

Coastwatch

NORTH CAROLINA SEA GRANT • AUTUMN • 2022 • ISSUE 3 • \$6.95

WHAT'S SO SPECIAL ABOUT
NORTH CAROLINA'S OYSTERS?
Savoring the N.C. Oyster Trail



Fall 2022: Celebrating Seafood and More

This time of year is made for venturing outdoors to enjoy the nicer weather and to take advantage of the opportunities our coast provides — fishing, hiking, birding, boating, lighthouse exploring, and eating, among many other great pursuits — once the temperatures dip below hot-hot-hot.

For example, you can learn all about North Carolina’s great seafood, *and eat it*, at the NC Seafood Festival in Morehead City from Friday, September 30, to Sunday, October 2 — starting with a popular middle-school event that North Carolina Sea Grant is supporting.

On Friday, from 8:00 a.m. to 2:00 p.m., “NC Seafood SMART!” will provide a *free* field trip on the Morehead City waterfront. Middle schoolers can participate in local seafood-related exhibits from area marine science labs and the fishing community about new research, environmental awareness, and technology. In past years, students have enjoyed boarding a shrimp boat and exploring the gear, among other adventures.

North Carolina Sea Grant also will be exhibiting for Fisherman’s Village, Carteret Catch’s annual event during the festival. On Saturday, October 1, on the lower level of Jack’s Waterfront Bar at 513 Evan’s Street, visitors will find free seafood availability charts, seafood quality charts, *Mariner’s Menu* recipe cards, and much more.

Also, look for the return of StriperHub to the Seafood Festival Chef’s Tent, which is always hopping on Saturday and Sunday. StriperHub is a Sea Grant-supported network that helps fuel the industry-wide cultivation of striped bass. *Coastwatch* covered StriperHub’s work in the Spring 2021 issue: go.ncsu.edu/stripes.

You’ll also find our team at the Outer Banks Seafood Festival in Nags Head on October 15. The Nags Head festivities will honor and celebrate our coastal seafood heritage and community — and feature live



Susan White

bands and entertainment all day.

That same week, our state will be “shellebrating” a beloved shellfish. NC Oyster Week runs October 10 to 16. In fact, North Carolina Sea Grant — with the N.C. Department of Natural and Cultural Resources, NC Oyster Trail, and the NC Coastal Federation — offers an entire month of oyster facts, resources, and programming during October. Check your favorite social media for #NCOysterMonth.

If you’re interested in learning more about our state’s shellfish farming, and eating oysters while you learn, you can do so year-round and at your own pace on the NC Oyster Trail. To get started on the journey, enjoy “Savoring the NC Oyster Trail” on page 6.

Speaking of seafood, researchers from UNC Wilmington are expanding opportunities for cultivating tasty black sea bass, and our story about it in this issue includes a great recipe (page 42). There are many more recipes to explore, too, as you bring the taste of our coast to your own kitchen. Each issue of *Coastwatch* features samples from *Mariner’s Menu*, our popular seafood guide — which includes tips about how to make seafood an everyday, healthy meal. Visit MarinersMenu.org.

This fall also marks the return of the North Carolina Coastal Conference, and registration is now open. Please join us November 7 and 8, online or in person at NC State in Raleigh, for a wide array of presentations and panel discussions highlighting coastal science and community perspectives. There even will be an option to enjoy local, farm-raised striped bass for lunch. Visit go.ncsu.edu/Coastal-Conference.

Enjoy your outdoor adventures this fall — and if you have suggestions for the Coastal Conference, or any other input, please email me at snwhite3@ncsu.edu.

— Susan White, Executive Director, North Carolina Sea Grant

IN THIS ISSUE

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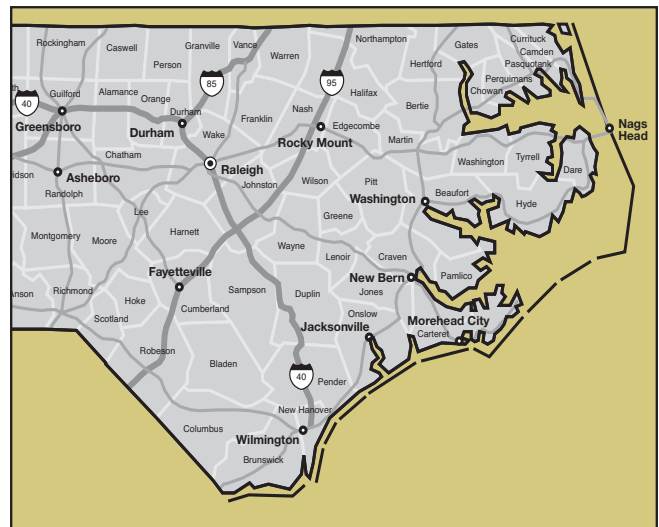
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The Autumn 2022 issue of Coastwatch covers too many locations to note, including three river basins — as well as numerous places up and down the coast and as far west as the town of Cashiers on the NC Oyster Trail.





Coastwatch

FEATURES

COASTAL CURRENTS2

WHAT'S SO SPECIAL ABOUT NORTH CAROLINA'S OYSTERS?

Savoring the NC Oyster Trail

Farms, tastes, and tales — now foodies and adventurers can explore the magic of the North Carolina oyster.6

IS THERE A FUTURE FOR OYSTER RELAYING IN NORTH CAROLINA?

For years, oyster farmers in our state have reported greater numbers of healthy oysters in areas that they harvest.14

TROUBLED WATERS

Flooding, Contaminants, and Heightened Risks

Underserved communities disproportionately experience the adverse effects of flooding and poor water quality. Why is this?22

NATURAL SOLUTIONS AND A CLEAN WATER FUTURE FOR THE CAPE FEAR

A new project looks at wooded buffers to reduce pollution.30

HOOK, LINE & SCIENCE

Hurricanes, Blue Marlin, and Radiation

One blue marlin travelled 1,273 miles — over 15 miles per day.36

ECOFRIENDLY SOLUTIONS

Social Media for Sharks

Can *YouTube* help conserve misunderstood wildlife?39

HEALTHY HABITATS

How Do Restored Oyster Reefs Compare to Live Oyster Reefs?

Restored oyster reefs become more similar to live reefs over time.40

CLIMATE RESILIENCE

NC's State-of-the-Art Warning System Strengthens Flood Planning

NC's new flood-warning system includes 400 river and stream gauges.41

CULTIVATING THE SEA

Is There a Profitable Market for Farm-Fresh Black Sea Bass?

Thanks to breakthroughs from a team at UNCW, this seafood favorite could reach many more consumers.42

MARINER'S MENU

Oysters Casino, Snapper Fillets, Stuffed Clams, and More

These treats are the tip of the iceberg from *MarinersMenu.org*.44

❑ *Front Cover: on the NC Oyster Trail, courtesy of Justin Kase Conder.*

❑ *Table of Contents: courtesy of Nick Funnell.*

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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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CURRENTS



This year's NC STEM Policy Fellows (left to right): Joshua Reding, Anastasia Dulskiy, Nitesh Kasera, Maya Hoon, Aditya Keskar, and Rachel Johnson.

NC STEM POLICY FELLOWS BEGIN STATE ASSIGNMENTS

Six STEM Policy Fellows recently began service in North Carolina state government. The year-long assignments provide graduate students with opportunities to explore careers outside academia.

"We look forward to highlighting the successes of these new fellows as they work to tackle key science policy issues across the state," says Susan White, North Carolina Sea Grant's executive director.

- **Anastasia Dulskiy**, a master's student at the University of North Carolina at Chapel Hill, studies the microbial ecology of corals. She is serving the North Carolina Office of Recovery and Resiliency.

"I look forward to applying my skills as an ecologist to the field of environmental policy, helping to support more resilient coastal communities here in North Carolina," says Dulskiy.

- **Maya Hoon** serves with the N.C. Department of Transportation. Hoon, a former joint fellow with North Carolina Sea Grant and the NC Water Resources Research Institute, earned her master's in environmental sciences and engineering from UNC-Chapel Hill, where she worked with the NC Environmental Justice Network.

"I am incredibly grateful and excited that I will get to join the NCDOT team in tackling today's complex and daunting climate change issues and ensure equitable changes for all N.C. communities," Hoon says.

- **Rachel Johnson**, a doctoral candidate at UNC-Chapel Hill, studies antibiotic activity and resistance. She serves in the North Carolina Department of Environmental

Quality's State Energy Office.

"I am looking forward to learning more about North Carolina's green energy initiatives and finding ways to assure equity in our state's energy structure," says Johnson.

- **Nitesh Kasera**, a doctoral candidate at NC State University, studies the conversion of agricultural wastes into high-performance adsorbents.

"I am excited to join NC Biotechnology Center as a STEM Policy Fellow and look forward to learning about how public policies, scientific research, and industrial endeavors are coming together in developing North Carolina's biotech economy," Kasera says.

- **Aditya Keskar**, a doctoral candidate at NC State, is lead student researcher on a project investigating various short-term and long-term impacts on energy efficiency measures.

Keskar is serving the State Energy Office and hopes to tackle "the pressing energy transition challenges of our time."

- **Joshua Reding**, a doctoral candidate at UNC-Chapel Hill, studies white dwarf stars. He serves the N.C. Department of Commerce's Office of Science, Technology, and Innovation.

"I look forward to supporting and promoting the great innovators of North Carolina as a STEM Policy Fellow," Reding says.

North Carolina Sea Grant administers the NC STEM Policy Fellowships, with a generous matching grant from the Burroughs Wellcome Fund and support from the host offices.

— Carrie Clower

- **NC STEM Policy Fellowships:**
go.ncsu.edu/stem-fellows



Madison Lytle

COASTAL RESEARCH FELLOWS STUDY SEAGRASS AND DREDGE PLUMES

North Carolina Sea Grant and the N.C. Coastal Reserve and National Estuarine Research Reserve have awarded Coastal Research Fellowships to Madison Lytle and Andrew McMains.

“Support for these fellowships allows us to address important site management topics facing North Carolina’s coast,” says Rebecca Ellin, program manager of the Coastal Reserve.

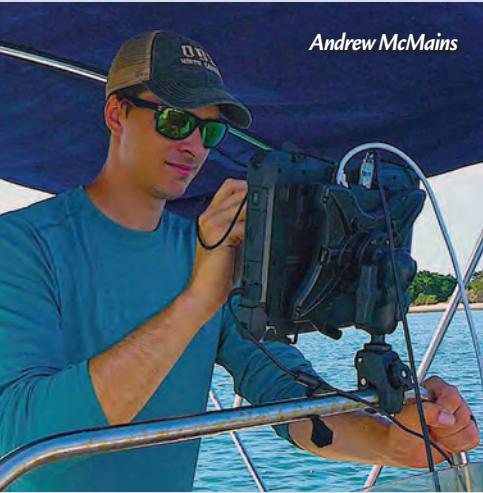
Madison Lytle, a doctoral student in integrative, comparative, and marine biology at the University of North Carolina Wilmington, will research how water clarity affects *Halodule wrightii* — a light-dependent type of seagrass. This declining species plays an important role in aquatic ecosystems.

“Seagrass is a critical habitat for a multitude of species in our estuarine systems,” says John Fear, North Carolina Sea Grant’s deputy director. “Understanding the factors impacting its ability to thrive is vitally important.”

Andrew McMains, a doctoral student in East Carolina University’s program in biology, biomedicine, and chemistry, will record the numbers and types of fish found in an inlet and an estuarine channel, with a focus on how they respond to dredge plumes.

“Studies like this,” Fear says, “could help identify better management strategies, enhancing our ability to maintain critical channels as well as our natural fisheries resources.” — *Carrie Clower*

- Coastal Research Fellowship: go.ncsu.edu/CRF



Andrew McMains

NC FISH FORUM MARKS THREE YEARS OF COLLABORATION

In 2019, the University of North Carolina at Chapel Hill, Duke University, and North Carolina State University organized the NC Fish Forum to help people understand what fish are safe to eat and in what quantities. The partnership continues to reveal new insights about contaminants in fish, increase collaboration between health departments and researchers, inform more health-protective advisories, and communicate risks.

For many people, fishing is a source of affordable food, but some types of fish can contain potentially harmful contaminants. Findings from the forum have highlighted key challenges, including limited awareness of advisories and lack of collaboration between health departments and researchers.

- more: go.ncsu.edu/fish-forum

To increase awareness about advisories, the researchers developed outreach materials about safely catching and preparing fish. Collaborators also are creating resources on how to collect fish samples that health departments can use to inform new advisories and how to confidently communicate health risks to affected populations.

In addition, research from Duke University on the Cape Fear River informed a state regulator’s decision to update consumption advisories for several species and locations along the river.

The National Institute of Environmental Health Sciences Superfund Research Program funds the project. — *Mali Velasco*



DAN DINICOLA JOINS SEA GRANT

After a national search, North Carolina Sea Grant welcomed Dan DiNicola aboard in July as science writer and digital content producer, a role that includes serving as science editor for *Coastwatch*. DiNicola began his career in marine policy and species conservation before transitioning to science communication, with an emphasis on visual storytelling.

“I am passionate about being in the field and making complex topics resonate with audiences,” says DiNicola, who comes to North Carolina by way of the Pacific Northwest, where he was the communications manager for the University of Washington School of Aquatic and Fishery Sciences and for the marine biology program for four years.

In that role, he transformed communications for one of the nation’s preeminent fisheries institutions, while also ushering in a new era of marine science at the university by developing recruitment strategies for its nascent undergraduate marine biology program.

Prior to his time at the University of Washington, he was the communications specialist at the University of Miami for RECOVER, which investigated the impacts of the 2010 Deepwater Horizon oil spill.

“We are pleased to have Dan bring his skills and expertise to our team,” says Susan White, North Carolina Sea Grant’s executive director.

- Dan DiNicola
go.ncsu.edu/Dan-D



NC's JOHNNA BROOKS NETS NATIONAL FELLOWSHIP

Johnna Brooks of North Carolina State University has received a joint fellowship with the 2022 National Marine Fisheries Service and Sea Grant.

“Through the NMFS-Sea Grant Fellowship Program, this year’s class of talented fellows will advance their scientific and technical skills while informing current sustainable fisheries and environmental management challenges,” said Jonathan Pennock, director of the National Sea Grant College Program.

