- NOFO @ THE PIG (RALEIGH)
- POOLE'S DINER (RALEIGH)
- SAINT JACQUES (RALEIGH)
- ST. ROCH (RALEIGH)

ONLINE RETAIL

- BELLA BEAN ORGANICS
- LOCALS BUTCHERY

GROCERY STORES

- DURHAM CO-OP MARKET
- WEAVER ST. MARKET

striped bass tacos with creamy guacamole, or Parmesan-encrusted striped bass — or, for that matter, any of the many other dishes that rely on the succulent fish. For diners enjoying a mouthwatering striped bass entrée, the Reading team's discovery was always meant to be. 🍽️

- RECIPES FOR STRIPED BASS FROM MARINER'S MENU

GO.NCSU.EDU/COOK-STRIPED-BASS

- BEN READING AND LINNEA ANDERSEN DISSECTING A STRIPED BASS (VIDEO)

GO.NCSU.EDU/DISSECT

- "METHODS OF DOMESTIC STRIPED BASS (*MORONE SAXATILIS*) SPAWNING THAT DO NOT REQUIRE THE USE OF ANY HORMONE INDUCTION" IN THE JOURNAL *AQUACULTURE*

GO.NCSU.EDU/NO-HORMONES

- "VOLITIONAL TANK SPAWNING OF DOMESTIC STRIPED BASS (*MORONE SAXATILIS*) USING HUMAN CHORIONIC GONADOTROPIN (HCG) AND GONADOTROPIN RELEASING HORMONE ANALOGUE (GnRH)-INDUCED 'PACE-SETTING' FEMALES" IN THE JOURNAL *AQUACULTURE*

GO.NCSU.EDU/SPAWNING

- SUSTAINABLE FISHERIES AND AQUACULTURE IN *COASTWATCH*

GO.NCSU.EDU/COASTWATCH-AQUACULTURE

- "REGULATING REPRODUCTIVE CYCLES FOR CAPTIVE SPAWNING" IN THE FISH PHYSIOLOGY SERIES OF *AQUACULTURE*, VOLUME 38

GO.NCSU.EDU/CAPTIVE-SPAWNING

- MORE ABOUT COASTAL AND MARINE AQUACULTURE

NCSEAGRANT.NCSU.EDU/AQUACULTURE/

BREAKING Systemic Barriers

BEING BLACK IN THE AQUATIC SCIENCES AND RELATED FIELDS

BY LAUREN D. PHARR



Kayelyn Simmons, winner of a prestigious John A. Knauss Marine Policy Fellowship from Sea Grant

Lauren D. Pharr is studying for her master's degree in fisheries, wildlife, and conservation biology at NC State University. She is a wildlife biologist and ornithologist, as well as a science communicator for North Carolina Sea Grant. Previously, her writing has appeared in Coastwatch, The Cincinnati Zoo Blog, and BBC Wildlife.

Diversity fuels innovation and performance, according to a study from *Harvard Business Review*. It allows us to experience different perspectives and incorporate various ideas, which, in turn, ultimately helps broaden the array of available options and opportunities.

Yet, communities of Black, Indigenous, and People of Color (BIPOC) are underrepresented in science. Pew Research Center reports that African American scientists, in particular, make up only 9% of the STEM workforce.

When we look at the aquatic sciences and related disciplines, from marine biology to wetland ecology to coastal resilience, we can see how Black scientists are persisting and breaking barriers in white-dominated fields. While these scientists conduct the work they love, they also encounter hardships in both academic and research settings.

Here are four stories from Black scientists about their first-hand experiences with systemic obstacles, their resilience, and their advice about how to move forward.

A Black Woman in Marine Biology

Kayelyn Simmons, a 2021 recipient of Sea Grant's prestigious John A. Knauss Marine Policy Fellowship, is no stranger to the ocean.

"As a kid, I grew up spending most of my time outside," says Simmons, who became open water S.C.U.B.A.-certified in 2009. "I was definitely a 'wild child.' My earliest memories are of taking family vacations to Hilton Head and Myrtle Beach. This is what got me interested in marine biology."

Simmons, now a Ph.D. candidate in the Marine, Earth and Atmospheric Sciences program at NC State University, originally had wanted to become a veterinarian for marine

animals. However, over time she sought out another career path that would fulfill her love for the ocean and the outdoors. She attended Hampton University, an HBCU (Historically Black College or University) in Hampton, Virginia, where she received her bachelor of science degree in marine and environmental science.

While at Hampton, one of her professors, Deidre Gibson, saw Simmons's potential and mentored her, even speaking to her mother so she could pursue an undergraduate internship funded by the NOAA Living Marine Resources Cooperative Science Center.

Simmons soon began her first internship at the Monterey Bay Aquarium Research Institute in Moss Landing, California. She conducted research studying deep-sea marine worms and recalls getting to eat her lunch on the beach while viewing seals and dolphins. The internship also provided her the opportunity to become

S.C.U.B.A.-certified.

"Once I became S.C.U.B.A.-certified and completed my internship, that's when I officially decided no more vet school," she says. "I wanted to do marine biology."

The years ahead would bring Simmons great successes but also moments of struggle. Being Black in marine science is one thing, but being a Black *woman* in marine science presented other challenges during her fieldwork.

"As a Black woman, I feel like sometimes when I come off as a strong person, people think that I'm not being considerate," she says. "However, it seems like that kind of initiative is acceptable for anyone else. Even when trying to make a connection and collaborate with other agencies, I found my thoughts and ideas being conveyed and taken by someone else."

She also notes another added layer of concern to Black women that our counterparts might



At Hampton, Deidre Gibson (right) mentored Kayelyn Simmons (left), even speaking to Simmons's mother so she could pursue an undergraduate internship funded by the NOAA Living Marine Resources Cooperative Science Center.



Prior to graduating from The Citadel, Austin Gray (above and left) initially thought he would practice medicine or serve in the Air Force. Instead, the former North Carolina Sea Grant and Water Resources Research Institute Fellow earned his Ph.D. and now works in environmental toxicology.

not face, particularly out in the field: our hair.

"I was in the car with one of my colleagues on the way back from fieldwork," Simmons recalls. "As I went to fix my hair, I noticed that she made the effort to adjust her rear-view mirror to look at me in amazement. I thought, 'Am I her first Black friend?' I had not experienced that since childhood, and oddly enough it made me feel slightly uncomfortable."

From then on, planning how she would fix her hair and dress before going out into the field became a whole new task for Simmons. She now

gets easy-to-manage braids in all kinds of colors: blonde, red, even blue and black. (She also buys very fashionable underwater leggings.)

In academic settings, Simmons also has noticed incidences as a Black marine biology student that have led her to feel strongly that we need to change how we think about progress when it comes to diversity.

"I wish we not only focused on diversity with regard to inclusion but also diversity as an *investment*, where we do not only value meeting simple requirements," she says. "Just how advisors or mentors see and cultivate their students' strengths — I know not every African American student who successfully enters college gets the chance to have someone see and invest in them. It will take more work beyond diversity and inclusion to achieve diversity investment."

A Black Aquatic Ecologist Sampling Streams and Wells

Prior to graduating from The Citadel in 2013, Austin Gray initially thought he would

practice medicine or serve in the Air Force. Instead, the former joint North Carolina Sea Grant and Water Resources Research Institute Fellow earned his Ph.D. and now works in environmental toxicology.

Originally from North Charleston, South Carolina, Gray is the youngest of five boys. He says he found his voice early on and always made it a point to state his opinion. He remembers he also developed an early affinity for science.

"You could say it all started from watching Bill Nye the Science Guy," he says. "When I was young, I wanted to be an M.D., but I didn't really know what that truly entailed. After my first year of college, I landed a work study job in an aquatic toxicology lab with John Weinstein, cleaning glassware. As time went on, I found myself beginning to listen more about the research that was taking place."

Weinstein's research, at the time Gray started working in his lab, focused on personal care products, specifically "green products"

Continued



Adam Rosso

Alex Troutman (above and right) conducts research on the diets of seaside sparrows, a species endemic to marshes and wetlands. With sea levels continuing to rise and continuous coastal development, these sparrows are losing their habitat.

that were marketed as environmentally friendly. “Our research, however, found that some of these products were either more toxic or equally toxic to the environment.”

Becoming more intrigued, Gray began to work his way into the field to help with the project alongside graduate student Jonte Miller. By the end of the summer, his interest had been sparked. He wanted to understand how emerging contaminants can impact aquatic habitats, and by the beginning of his junior year, he began his own independent research project.

He went on to get his master’s in biology at The Citadel, investigating microplastics. After a subsequent year with the Medical University of South Carolina in the NIH’s Post-baccalaureate Research Education Program, he entered the University of North Carolina at Greensboro’s Environmental Health Science program. There, he earned his Ph.D., studying antibiotics in rural and urban streams in the Piedmont of North Carolina.

“A typical day would vary between doing lab work and fieldwork,” he says. “The lab work would involve me getting up early and working through my research protocol, thinking about what I wanted to accomplish that day, as well as performing extractions on water, sediment, or aquatic invertebrates I had collected. Collecting samples can make up about a 6-to-8-hour day. Fieldwork requires a lot of time prior in

preparation, to ensure all needed supplies are sorted and organized.”

Fieldwork also brings opportunities for Gray to share his passion for what he does with people who inquire, creating many positive educational experiences. However, sometimes conducting fieldwork also brings challenges.

“I enjoy interacting with the public,” he says. “There’s always someone around who is curious about what I am doing. This is a chance for me to relay my research and to make that connection. Yet, you can imagine being Black in science comes with a lot of hazards, warnings, and issues of safety.”

In the field, Gray can recall being approached by a group of men, and being singled out amongst his research group and addressed as “homie.” Luckily, his advisor intervened to remove him from the situation. During his dissertation work, when he studied antibiotic pollution in rural drinking wells, after successfully recruiting study participants to allow him to sample water on their property, it became a different story once they found out he was Black.

While out in certain parts of North Carolina, Gray has also found himself being followed by trucks with Confederate flags.

“Now when I go out, I call or message my mom and wife to update them on my progress and where I am, he says. “This is not something that certain groups of people would probably have

to think about when they’re doing their fieldwork.”

Even in academic settings, Gray has felt isolated. Being an “A” student in graduate school, though, and receiving presentation awards, grants, and fellowships, won him a belated sense of respect from peers and faculty.

“I found that after I performed above their expectations, or received an award, then people would interact with me more,” he says. “It showed me they didn’t think I was capable, until I proved to them I was.”

With the University of Cincinnati’s Latonya Jackson in 2018, Gray co-founded a diversity committee within the globally-recognized Society of Environmental Toxicology and Chemistry. They had realized that institutions (and society as a whole) were not dedicating or promoting many resources to support the careers of Black scientists and other scientists from groups historically excluded.

For Gray, it was important they founded that committee, despite many barriers, at a time when people often were more hesitant to focus on diversity in science.

“With everything that was highlighted with the tragedies of George Floyd and Breonna Taylor in 2020, I think it took this for institutions to begin to realize how our institutions are lacking diversity, and in turn lacking understanding into the needs and worries of people from underrepresented and exploited groups in science,” he says. “Now that



we have been 'seen,' I wish they would have seen us earlier, along with the countless others."

A Black Wetland Ecologist in the Marsh

Alex Troutman, a graduate student at Georgia Southern University and recent recipient of the Bill Terrell Graduate Research Grant from the Georgia Ornithological Society, has always loved being in natural settings.

Troutman grew up about 20 minutes from Atlanta in Austell, Georgia, and he credits fishing with his family, visiting state parks, and the creek in his own backyard for inspiring him to pursue a career in ecology.

"I had a friend who would always come over, and we would go out and try to find salamanders," says Troutman. "We would also have competitions every summer to see who could catch the most fish."

In college, Troutman wavered about what he wanted to do for his career, jumping between becoming a veterinarian and studying middle

school education. However, a mammalogy and ornithology course inspired him, and he found an opportunity to pursue his passion for the outdoors.

After graduating with a degree in biology from Georgia Southern, Troutman worked for a few years as a professional biologist with multiple agencies and various wildlife species, including the endangered Kemp's Ridley sea turtle and Karner blue butterflies. He now pursues a master's in conservation biology at Georgia Southern.

His research involves investigating the diets of nestling seaside sparrows, a species endemic to marshes and wetlands. With sea levels continuing to rise and continuous coastal development, these sparrows are losing their habitat for nesting, along with their primary source of food: insects.

Being out in the marsh can be fun; every day brings something different. Working with the tide is key, or else you can get flooded out. It can also be a challenge walking through the terrain.

"One wrong step, and you may have found yourself 5 feet deep in mud," Troutman jokingly says.

As a Black man in a white-dominated field, Troutman says he has been fortunate in his many professional positions, but he also says that carrying out fieldwork near the place of a tragic act of racist violence can leave him uneasy.

"Both of my field sites are within a 7-mile radius of where Ahmaud Arbery was murdered," Troutman says. "I have to pass his neighborhood every time I go to the field site; it is challenging and heartbreaking. I usually walk slower to the truck or add another task to do while in the field, until people leave. Other times, it's hearing yelling from a passing truck. Most of the time it's something related to my university." Georgia Southern's logo is on the field truck. "But other times it's the N-word or something else obscene."

Troutman says that the murder of Arbery, an unarmed 25-year-old Black man who was pursued and fatally shot while jogging near Brunswick, Georgia, resonates with him for many reasons. As a seasonal wildlife biologist, Troutman's work often takes him into predominantly white neighborhoods, where he too goes out to exercise or look for wildlife.

"We have to make ourselves less threatening just to enjoy the outdoors like our white counterparts," Troutman says. "If we want to go for a run, then instead of a hoodie, maybe we should wear a sweatshirt and a ball cap or beanie instead. We can be warm but still not look threatening. Or maybe it's smiling and waving at people that pass you by, so you look friendly."

An Afro-Latina Social Scientist Researching Disasters and Climate Change

Michelle Dovel's Afro-Latina roots are strong. Born in Miami to African American and Dominican parents, she describes herself as having been a very quiet, shy, and reserved kid. However, as she reached her teen years, she broke out of her shell and eventually became more vocal and outgoing. Moreover, she has always been naturally observant and fascinated by both the natural and social sciences.

Dovel says the events leading up to Hurricane Katrina, as well as the aftermath, prompted her interest in disaster and climate change research. At 17, she remembers watching images on television of people treading through the chest-high floodwaters and climbing onto their rooftops to cry for help. The catastrophic event devastated the Gulf Coast, displacing hundreds of thousands of residents, leaving areas of Alabama, Louisiana, and Mississippi utterly destroyed. *Continued*

She also remembers what people had to say about the hurricane's victims: "They're stupid. They should have left."

At the time, she says, she didn't have the language or tools to really deconstruct what was happening. But a few years later she would.

While at the University of Florida, Dovel was assigned a reading from Michael Eric Dyson's *Come Hell or High Water* that answered her questions and provoked new curiosities regarding disasters and social inequalities. She went on to complete both her master's and Ph.D. in sociology at Howard University, studying disaster research and climate change. She focused on answering some of the same questions Katrina and other disasters had raised for her and many others: "Why didn't residents evacuate before the hurricane? Why do people often decide to return to high-risk, vulnerable areas?"

As a former graduate research fellow with both NOAA and the Bill Anderson Fund, and now as a visiting assistant professor and researcher at Howard, Dovel continues to break barriers as an Afro-Latina social scientist.

"Growing up, I thought that people like me don't get Ph.D.s," she says. "But as an Afro-Latina and social scientist, I have received three research grants: two from the Department of Homeland Security and another from the National Science Foundation."

Such success is rare so early in any young researcher's career, but Dovel doesn't care about accolades; she cares about her students and loves to use her teaching and research as an avenue to train them, as she puts it, "to be amazing." North Carolina Sea Grant hosted Dovel and two undergraduates from Florida A&M during the summer of 2019, for instance, while she gave them hands-on experience conducting research in coastal communities.

Dovel also has experienced daily moments of struggle and uncertainty.

"As a Black and Latina woman I live in a world that constantly tells me that I'm not good enough and reminds me every day that I don't deserve to be in certain spaces," she says. "There are certain things that I have to do to make sure I am not a threat to anyone, and I know that my professional and academic success does not shield me or any other BIPOC from racism or sexism. When I walk outside, no one knows I'm a professor at one of the most prestigious HBCUs with an NSF-funded project, and I can't walk

around with a sign on my back that says, 'I'm not a threat. Don't shoot me.'"

Once, after she received a travel grant to a conference, tired from walking and wanting a drink and a snack, she headed to the refreshment table, where a conference employee stopped her.

"That's not for you," said the employee. "That's for people who are here for the conference."

Dovel found herself upset by having to reassure the employee that she was a part of the conference.

"It's instances like these where you feel like you have to make sure your nametag is visible," she says, "just so you won't be singled out because you are Black."

Listening and Learning

These experiences are all too real for Black scientists, but they have informed the perspectives of Kayelyn Simmons, Austin Gray, Alex Troutman, and Michelle Dovel about how institutions and organizations can better raise awareness and promote diversity, equity, and inclusion.

Simmons suggests publicizing resources

and recognizing faculty, staff, and researchers who actively are working for diversity. Dave Eggleston, for instance, her advisor at NC State, is trying to establish partnerships with HBCUs in North Carolina for internships through their lab.

"If there were more professors, mentors, or science leaders that focused on investing in students from diverse backgrounds or even partnering with minority-serving institutions, then diversity and inclusion would be an everyday endeavor," she says. "Instead, the focus would be on promoting professional growth and development for life after college."

Gray wants to contribute to permanent change within academia. He will be an assistant professor in the department of biological science at Virginia Tech beginning in August and plans to start his own laboratory, with training dedicated to inspiring a new, more diverse generation of scientists from a wide range of backgrounds.

Gray says it means a lot for students to see a young Black professional who looks like them.

"For institutions working towards diversity or changing their demographics, it has to be done in a genuine effort, rather than just an effort to





Even with her early career successes, including two grants from the Department of Homeland Security and another from the National Science Foundation, Michelle Dovil most enjoys mentoring her students. In 2019, North Carolina Sea Grant hosted Dovil (middle, above) and Florida A&M undergraduates Tia Maxwell (left) and Tenesha Washington (right), while they conducted research in coastal North Carolina communities.

appease people,” he says. “If it’s done genuinely and it’s done where the voices of those that are marginalized or hurt are valued, then you will see a change.”

When it comes to diversity and inclusion, Troutman is no stranger to the cause. He co-organized *Black in Marine Science Week*, a social media campaign that celebrated minority peoples who work in the marine sciences and other related fields. He says he hoped the campaign would amplify and encourage minorities to pursue a career in the marine science field.

Troutman also is devoted to encouraging people of all ages to learn about nature and enjoy the outdoors. He hopes to create a foundation that brings Black, Brown, and students of lower socioeconomic status into a natural resource field.

“So many people highlight the ‘glamour jobs’ like engineering or being a doctor, but they rarely highlight the outdoor and natural resource jobs,” says Troutman. “Although they may not be six-figure positions, we still need people to do these jobs.”

Dovil says that she has seen many statements on diversity, equity, and inclusion from

D.E.I. committees, and she has attended many meetings. But she has not yet witnessed a lot of structural changes to enhance recruitment, retention, and promotion.

She recommends that institutions and organizations do more than put out D.E.I. statements and actually work on tackling these structural problems. Most of these institutions and organizations are aware of their issues regarding a lack of diversity, equity, and inclusion, she says. They have the data — such as how many white, Black, Latino and Latina people they hire, retain, and promote.

Dovil says you can look around your meetings and lunchrooms and see some of these issues. “Just hiring more women is not sufficient when it comes to diversity and inclusion.”