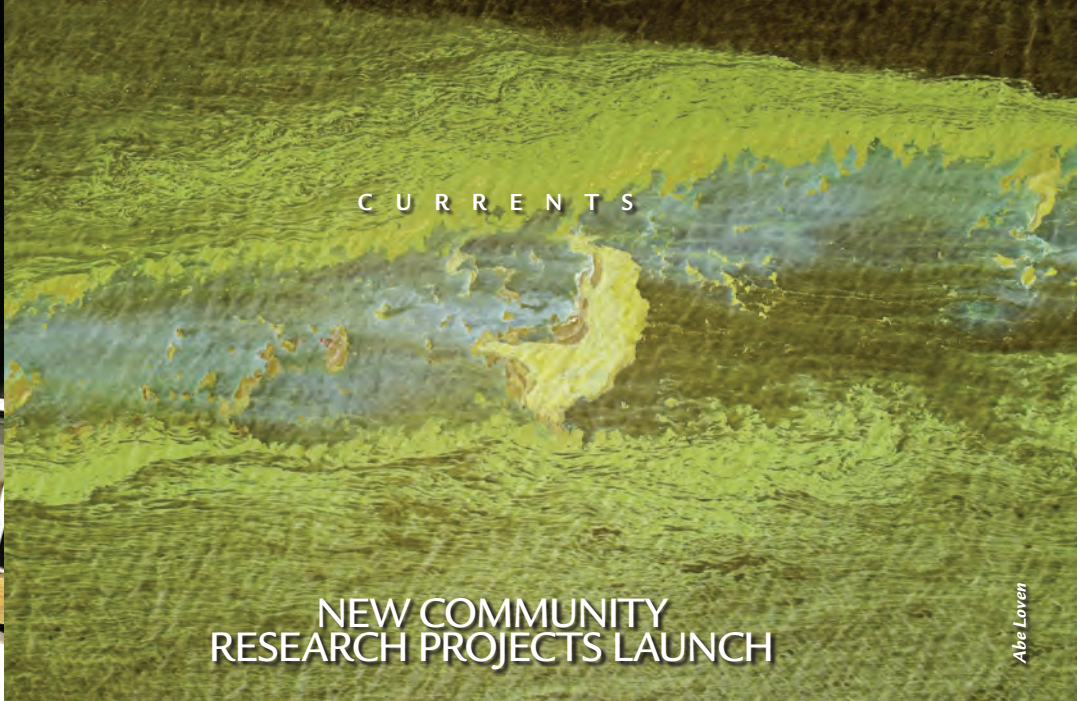
Since 1999, the NMFS-Sea Grant Joint Fellowship program has trained the next generation of specialized experts in fisheries management. The program addresses the critical need for future fisheries scientists by supporting students pursuing doctoral degrees in related fields.

Brooks is one of seven fellows in “population and ecosystem dynamics,” a field vital to high quality fishery stock assessments. She will serve at the Southeast Fisheries Science Center, looking at the development of a seasonal size-structured, tag-integrated, stock assessment model of estuarine fish.

NC State applied ecologists Jeffrey A. Buckel and Jie Cao will provide guidance as faculty advisors, and Kyle Shertzler, the center’s stock assessment team leader, will serve as the NOAA mentor for Brooks.

In addition to NC State, this year’s fellows attend universities in Alaska, California, Florida, Michigan, Massachusetts, New York, and Washington.

- **NMFS-Sea Grant Fellowship:**
go.ncsu.edu/NMFS-SeaGrant



NEW COMMUNITY RESEARCH PROJECTS LAUNCH

A study of how algal blooms affect air and water quality in northeastern N.C. is one of four new Community Collaborative Research Grants. Projects also will evaluate soil and water in Waccamaw Siouan communities, address plastics in western North Carolina headwaters, and train high schoolers on water research in Mecklenburg County.

Four new projects are launching this year as part of the Community Collaborative Research Grant Program (CCRG). Projects will support youth education, tribal knowledge, air and water quality, and an exploration of plastic contaminants in headwaters.

North Carolina Sea Grant and the N.C. Water Resources Research Institute (WRI) administer the CCRG Program in partnership with the William R. Kenan Jr. Institute for Engineering, Technology, and Science (KIETS).

“The CCRG program continues statewide engagement with this latest round of projects,” says John Fear, deputy director of North Carolina Sea Grant and WRI. “The ongoing focus on local needs and use of local knowledge sets up these projects for success.”

KIETS associate director Raj Narayan says the CCRG Program provides researchers and community leaders with opportunities to work together to address compelling topics and challenges.

“The new projects continue to focus on issues of importance across our state,” Narayan says. “From the mountains to the coast.”

Jerry Miller of Western Carolina University and Eric Romanisyn of Haywood Waterways Association will study plastic particles in small headwater basins of the Southern Appalachians. The project will provide hands-on learning experiences for high school students and community members, demonstrating the significance of plastic

contamination and the need for sound management.

In Mecklenburg County, Olya Keen of the University of North Carolina at Charlotte and Ebone Lockett of Harvesting Humanity LLC will recruit high school students for hands-on research that includes elements of laboratory research and field sampling. The students will discover, explore, and work to mitigate issues related to water cycling throughout homes, schools, businesses, and neighborhoods.

In the southeastern part of the state, Ashley Patrick Lomboy, Waccamaw Siouan Tribe member and founder of Waccamaw Siouan STEM Studio, and Eric Britt Moore of the University of North Carolina Wilmington will combine academic and Traditional Ecological Knowledge practices to evaluate soil and water health in Waccamaw Siouan communities. With data from the project, the Tribe can assess soil and water contamination.

In northeastern N.C., Hans Paerl of the University of North Carolina at Chapel Hill’s Institute of Marine Sciences and Colleen Karl of the Chowan Edenton Environmental Group will work with multiple communities to investigate associations between harmful algal blooms and air and water quality. Findings will benefit local high-school science classrooms, the Albemarle Regional Health Services system, state agencies, academic institutions, and the general public.

— Lauren D. Pharr

- **Community Collaborative Research Grants:**
go.ncsu.edu/CCRG



REGISTER NOW FOR THE NC COASTAL CONFERENCE

Registration for the 2022 North Carolina Coastal Conference is now open. On November 7 and 8, the hybrid conference will take place online and in person at NC State University in Raleigh.

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

The event will offer presentations on a range of current issues relevant to our coast and the watersheds that feed our estuaries and ocean. Topics will focus on research and outreach, across disciplines that include STEM fields, arts, education, and the humanities.

- [read more and register: go.ncsu.edu/coastal-conference](https://go.ncsu.edu/coastal-conference)



COASTWATCH SWEEPS NC SCIENCE JOURNALISM AWARDS

The Science Communicators of North Carolina have awarded all three of the organization’s top 2022 honors for journalism to *Coastwatch* cover stories.

Lauren D. Pharr took third place for “Wings of Change: The Impacts of a Warming Climate on Birds of North Carolina.” Pharr is a contributing editor for *Coastwatch*, a Ph.D. student at NC State University, and a former Global Change Fellow with the Southeast Climate Adaptation Science Center.

“Lauren’s expertise as an avian ecologist radiates through ‘Wings of Change,’” says *Coastwatch* editor Dave Shaw. “Her writing makes it an elite story.”

Julie Leibach, former science editor of *Coastwatch*, split first place honors with Shaw for the year’s best science journalism. Leibach’s “Model Behavior” describes how researchers draw on lifeguard expertise — and artificial intelligence — to improve rip current forecasting.

“Julie’s articles never fall below exceptional,” says Shaw, adding that during Leibach’s four-year stint with *Coastwatch*, her features picked up seven honors and awards.

Shaw’s own “Magic at 64.4 Degrees” tells how diligence and expertise contributed to a breakthrough that positioned farmed striped bass for commercial success — and how the scientists behind the innovation also credited another key ingredient: luck. According to one judge, the story “went way beyond this particular result and made it into a piece about science as a whole.”

- ncCoastwatch.org



Allie Best

SEA-SPACE FELLOWS STUDY SPARROWS AND PRESCRIBED BURNS

North Carolina Sea Grant and NC Space Grant have awarded joint graduate research fellowships to **Allie Best** of the University of North Carolina Wilmington and **Nicholas Corak** of Wake Forest University.

The fellowships support graduate students studying high-priority needs within North Carolina watersheds, coastal areas, and nearshore environments. Their research projects can make use of data from NOAA and NASA’s vast archives, as well as the agencies’ remote-sensing data.

“Technological innovations have expanded how researchers can study our state’s coastal region,” says Susan White, executive director of North Carolina Sea Grant and NC Space Grant. “And this partnership has expanded the scope of research topics and techniques for students with interests in coastal issues, aerospace, or both.”

Allie Best will model specific habitat needs of the wintering swamp sparrow, a species almost exclusively restricted to brackish marshes along the Atlantic coast — areas that are experiencing sea level rise. Her work will help inform conservation goals and management strategies for the species.

Through partnerships with coastal agencies, including The Nature Conservancy and the Audubon Society, Nick Corak will identify coastal study sites where prescribed burns occur regularly using satellite remote sensing from NASA and on-site measurements

— Katie Mosher & Lauren Pharr



Nicholas Corak

- [Sea-Space Fellowships: go.ncsu.edu/sea-space-fellowship](https://go.ncsu.edu/sea-space-fellowship)

WHAT'S SO SPECIAL ABOUT



NORTH CAROLINA'S OYSTERS?

Savoring the NC Oyster Trail

BY MICHAELA ABRAHAM





Katherine McGlade,
Slash Creek Oyster Farm.

OYSTERS

once were as popular as the fast-food burger is today. Since the late-1880's, people have collected, consumed, and enjoyed oysters up and down the East Coast.

In North Carolina, the eastern or American oyster (*Crassostrea virginica*) lives in waters stretching the southern end of the Albemarle Sound to the sounds and estuaries bordering South Carolina. North Carolina is the only state that harbors both deep water reefs in the Pamlico Sound and low-depth reefs in intertidal waters, as well as reefs that run alongside the shorelines of our marshes.

WHERE HAVE ALL THE OYSTERS GONE?

People have harvested wild oysters off the coasts of North America for over 3,000 years.

Around 85% of oyster reefs worldwide have been demolished as a result of overexploitation. North Carolina's original oyster stocks have now been reduced by approximately 95%, according to the North Carolina Coastal Federation.

Due to historic overharvesting and other environmental stressors, the North Carolina Division of Marine Fisheries

(NCDMF) considers the eastern oyster to be a species of concern. Since 2020, 22 million bushels of cultch material — such as oyster shells and limestone marl — have been planted in order to create new oyster habitat, part of a century-long endeavor in the state.

CONSERVING A SPECIES AND BOOSTING AN INDUSTRY

The state's Oyster Steering Committee is a non-regulatory board comprised of researchers, restoration specialists, coastal managers, permit officers, oyster growers, and educators. The committee has been responsible for leading revisions for the ongoing *NC Oyster Blueprint Plan*, which has expanded and built upon the state's *Fishery Management Plan for Oysters*, the work of the Division of Water Resources' Basin Planning Branch, and the *North Carolina Strategic Plan for Mariculture*.

With the expertise of partners like North Carolina Coastal Federation, North Carolina Sea Grant, and federal and state agencies, the *Blueprint* recommends strategies to ensure that N.C oysters can foster a productive coastal ecosystem and thriving oyster fishery and aquaculture industry.

In addition to the *Blueprint*, the *North Carolina Strategic Plan on Shellfish Mariculture* presented recommendations in 2018 to sustainably grow the state's shellfish mariculture industry by supporting local shellfish growers. This plan set 2030 targets for the shellfish industry that included \$100 million in value, \$33 million in landings, and generating 1,000 new jobs.

North Carolina's aquaculture industry also received national recognition by becoming the first state in the southeast to join NOAA's National Shellfish Initiative. Shellfish farming has the potential to reduce pressures on wild oyster harvests and provide a consistent seafood source. A collaborative North Carolina Sea Grant project determined that in 2019 shellfish landings in the state generated over \$27 million and provided 500+ jobs, with more than half of this economic impact coming from farmed oysters.

Restoring and protecting oyster populations — and growing enough oysters to meet market demand —

requires thriving businesses, increased environmental stewardship, and awareness of our coastal resources. Not surprisingly, recommendations in the *Strategic Plan for Shellfish Mariculture* included a "North Carolina Oyster Trail."

THE NC OYSTER TRAIL

From craft beer to barbeque, culinary and beverage trails feature regional delicacies and provide opportunities for visitors to connect with local food producers. From its launch in 2020, the NC Oyster Trail has covered the state's entire coast. North Carolina Sea Grant and North Carolina Coastal Federation administer the NC Oyster Trail, in partnership with the NC Shellfish Growers Association, to "provide experiences that help sustain and grow N.C. oysters, resulting in economic, environmental, and social benefits to the state's seafood industry and coastal communities."

The Trail includes over 75 members across the state that

Continued

Oysters Carolina offers tours of their Carteret County farm.



offer a wide variety of shellfish tourism experiences. Along the Trail, you can find seafood restaurants and markets, shellfish farm tours, recreational and educational activities, and special events highlighting N.C. oysters. “The Oyster Trail has been essential in connecting travelers, foodies, and outdoor adventure lovers to the magic of the North Carolina oyster,” says Jane Harrison, coastal economics specialist for North Carolina Sea Grant and lead coordinator of the Trail.

NCOysterTrail.org displays an interactive map of where to eat local oysters or tour a shellfish farm. There are also several educational programs and volunteer opportunities to learn more about the eastern oyster’s importance to North Carolina’s coastal environment.

Here’s a sampling of just a few of the places to taste and learn more about our state’s unique oysters.

TOUR A WORKING SHELLFISH FARM

Do you know where your seafood comes from? Hop on a boat and learn how we grow oysters in North Carolina. Smell that salt breeze and slurp down some of the most sustainable seafood on the planet.

Slash Creek Oyster Farm (Hatteras Island)

Katherine McGlade and husband Spurgeon Stowe’s Slash Creek Oyster Farm provides tours of their operation that are an hour and a half, beginning at the dock at Slash Creek Oyster House. Visitors learn about the equipment and their processes for growing oysters, then take the oyster boat (“The Half Shell”) for a 10-minute ride to their lease to see the different stages of oyster growth.

Roysters NC (Beaufort)

Roysters NC is a family-owned and operated oyster farm in Carteret County’s North River. Visitors can schedule a boat tour to visit a cluster of four shellfish farms in and around North River and Wards Creek, and bring-your-own-kayak tours also are available upon request. These excursions provide opportunities to explore the waters — and what grows in them — between Beaufort and Harkers Island.

Middle Sound Mariculture (Hampstead)

Middle Sound Mariculture grows oysters in Masonboro, Stump, and Topsail Sounds. Known for their salty, buttery, rich “Masonboro Pearls” — named after the farmer’s daughter, Pearl — Middle Sound Mariculture offers farm tours via Epic Excursions NC and sells oysters directly to visitors.

A delicacy at Wrightsville Beach Brewery.





Middle Sound Mariculture, known for its salty, buttery “Masonboro Pearls.”

SAVOR THE COAST’S DISTINCT FLAVORS AT MARKETS AND RESTAURANTS

Our state’s oysters are available at a variety of markets and restaurants on the coast and inland, including these places on the NC Oyster Trail.

Locals Seafood (Durham and Raleigh)

Locals Seafood, a restaurant and fish market in Durham Food Hall and a soon-to-open establishment in east Raleigh, serves North Carolina oysters year-round, alongside a menu of cooked seafood dishes and a full bar. They have several seafood markets throughout the Triangle.