It also is not enough to try to be diverse and inclusive, she explains.

“Institutions and organizations must also acknowledge all forms of racism that take place and actively work to be antiracist,” she says. “I just find it interesting how some people can manage to do quantum physics and get men on the moon, but they just can’t understand basic race relations in America.” 🌐

- Watch a video about the innovative research that Michelle Dovil and her students conducted at the North Carolina coast
go.ncsu.edu/Dovil
- The Society of Environmental Toxicology and Chemistry, where Austin Gray co-founded a diversity committee
globe.setac.org
- “Citadel Study Casts Doubt on ‘Green’ Product Claims,” the research that drew Austin Gray to the field
go.ncsu.edu/not-green
- The NOAA Living Marine Resources Cooperative Science Center, which supported an internship for Kayelyn Simmons
umes.edu/lmrcsc/
- North Carolina Sea Grant’s commitment to diversity, equity, and inclusion
go.ncsu.edu/DEI

BY HALEY PLAAS

IN FULL

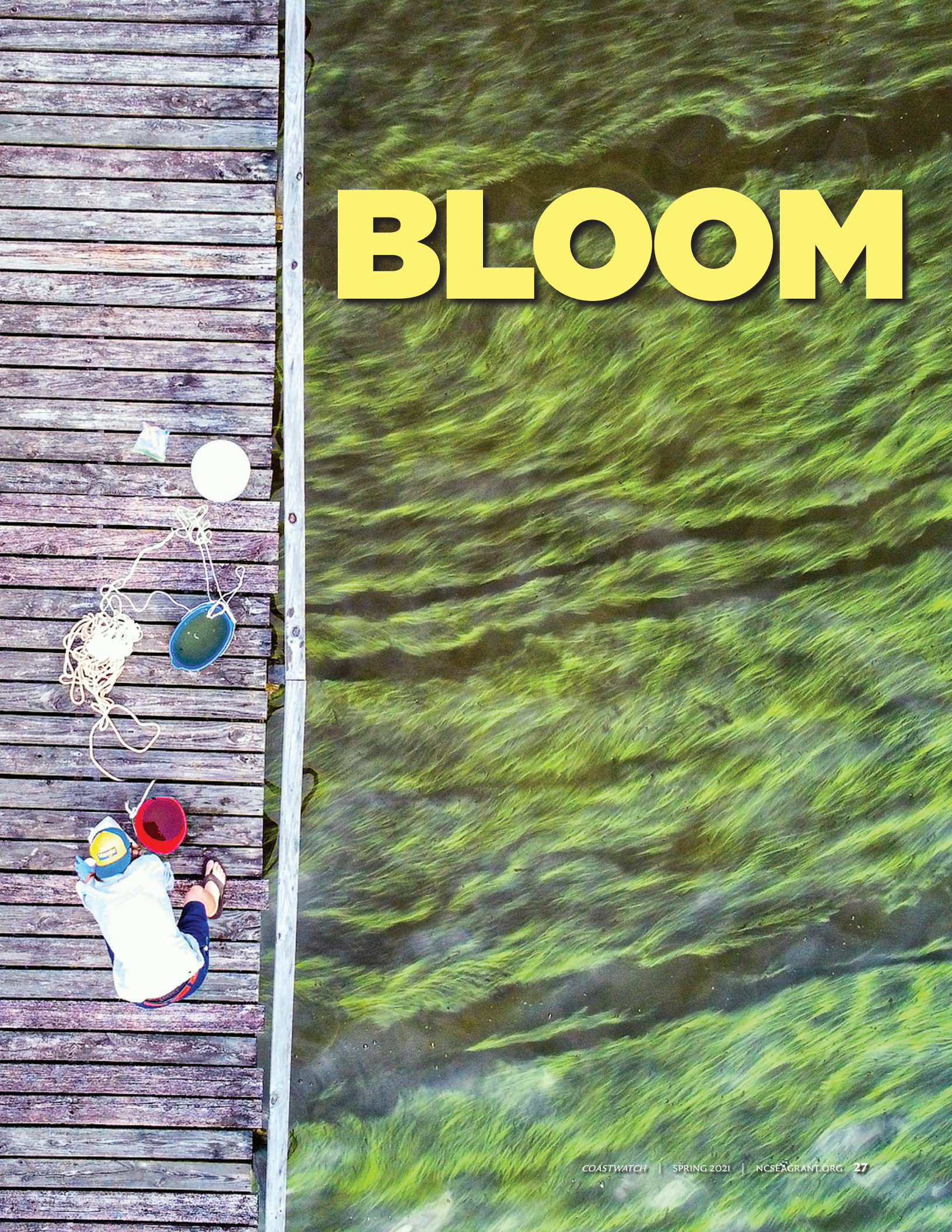
Algae, Air Quality,
and New Research
on the Impacts
of Cyanotoxins

Continued

Studying cyanobacterial spray aerosols on the Chowan River.

Abe Loven

BLOOM





Between experiments, Haley Plaas (right) chatted with community members about their personal experiences and heard longstanding concerns about the nutrient sources that fuel algal blooms and the impact of the blooms on blue crab fisheries. Such discussions, like the one above with the Chowan Edenton Environmental Group's chair, Colleen Karl, have helped shape subsequent research.

Haley Plaas is a Ph.D. student in environmental sciences and engineering at the University of North Carolina at Chapel Hill's Institute of Marine Sciences in Morehead City. She received the joint Albemarle-Pamlico National Estuary Partnership - North Carolina Sea Grant Fellowship in 2019 and a National Science Foundation Graduate Research Fellowship in 2020.

In 2015, I bid my Midwestern home goodbye and set out to pursue a degree in marine science at the University of Miami, Florida.

My first exposure to harmful algal bloom (HAB) research was at the Mote Marine Lab in Sarasota, Florida.

That summer, Florida endured dual toxic algal blooms: a massive red tide bloom in the Gulf, and an extensive network of blooms from cyanobacteria — blue-green algae — downstream from Lake Okeechobee. I was taken aback by the immense damage to Florida's beaches, air quality, tourist industry, fisheries, and public health, all from microscopic algae. And it wasn't just happening in Florida. HABs like these were expanding in aquatic ecosystems around the globe, threatening key water resources in countless communities.

So many complex environmental issues are invisible, but the hallmark green surface scum of a dense cyanobacterial bloom refuses to be ignored. These blooms often resemble toxic sludge in a children's animated movie. The far-reaching

impacts of HABs certainly had caught my attention, and I felt compelled to tackle this environmental health crisis in my career.

HARMFUL ALGAL BLOOMS AND AIR QUALITY

In 2019, I joined Hans Paerl's lab group at UNC's Institute of Marine Sciences. Estuaries in North Carolina are just one of the many watersheds susceptible to the expansion of HABs. While we know cyanobacterial blooms are a significant threat to water quality in coastal North Carolina, we aren't sure to what extent blooms affect air quality.

It's possible that cyanotoxins become airborne and are inhaled. Such cyanotoxin exposure has been linked to respiratory distress, but the long-term human health implications of this are unknown. My own research investigates the formation of aerosols carrying cyanotoxins during cyanobacterial blooms.

If you've been to the beach on a choppy day and seen a haze above the surf, you've seen the production of such aerosols. Spray aerosolization occurs at the water's surface,

when particles from the water are emitted into the air. During wind and wave action, air bubbles become trapped beneath the water's surface. As they rise through the water column, they can collect suspended fragments of cells or sediments and dissolved chemicals, including toxins.

Once the air bubbles reach the surface and burst, the process ejects a spray of hundreds of microscopic particles of water into the air, like when a child blows a bubble and pops it in your face. These particles are the spray aerosols, and they carry much more than saltwater. All sorts of microbes, pollutants, proteins, and chemicals from the water also go airborne.

While scientists have long studied this process in seawater, researchers are only just analyzing it in freshwater. Due to salinity differences, freshwater spray aerosols vary in their size and chemical composition.

Hydrophobic compounds — compounds with a greater affinity for air than water — are most likely to be more concentrated in spray aerosol than in water. This is important when measuring toxins in aerosol, because inhaling them can result in greater toxicity than simple exposure from swimming or drinking water. In addition, depending on the aerosol diameter, concentration in the air, and the ambient weather

conditions, spray aerosols can remain suspended for hours to days at a time.

Much evidence suggests that spray aerosols can transport both cyanobacterial cells and toxins; however, what we don't yet know is how frequently this happens and when it's bad enough for people to be concerned. We are exploring these questions in the field to help the State of North Carolina determine if guidelines should be implemented and how and where interventions would be most effective to protect public health.

In summer 2020, our pilot project studied cyanobacterial spray aerosols in the airshed of the Chowan River, which has endured recurrent toxic cyanobacterial HABs over past summers. We collected water and aerosol samples and are evaluating the concentration of cyanobacterial DNA and microcystin, the primary toxin of concern.