Native Prime Provisions (Cashiers)

Native Prime Provisions occupies the westernmost point on the NC Oyster Trail. They have a nine-seat chef tasting counter where they serve lunch and dinner, and they carry oysters from Sticky Bottom, Slash Creek, and Ocracoke Mariculture.

Seaview Crab Company (Locations in the Wilmington area and inland)

Seaview Crab Company Kitchen & Deli’s seafood is fresh, hot, and affordable. Executive chef Brandon Stark prepares dishes with seafood from their market, and customers can order food to go or enjoy it at their outdoor seating area. Nationwide shipping is also available for all their retail products, including fresh seafood.

Oysters Carolina (New Bern)

Oysters Carolina offers farm-to-table, same-day delivery anywhere in North Carolina for free. Their award-winning oysters are consistently rated among the saltiest in the country. Although oyster farming is notoriously demanding, Oysters Carolina eschews mechanical devices; they use arm strength to lift hefty oyster cages. They also offer farm tours at their Carteret County location on request.

Wrightsville Beach Brewery (Wilmington)

Wrightsville Beach Brewery serves N.C. oysters from within 60 miles, whenever possible. They have special wine pairing recommendations based on the dish and the type of oyster. Menu items include po’ boy pizza with sauteed oysters, fried oysters over kimchi-spiced N.C. collards, and fried oyster po’ boys.

Ocracoke Oyster Company (Ocracoke)

Ocracoke Oyster Company serves fresh Ocracoke Island Devil Shoals oysters harvested daily. They offer many varieties of baked and raw oysters, as well as fried, and oyster stout beer is available on tap.

Parley’s Sip & Steam (Washington)

Parley’s Sip & Steam offers a wide variety of prepared oysters: raw, steamed, or their house specialty oysters. Oysters Rockefeller, Parley Den oysters, and No Quarter oysters are just some of the locals’ favorites. Customers can eat their N.C. seafood with live music each weekend, as well as paired spirit tastings and charcuterie boards. *Continued*

Where the “oyster stout” beer flows:
Ocracoke Oyster Company.



Saltbox Seafood Joint (Durham)

James Beard Award-winning chef Ricky Moore draws inspiration at Saltbox from classic American fish camps and waterside seafood shacks, with an emphasis on N.C. seafood. At his counter-service restaurant, the fish and shellfish options vary daily. A handwritten menu on a chalkboard tells of the day’s offerings.

DISCOVER LOCAL OYSTER LORE AND ADVENTURE

North Carolina oysters are available year-round. Wild oyster season begins October 15, but farmed oysters make it possible to enjoy oysters anytime. Here’s how to support a healthy coast and the livelihoods of our state’s watermen and women.

North Carolina Coastal Federation (Newport, Wanchese, Wrightsville Beach)

North Carolina Coastal Federation is a member-supported nonprofit organization focused on protecting and restoring North Carolina’s coastal waters. Their coastal locations provide opportunities to learn more about their living shoreline, water quality, and oyster restoration efforts, as well as opportunities to volunteer or become a Coastal Federation member.

North Carolina Estuarium (Washington)

The North Carolina Estuarium is an environmental education center located in Washington, a soundside community with a deep maritime heritage. The Estuarium provides extensive information about the importance of our state’s estuarine ecosystems and why we should protect them, including exhibits about the state’s oysters and oyster fishery.

Science by the Sea (Beaufort)

Science by the Sea provides eco-adventures with a choice of three modes of transportation: kayak, stand-up paddleboard, and a flat-bottomed bateau cruise. Tours depart from the historic Beaufort waterfront and visit the four islands in the Rachel Carson Reserve. Visitors can observe diverse habitats and estuarine creatures, including oysters, that dwell in these waters.

SHELLEBRATE: NORTH CAROLINA OYSTER WEEK

Join the NC Oyster Trail October 10 to 16 to “shellebrate” the history, culture, economy, and ecology of oysters in our state.

Last year, Governor Roy Cooper officially declared North Carolina Oyster Week in a statewide proclamation.

Eighteen in-person and virtual events for the public provided opportunities to engage with oyster growers and harvesters, seafood restaurants, seafood retail markets, recreational outfitters, coastal conservation and education organizations, and seafood festivals.

Again this year, throughout October, a wide range of different events and programs will continue the shellebration. Visit NCOysterTrail.org for the complete list of festivities, more places to see on the Trail, and other resources. Follow the NC Oyster Trail on Facebook and Instagram. 📱

Michaela Abraham is a North Carolina Sea Grant community engaged intern who studies fisheries, wildlife, and conservation biology at NC State University.

read more

The NC Oyster Trail
• NCOysterTrail.org

“Is There a Future for Oyster Relaying in North Carolina?”

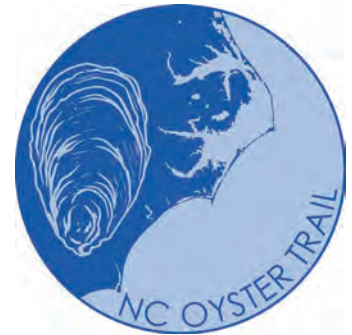
• [pp. 14-21 in this issue of Coastwatch](#)

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North Carolina Estuarium, an environmental education center in Washington.



Nick Fumell

BY NICK FUNNELL

Is There a Future for Oyster Relaying in North Carolina?

For years, oyster farmers in our state have been telling researchers that they have seen greater numbers of healthy oysters in areas they harvest than in those they leave alone.

Relaying oysters: Perry Bayer (left) and son Christian (right) of My Lord Honey Seafood in Beaufort. The duo worked through roughly 15 bushels in 15 minutes, sorting onsite, ultimately removing about 2 bushels from the designated sampling area.







Nick Funnell

Farmed oysters (left) are available year-round. But from early April to mid-May in North Carolina, several areas that are usually closed to harvest are opened — under heavy restrictions — and farmers are allowed to transport oysters to active leases, a process known as “relaying.” Above, Institute for Marine Sciences technician Creed Branham measures water temperature in a “No Relay” box.

Nick Funnell is a graduate student in environment, ecology, and energy at the University of North Carolina at Chapel Hill. With Joel Fodrie, estuarine and fisheries ecologist at the UNC-CH Institute for Marine Sciences, Stevenson Weeks of Crab Point Seafood, and recent UNC-CH graduate student Zofia Anchondo, Funnell worked on a Community Collaborative Research Grant project to determine the ecological impacts of shellfish relays in North Carolina.

For North Carolina oyster farmers, periodic closures mean that the summer season can generate less revenue than that of their counterparts in northern states, who enjoy cooler water temperatures throughout the year. Warmer summer weather, combined with storm-induced freshwater pulses, provides a perfect environment for bacterial growth in N.C.’s many estuaries. Out of an abundance of caution for consumer health, the sale of local oysters is occasionally halted during periods of heat and rain to prevent the possibility of shellfish poisoning. Consumers can breathe easy, though, because oyster health is meticulously monitored.

Once the summer thunderstorms quiet and the temperatures drop, N.C. oyster farmers kick into high gear to make up for lost time

and money. In addition to the normal activities of product distribution and lease upkeep, fall and winter are also the seasons for wild harvest. Permitted shellfishers of any experience level may remove oysters from open public waters between October and March (within the rules, of course). Some of these folks are doing so recreationally, removing a bushel or two here and there for a neighborhood oyster roast.

The entrepreneurial oyster farmer, however, sees this season as a prime opportunity to add future profits to a farm at no cost beyond labor. The more days spent harvesting wild oysters, the more oysters added to a farm. Wild harvest can be quite competitive for those involved, who often guard the locations of their favorite reefs with careful secrecy.

Continued



Baxter Miller

These farmers also know the value of local sustainability. They want to remove enough oysters to warrant the trip, while ensuring their secret spot remains a productive reef for years to come.

Relaying Season

When the calendar flips to April, however, the rules change. Open access wild harvest ends. Spring rains begin. Leases are closed for business when freshwater pulses arrive. For some shellfishers, this period can finally be a time to relax after a hard winter of constant harvest and sales. For others, an opportunity to procure additional wild oysters arises.

From early April to mid-May, several previously closed areas throughout eastern North Carolina are opened for harvest — under heavy restrictions. The process of harvesting oysters from usually closed areas and transporting them to active leases is known as relaying. Because temporarily accessible areas are restricted due to consistently high pollution levels, relaying requires farmers to close their own leases for four to six weeks to allow ample time for the oysters to clean themselves before sale to the public.

In early March, the N.C. Department of Marine Fisheries announces the opening of the relaying permit application and determines which closed areas will be open for business. People who successfully apply may then harvest during set windows of time (typically one or two days a week for six weeks) under careful supervision from N.C. Marine Patrol.

Disturbance Theory

Within the shellfishing community, relaying is a highly controversial practice. The argument is fundamentally environmental. Critics say that the removal of oysters — which have prodigious filtering abilities — from polluted areas will further degrade areas with already poor water quality. Proponents argue that the removal of oysters actually promotes further reef growth and becomes a net environmental benefit.

One shellfisher told me a reef he and a few

others had “completely flattened” just one year earlier yielded the largest legal-sized oyster haul they had ever experienced. The story grabbed my attention. The typical growth rate of oysters is generally considered to be about 1 inch per year. If the recovery of this reef was indeed what he claimed, these oysters would have roughly tripled the standard growth rate.

The central mechanism of this shellfisher’s account is well-established in ecology. He was describing disturbance theory — the idea that disruptions (either physical or biological) play a prominent role in ecosystem structure. This is closely tied to the theory of succession, which includes the classic example of the subsequent diversity bloom that can occur after periodic fires.

In disturbance theory, too many fires would lead to a non-diverse population of hearty grasses; too few fires would create an old growth forest with no understory. The happy medium is occasional fire activity, which would feature periods of high plant diversity as succession marches along before fire interrupts. This pattern of occasional interruption is known as intermediate disturbance.

If you are a farmer or gardener, you are an expert in disturbance theory. Your choice of when to prune, harvest, and mow all constitute carefully timed disturbances. Plow just before harvest: no bounty. Leave a species alone indefinitely: it grows wild. Well-disturbed is well-maintained.

For years, local oyster farmers in Carteret County have been telling researchers that they have seen greater numbers of healthy oysters in areas that they harvest than those that they leave alone.

We put these observations to the test. Using the expertise of these local oyster farmers, our resources at UNC-CH, and funding from North Carolina Sea Grant, we investigated several ecological factors associated with relaying. In neighboring areas where relaying occurred and did not occur, we measured oyster populations, their predators, health, and ability to remove nutrients to determine the impacts of relaying and non-relaying. *Continued*

Is oyster relaying a dying practice — or a way to bolster the state’s oyster production?



Nick Emmell



HC C1
5/20



Joey Reustle

As of the one-year mark post-relay, oyster abundances in relayed areas have not yet recovered to pre-harvest levels. Despite the lack of recovery, the overall reduction in oysters from relaying appears to be relatively minor, as relayed areas still have very high numbers of oysters by ecological standards. Some experts consider the threshold of a healthy reef to be 10 oysters per square meter; our relayed reefs already exceed that — with an average of over 600 oysters per square meter.

We will be revisiting these sites once again in the fall and possibly beyond to track long-term recovery trajectory, as knowing the full recovery time of any given area is paramount for harvesters and regulators alike.

Is Relaying a Dying Practice?

Although shellfish relaying of some sort occurs in every state on the East Coast, oyster relaying in North Carolina might be a dying practice.

Wild harvest of oysters is hard work. I can

personally attest to its challenges after asking some of the local farmers to teach me their techniques. Wild harvest is also old school. The classic oyster farm is essentially a natural reef, carefully managed by the lease holder. The farmer builds a bottom reef through wild harvest and relaying, letting it grow year after year.

The popularity of these bottom reef leases, however, is waning in favor of floating bags. Working a floating bag lease is still demanding, but it relies much less on adding wild oysters than it does on purchasing and developing spat (oyster larvae) in protective cages. It's somewhat of a cleaner process — easier to observe, easier to manage (aside from storm vulnerability). While some oyster farmers do use relayed oysters to fill their water column bags, they are the exceptions.

From my conversations with various oyster farmers and my observations in the field, I speculate that diminished interest in relaying is correlated with state government regulations.

Each year, the North Carolina Division of Marine Fisheries (NCDMF) receives fewer and fewer relaying permit applications. Given the potential consumer health hazards associated with relaying — due to pollution related to land use, development, and agricultural runoff — the practice is heavily regulated. On any given relay day, Marine Patrol officers oversee the area and then escort each harvester back to his or her lease. At times, Marine Patrol boats have outnumbered harvesters.

Ten years ago, relaying was allowed for six weeks, from April to mid-May, five days a week, at each open site (30 days per site). This past year, relaying was still six weeks, still from April to mid-May, but only two days a week, and alternating sites per week (six days per site).

Though there may be some occasional finger pointing and grumbling among shellfishers and coastal government organizations, the core causes of closures and the ever-shrinking areas suitable for healthy oysters come from upriver. Only comprehensive land management that incorporates both inland and coastal stakeholders throughout N.C.'s watersheds can address pollution that forces both periodic and consistent shellfishing closures. In the meantime, the exact impacts of relaying are important to study as we attempt to restore wild oyster populations all along the East Coast. If relaying does indeed promote wild oyster growth, the practice is not so antiquated that it is beyond saving. We ought to understand relaying before it disappears from our waters. 🍽️

Don't miss "What's So Special About N.C. Oysters?" on pp. 6-13 in this issue of *Coastwatch*.

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Officials meticulously monitor oyster health, and out of an abundance of caution for consumers, the sale of local oysters is occasionally halted during periods of heat and rain. Opposite page: The author (right) and IMS's Creed Branham excavate oysters.