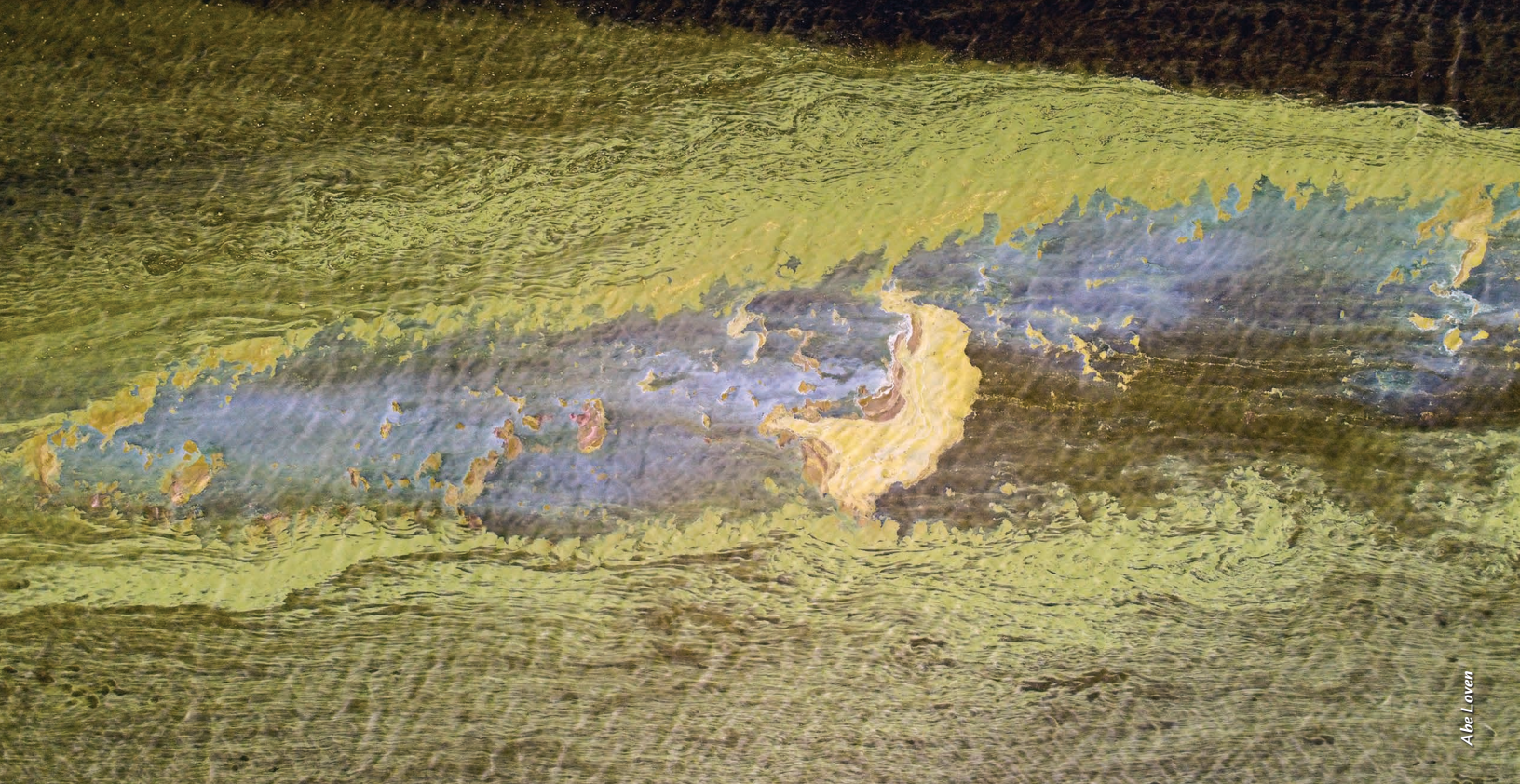
Although we do not yet have data on cells or DNA in aerosol, preliminary findings from this study do not suggest there were quantifiable toxin concentrations in the air; however, we present this information with caution, given that water concentrations of microcystin were also low or non-detectable in our samples.

Continued

Cyanotoxin exposure has been linked to respiratory distress, but the long-term health implications are unknown. Plaas's research investigates the formation of aerosols that carry such toxins during blooms.

Abe Loven





Abe Loven

Some days, Plaas and community scientists with the Chowan Edenton Environmental Group (CEEG) operated like a band of storm chasers. When the CEEG's network reported bloom sightings, they all jumped in their cars and sped toward those locations.

COMMUNITY SCIENCE

We could not have conducted our research without the immense support we received from the community scientists of the Chowan Edenton Environmental Group (CEEG). Each and every sampling day, from 7 a.m. to 7 p.m., two or three CEEG members worked alongside our team, helping to lug equipment around, store aerosol samples, and filter water for our various measurements. (See the community science field guide for the CEEG at the end of this article.)

Our field sites were quite literally the backyards of their homes. Some days, we even operated like a band of storm chasers: When the CEEG's network reported bloom sightings, we would all jump in our vehicles and speed toward those locations.

Between experiments, we chatted about our shared interests in research and their personal experiences with blooms over the past several decades. These discussions brought up the town's long-standing questions about the nutrient sources that are fueling current blooms and the impact of the blooms on blue crab fisheries, providing meaningful insight to direct future studies.

The entire point of scientific research is to advance knowledge for the benefit of society, and what better way to ensure your community is benefiting from your work than getting the feedback firsthand? In coastal North Carolina and beyond, we must strive to recognize these intersections and build upon connections in our communities.

This summer, when I resume researching the toxin aerosol question, the NOAA Beaufort Laboratory will lead a study of the HABS' effects on blue crab populations, while

Hans Paerl and Nathan Hall will investigate the blooms' causes and controls.

In summary, I hope my research will provide state agencies, especially our partners at the North Carolina Department of Environmental Quality and the North Carolina Division of Marine Fisheries, with information to keep the public safe from the adverse effects of HABS in the water or the air. It's important to remember that our air quality is strongly linked to water quality, in much the same way that the health of our ecosystems and communities intersect.

- *In Full Bloom*, the upcoming documentary about research and community science on the Chowan River tarheels.live/infullbloom/
- Haley Plaas and Hans Paerl's "Toxic Cyanobacteria: A Growing Threat to Water and Air Quality" go.ncsu.edu/cyano
- "Chowan Edenton Environmental Group Community Scientist Water and Air Quality Monitoring Manual" go.ncsu.edu/water-air
- Chowan Edenton Environmental Group chowanedentonenvironmentalgroup.org/
- more about Haley Plaas's work go.ncsu.edu/Plaas

Illegal Angling, Measuring the Megalodon, and More

The Latest Science for Anglers

CURATED BY SCOTT BAKER AND SARA MIRABILIO

DO ANGLERS FISH IN AREAS CLOSED TO FISHING?

Despite patrolling and education efforts, research shows that illegal fishing still occurs — and at predictable times.

• Research Need

For fish populations in trouble, fishery managers sometimes limit or completely disallow fishing in certain areas if they contain critical habitats that support the populations under recovery. In some cases, no fishing is allowed within an area. For example, there are

eight marine protected areas between Cape Hatteras and the Florida Keys established to protect several species of the deep-water snapper-grouper complex. The effectiveness of these off-limit fishing areas ultimately depends on enforcement (catching violators and deterring others) and compliance (persuading people to follow the rules).

The assumption is that the overwhelming majority of resource users follow the rules. But the ocean is vast, and monitoring large swaths of it requires intensive labor and resources that many agencies do not possess.

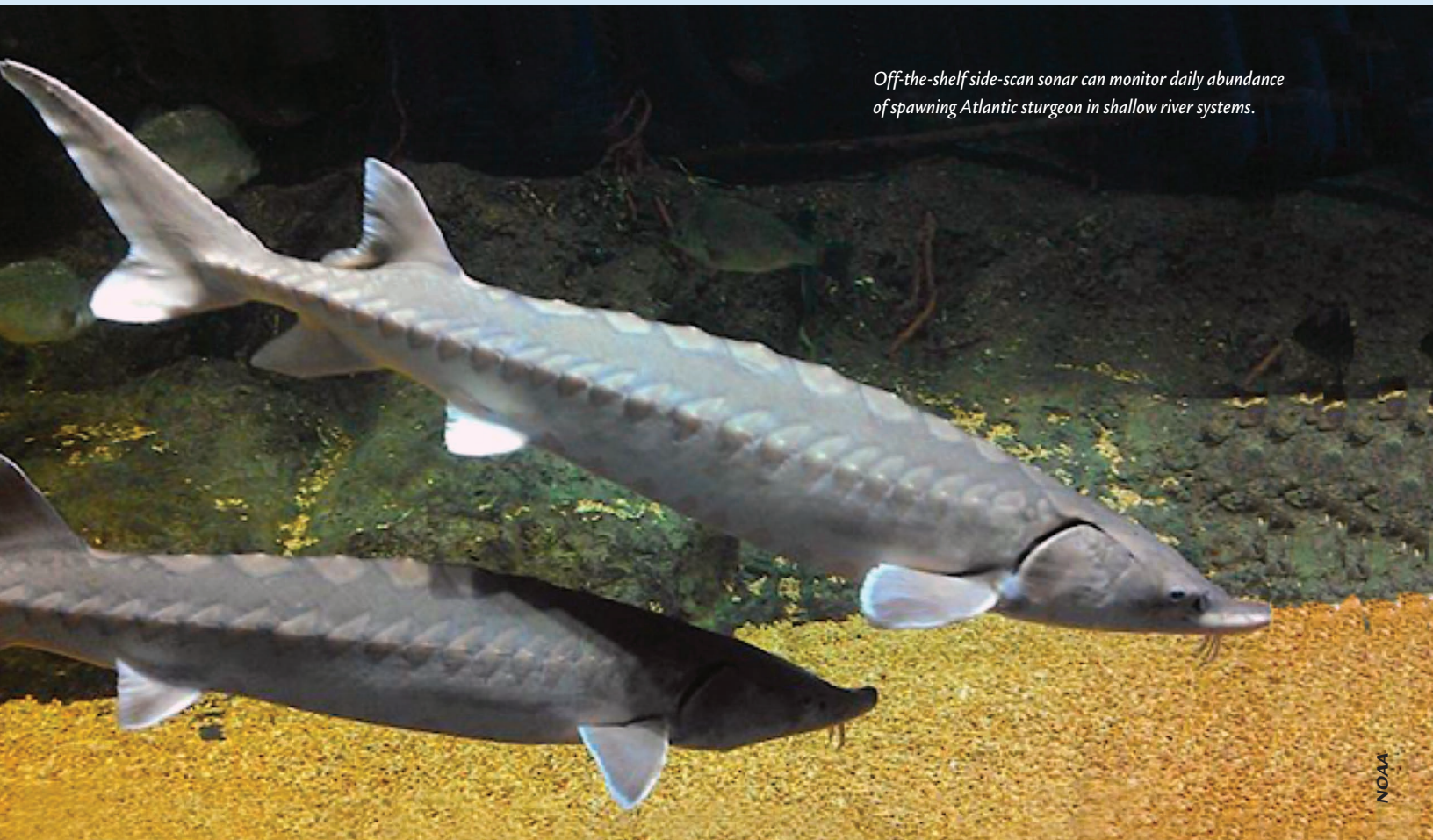
However, if it were possible to predict illegal fishing patterns in managed areas, this

might lead to more efficient enforcement and conservation efforts.