TROUBLED

FLOODING, CONTAMINANTS,

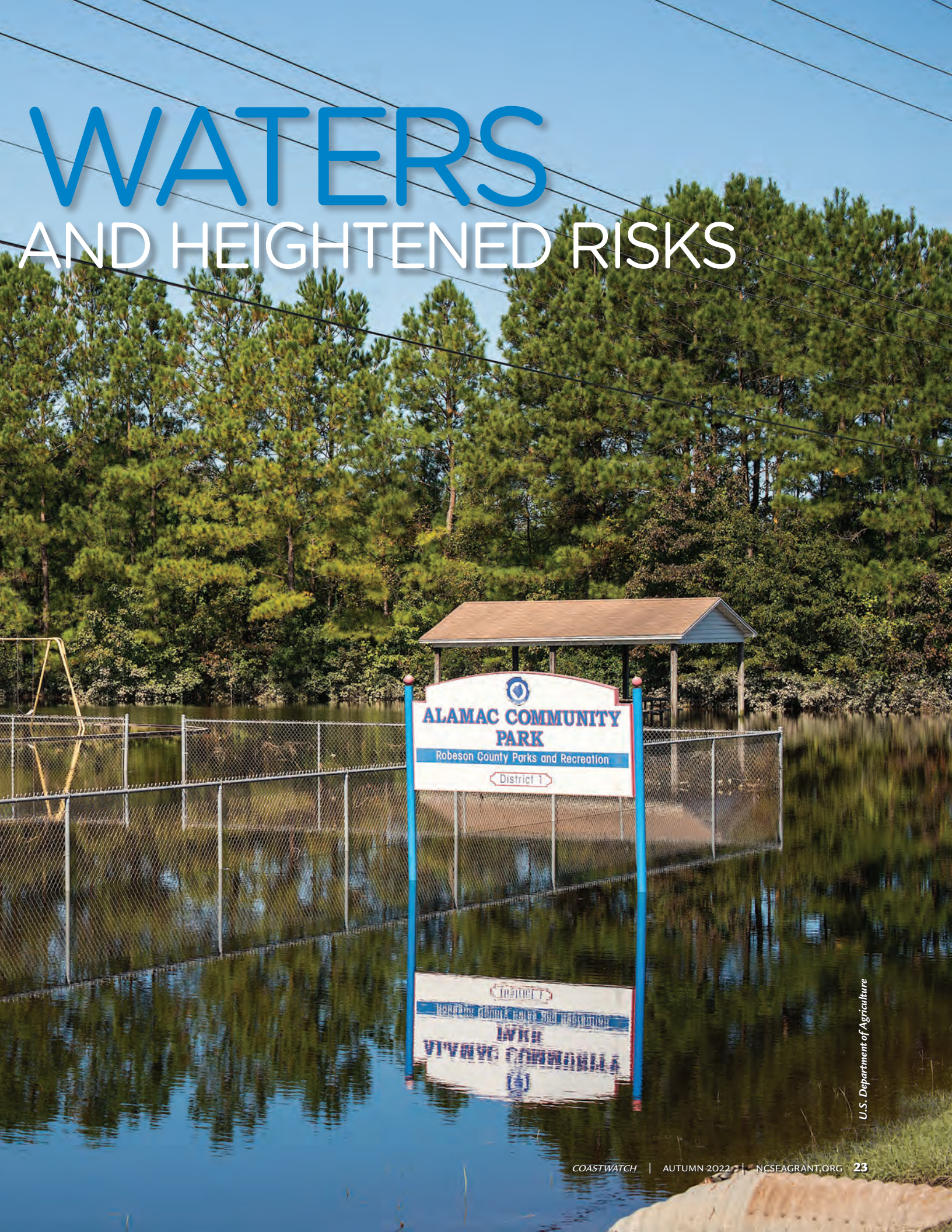


BY LAUREN D. PHARR

Underserved communities in North Carolina disproportionately experience the adverse effects of flooding and poor water quality. Why is this? And what can we do about it?

Robeson County, North Carolina, after Hurricane Matthew.

WATERS AND HEIGHTENED RISKS



U.S. Department of Agriculture



NC DOT / CC BY 2.0

People who live in high frequency flood areas continuously experience health-related problems.

Short and long-term effects of flooding can have significant impacts on communities and their public health. Floodwaters can overflow from wastewater treatment plants, sewer manholes and mains, and individual or community septic systems into ball fields, playgrounds, and yards — contaminating buildings and outdoor areas with bacteria and viruses and increasing the likelihood of human exposure.

In North Carolina, perfluoroalkyl and polyfluoroalkyl substances (PFAS), lead, plastics, hog waste, and other contaminants also can impact water quality even without flooding. Under-resourced and underrepresented communities often face these and other contaminants.

The disproportionate effects of flooding and contamination have been the subject of recent and ongoing initiatives at North Carolina Sea Grant. These projects have included extension director Frank López's work with a traditionally under-resourced neighborhood subject to flooding in New Bern, as well as research addressing how K-12 students in an under-represented coastal community conceptualize disaster compared to adults.

North Carolina Sea Grant also continues to support work from early career and established scientists from traditionally under-represented communities. Projects

have addressed causes of under-representation of Latino and Latina community voices after coastal flooding, and, among several other initiatives, how academic and Traditional Ecological Knowledge practices together can evaluate soil and water health in the Waccamaw Siouan communities in the southeastern part of the state.

Much more work has addressed the impacts of flooding and contaminants on vulnerable communities — including the first three projects below. A fourth project shows how children and young adults are becoming more curious and eager to learn about science and the environment, which provides valuable opportunities for long-term solutions that address flooding and water quality.

RACE, INCOME, AND THE BLOOD LEVELS OF LEAD IN CHILDREN

Even with passage of the EPA's Safe Drinking Water Act in 1974 and subsequent amendments to it, many people — particularly in low-income and underrepresented minority communities — continue to battle contaminated water sources. In fact, EPA data from 2016 to 2019 reveals that public water systems that consistently violate the Safe Drinking Water Act are 40% more likely to serve people of color.



Louie Rivers (here), specialist in environmental justice and science policy: “The issues that we see in environmental justice communities will eventually show up in more affluent communities five or six years down the road.”

Lead is one of the most common environmental contaminants, and even in small amounts it can be harmful to human health. In fact, a recent long-term study from researchers at Duke University estimated the impacts of lead exposure on IQ points, finding that exposure to car exhaust from leaded gas during childhood stole a collective 824 million IQ points from more than 170 million Americans alive today, which is about half the population of the United States.

Exposure comes in several forms, says Riley Mulhern, who received his Ph.D. from the Gillings School of Global Public Health at the University of North Carolina at Chapel Hill.

“Lower-income housing can have more lead-based paint and can potentially have older lead pipes,” Mulhern explains. “The housing is usually located in areas with historical contamination — for example, construction or soils with lead.”

Mulhern lived in Bolivia for two years to help indigenous communities who wanted information about how contamination from mining operations was affecting their water. The experience led Mulhern to work with

private well users in our state in areas where lead, perfluoroalkyl and polyfluoroalkyl substances (PFAS), and flooding potentially impact drinking water.

In particular, as a joint graduate research fellow with North Carolina Sea Grant and the Water Resources Research Institute, Mulhern analyzed datasets that paired race, socioeconomic status, and characteristics of water utility infrastructure with blood lead levels in children.

Although the primary goal of the analysis was to understand how the characteristics of a community’s water system affect lead exposure, Mulhern and his team found greater risk of elevated lead

levels in children from low-income and predominantly African-American neighborhoods.

“The most important things were race and economic status,” Mulhern says. “We found the same pattern that’s been found elsewhere around this same issue of these overlapping risks of lead contamination in Black communities and low-income areas.”

As a research environmental engineer with RTI International, Mulhern currently is working on analyzing lead risks using open-source methods to make the work more accessible to other researchers. He also continues his important work with private well owners in Robeson County, one of the lowest income counties in the state and home to many members of the Lumbee Tribe.

“Drinking water quality and water provision is a public service, and there are some people who are stressing about it every single day,” Mulhern says. “We need to care about these types of analyses and doing this type of work, because it informs how we design our urban systems, our world, and our society.”

Continued

THE COLOR LINE, THE WATER LINE, AND GREEN INFRASTRUCTURE

Nuisance flooding — low levels of flooding that do not pose significant threats to public safety but can strain infrastructure and cause property damage — and catastrophic flooding from high precipitation weather events combine to impact coastal and inland low income and underrepresented communities.

According to a United Kingdom study published in the *National Library of Medicine*, people who live in high frequency flood areas continuously experience health-related problems from emotional grief to death, as well as other long-term psychosocial effects like distress, anxiety, and depression.

For people experiencing frequent flooding, outsiders sometimes offer suggestions, like moving to higher ground or out of the area altogether. However, for neighborhoods with historic roots and with less influence on local decision-making, moving is easier said than done.

In the Walnut Creek Watershed, residents of Rochester Heights, the first subdivision for African Americans in Raleigh, experienced catastrophic flooding events from hurricanes Fran in 1996 and Floyd in 1999. The community remains vulnerable, due to poorly draining land cover and proximity to wetlands, and residents continue to battle nuisance flooding.

“There was a color line in Raleigh, and the Black community was moved behind that color line into the lowest part of the city, which would become frequently flooded,” explains Louie Rivers, a specialist in environmental justice and science policy at North Carolina State University and with the EPA. “Rochester Heights is the oldest Black community here, and it is always known to flood.”

Rivers works alongside the Walnut Creek Wetland Community Partnership and Partners for Environmental Justice with Christy Perrin, sustainable waters and



Youth conservation job training participants learn about environmental research opportunities from Liani Yirka (above), assistant director of Walnut Creek Wetland Park. Below: The St. Ambrose Episcopal Church rain garden.

communities coordinator for North Carolina Sea Grant and the Water Resources Research Institute. Ryan Emanuel, an environmental scientist and community-engaged scholar at Duke University, is also a key collaborator.

“There are so many efforts that partners are involved in,” says Perrin. “For example, we have been working to implement green stormwater infrastructure to reduce



Post-Florence flooding in eastern North Carolina farmland.

stormwater runoff, as well as collaborating with The Conservation Fund to identify, design, and construct nature park facilities on the south side of Walnut Creek that equitably support community interests.”

St. Ambrose Episcopal Church, a landmark of the community, hosted and incorporated one such green infrastructure project — a demonstration rain garden that slows water runoff while filtering its pollutants. Projects like these, participants hope, offer the first of many practical solutions.

With the EPA, Rivers also focuses on developing science that supports the agency’s regulatory work, as well as other environmental agencies’.

“We have a duty to our citizens to have equal protection and equal access to the environment,” he says. “The issues that we see in environmental justice communities,” where, for instance, people in communities like Rochester Heights suffer the effects of flooding disproportionately, “will eventually show up in more affluent communities five or six years down the road. We should care about these issues now.”

HOG FARMS, HISTORY, AND UNTOLD CONSEQUENCES

Although many people consider the Midwest the traditional home for hogs, North Carolina went from the fifteenth-ranked state to second in hog production from the mid-1980s to mid-1990s. This growth included the emergence of thousands of concentrated animal feeding operations, also known as CAFOs.

These industrial-scale farms house thousands of animals whose waste periodically supplies “spray fields” — which can contain dangerous pathogens and antibiotic-resistant bacteria that eventually affects drinking water sources. Emissions from CAFOs also can contribute to respiratory infections and elevated blood pressure. (For more on the impacts of CAFOs, see Andrew Moore’s “Natural Solutions and a Clean Water Future for the Cape Fear” in this issue.)

Many CAFOs are located in the eastern half of the state, part of what colloquially is known as the Black Belt. The area once

included the sites of many plantations, and freed slaves continued to farm and sharecrop in eastern North Carolina after emancipation.

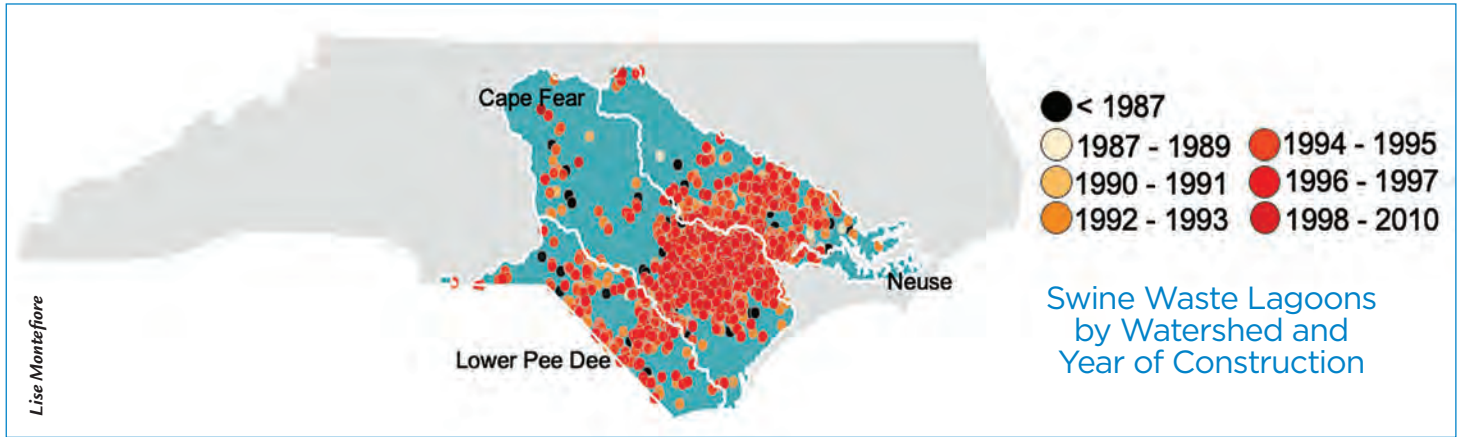
According to a study on CAFOs published in *Environmental Health Perspectives*, many Black residents who reside in the region today, a century and a half later, are experiencing higher rates of poor health from CAFO emissions, which are contributing to mucosal irritation, respiratory ailments, and elevated blood pressure. Therefore, learning about emerging techniques that we can use to understand water quality and other environmental and health impacts on communities from CAFOs is essential.

Lise Montefiore, a former joint research fellow with North Carolina Sea Grant and the Water Resources Research Institute, reconstructed the growth of swine CAFO waste lagoons since 1985.

“I was thrilled by this idea because I wanted to use satellite images,” explains Montefiore, who earned her Ph.D. at NC State in biological and agricultural engineering. “I wanted to connect this idea to water quality. After conducting some research, it was clear that farm locations and their year of construction were critical and needed information to understand the potential connection between historical swine CAFOs growth and long-term water quality trends.”

Montefiore and NC State’s Natalie Nelson, her advisor, developed a dataset that reports the time of construction of swine waste lagoons in North Carolina. The use of the dataset can inform management practices and shed light on environmental and public health trends in the Coastal

Continued



RIGHT: Hands-on projects like cleanups engage student interests.

Plain of North Carolina. For example, watersheds with a history of extensive animal production over several decades likely possess large legacy stores of nutrients from waste, which, in turn, can mask the effects of current management practices. This, in turn, could discourage water quality management and policies that actually would benefit under-resourced communities in the end.

As a postdoctoral researcher with NC State, Montefiore now works with a team of researchers in Florida and North Carolina. The team uses modeling approaches to understand the interactive effects of lake level management on downstream water quality.

Montefiore says a retrospective look at how people have used the environment is essential. "Historical data are needed to accurately understand how changes in the agricultural landscape may be related to long-term consequences on natural resources and adjacent communities."

PLASTIC, PFAs, AND A RISING GENERATION OF ENGAGEMENT

"I was in high school when I wrote my senior paper on wanting to be a teacher," explains Jenna Hartley, environmental educator and post-doctoral researcher at the University of North Carolina at Chapel Hill. "After completing my masters in education while teaching in New York City, I moved back to North Carolina and taught AP Environmental Science. I saw kids connecting to



environmental science, especially about how they could make a difference."

Hartley served as a high school science teacher for seven years and as a fellow at the EPA for six years before and while pursuing her Ph.D. in parks, recreation, and tourism management at NC State. Under the guidance of NC State's Kathryn Stevenson, Hartley's marine debris environmental education research, which North Carolina Sea Grant has supported, involved studying the impacts of hands-on, in-person, experiential education activities.