• What did they study?

Scientists in Australia used shore-based surveillance cameras and a predictive model they created to examine illegal fishing activity at two areas designed to protect threatened black cod and endangered grey nurse sharks. Researchers looked at footage sampled in 30-minute increments collected over the course of more than a year across sites to determine whether boats observed were illegally fishing or not, as well as to document weather conditions

Continued



Off-the-shelf side-scan sonar can monitor daily abundance of spawning Atlantic sturgeon in shallow river systems.

NOAA

(like wind, rain, and wave intensity) and time of day.

• *What did they find?*

Video footage revealed that illegal fishing occurred regularly within the two areas under observation, with higher activity occurring at the site closer to the boat ramp. A total of 185 boats illegally fished during the study, primarily by hook and line.

Illegal fishing happened most often on non-working days, like weekends or holidays, and on fair weather days — those with light winds and calm seas. Unsurprisingly, these days also were consistent with high recreational activity on the water.

Scientists also found that illegal fishing occurred despite patrolling and education efforts by local fisheries officers.

• *So what?*

Video cameras and modeling can improve the efficiency of fisheries monitoring by providing managers key insights into the behavior of fishers venturing into managed areas. With better enforcement, species in marine protected areas will have a better chance to thrive.

In the South Atlantic region, most of the managed areas are far offshore, outside the reach of shore-based cameras. However, the predictive model results linking fishing activity to weather, day of week, and time of day are more universal and applicable to areas beyond Australia.

It never hurts to confirm that most rule followers and law breakers appear to dislike fishing offshore in bad weather.

— compiled by Allison Fisk

CAN WE USE OFF-THE-SHELF SONAR TO COUNT ATLANTIC STURGEON?

Low-cost technology could allow for regionwide comparisons of daily numbers of the species.

• *Research Need*

Atlantic sturgeon (*Acipenser oxyrinchus*) are endangered fish inhabiting rivers, estuaries, and marine environments along the Atlantic coast of North America, including the waters of North Carolina. Hatched in freshwater, these fish spend most of their adult lives in the ocean and then return to freshwater systems to spawn and lay eggs. Once present in large numbers, these animals are now off-limits to fishing and share the same waters and environments where popular fish species thrive.

To better understand their changing population levels, scientists need to count spawning Atlantic sturgeon and their offspring. Tag and recapture methods — using either simple streamer tags or more sophisticated electronic tags — have been the go-to methods to follow the fish, but these techniques are resource-intensive and can harm the fish if conducted incorrectly.

It would be nice to have a method to passively observe and count these animals on a regular basis. And what if you could do this without getting out of the boat? Better yet, what if you could walk into Bass Pro Shops and purchase an off-the-shelf side-scan sonar unit that can “see” individual Atlantic sturgeon under the boat?

- *What did they study?*

Scientists equipped a boat with a Humminbird side-scan sonar and surveyed nine sections of Atlantic sturgeon spawning grounds on the uppermost portion of the Savannah River in Georgia. On each of 50 occasions from August to November 2017, researchers laid down a strip of imagery that they could analyze in the lab.

The team focused on counting objects in the imagery that looked like Atlantic sturgeon (based on shape, dorsal fin and tail structure, shadow, and other factors) that were roughly 4 feet long, the minimum size capable of spawning. Computer modeling then used the fish counts to estimate the total number of spawning Atlantic sturgeon in the study area.

- *What did they find?*

The team observed at least one Atlantic sturgeon on each of the 50 sampling runs and estimated maximum daily numbers of spawners at 35 to 55 fish.

- *Anything else?*

The flow rate of the Savannah River had an impact on Atlantic sturgeon detections. Specifically, as the flow rate increased, the chance of detecting fish decreased. Although scanning while moving upstream or downstream didn't affect the count, downstream imagery was clearer and made for easier fish counts.

Continued



New research suggests the extinct megalodon shark might have been nearly 60 feet long.

N.C. Aquarium at Fort Fisher

- *So what?*

The study provides evidence that off-the-shelf side-scan sonar is capable of monitoring daily abundance of spawning Atlantic sturgeon in shallow river systems. The authors encourage others monitoring sturgeon to further experiment with this low-cost technology, which could allow for region-wide comparisons of the daily abundance of Atlantic sturgeon.

— compiled by Scott Baker

HOW BIG WAS THE MEGALODON SHARK?

New research suggests the extinct species could have been nearly 60 feet long.

- *Research Need*

The megalodon shark once lived world-wide in tropical-temperate regions. Historically, the megalodon is estimated to be the world's largest predator shark ever to have existed.

With the fossil record incomplete, it can make the estimations of large extinct taxa like the megalodon very hard to predict. In order to estimate sizes of extinct species, paleontologists must rely on the linear relationships of living relatives, such as the great white shark and others.

However, these relationships remain questionable due to the vast difference in size between species.

Can the traits of other sharks from different lineages help scientists determine the size of a megalodon? Can the body dimensions of the great white shark, as well as other large predatory sharks alive today, inform the size of the head, dorsal fin, and tail height of the extinct predatory megalodon?

- *What did they study?*

To help determine the most accurate body measurements of the megalodon, researchers used five species of shark — great white, shortfin mako, longfin mako, salmon shark, and porbeagle — and compared dental,

physical, and environmental similarities. They also used scaled images of these species to acquire accurate body dimensions at various life stages.

- *What did they find?*

The measurements taken confirm that the maximum size of a megalodon was about 50 to 60 feet. For reference, that's somewhere between the length of a tractor trailer (48 feet) and a bowling lane (63 feet).

A 52-foot megalodon shark likely would have had a head about 15 feet long, a dorsal fin about 5 feet tall, and a tail about 12 feet high.

- *Anything else?*

The largest estimated size of the megalodon is more than twice the size of the largest living shark in the Lamniformes family, which includes the great white.

- *So what?*

This analysis marks the first quantitative method used to determine the estimated size and shape of megalodon body parts. For example, the measurements of the dorsal and caudal fins suggest that these were used for swift predatory locomotion and periods of long swimming.

— compiled by Lauren D. Pharr

ARE FEWER PEOPLE GETTING SALTWATER FISHING LICENSES DURING THE COVID-19 PANDEMIC?

Year-to-date totals are typical, yet the changes in sales by type of license are anything but.

- *Research Need*

My friends, family, and colleagues who live up and down the North Carolina coast have all commented in some way or another about

the throngs of people on the coast this past spring, summer, and fall. This should not be surprising, considering that people abandoned most far-flung summer travel plans in 2020 because of the global COVID-19 pandemic. People are simply spending their leisure time closer to home.

In theory, that could mean more beachgoers and perhaps more fishers. If you are an angler, maybe you witnessed more people than typical on the water in 2020.

But why should we care what happens with the Coastal Recreational Fishing License (CRFL)? Well, CRFL sales improve the ability of our state natural resource agencies to manage our fisheries, and some of the fees go towards projects and new initiatives to support fishing. Fewer CRFL sales translate into less revenue.

To determine if anglers fished more often than usual, we can look at license sales, as the North Carolina Wildlife Resources Commission (NCWRC) tabulates them monthly. The NCWRC is the agency responsible for the administration of all freshwater and saltwater fishing licenses in the state.

- *What information is available?*

I looked at publicly available data from NCWRC, examining the 10 categories of annual and 10-day fishing licenses that involved a saltwater component (CRFL). I excluded all types of lifetime CRFL licenses, because the factors impacting these purchases are more nuanced.

For each license category, I computed the sales for the period January 1 to August 31 for 2017, 2018, and 2019 and compared that to the same period for 2020. This revealed whether the 2020 sales data was lower or higher than the previous 3-year average, and if so, in which categories.

- *What do the numbers tell us?*

From January through August of 2020, people purchased 319,661 CRFL, which is a 2% increase compared to the 2017-2019 average

(314,024) during the same months. There is typically some fluctuation in sales from year to year, and the chart below shows that the 2020 totals are within the range of the previous three-year average.

But since we can all agree that 2020 was not a typical year, I wanted to dive a little deeper to look at the changes in sales by license type to see if some licenses performed better than others.

Immediately, we see some departures from

normal numbers, which COVID-19 may have caused, at least in part.

First, sales of non-resident 10-day licenses (the largest CRFL category by number) were down 8%, which is likely reflective of the reduced travel during the pandemic. Out-of-state anglers come from far and wide to cast a line in N.C.

However, Annual Resident CRFLs were also down. Perhaps some residents planning on just saltwater fishing instead opted for an Annual Resident Unified Inland/CRFL

(+98%), which allows fishing in BOTH fresh and saltwater.

We also know that COVID-19 adversely impacted seniors in 2020, and it seems logical that COVID-19 also may be limiting seniors' ability to get out and fish. Of all CRFL types, sales of the Annual Senior CRFL (-43%) and Annual Unified Senior Sportsman CRFL (-65%) declined the most. Incidentally, these two CRFLs had the lowest sales volumes of any licenses that allow saltwater fishing.

Last, and perhaps most importantly, the number of Annual Subsistence Waiver CRFLs declined greatly (-39%). The Department of Social Services issues this license upon request to any individual who receives benefits from Medicaid, Food Stamps, or Work First Family Assistance. If COVID-19 was partly responsible for this decline, then it could be due to less demand overall (fewer people wanting or able to fish) or due to decreased access to the waiver-granting agency during the pandemic. Either way, this decline is troubling.

• What about actual fishing effort?

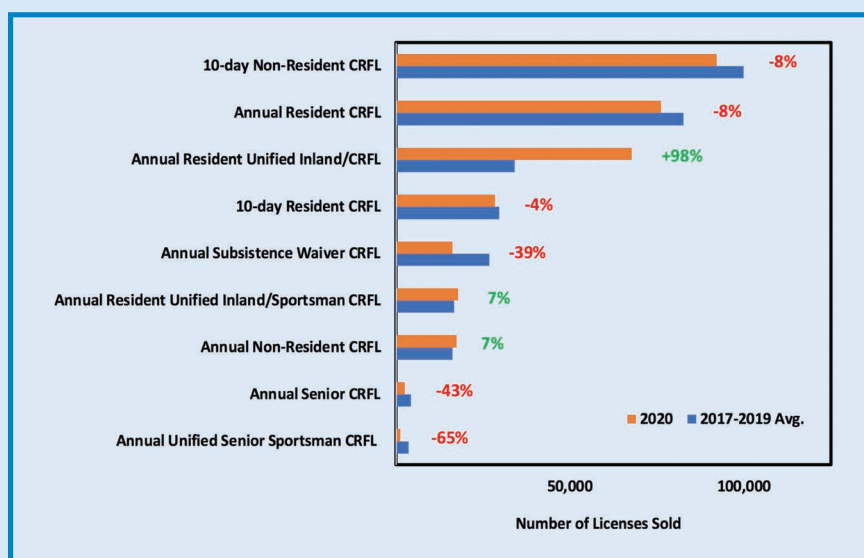
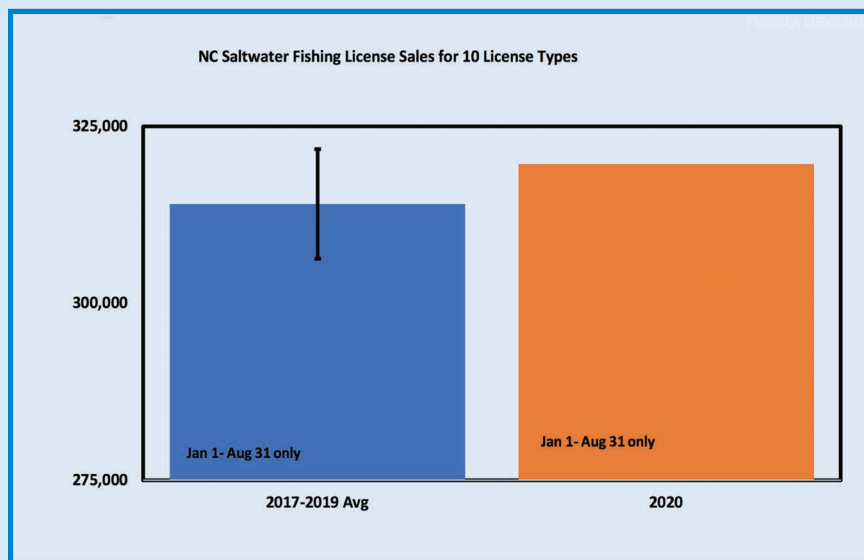
It's too early to tell whether CRFL sales reflect actual observed changes in fishing effort and catch. Those estimates are gathered in waves of data collection throughout the year and take months to process and interpret.

The North Carolina Division of Marine Fisheries will be able to tell if fishing effort actually increased or decreased in 2020 compared to previous years sometime by the spring or summer of this year.

• Anything else?

According to staff at the NCWRC, pleasure boat registrations were on pace last year for the top annual total in 5 years. I know that I saw a lot of boats on the water near me in 2020. 🚤

— Summary by Scott Baker



Through August overall sales of fishing licenses in 2020 were typical, but the changes in sales by type of license told a different story.

the full studies and more at
HookLineScience.com

SPRING SUCCULENCE

VANDA LEWIS AND JOYCE TAYLOR

MARINER'S MENU, ONE OF THE FASTEST-GROWING SITES FOR SEAFOOD RECIPES ON THE WEB, FEATURES BLOGGER AND PHOTOGRAPHER VANDA LEWIS'S PICTURES WITH RECIPES THE LATE JOYCE TAYLOR DEVELOPED. ENJOY THESE DELIGHTS THIS SPRING.



Tex-Mex Shrimp



Vanda Lewis

Stuffed Soft-Shell Crabs



Vanda Lewis



Monkfish Bisque

Vanda Lewis

STUFFED SOFT-SHELL CRABS

- 8 soft-shell crabs, cleaned
- 1/4 cup butter
- 1/4 cup green onions, minced, including tops
- 1/4 teaspoon garlic, pressed
- 2 teaspoons fresh parsley, minced
- 1 teaspoon fresh thyme, chopped
- 1/4 teaspoon salt
- 1/4 teaspoon white pepper, freshly ground
- 3/4 cup fresh bread crumbs
- 1/4 cup Parmesan cheese, freshly grated
- 3 tablespoons butter, melted

Preheat the oven to 400° F.

Melt 1/4 cup butter in a medium skillet and lightly sauté the onions. Stir in garlic, parsley, thyme, salt, and pepper. Remove the skillet from heat, and combine with crumbs and Parmesan.

Place crabs in a well-greased baking dish, bottom sides down. Lift each side of top shells, and fill with stuffing mix. Replace the shells. Brush crabs with 3 tablespoons of melted butter. Bake at 400° F until shells are reddish-brown and until the crabs are done, about 15 minutes.

Tips: If you want fresh soft-shell crabs, check with markets when the moon is full.

Many markets also carry frozen soft-shell crabs. Visit MarinersMenu.org for cleaning instructions and more.

TEX-MEX SHRIMP

- 1 pound large shrimp, peeled
- 1/2 cup butter, melted
- 1/4 cup tequila (white or silver)
- 2 tablespoons fresh lime juice
- 3/4 teaspoon chili powder
- 3/4 teaspoon salt
- 1/4 teaspoon black pepper, freshly ground
- 1/2 teaspoon garlic, minced
- 1/2 teaspoon Tabasco sauce

For marinade, in a small bowl combine butter, tequila, lime juice, chili powder, salt, pepper, garlic, and Tabasco. Reserve 1/4 cup marinade.

Stir the shrimp into the remaining marinade, and mix well. Cover, and refrigerate for 20 minutes, stirring once.

Place the rack in the top third of the oven, and preheat the broiler.

Remove shrimp from the marinade. Place them on a greased broiler pan. Broil about 2 to 3 minutes. Turn shrimp over, and brush with the remaining marinade. Cook about 2 to 3 minutes longer or until done.

MONKFISH BISQUE

- 1 pound of poached monkfish (begin with 1 1/2 pounds of raw fish)
- 4 tablespoons butter
- 1/2 cup potatoes, diced
- 1/2 cup carrots, chopped
- 1/2 cup celery, chopped
- 3/4 teaspoon salt
- 1/2 teaspoon white pepper, freshly ground
- 1/2 teaspoon dried basil
- 2 cups chicken broth
- 1/4 cup dry white wine
- 2 cups heavy cream

Poach the fish in lightly salted water. Coarsely chop, and set aside.

In a medium saucepan, melt butter. Sauté potatoes, carrots, and celery until tender. Remove from the pan, and purée. Return to the pan. Add salt, pepper, and basil. Add broth, wine, and heat. Blend in the cream, stirring continuously.

Add fish, and heat for about 5 minutes. 🌱

Note: Don't miss our recipe for Grilled Striped Bass with Herb Butter on page 16.

Visit the Mariner's Menu archive of free recipes: MarinersMenu.org.



COMPARING APPLES TO OYSTERS

JANE HARRISON INTERVIEWS AARON CORN

Hendersonville Farmers Market

Henderson County is the largest producer of N.C. apples and a major tourist attraction.

Farmers and fishers have much in common in the way of obstacles and opportunities.

I'm a strong believer in learning from others' experiences, and in the case of my work, learning from communities and industries beyond the coast. As a faculty member in North Carolina State University's Agricultural and Environmental Economics Department, I have the privilege of teaching — and gaining insight from — my students. One of their assignments is to develop an economic investment proposal for a North Carolina community. Many of them choose the place they're from, and often an industry they intimately know.

The following Q&A arose from a proposal by agribusiness major Aaron Corn, who grew up working in the apple industry in western North Carolina and who has plans to continue that work after graduation. His entrepreneurial aspirations are not too different than those of folks working in the seafood industry and, in particular, the oyster aquaculture sector where I focus some of my time as North Carolina Sea Grant's coastal economics specialist.

— JANE HARRISON

Sea Grant: Tell me about where you're from and its economic history.

Aaron Corn: I'm from Henderson County. It was founded in 1838 and got its start with agriculture. In the 18th century, William and Eleanor Mills first settled in Fruitland, where Mr. Mills planted hundreds of fruit trees every year. His neighbors soon followed suit, founding what would one day be a multimillion-dollar industry.

From the 18th to the early 20th century, the area relied heavily on agriculture — specifically apples and other fruits. Henderson County was also early to attract

tourists. Large planters from the South Carolina low country would come here to escape the heat and insects.

In the 1920s and 30s, with the Great Depression in full swing, many people moved to western North Carolina in search of employment and began farming. That started the boom in roadside stands, which helped Henderson County become synonymous with apples and other fruits. These people took a large gamble on the area, and it panned out in the end. Tourism is still seen today and continues to be an integral part of the economy.

Q: What are the economic development challenges that Henderson County faces?

A: "Used to be" is a phrase too often heard in Henderson County and many other rural areas. When I'm riding with my employer, Wayne Barnwell, a 72-year-old native of Henderson County, he'll point out a piece of land with houses on it and tell me who used to own it and what used to be there. More than often, it seems that former farmland is being taken over by housing or new businesses, which can drive up taxes on working farmland, making it more difficult for farmers to continue what they're doing. This is no less true than in

my hometown of Hendersonville.

Agriculture in Hendersonville has taken a backseat over the past several decades, and as of 2020 it only made up 2% of the population's employment. It started to lose its importance around the 1960s and 70s, when manufacturing and other careers became more prominent in the area.