"The Duke University Marine Lab developed this incredible curriculum for 4th and 5th graders on marine debris, and it was really interdisciplinary," she says. "The kids made art and wrote



Jenna Hartley

As students explore creek beds and waterways and participate in similar projects, they gain valuable experience and often become invested in the environment.

haikus and plays, but at the same time, they were learning about the science of plastics.”

Almost 40 North Carolina counties were involved in the initiative, and at many of the schools all students were on free or reduced lunch. Teachers at schools in Wilmington would explain how *none* of their students had ever stepped foot in the sand, because even cheap beach accessibility (e.g., “only” paying to park) is something that many families couldn’t afford.

Hartley applied for grants to support field trips for students to waterways. These included clean-up activities for an entire 4th grade from a Wake County school at the Eno River State Park and the entire 4th and 5th grades from a Brunswick County school at the beach.

“Hands-on experiences like these empower kids and show them they can be a part of the solution and be impactful now,” she says. “They don’t have to wait until they’re 18, or until they have a job.”

Now as a postdoctoral researcher at the UNC Institute for the Environment, Hartley works with principal investigators Kathleen Gray and Dana Haine on Iterative Design to Engage All Learners, a National Institutes of Health project that supports teachers

and scientists in co-creating lessons about perfluoroalkyl and polyfluoroalkyl substances (PFAS). Studies have linked PFAS to a variety of health effects, including decreased fertility, low birth weight, and increased risk of some cancers, among others.

Participating teachers, who are all from PFAS-impacted communities (such as Greensboro, Fayetteville, and Wilmington) and under-resourced schools, are learning about PFAS and inclusive teaching strategies for the classroom.

Hartley says that for youth in under-resourced and underserved communities, pollutants are especially important to understand — because these students are more likely to bear the adverse effects.

“The sooner we can help build scientific literacy on these important topics, the better,” Hartley says. “These public health and environmental challenges that are facing North Carolina communities require scientifically literate responses. Informed and engaged residents will be better positioned to address the public health and environmental challenges facing their communities. Giving our students curricula that is real-time, local, and relevant can increase their interest, benefiting both them and the communities where they live.” 🌐

Lauren D. Pharr is an award-winning science communicator with North Carolina Sea Grant, contributing editor for Coastwatch, Ph.D. student at NC State University, and 2021-2022 Global Change Fellow with the Southeast Climate Adaptation Science Center.

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Frank López and resilient housing for New Bern

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Riley Mulhern and lead contamination

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Louie Rivers and flooding in environmental justice communities

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Christy Perrin and Walnut Creek community projects

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Lise Montefiore and hog farms

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Jenna Hartley and environmental education

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North Carolina Sea Grant — Water Resources Research Institute Graduate Research Fellowship

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WITH MORE PEOPLE LIVING IN THE CAPE FEAR RIVER BASIN AND CLIMATE CHANGE BRINGING HEAVIER RAINS, A NEW PROJECT IS FORECASTING THE EFFECTS OF STORMWATER RUNOFF AS WELL AS HOW STRATEGIC BUFFERS CAN LESSEN POLLUTION.

NATURAL SOLUTIONS AND A CLEAN WATER FUTURE FOR THE CAPE FEAR

BY ANDREW MOORE

UPPER CAPE FEAR RIVER BASIN.

The Cape Fear River Basin — the largest of four watersheds entirely contained within North Carolina — is a lifeline for many communities, especially those along the coast. More than 6,500 miles of streams and rivers provide drinking water and recreational opportunities for millions of people living within the boundaries of the watershed’s 116 cities and 29 counties — from the urban areas of Greensboro, Durham, and Fayetteville to the coastal communities of Southport and Wilmington.

Unfortunately, with climate change accelerating, the Cape Fear River Basin and its natural resources likely will face more extreme flooding and droughts in the coming decades, exacerbating existing water quality issues that rapid urbanization and the expansion of livestock agriculture throughout the basin have created.

“Climate change is going to make everything more challenging,” says Katherine Martin, who leads the watershed ecology research group in collaboration with NC State’s Center for Geospatial Analytics and the Southeast Climate Adaptation Science Center. “The current models suggest that our precipitation events are going to become more extreme. We’re going to have more rain when it’s raining and then longer dry periods. That’s going to create challenges for water quality even if we maintain the land exactly as it is right now.”

Martin is working alongside Elly Gay, a doctoral student in the Department of Forestry and Environmental Resources, and researchers at The Nature Conservancy’s North Carolina Chapter on a North Carolina Sea Grant project to protect water quality in coastal areas throughout the Cape Fear River Basin.

Martin and Gay are using a series of computer models to investigate the effects of the forested areas surrounding water bodies — called “riparian buffers” — on coastal water quality. In particular, the researchers are examining the impact of placing buffers of varying widths in upstream locations where high concentrations of pollution are likely to overlap with increased development.

North Carolina already requires 50-foot-wide riparian buffers in some watersheds. However, fixed-width buffers aren’t always efficient in mitigating pollution because they’re not customized to the complex processes of each watershed.

“Riparian buffers are intentionally conserved or placed to benefit water quality



ELLY GAY (LEFT) AND KATHERINE MARTIN (RIGHT) ARE USING COMPUTER MODELS TO ANALYZE THE BENEFITS OF STRATEGIC RIPARIAN BUFFERS ON WATER QUALITY IN THE CAPE FEAR RIVER BASIN.

and quantity,” Gay says. “Our goal is to see if we can maximize that effect by placing buffers with strategic widths in places that are at risk of declining water quality.”

A WATERSHED ON THE DECLINE?

Martin and Gay’s research comes at a time when the Cape Fear River Basin’s waterways face ongoing water quality challenges. The North Carolina Department of Environmental Quality (NCDEQ) recently designated nearly 100 waterways throughout the basin as “impaired” due to pollution. That includes more than 800 miles of streams, creeks, and rivers, as well as some 8,700 acres of lakes, reservoirs, shellfish growing areas, estuaries, and river mouths.

In addition to the unregulated and potentially cancerous chemicals that have been dumped into the Cape Fear River by Dupont and Chemours since the 1980s, some of the basin’s waterways contain an overabundance of sediment, nitrogen, and phosphorus. This can sometimes cause algae to grow faster than some waterways can handle — creating an algal bloom — and can reduce the oxygen in the water, killing large numbers of fish.

Local, state, and federal authorities closely monitor sediment and nutrient pollution, but it can still pose a serious public health threat if algal blooms contaminate drinking water sources. Algal blooms sometimes produce toxins that can cause skin rashes, liver and

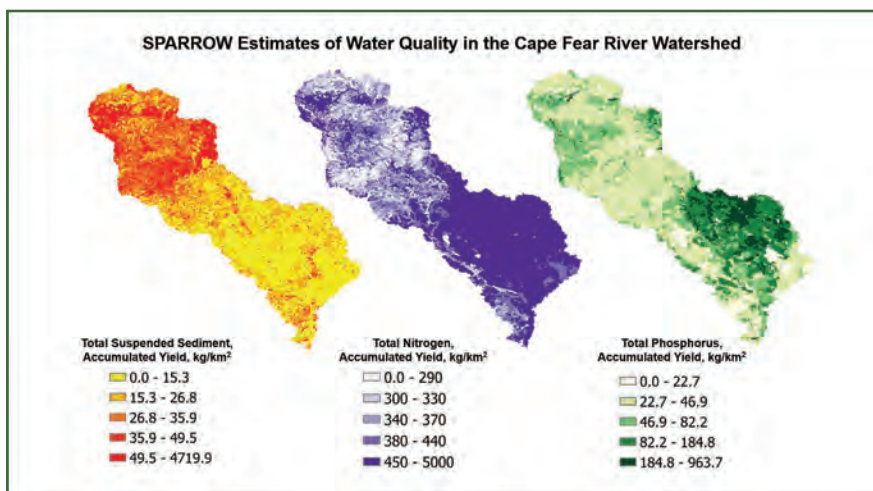
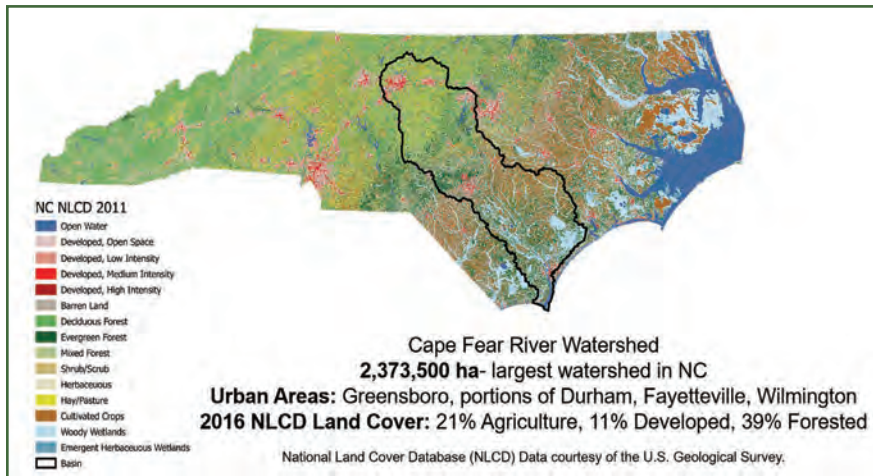
kidney damage, respiratory problems, and neurological symptoms. While most utilities have methods to remove these toxins, they’re not always a part of the standard water treatment process.

Using the U.S. Geological Survey’s SPARROW model, Martin and Gay discovered that the highest concentrations of sediment occur in the Piedmont, from Greensboro to Fayetteville, while the highest concentrations of phosphorus and nitrogen occur in the Coastal Plain, mostly in Sampson, Duplin, and Pender counties.

“Our hypothesis is that the sediment is primarily from urban development and the nutrients are from agriculture,” Martin said. “There are also different soils in the Piedmont that are more erodible than the sandy soils in the Coastal Plain,” which could contribute to higher amounts of sediment upstream in the Piedmont.

The Piedmont is rapidly expanding in the Cape Fear River Basin as many of its cities and counties transform rural land into urban infrastructure to accommodate growing populations. One projection shows that the region’s urban areas could expand by 165% through 2060. Unfortunately, heavy rainfall can erode exposed soils at development sites and then flush sediment into nearby waterways, according to Martin.

At the same time, Martin says, concentrated animal feeding operations (CAFOs) remain a primary source of nitrogen



AS LAND DEVELOPMENT INCREASES, SUSPENDED SEDIMENT SIGNIFICANTLY AFFECTS WATER QUALITY MORE IN THE UPPER HALF OF THE CAPE FEAR RIVER BASIN, WHEREAS NITROGEN AND PHOSPHORUS POSE BIGGER CHALLENGES IN THE LOWER HALF.

and phosphorus in the Cape Fear River Basin. These operations, mostly in Sampson and Duplin counties, discharge animal waste into open lagoons and then apply it on fields as fertilizer. When flooding occurs, the lagoons overflow and the fields become oversaturated, sending waste into nearby waterways. (For a look at how CAFOs burden underserved communities, see Lauren D. Pharr’s “Troubled Waters” in this issue.)

Climate change is likely to compound these existing water quality issues, according to Martin. In fact, the North Carolina Institute for Climate Studies expects climate change to increase the number of hurricanes passing near or over the state, bringing heavy rainfall that will in turn increase the potential for stormwater runoff. In 2018, Hurricane Florence alone caused several CAFOs to spill more than 7 million gallons of animal waste into the Cape Fear River Basin.

THE FUTURE OF URBAN EXPANSION — AND THE HOTSPOT AREAS TO ADDRESS

Martin and Gay now plan to use the “FUTURES” model, which researchers at the Center for Geospatial Analytics created, to simulate potential new development scenarios throughout the Cape Fear River Basin to better understand how upstream land-use changes could impact downstream water quality.

The Cape Fear River Basin covers more than 9,000 square miles across North Carolina and contains some of the state’s fastest-growing cities — the Wilmington metro area alone gained more than 5,500 new residents from 2020 to 2021. As of 2016, the basin’s total land cover consisted of 39% forests, 21% agriculture and 11% development. Martin and Gay’s preliminary analysis shows that development within the basin will increase to 14% by 2060.

“We’re concerned because there’s a lot of urban expansion happening in the watershed,” Martin says. “And while we want great places for people to live and work, the kind of growth we’re seeing doesn’t come without some trade-offs for water quality. When natural land cover is replaced with impervious surfaces, such as parking lots and sidewalks, it changes the frequency and volume of stormwater runoff so that it carries more pollutants into our waterways.”

Going forward, Martin and Gay plan to combine the data from their SPARROW analysis with the urban growth simulations from the FUTURES model in order to identify areas where water quality might be particularly vulnerable to sediment and nutrient pollution in the coming decades.

“These are the hotspot areas where we’ll likely consider simulating strategic riparian buffers to see if we can limit the effects of increased urban cover,” Gay says.

North Carolina’s coasts are extremely dynamic and important areas that also support the livelihoods of 20 counties, she adds. “Our hypothesis is that strategically placed riparian buffers upstream can benefit downstream water quality not only for watershed health — but also for these coastal communities.”

RIPARIAN BUFFERS AS NORTH CAROLINA’S NATURAL FILTERS

Riparian buffers are commonly established and maintained throughout watersheds to serve as natural filters against pollution from development, agriculture, and other land uses, according to Danica Schaffer-Smith, a project collaborator and watershed scientist for The Nature Conservancy. The trees, shrubs, and grasses within these buffers essentially slow the flow of stormwater runoff, trapping sediment and allowing polluted water to settle out over the ground.

“Nutrients like phosphorus are often bound up with that sediment,” Schaffer-Smith explains. “Ideally vegetation within buffers not only helps to block pollutants from getting into waterways, but also absorbs those nutrients as it continues to grow.”

In 1997, the NCDEQ established its riparian buffer protection program to maintain buffers along streams, lakes, ponds, and estuaries throughout the Neuse River Basin. The program has since expanded to include the Catawba and Tar-Pamlico river basins and the

Continued



STRATEGICALLY PLACED RIPARIAN BUFFERS UPSTREAM CAN IMPROVE DOWNSTREAM WATERSHED HEALTH AND BENEFIT COASTAL COMMUNITIES.

Goose Creek, Jordan Lake, and Randleman Lake watersheds. Both the Jordan Lake and Randleman Lake watersheds are located in the upper portion of the Cape Fear River Basin.

North Carolina’s buffer protection program recommends 50-foot-wide, two-zoned buffers: 30 feet of undisturbed vegetation adjacent to the waterway and an outer 20 feet of managed vegetation. While most studies show that wider buffers typically capture larger concentrations of nutrients than narrower buffers, the scale and placement of buffers required to improve water quality across regional watersheds isn’t well understood, according to Martin.

The Source Water Assessment Program characterizes both Jordan Lake and Randleman Lake, which provide drinking water for more than 700,000 residents across the Piedmont, as “highly susceptible to potential contamination sources.” Jordan Lake, in particular, has consistently experienced high levels of nutrient pollution over the years. Recently, multiple dogs died after exposure to an algal bloom while swimming at one of the lake’s boat launches.

Anna Gurney, a spokesperson for NCDEQ, says the agency’s riparian buffer protection program is part of a comprehensive management strategy for each watershed, with the agency adding waterways on a case-by-case

basis. She says the agency has implemented riparian buffers when there was a legislative mandate to do so or when the agency identified “a clear necessity for significant measures, either to recover impaired waterbodies or as part of a protection strategy for listed species.”

Martin and Gay both say that determining the prevalence and effectiveness of riparian buffers in the Cape Fear River Basin is difficult, largely because most of the basin lies outside the state’s buffer protection program. However, under the regulations outlined in the Coastal Area Management Act, some coastal cities and counties within the basin incorporate setbacks in their development codes to ensure buildings maintain a minimum distance from conservation areas.

Once she and Gay identify areas where pollution and future development overlap throughout the Cape Fear River Basin, they plan to work with Schaffer-Smith to use the “Soil and Water Assessment Tool” to compare the effectiveness of 50-foot and 100-foot-wide riparian buffers.

“The model will help us understand what sort of improvements we can get if we implement these buffers strategically,” says Schaffer-Smith, who led the development of the tool for the Cape Fear River Basin during her time as a NatureNet Science Fellow

with the Center for Biodiversity Outcomes at Arizona State University and The Nature Conservancy. “The findings will help us to do conservation and restoration in the best places.”

STRATEGIC SOLUTIONS, HEALTHY WATERWAYS

Research shows that the effectiveness of riparian buffers depends on a number of factors, including watershed size, regional geography and climate, present-day and historical land cover, the locations of pollution sources, and more.

For coastal communities in the Cape Fear River Basin, Martin and Gay believe that using buffers in smaller watersheds could significantly improve water quality throughout the southeastern part of the basin, an area with high concentrations of nutrients. If successful, Martin says, the strategic placement of riparian buffers could help cities and counties accommodate growing populations, adhere to state and federal regulations, and protect water quality.

The buffers also could reduce the cost to treat drinking water. One utility in the basin spends between \$800 and \$1,300 per day to treat algal blooms that sediment and nutrient pollution cause, according to NOAA.

“If we have forests on the landscape, the

water going into the water treatment plants is cleaner to start with,” Martin says. “So there’s less need for treatment.”

Martin adds that the buffers could benefit North Carolina’s commercial and recreational fisheries, which depend on clean estuaries for nurseries for young fish. According to NOAA, the fisheries of the Cape Fear River generate nearly \$14.2 million in income and \$35.7 million in revenue, thanks in part to the wide range of commercially viable species available in the 35 miles of river between Wilmington and the Atlantic Ocean.

Additionally, the strategic use of buffers could ease concerns of some landowners and developers. “Right now, every person who owns a property near a waterway has to maintain that 50-foot buffer if they’re in a basin that’s part of the state program,” Schaffer-Smith explains. “If we’re able to place fewer buffers in locations where they have the greatest impact on water quality, there might not be as many landowners affected. It might also be a better use of taxpayer dollars.”

Ultimately, Martin and Gay’s work will provide policymakers and natural resource managers with the information they need to decide whether strategic riparian buffers are an appropriate solution for addressing the potential impacts of urbanization and climate change in the coming decades.

Martin says the findings could have implications for much of the Cape Fear River Basin. “The specialty of our research group is looking at future conditions and saying, ‘This is what might happen. Is this what we really want? Or do we want to try to do something different?’” 🌱

NC State collaborators include Ross Meentemeyer, Goodnight Distinguished Professor of Geospatial Analytics; Georgina Sanchez, research associate at the Center for Geospatial Analytics; Caroline Zuber, undergraduate research assistant in the Department of Forestry of Environmental Resources; Shannon McAvoy, doctoral candidate in the Department of Forestry and Environmental Resources; and Dominic Libera, postdoctoral researcher in the Department of Forestry and Environmental Resources. Other project collaborators include Julie DeMeester, water program director at The Nature Conservancy’s North Carolina Chapter, and Tatiana Height, founder of Height Environmental Justice and Planning.

READING AND RESOURCES

WATERSHED ECOLOGY RESEARCH GROUP

- [GO.NCSU.EDU/WATERSHED-ECOLOGY-RESEARCH-GROUP](https://go.ncsu.edu/watershed-ecology-research-group)

THE NATURE CONSERVANCY’S NORTH CAROLINA CHAPTER

- [GO.NCSU.EDU/THE-NATURE-CONSERVANCY-NORTH-CAROLINA](https://go.ncsu.edu/the-nature-conservancy-north-carolina)

NORTH CAROLINA DEPARTMENT OF ENVIRONMENTAL QUALITY

- [GO.NCSU.EDU/NC-DEPARTMENT-ENVIRONMENTAL-QUALITY](https://go.ncsu.edu/nc-department-environmental-quality)

NCDEQ 303(D) INTEGRATED REPORT FILES

- [GO.NCSU.EDU/WATER-QUALITY-ASSESSMENTS](https://go.ncsu.edu/water-quality-assessments)

U.S. GEOLOGICAL SURVEY SPARROW MODELING

- [GO.NCSU.EDU/SPARROW-MODELING](https://go.ncsu.edu/sparrow-modeling)

NORTH CAROLINA CLIMATE SCIENCE REPORT

- [GO.NCSU.EDU/NCICS-CLIMATE-SCIENCE-REPORT](https://go.ncsu.edu/ncics-climate-science-report)

WATERKEEPERS IDENTIFY MULTIPLE CAFO AND COAL ASH SPILLS

- [GO.NCSU.EDU/WATERKEEPER-ALLIANCE-HURRICANE-FLORENCE](https://go.ncsu.edu/waterkeeper-alliance-hurricane-florence)

FUTURES URBAN GROWTH MODEL

- [GO.NCSU.EDU/FUTURES-URBAN-GROWTH-MODEL](https://go.ncsu.edu/futures-urban-growth-model)

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES — ALGAL BLOOMS

- [GO.NCSU.EDU/NIEHS-ALGAL-BLOOMS](https://go.ncsu.edu/niehs-algal-blooms)

CENTERS FOR DISEASE CONTROL AND PREVENTION: HARMFUL ALGAL BLOOM-ASSOCIATED ILLNESS

- [GO.NCSU.EDU/CDC-ALGAL-BLOOM-EXPOSURE](https://go.ncsu.edu/cdc-algal-bloom-exposure)

RIPARIAN BUFFER PROTECTION PROGRAM

- [GO.NCSU.EDU/RIPARIAN-BUFFER-PROTECTION-PROGRAM](https://go.ncsu.edu/riparian-buffer-protection-program)

SOURCE WATER ASSESSMENT PROGRAM

- [GO.NCSU.EDU/SOURCE-WATER-ASSESSMENT-PROGRAM](https://go.ncsu.edu/source-water-assessment-program)

SOIL AND WATER ASSESSMENT TOOL

- [GO.NCSU.EDU/SOIL-WATER-ASSESSMENT-TOOL](https://go.ncsu.edu/soil-water-assessment-tool)

RIPARIAN BUFFERS AS A CRITICAL LANDSCAPE FEATURE: INSIGHTS FOR RIVERSCAPE CONSERVATION AND POLICY RENOVATIONS

- [GO.NCSU.EDU/MDPI-RIPARIAN-BUFFERS](https://go.ncsu.edu/mdpi-riparian-buffers)

COMMUNITY BENEFITS OF CONSERVING THE CAPE FEAR RIVER BASIN

- [GO.NCSU.EDU/NOAA-CAPE-FEAR-BENEFITS](https://go.ncsu.edu/noaa-cape-fear-benefits)

STUDY — CAPE FEAR RIVER FISHERIES ACCOUNT FOR \$35.7 MILLION IN REVENUE

- [GO.NCSU.EDU/STAR-NEWS-CAPE-FEAR-STUDY](https://go.ncsu.edu/star-news-cape-fear-study)

KATHERINE MARTIN

- [GO.NCSU.EDU/KATHERINE-MARTIN](https://go.ncsu.edu/katherine-martin)

DANICA SCHAFFER-SMITH

- [GO.NCSU.EDU/DANICA-SCHAFFER-SMITH](https://go.ncsu.edu/danica-schaffer-smith)

NORTH CAROLINA SEA GRANT’S FUNDING OPPORTUNITIES

- [GO.NCSU.EDU/SEA-GRANT-FUNDING](https://go.ncsu.edu/sea-grant-funding)

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HURRICANES, BLUE MARLIN, AND RADIATION

Research and News for Anglers

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

EDITOR'S NOTE: Congratulations to Scott Baker and Sara Mirabilio. Hook, Line & Science recently won a Grand Award for Publication Excellence, the highest honor from the national APEX Awards.

HOW DO HURRICANES AFFECT FISH POPULATIONS ON THE N.C. COAST?

The news media and the data often tell two different stories.

The 2022 Atlantic hurricane season officially will end on November 30. Hurricanes, of course, are a fact of life for many coastal communities in the Southeast. And with global ocean temperatures on the rise, scientists forecast more powerful and frequent hurricanes than in years past.

Knowing how different fish species respond to extreme weather is important for future management, policy, and conservation considerations. But how can we find out if and how hurricanes affect fish populations?

Consider two sources: first, data that state agencies collect for this purpose, and second, reports in the news media, which often include a mixture of public opinion and fact.

Most experts consider long-term datasets — for example, a trawl survey conducted at the same location and month, year after year — to be the most useful and least biased tool for this purpose. A collection of different surveys will capture all or most important species through time to showcase population trends, but this data is complex and not always available to the public in timely fashion.

On the other hand, the news media will write about hurricane impacts, but these articles can focus on popular and economically important species — not necessarily the species that might exhibit the most change. This is important if the species the media neglects to cover are important to the health of the ecosystem.

Given that information from fisheries surveys and the news media both contribute to the formation of policies, it's important to understand if and when there might be a disconnect between the two when we consider impacts from hurricanes.

• *What did they study?*

Scientists selected three study locations, one in North Carolina and two others also in the Southeast, that hurricanes frequently impact and that also have complete records of data. In our state, the North Carolina Division of Marine Fisheries provided the researchers with survey data from the Albemarle-Pamlico Estuary from 2004 to 2016.

To understand how the news media described hurricane impacts on specific species and fisheries, the research team also examined all hurricane-related newspaper articles that originated from surrounding

areas, including Greenville, Kinston, New Bern, Havelock, Swansboro, and Morehead City in North Carolina.

The scientists looked at the top 10 species by the number of media mentions and each species' percent change in population, according to the fisheries data.

• **What did they find?**

The research team gathered information on 166 species in North Carolina over the 13-year study period. During this time, North Carolina experienced five hurricanes and four tropical storms — the most of any study site.

In general, periods of low hurricane activity brought different compositions of species than periods of high hurricane activity. Most of

the storms were relatively “mild,” and impacts on fish populations generally did not last more than a couple of years.

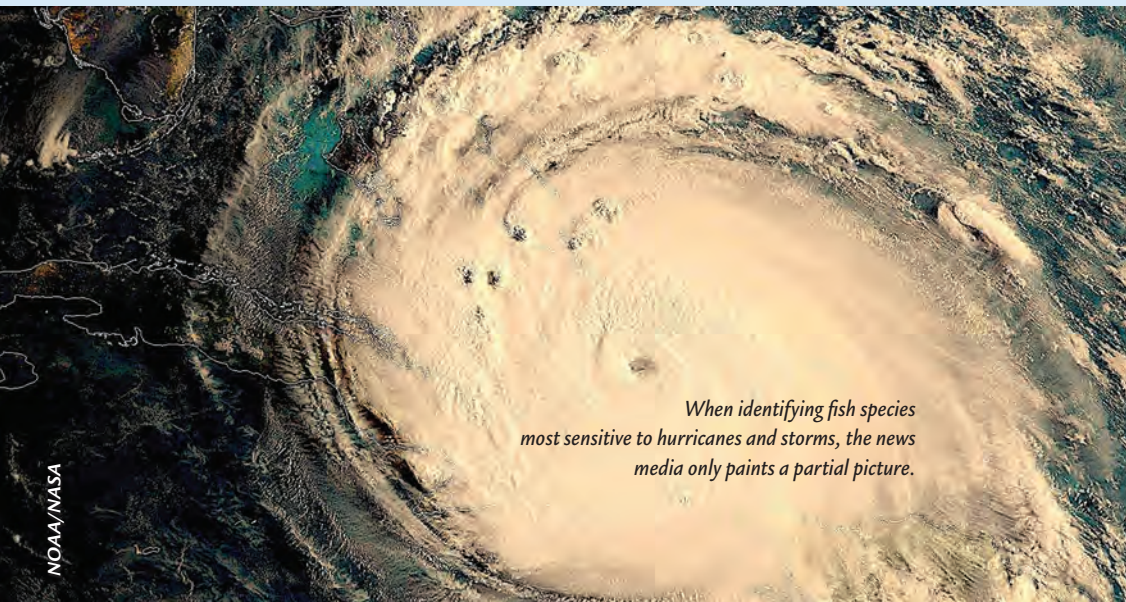
Only one species made the top 10 list for both media mentions and the amount of change in the fisheries data: Spanish mackerel.

According to the data, most of the biological changes observed were in less economically valuable or less popular species. Species with the most percent change in population (from most to least change) were Spanish mackerel, smooth dogfish, cownose ray, horseshoe crab, common carp, longnose gar, spot, white catfish, weakfish and bowfin.

However, species with the most media mentions (from most to least) were Spanish mackerel, flounder, drum, king mackerel, shrimp, mahi-mahi, snapper, mullet, and wahoo.

• **So what?**

The study's authors suggest that there is a potential for research and policy biases related to hurricane impacts given the focus of news media attention on popular species over less glamorous — but highly impacted — species. This suggests that managers and researchers could improve hurricane preparedness and mitigation by focusing on the data, and not on news coverage, when identifying species most sensitive to hurricanes and storms. — by Scott Baker



When identifying fish species most sensitive to hurricanes and storms, the news media only paints a partial picture.