Another factor that took its toll on farmers was the declining price that processors, such as Gerber, were willing to pay for fruit. They were the primary buyers for commodities in this area, and with the declining profit and higher costs of production, many farmers got out while they were still ahead. Or, in some cases, the farmer passed away and the family didn't want to continue farming. The final nail in the coffin for some was Gerber closing its facility in Asheville — the next town over — in 1998. The cost of transportation to the next closest facility,

located in Fremont, Michigan, ate into farmers' profits even more.

Q: What economic opportunities exist for the area?

A: Even with the loss of some farmers, many have persisted and found new markets for their commodities. Some farmers expanded their roadside stands, making them more family-friendly, with extra attractions — primarily for younger children — and more products, like slushies and baked goods. In more recent years Henderson County has seen a surge in alcohol production, including hard ciders and wines, which has opened a brand-new demographic that had not previously been reached. Many cideries and wineries are located where there is a good view or some other kind of natural landmark, creating even more business.

Henderson County is still the largest producer of apples in North Carolina and

a major tourist attraction, which begs the question: How do we preserve our agricultural heritage for the future? Working in agriculture has been my passion for as long as I can remember. Even as a young child, I watched the tractors work in the orchard across from my house. My goal is to develop a business that will not only be profitable to me and my family, but that will also help preserve the heritage that many farmers in this community have built up over generations.

Q: There is a similar motivation for commercial fishers who have been working the water over generations. I know one oyster grower who is a seventh-generation fisherman. How would you jumpstart your apple business?

A: The process of selling commodities to consumers, whether wholesale or retail,

Continued



Apple grower Aaron Corn says that agriculture comprises only 2% of employment in his hometown of Hendersonville.

needs to be more streamlined. There is a large amount of profit left on the table. My company will essentially be a repacking and distribution center for apples and other fruits that will work with growers to get them the maximum profit while also allowing agriculture to maintain its prominence.

In Henderson County, agritourism peaks from late August to early November, leaving a small window for farmers to sell their products at the highest profit to them. I would like to encourage growers to stay open longer by offering incentives to produce pies and fruit cakes, for instance. With my company, I would like to get these products on the internet and push them through companies like Amazon, where people already purchase consumable items.

I also believe products like pie mixes and other baking kits would be a great seller for people who want a homemade feel but who won't go out to roadside stands and buy the raw materials. This strategy would encourage people to buy more local products

and to stay away from out-of-state products in grocery stores.

More profit also can be made by working with the local government to have local fruits and veggies resold within Henderson and surrounding counties. There was nothing in high school worse than getting an apple for lunch and seeing that it came from Washington state or Michigan. I believe that if we could work with the local government to offer incentives to local schools, restaurants, and stores, we could create a market for more growers to sell to while giving local businesses more pride in their product.

Yet another area I feel can be improved is the wholesale profit-adding market. Most local growers send their apples out of state for commercial production into items like sliced fruits and ciders. My plan is to work with the Western North Carolina Apple Growers Cooperative — which currently only provides cold storage — to add packing capabilities and equipment to make value-added products so that growers can get top dollar for their crop.

Q: I see parallels in the seafood industry. Some fishermen are pursuing value-added processing, direct-to-consumer sales, farm-to-school programs, and agritourism, such as oyster farm tours. Is there anything else you'd like to add about your ideas for Henderson County?

A: Ultimately, the purpose of my company will be to help growers maintain and, in some cases, grow their presence in the community. There's a sense of sadness for a person who has a passion for agriculture, like I do, watching their community drifting farther and farther away from the very industry that founded this town — and my goal is to prevent that. Smelling those sweet apple blossoms in the spring, watching beautiful apples develop from a small bud, and harvesting a crop you've put a year of work into is something many people will never experience. But to me, it's my life, and I'll do everything in my power to see it continue and thrive so that hopefully one day, when I'm 72 years old, I won't have to say "used to be," but instead that *it is*. 🍏

Aaron Corn is an NC State University agribusiness major and an apple grower.



Courtesy Aaron Corn



Baxter Miller

Oyster growers depend on tradition and innovation to meet consumer demand.

VALUE-ADDED PRODUCTS BENEFIT THE SEAFOOD INDUSTRY, TOO

BY JANE HARRISON

Just as value-added apple products abound, so do opportunities for novel seafood items and marketing. North Carolina's seafood industry can increase its market share by meeting consumer demand for convenient, nutritious, and delicious protein options. From ready-to-eat products like smoked fish dip to heat-and-serve options, such as chowders, seafood can transcend the restaurant setting.

Packaging that highlights product origin is a simple and lucrative value addition. Recent research conducted by North Carolina Sea Grant indicates a preference among North Carolinians for seafood from our state and the U.S. over foreign products. Indeed, local seafood can command a price premium in certain markets. Learn more at go.ncsu.edu/NCSeafoodDemand.

Like the apple industry, the seafood industry faces fragmented and underdeveloped supply chains, an issue explored in a North Carolina Sea Grant report, available at go.ncsu.edu/seafood-supply-chain. Additional processing and cold-storage aggregation facilities are needed to increase capacity to freeze large volumes of seasonal seafood and permit the distribution of local products throughout the year.

Promotion is critical for harvesters to earn a price premium. Ongoing education campaigns by groups including NC Catch, the N.C. Department of Agriculture & Consumer Services, and the NC Oyster Trail also play a key role in connecting consumers to N.C. seafood. Branding like "Got to Be NC Seafood," along with print and social media promotion, builds awareness and reminds consumers about options for N.C. seafood.

For more seafood producer resources, visit go.ncsu.edu/producer-resources.



CRABITAT

Erin Voigt

Juvenile Blue Crab Habitats in Pamlico Sound

BY ERIN VOIGT

Erin Voigt is a Ph.D. candidate at North Carolina State University studying juvenile blue crab habitat use. She initially became interested in marine biology and coastal studies while at St. Mary's College of Maryland, which is located on a tributary of the Chesapeake Bay. She is a Global Change Fellow with the Southeast Climate Adaptation Science Center and a joint fellow with North Carolina Sea Grant and the Albemarle Pamlico National Estuarine Partnership.

IF YOU LIVE ON THE EAST COAST OF THE UNITED STATES OR ENJOY EATING SEAFOOD, YOU MOST LIKELY ARE FAMILIAR WITH THE ATLANTIC BLUE CRAB. This feisty crustacean's scientific name, *Callinectes sapidus*, means "savory beautiful swimmer" and pretty much sums up its reputation. Blue crabs are a favorite delicacy along the Atlantic and Gulf coasts — and are one of the most lucrative fishery species in North Carolina.

However, while many are familiar with the adult blue crab, few know about their strange juvenile stages. Blue crabs, like many marine invertebrates, have what scientists refer to as a complex lifecycle, which means that they go through drastic changes in body shape and location as they age, similar in some ways to a caterpillar turning into a butterfly.

Early Life Stages and Migration

As "zoea" during the first stage of their life cycle, blue crabs are a little larger than the tip of a pencil and look a bit like aliens, with three large spikes protruding from their heads, a huge eye spot, and a shrimp-like tail. Zoea hatch from eggs held on their mother's abdomen, usually at the mouth of an estuary, or, as is the case of the zoea I study, at the inlets that punctuate the Outer Banks. After hatching, these zoea travel east out into the open ocean, where they grow and molt for about a month.

Right before each blue crab journeys back to its home estuary, it changes body shape and becomes a "megalopa." In this stage, juveniles become more crablike, growing small claws and legs, yet retaining the large head spikes and shrimp-like tail. Megalopa ride with the changing wind patterns that mark late summer and early fall west towards the coast. Once back in the estuary, they search for an optimal habitat, before they

*Zoea on a quarter's edge**Megalopa*

then settle and undergo their last transition into an “instar.” At this stage, they resemble a much smaller version of the adult blue crab.

Juvenile Crabs and Choosing a Habitat

Entering back into Pamlico Sound and finding a suitable habitat is difficult due to the unique geography of the sound. Pamlico Sound is a wide and shallow basin, separated from the ocean on its eastern shore by a chain of barrier islands, with only a few narrow inlets allowing limited contact with marine waters. The western shore of the sound is equally distinctive, containing a vast mosaic of marshland, marine forests, and draining freshwater rivers.

This unique geography, while complicating migration, also provides a bounty of different habitat choices. For juvenile blue crabs, this includes three main habitats: dense seagrass beds which dominate the eastern shore of Pamlico Sound; a combination of patchy ephemeral seagrass beds; and the more pervasive shallow marsh-adjacent habitat (known as “shallow detrital habitat” or SDH) that dominates the western shores of Pamlico Sound.

During years with limited direct hurricane impacts, juvenile crabs will enter the sound primarily through both Oregon Inlet and Hatteras Inlet and will settle into the dense seagrass beds. As more crabs settle in these eastern seagrass beds, the population density of crabs gets too high to sustain them, and some will migrate across the sound to other habitats.

In essence, these crabs often use the eastern seagrass beds only as a landing zone before moving on to habitats on the western shore. However, during years with direct tropical storm impacts, the force of stormwater flowing into the sound can propel megalopa from the open ocean, past the eastern habitats, and directly to habitats on the western banks.