NOAA/NASA

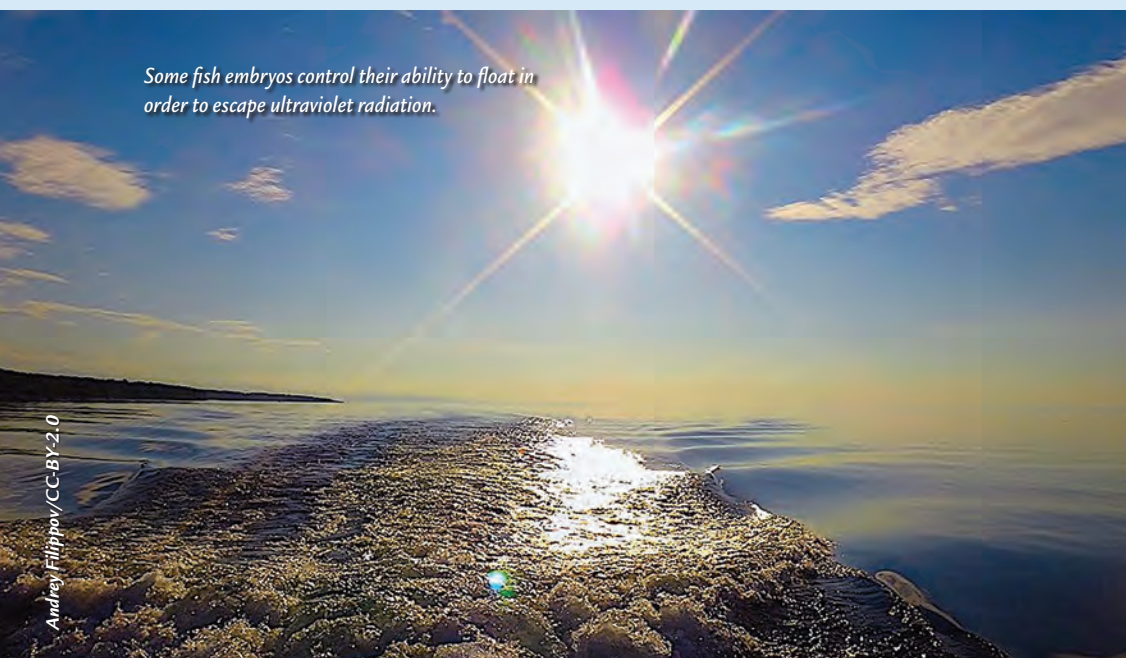
DOES ULTRAVIOLET RADIATION AFFECT OUR FAVORITE SPORT FISH?

Cobia, snapper, and tuna embryos have a fascinating way of avoiding harmful rays.

Aquatic organisms employ a variety of different mechanisms to reduce the harmful effects of UVR exposure. The embryos of fish floating in or near surface ocean waters once were thought to have little to no control over their mobility, though, leaving them at high risk for damage associated with UVR. In fact, recent findings on mahi-mahi — a species that lives and spawns in surface waters — found that UVR did indeed affect the species' embryos.

But is UVR affecting the embryos of similar species of fish who share the same spawning behaviors? If so, how?

Continued



Some fish embryos control their ability to float in order to escape ultraviolet radiation.

Andrey Filipov/CC-BY-2.0

• *What did they study?*

Researchers investigated the potential role of embryos' control over their ability to float ("buoyancy control") for three species of marine fish that spawn on open waters: cobia, red snapper, and yellowfin tuna. The team used red snapper and cobia embryos from The University of Miami Experimental Hatchery and yellowfin tuna embryos from the Inter-American Tropical Tuna Commission's Achotines Laboratory.

• *What did they find?*

The embryos of all three species increased their body density to create "negative buoyancy" — in other words, to sink — after they faced UVR exposure.

The team also determined that buoyancy changes due to UVR exposure are not unique to the embryos of fish who spawn in the upper levels of the ocean. Previous research, for instance, found that UVR affected many other species, including dab, plaice, the common sardine, anchoveta, mahi-mahi, and two species of marine cod.

• *So what?*

These findings suggest that fish embryos could be considerably deeper in the water column than scientists previously thought — and the study supports the idea of the universal utility of buoyancy control as a way some fish embryos can avoid UVR and other environmental stressors.

— by Lauren D. Pharr

WHERE CAN ANGLERS FIND BLUE MARLIN?

A new study reveals the depths and temperatures that blue marlin prefer.

From April through August each year, North Carolina anglers fishing in offshore tournaments, like the NC Billfish Series, lower the riggers and throw out the baits in search of species like blue marlin.

The blue marlin is a prized, large species — and many deep-sea saltwater anglers consider it the ultimate catch. It doesn't live close to the bottom or near the shore, but out in the open waters of the Atlantic, Pacific, and Indian Oceans. A member of the family Istiophoridae (the same fisheries family that includes several other billfishes), the blue marlin is highly migratory.

NOAA Fisheries manages blue marlin and fisheries of other highly migratory species (e.g., tunas, sharks, swordfish, and other billfish) in the U.S. Atlantic Ocean, the Gulf of Mexico, and Caribbean waters. The latest population assessments indicate that the Atlantic stock of blue marlin is overfished. Consequently, catch and release is the most common method that anglers use with blue marlin in our country.

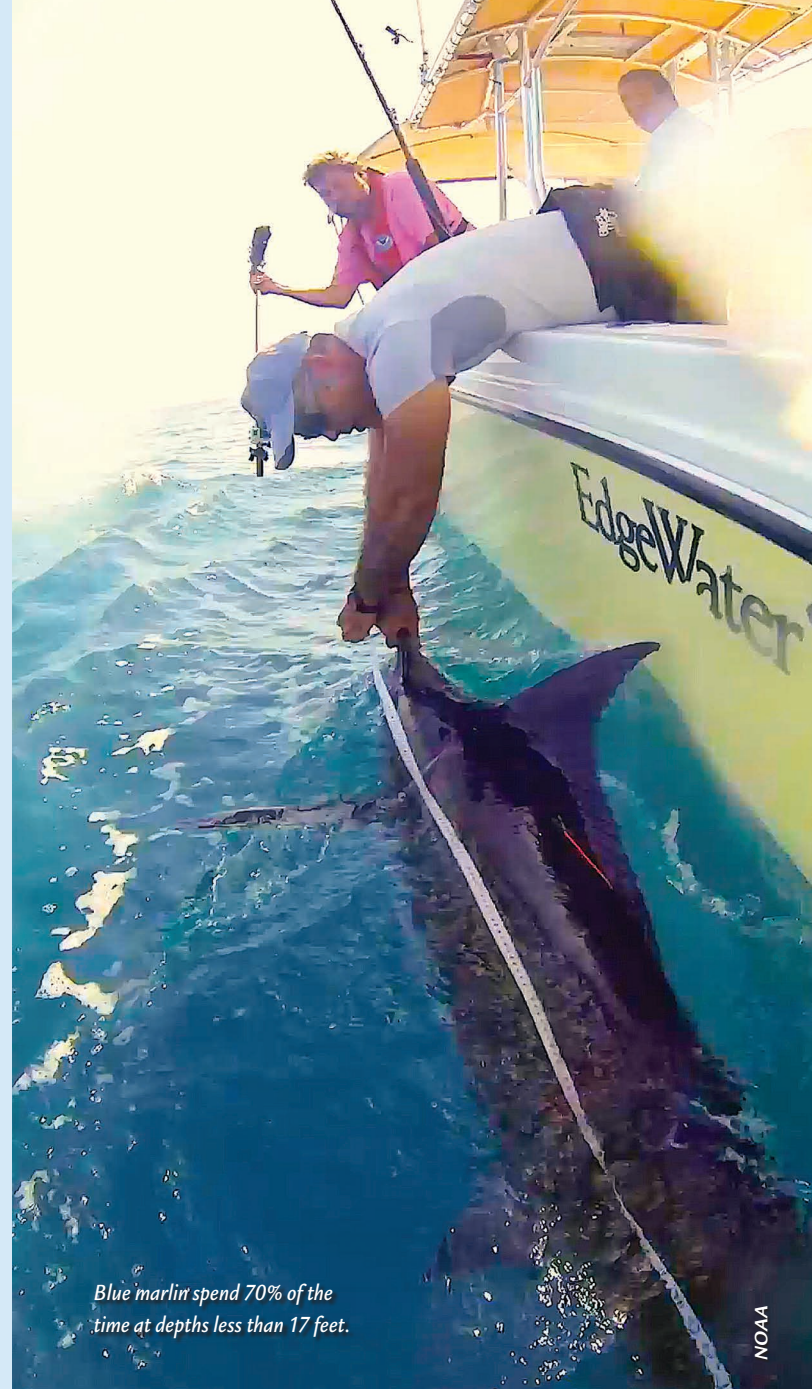
While traditional and satellite tagging studies have shown that blue marlin can travel long distances relatively quickly, more detailed information is necessary to understand the behavior of this species and to craft effective management.

And while this information is of obvious interest to fishery scientists, I expect that aspiring blue marlin anglers might be interested in the findings as well.

• *What did they study?*

Working in cooperation with experienced billfish anglers, scientists captured and tagged three blue marlin off Madeira, Portugal, in the northeast Atlantic. The fish ranged from 500 to 705 pounds.

Satellite tags recorded temperature, depth, and light every 60 seconds and then transmitted data by satellite once the tag popped off the animal and floated to the surface.



Blue marlin spend 70% of the time at depths less than 17 feet.

NOAA

• *What did they find?*

The study tracked the three blue marlin for 24, 76, and 83 days. The fish at large for 83 days travelled a straight-line distance of 1,273 miles, averaging over 15 miles per day. The researchers followed blue marlin from Portugal to the Canary Islands and Cape Verde, close to the African and European Atlantic Ocean continental shelves.

The fish spent roughly 70% of the time at depths less than 17 feet and most of the time in waters between 68.0°F and 78.8°F.

Each of the fish made regular and quick dives to waters deeper than 700 feet.

• *What else did they find?*

Similar to wahoo that we profiled earlier in Hook, Line & Science, blue marlin are not "warm blooded" and do not have the capacity to conserve metabolic heat. This is likely the reason why blue marlin only spent brief periods of time in deeper, cooler waters.

— by Scott Baker

read more and access the full studies: HookLineScience.com



Greg McFall/NOAA

Social Media for Sharks

A NEW STUDY SHOWS THAT YOUTUBE CAN SERVE AS A CONSERVATION MANAGEMENT TOOL WHEN IT COMES TO MISUNDERSTOOD WILDLIFE.

BY LAUREN D. PHARR

AS TOP PREDATORS WHO HELP KEEP THE FOOD WEBS OF THEIR ECOSYSTEMS IN BALANCE, SHARKS PROVIDE MANY KEY ECOLOGICAL AND ECONOMIC BENEFITS. Sharks also are a food source both in our country and, especially, in Asia. However, in many fisheries several species are over-exploited.

The news media can influence our attitudes towards sharks, both positively and negatively. The media often depicts sharks as violent killers that actively seek out opportunities to harm humans; of 300 U.S. and Australian news articles about sharks, over half included references to shark attacks, whereas only 11% focused on shark conservation.

In our own backyard, North Carolina has been home to several memorable and high-profile shark encounters over the years — including some in Brunswick County, when North Carolina Sea Grant quickly dispatched *Shark Sense* brochures to area beaches.

Not surprisingly, fear of sharks persists, even in places where overall attitudes are

the most positive. But would viewing shark-related YouTube videos affect people's tolerance of sharks?

THE STUDY

To understand how viewing shark-related YouTube videos may impact human perception of sharks and shark management, researchers identified and surveyed residents of North Carolina, where about 50 species of sharks can be found.

The study employed framing theory, which suggests that the ways in which we present information will influence both how people process it and their resulting actions. The team randomly assigned 335 participants one of two video treatments that framed sharks either positively or negatively.

THE FINDINGS

As hypothesized, each video treatment affected tolerance for sharks in line with its framing. Positive framing caused a 130% increase in acceptance of sharks, and negative framing brought an 18% decrease in acceptance of sharks. The study also found that a college

education was a good predictor of acceptance of sharks.

These findings suggest positive messages about sharks on social media promote tolerance of sharks and can influence public acceptance of conservation goals. This reveals an opportunity for wildlife professionals and communicators to counteract the negative representations of sharks in popular media and film, particularly through YouTube, which people can use quickly and cheaply. 📺

the full study

- go.ncsu.edu/shark-science

Shark Sense

- go.ncsu.edu/shark-sense

Lauren D. Pharr is an award-winning science communicator with North Carolina Sea Grant, contributing editor for Coastwatch, Ph.D. student at NC State University, and 2021-2022 Global Change Fellow with the Southeast Climate Adaptation Science Center. She co-authored the scientific study behind this story.

"Social Media for Sharks" originally appeared in the award-winning HookLineScience.com.

A ruddy turnstone on the shores of the Mosquito Lagoon.



Kate Perez/CC-BY-SA-4.0

How Do Restored Oyster Reefs Compare to Live Oyster Reefs?

A NEW STUDY SHOWS ADDITIONAL BENEFITS FROM OYSTER REEF RESTORATION
— AFTER ONLY SIX MONTHS.

BY CHRISTINE RYAN

ANYONE WHO HAS SPENT TIME IN THE ESTUARIES OF NORTH CAROLINA LIKELY HAS SEEN BAGS OF OYSTER SHELLS AND LAYERS OF REPAIRED OYSTER REEFS. BUT DO THESE RESTORED REEFS ACTUALLY FUNCTION LIKE NATURAL REEFS?

While researchers have shown that restored reefs can successfully produce oysters similar in size and density to natural reefs, there has been little study of the impact of restored reefs on bird populations. Many birds use natural reefs for foraging and resting, and scientists wanted to know if restored reefs could support bird populations in similar ways.

MOSQUITO LAGOON

On Mosquito Lagoon, along the east coast of central Florida, scientists focused on “benthic” (bottom-dwelling) invertebrates, which serve

as an important food source for many birds at the coast. The staff collected sediment samples from live, restored, and dead oyster reefs, and then counted and sorted the benthic invertebrates within the samples. They also recorded monthly observations of the birds at the reefs.

Within six months after restoration, the composition of all types of invertebrates in the restored reef sediments became more similar to the live reefs and less similar to dead reef sediments.

The most abundant benthic invertebrate at all reef types was “polychaete” (segmented) worms.

In addition, the research team observed over 1,500 birds from 36 unique species, with white ibis the most common on live reefs and ruddy turnstone the most common on restored reefs. On dead reefs, the most common species was royal tern.

FOR THE BIRDS

Dead reefs had the highest average number of birds per square foot and the highest average number of birds per square foot that were resting. However, the number of foraging birds per square foot at each of the three reef types was similar.

When evaluating the effects of oyster reef restoration, scientists previously have focused on oysters and the physical characteristics of reefs. They now are moving toward monitoring the broader ecosystem of restored reefs as habitat for other species. By doing so with this study, they found that restored oyster reefs become more similar to live reefs over time. 🌱

the full study

- go.ncsu.edu/restored-reefs

Christine Ryan is the inaugural communication fellow for the award-winning Hook, Line & Science series, which originally published this story: HookLineScience.com.

NC'S STATE-OF-THE-ART WARNING SYSTEM STRENGTHENS FLOOD PLANNING

BY BARBARA DOLL

This hurricane season, the N.C. Department of Transportation (DOT) is relying on an advanced flood-warning system that includes 400 river and stream gauges. Transportation Secretary Eric Boyette calls it a “state-of-the-art warning system” that “will help us be better prepared for the next major storm.” Barbara Doll, North Carolina Sea Grant’s water protection and restoration specialist, has helped lead a Sea Grant collaboration with the DOT and NC State University’s Department of Biological & Agricultural Engineering (BAE) to improve flood preparedness and resilience in North Carolina. She has worked closely with BAE’s Jack Kurki-Fox and Dan Line, who have provided integral support on flood modeling and resilient route analyses. Here, Doll explains how the new flood warning system will help our state plan for more resilient transportation.

OUR STATE HAS FACED MAJOR TRANSPORTATION DIFFICULTIES FROM THREE MAJOR EXTREME CLIMATE EVENTS: FLOYD, MATTHEW, AND FLORENCE.

Cars were submerged. Some road crossings (bridges and culverts) completely washed away, and people drowned as a result of flooded roadways. Hundreds of local roads were closed, and major interstate highways were overtopped, paralyzing emergency access and management services. Thousands of people, trapped by floodwaters, required rescue. In the aftermath of these extreme events, we realized that we must improve our resilience — and the transportation system was at the heart of the issue.

With research funding from N.C. Department of Transportation (DOT), North Carolina Sea Grant, and NC State University’s Department of Biological & Agricultural Engineering (BAE), we have identified and modeled various approaches for improving preparedness and resilience to future extreme rainfall events in the Neuse River Basin. Our efforts have included modeling larger bridges and culverts on rivers and streams that will convey more water, as well as identifying key locations where gauging stations should be added along rivers to help monitor water levels to improve early warning and validate models of future extreme flow events.

As part of this project, Sea Grant convened a meeting of federal and state agencies, academic researchers, and private consulting

firms to discuss storm and disaster warnings, with a focus on our transportation system. A key idea that arose from this meeting was a need to identify “resilient routes” — roadways that remain passable during or shortly following extreme rainfall and flooding events. If there is no “safe” route, it is important to identify and quantify the change(s) needed to make the best route safe. Resilient routes are needed at both the community and regional scales.

Following these discussions, DOT and North Carolina Emergency Management tasked Engineers, Surveyors and Planners Associates, Inc. with developing a transportation-focused alert component to the NC Emergency Management’s existing web-based platform: the Flood Inundation Mapping and Alert Network (FIMAN). FIMAN provides real-time and forecasted flood inundation maps — flooding impacts and alerts intended to support risk-based decisions regarding flooding.

The new “FIMAN-T” now expands this tool to include flood inundation depths along roads, bridges, and other NCDOT assets. This data additionally enables the analysis of the flood vulnerability of existing infrastructure.

FIMAN-T represents a major step in how we can work to improve our transportation resilience. North Carolina Sea Grant and BAE are currently working on a procedure for resilient route identification in three study watersheds located across the state.

This involves first identifying transporta-

tion access priority locations, such as industry, commerce, communities, military bases, and evacuation routes. Possible routes connecting these priority locations are then identified. The existing capacity of each route is determined, and any necessary infrastructure upgrades and their associated costs are also estimated.

The most resilient route can then be optimized through this analysis. Our team is developing the watershed models and working with the SAS Institute to develop visual data analytics mapping tools to support the process of resilient route identification. 📍

more on N.C. coastal rivers and flood mitigation

- go.ncsu.edu/floods

more on the NCDOT’s new flood warning system

- go.ncsu.edu/flood-warning

“The Road to Resilience” in Coastwatch magazine

- go.ncsu.edu/the-road

more from Coastwatch on coastal resilience

- go.ncsu.edu/Coastwatch-resilience

Alondra Nelson, acting director of the White House Office of Science and Technology Policy, commends North Carolina Sea Grant’s work on building flood-resilient transportation routes and early warning systems

- go.ncsu.edu/commending-NCSCG

Is There a Profitable Market for Farm-Fresh Black Sea Bass?

THANKS TO AQUACULTURE BREAKTHROUGHS FROM A TEAM AT UNCW, THIS SEAFOOD FAVORITE COULD REACH MORE CONSUMERS.

BY SARA MIRABILIO



UNCW's Wade O. Watanabe (left) and his team have pioneered research on farming different fish species, including black sea bass. Patrick M. Carroll (right), supervises UNCW's Aquaculture Facility.

IF YOU'VE BEEN FORTUNATE THIS SUMMER TO MAKE IT OUT FISHING ON HARD-BOTTOMED AREAS, INCLUDING SHIPWRECKS AND REEFS, YOU MIGHT HAVE LANDED A BLACK SEA BASS. This North Carolina favorite feeds on crabs, clams, and shrimp, which gives it a firm, white flesh and a delicate and sweet flavor — ideal for a variety of cooking techniques.

Both market demand and dockside wholesale prices have increased for black sea bass. Fishery managers, however, have determined that while the Mid-Atlantic stock is above their targets, the South Atlantic stock is not. As such, management agencies have implemented more stringent fishing regulations that limit current and future landings.

There is interest in developing commercial production of black sea bass among private growers in several states, including our own. With support from North Carolina Sea Grant, NOAA Aquaculture, and others, long-term comprehensive research at the University of North Carolina Wilmington (UNCW) has ranged from controlled breeding of larvae and juvenile production in hatcheries to grow-out (tending fish up to harvest sizes) in recirculating aquaculture systems.

The results have been promising — and have shown that black sea bass can be bred in captivity — but researchers also wanted to evaluate production considering market and economic factors to determine if black sea bass is commercially ready for farming.

THE MARKET

The research team built a pilot hatchery that used laboratory-based research at commercial scale to provide startup fish farmers with a source of fingerlings — fish less than a year old and about the size of a human finger.

Based on all the costs associated with operating the pilot hatchery, the scientists conducted an analysis, using a fixed set of economic conditions, of a hypothetical full-scale commercial black sea bass hatchery operation. The team made several assumptions in their calculations: project life was 30 years, with equipment replacement every 10 years, and the capacity of the hatchery was 100,000 advanced-stage fingerlings. The team also fixed other business-related factors (e.g., interest rates, land ownership, staffing, etc.).

For a hypothetical, commercial-scale hatchery, total initial investment costs of facility construction, recirculating systems, and hatchery-wide equipment and installation are \$778,527. Variable operating costs total up to \$71,426 per year, including labor expenses. Fixed operating costs, which account for loan interest and other expenses, total \$23,162 per year.

Break-even price per 5-gram fingerling is \$1.67 but a mere \$0.43 for a 1-gram fingerling. Both of these prices are highly sensitive, requiring an efficient, fruitful harvest every time.

High-value retail markets provide prices that could be much more profitable for startup growers, though. While wholesale prices for whole-on-ice black sea bass depend on size, with higher prices per



Dan DiNicola

Black sea bass at UNCW's Aquaculture Facility.

pound for larger fish, growers can target niche markets for ultra-fresh product, which garner premium prices for fish of assorted sizes.

BREAKTHROUGHS

Not only are black sea bass easy to catch in the wild, but they also adapt well to life in aquaculture tanks — even though female broodfish change sexes to male, usually when they reach 9 to 13 inches at 2 to 5 years old. (This means aging males must be replaced with wild-caught females.)

Over the years, UNCW researchers have made numerous discoveries that have advanced techniques for farm-raising the species. For instance, by manipulating the amount of exposure to daylight and using hormone treatments they could induce the females to ovulate. Early fingerlings — weighing less than 1 gram on average — are “transport-ready,” with excellent resistance to acute crowding and shipping. The team learned how to control infections during grow-out, too, by lowering water temperatures.

They also determined how to rear black sea bass larvae through juvenile stages using standard feeding regimens for marine finfish. Additionally, they found that using their own UNCW-formulated diets (which replaced 50% fish meal protein with poultry meal protein) led to better growth in early juvenile fish than two commercial diets, without adverse effects on survival.

WHAT'S NEXT?

The UNCW team's results have been promising. They successfully bred black sea bass in captivity, raised the species from egg to adult stages, and found that black sea bass can reach lucrative niche markets.

Availability of fingerlings from UNCW's hatchery has enabled startup farmers to grow and market black sea bass, but commercial expansion will require investment in research to lower production expenses. Research is needed to lower feed and fingerling costs, increase growth, minimize size variation, maximize fish densities in grow-out systems, and address waste management. 📧

the full study: go.ncsu.edu/black-sea-bass

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

HOOKLINESCIENCE.COM



Vanda Lewis

FIRM, WHITE FLESH AND A DELICATE AND SWEET FLAVOR

another fresh seafood recipe
from *Mariner's Menu*

Joyce Taylor and Vanda Lewis

Pan-Fried Black Sea Bass with Garlic Butter

- 1 1/2 pounds of black sea bass fillets
- 1/4 of cup milk
- salt
- black pepper, freshly ground
- flour
- 3 tablespoons of canola oil
- 6 tablespoons of butter
- 2 teaspoons of garlic, pressed
- 1 tablespoon of fresh lemon juice

Place milk in a shallow bowl. Dip fillets in milk and drain off the excess. Lightly salt and pepper them, then dredge in flour.

Heat oil over medium-high heat. Add 3 tablespoons of butter and heat to 350° to 375° F. Cook the fillets until golden, about 5 to 6 minutes. Flip them over and repeat, cooking until done. Remove them to a warm platter.

Wipe the pan clean with a paper towel. Melt remaining 3 tablespoons of butter, shaking the pan until butter foams and turns slightly brown. Add the garlic and sauté lightly. Do not allow it to get dark or to burn. Add lemon juice, and drizzle it over the fish.

more black sea bass recipes

- go.ncsu.edu/BSB-recipes

MARINERSMENU.ORG

Oysters Casino, Snapper Fillets, Stuffed Clams, and More

BY VANDA LEWIS AND JOYCE TAYLOR

Mariner's Menu, North Carolina Sea Grant's popular online seafood guide, features blogger and photographer Vanda Lewis's pictures with hundreds of recipes that Joyce Taylor developed. Enjoy these fall treats – and visit MarinersMenu.org for more.

OYSTERS CASINO

- 1 pint of oysters, drained
- 3 slices of bacon, chopped
- 4 tablespoons of onion, chopped
- 2 tablespoons of green pepper, chopped
- 3 tablespoons of celery, chopped
- 1 teaspoon of lemon juice
- 1/4 teaspoon of salt
- 1/4 teaspoon of black pepper, freshly ground
- 1/2 teaspoon of Worcestershire sauce
- 1/8 teaspoon of Tabasco sauce

Preheat the oven to 350° F.

In a skillet, fry the bacon until brown. Remove the bacon, and drain it on paper towels. Discard all but 1 1/2 of tablespoons of bacon grease. Add onion, green pepper, and celery to the skillet, and sauté until tender. Remove the skillet from the heat, and add the lemon juice, salt, black pepper, Worcestershire, Tabasco, and bacon. Mix well.

In a lightly greased baking dish, arrange the oysters, and then spread the bacon mixture on top. Bake until the oysters are done and the topping is brown, for about 10 to 15 minutes.



Oysters Casino



Striped Bass Tacos with Creamy Guacamole

STRIPED BASS TACOS WITH CREAMY GUACAMOLE

- 1 1/2 pounds of striped bass fillets, skinless, cut into 1-inch chunks
- salt
- black pepper, freshly ground
- 2 tablespoons of canola oil
- 2 tablespoons of butter
- 1 cup of cabbage, finely shredded
- corn or flour tortillas
- cilantro, garnish

Prepare creamy guacamole (below) and chill.

Lightly salt the fish. Sprinkle it generously with pepper.

Heat the oil in a large skillet to 375° F. Add the butter and melt.

Add the fish, and cook until golden brown, about 3 to 4 minutes. Turn the fish chunks over and repeat. Drain them on paper towels.

Place each serving of fish in a tortilla. Sprinkle on a light amount of cabbage. Spoon on the guacamole, and garnish it with cilantro.



Snapper Fillets Sautéed with Mushrooms



Easy Stuffed Clams

Creamy Guacamole

- 1 cup of sour cream
- 1/4 cup of red onion, thinly sliced
- 1 tablespoon of jalapeño, finely chopped
- 1 tablespoon of fresh lime juice
- 2 tablespoons of cilantro, chopped
- 1/2 teaspoon of salt
- 1/2 teaspoon of garlic, minced
- 1 avocado, chopped

In a small bowl, combine the sour cream, onion, jalapeño, lime juice, cilantro, salt and garlic. Mix it well. Gently mix in the avocado. Cover and chill.

SNAPPER FILLETS SAUTÉED WITH MUSHROOMS

- 6 small snapper fillets
- salt
- black pepper, freshly ground
- 2/3 cup of flour
- 3 tablespoons of vegetable oil
- 4 tablespoons of butter
- 1 cup of small mushrooms, thinly sliced
- 2 tablespoons of fresh lime juice
- 3 tablespoons of fresh parsley, finely chopped

Lightly salt and pepper the fish. Dredge it lightly in flour.

Heat the oil in a large skillet. Add 3 tablespoons of butter and heat. Sauté the fillets until golden brown, about 5 to 6 minutes. Turn the fillets over and repeat, cooking until done. Transfer the fillets to a warm platter.

In the same pan, melt 1 tablespoon of butter over high heat. Add the mushrooms, and sauté them until the liquid is gone and the mushrooms are browned. Arrange them over the fillets, and sprinkle with lime juice and parsley.

EASY STUFFED CLAMS

- 1 1/2 cups of clams, drained and finely chopped, (reserve clam liquid)
- 2 tablespoons of unsalted butter
- 1 cup of fine dry bread crumbs
- 1 teaspoon of fresh parsley, finely chopped
- 1/4 teaspoon of black pepper, freshly ground
- 1 teaspoon of fresh lemon juice
- 1/8 teaspoon of garlic powder
- 1/8 teaspoon of oregano
- 1/4 teaspoon of Tabasco sauce
- 10 to 12 large clam shells or other shells
- Paprika

Preheat the oven to 400° F.

Melt the butter in a medium saucepan, and then remove it from the heat. Add the remaining ingredients *except paprika*, and mix it well. Add enough of the reserved clam liquid to moisten the clam mixture.

Fill the shells with the mixture. Sprinkle paprika over the top. Bake it until hot and bubbly, about 10 to 15 minutes. 🍴

For hundreds of free seafood recipes, visit:

MarinersMenu.org



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The screenshot shows the website header with the Sea Grant North Carolina COASTWATCH logo and a navigation menu: About, Subscribe, Coastwatch Classroom, Coastal Resilience, Climate Change, Sharks, Seafood, More, Browse by Issue, and a search icon. The main content area features a large image of a shark with the text: **WINTER 2022 COASTWATCH**. Below the image, it states: "On December 14, the special all-digital Winter 2022 issue will available here at no cost: ncCoastwatch.org. *Coastwatch* will return in print with our Spring 2023 issue in March. Loyal print readers like you will still receive the same number of print issues you ordered. And you can *always* access free *Coastwatch* content at ncCoastwatch.org."


TEACH: Use free educator resources to enrich student learning.

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go.ncsu.edu/Coastwatch-Classroom

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