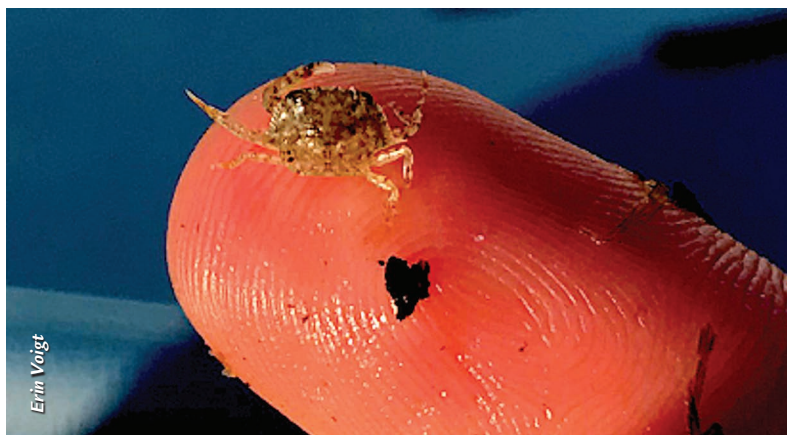
Understanding How Blue Crabs Use Pamlico Sound Habitats

This is where my research comes in. I look to understand how blue crabs use these three habitats. The complex transportation mechanisms of juvenile blue crabs make it difficult to compare the relative contribution of these habitats to the adult blue crab population. However, conservation managers badly need this information, especially with a marked decrease in North Carolina’s blue crab landings since 1999. Evidence suggests that low juvenile crab populations may be partially to blame.

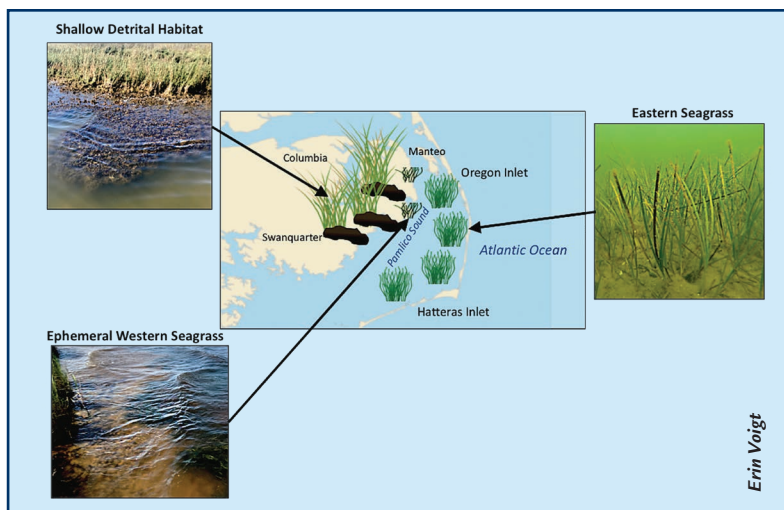
That said, understanding which of these habitats contributes the greatest number of juvenile crabs to the eventual adult population is not as easy as counting crabs. Rather, we need to consider three separate factors: the density of crabs found in each habitat (how many crabs per square meter); how large an area each habitat covers in Pamlico Sound; and how evenly distributed blue crabs are within a given habitat.

When I examined the density of blue crabs in all three habitats over three years, I found that the western seagrass beds had the greatest density of crabs — sometimes double that of the eastern seagrass and western SDH habitats. Eastern seagrass beds had the next highest density, closely followed by the SDH habitat.

Continued



Instar on a fingertip



Three distinct blue crab habitats in coastal N.C. waters



Adult female blue crab, in contrast to the male in the opening photo

Western seagrass beds, while they may have the most crabs per meter, are significantly smaller than the other two habitats. This means when I multiplied the density of crabs by the area of the habitat to get total abundance, I found that while the density was high the total abundance was low — which suggests that western seagrass beds do not contribute significantly to the overall crab population.

On the other hand, eastern seagrass beds are by far the largest, covering orders of magnitude more area than both the western seagrass and SDH beds combined. If I multiplied the density of blue crabs found in the eastern seagrass bed by its area, this habitat would be, by far, the most productive — and I would have answered our question.

I realized, though, that while I had measured blue crab density many times and in many locations within the eastern seagrass beds, most of my locations were located near either Oregon or Hatteras Inlets and would therefore be the closest habitats to all the incoming megalopa.

More Sample Sites and New Directions

When I increased the number of sampling locations for all three of the habitat types, I found that in the eastern seagrass beds the density of blue crab decreased significantly the farther away they were from either Hatteras or Oregon Inlets. While blue crab densities were very high near both inlets, seagrass beds located near Cape Hatteras and far away from the inlets had almost no crabs at all. Even more interesting is that this trend does not hold in the western shore habitats.

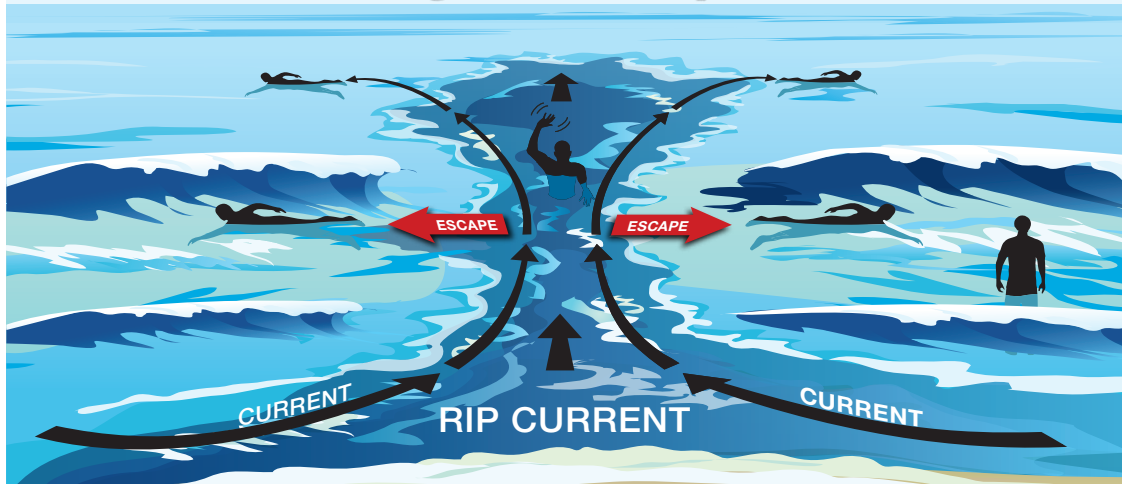
I currently am working on a model to combine the factors of crab density, habitat area, and crab distribution to calculate what proportion of juvenile blue crabs each habitat supports. Our results highlight the need to understand each of these factors before making decisions about the value of different habitats.

Furthermore, the results also support the theory that blue crabs use the eastern habitats as a landing zone, highly populating habitats near the inlet before migrating across the sound to the western habitats, where they spread out. Our study additionally highlights the importance of western habitats of Pamlico Sound in supporting the blue crab population — vital data for the fisheries and conservation managers responsible for helping to ensure and support a long and profitable blue crab fishery in North Carolina. 🦀

Watch a video about Erin Voigt's research: go.ncsu.edu/blue-crabs
 North Carolina Sea Grant's fellowships and other funding opportunities: go.ncsu.edu/sea-grant-funding

RIP CURRENTS

Know your options



Rip currents are powerful currents of water moving away from shore. They can sweep even the strongest swimmer away from shore. If at all possible, swim near a lifeguard.

IF CAUGHT IN A RIP CURRENT

- ◆ Relax, rip currents don't pull you under.
- ◆ Don't swim against the current.
- ◆ Swim out of the current, then to shore.
- ◆ If you can't escape, float or tread water.
- ◆ If you need help, yell or wave for assistance.

SAFETY

- ◆ Know how to swim.
- ◆ Never swim alone.
- ◆ If in doubt, don't go out.
- ◆ Swim near a lifeguard.

More information about rip currents can be found at the following websites:

weather.gov/safety/ripcurrent/
usla.org



RIP CURRENTS: KNOW YOUR OPTIONS

North Carolina Sea Grant joins the National Weather Service, oceanfront communities, and other partners to highlight surf-zone safety throughout the year. Learn more, and find links to order signs and magnets at ncseagrant.ncsu.edu/ripcurrents



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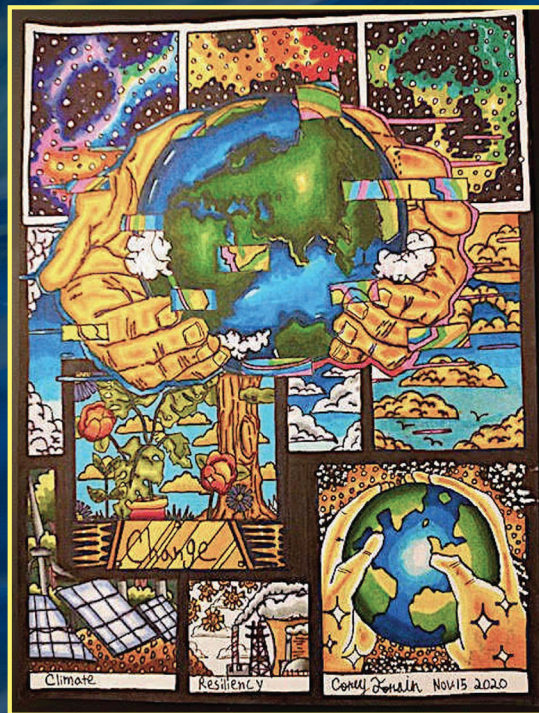
K-12 STUDENTS WIN ART AND POETRY PRIZES

The NC Climate Education Network's first statewide contest received over 150 entries of poetry and art from K-12 students. Earlier this year, organizers chose the best, most creative submissions that answered "What does climate resiliency mean to you?"

North Carolina Sea Grant, the State Climate Office of North Carolina, and the N.C. Department of Environmental Quality have partnered to create the network, which connects educators and researchers to learn about the latest in climate research and information.

Corey Torrain of Browns Summit won first place in drawing at the high school level for his art (shown here). You can see all the winning artwork and poetry at go.ncsu.edu/art-winners.

Browse *Coastwatch* by issue, by subject, and by what's most popular: NCCoastwatch.org



Corey Torrain's winning artwork

Teach

Use free educator resources to enrich student learning.


Access our new supplementary material for educators to dive into *Coastwatch* with students in grades 6 to 12. For more information: go.ncsu.edu/Coastwatch-Classroom


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North Carolina Sea Grant

Your link to research and resources for a healthier coast.