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Coastwatch

NORTH CAROLINA SEA GRANT • SPRING • 2020 • ISSUE 1 • \$6.95

THE GREATEST SHOW
ON THE EAST COAST
North Carolina's Nightscapes

A Special Note to Our Readers about COVID-19

We prepared this issue of *Coastwatch* before responses to COVID-19 quickly escalated. Many of the stories here will be much more relevant and meaningful when our lives return to “normal,” and some of the events we mention, such as statewide Star Parties, have been postponed indefinitely. We also know how much you appreciate our coast, which is why we decided to print and mail this issue.

We hope our valued readers, along with your family, neighbors and colleagues, will continue to take precautions to stay healthy and to limit transmission of the Coronavirus. Monitor updates from trusted state and federal sources, such as ncdhhs.gov and cdc.gov.

At North Carolina Sea Grant, this is a season for fellowships. Every year, I am impressed with the thoughtful applications that detail interests and accomplishments of a new generation of our coastal researchers, planners, decisionmakers, advocates, industry leaders, and ecosystem enthusiasts. They truly offer us encouragement and inspiration as we see the impacts of their leadership and innovation, often stemming from ever-expanding opportunities for interdisciplinary training that they seek out — or create — within our strong public and private institutions.

In this issue, you will read about four new Knauss Marine Policy Fellows from four North Carolina universities, taking on exciting new roles in Washington, D.C. Recently, we also had two full days interviewing applicants for the 2021 term. This national program celebrates 40 years, while other fellowships, such as NOAA Coastal Management/Digital Coast Fellowship and a National Sea Grant/National Marine Fisheries Service partnership also draw top-notch candidates.

Here in North Carolina, we have been thrilled with the response to our new North Carolina STEM Policy Fellowship that will place current or recent graduate students in state agencies to focus on topics related to science, technology, engineering, and/or mathematics. The program is a partnership with the Burroughs Wellcome Fund, with host offices in the N.C. Department of Commerce and the N.C. Department of Environmental Quality, and a professional development program being developed with Sigma Xi.

We also recently began hosting the first high school intern during my tenure. She already has learned to telecommute as she works on Oceans and Human Health priorities and other projects. I also enjoy that she adds splashes to layouts for some of our N.C. seafood recipes — and to my virtual presentations.

The cover story of this issue focuses on lifelong learning — via potential educational and tourism opportunities in the night skies in our coastal region. With funding from our N.C. Community Collaborative Research Grants, a team that includes the N.C. Land of Water and A Time for Science documented locations that can be research sites or future fieldtrip destinations. As he has done for the past 50+ years since he arrived at East Carolina University, Stan Riggs speaks eloquently about our ecosystems that include water, land, and sky.

I know that you will take time to enjoy the variety of topics in this issue of *Coastwatch*, including pieces written by our interns, funded graduate students, and multi-talented team members. Also, please take time to check our back cover and add your thanks to individuals who have donated to our North Carolina Sea Grant Program Enhancement Fund that supports our ongoing research, education, and outreach.

As always, if you have a topic of interest, send me an email via snwhite3@ncsu.edu.

— Susan White, Executive Director, North Carolina Sea Grant

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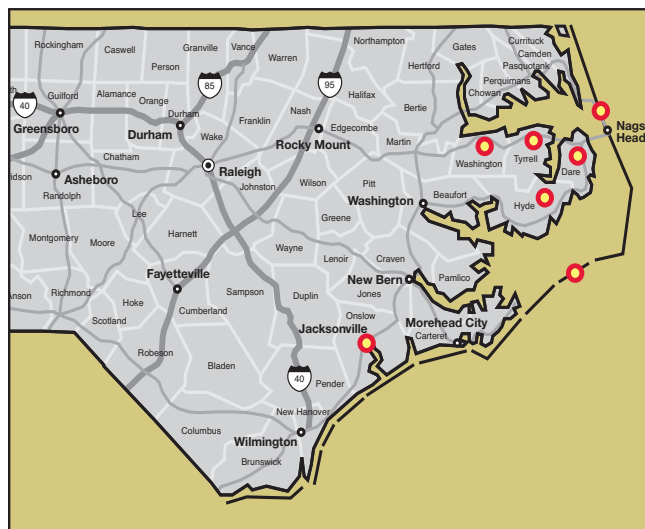
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The story settings in this issue include Camp Lejeune, Kitty Hawk, four counties on the Outer Albemarle Peninsula, and other places.





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■ *Front Cover:* Like a searchlight outside a movie premiere, Bodie Island Lighthouse shines outside our state's amazing theater of the dark. By Jamie Zink/CC-BY-SA 4.0 International. ■ *Table of Contents:* Little bluestem, by Joshua Mayer/CC BY-SA 2.0

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

Susan White is executive director.

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

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COASTAL TIDINGS

KNAUSS FELLOWS ARRIVE IN D.C.

Four North Carolina graduate students are among the new group of 69 Knauss fellows whose service recently began in Washington, D.C. The National Sea Grant Program selected Margaret Chory, Gabrielle Corradino, Cheyenne Stienbarger, and Jessamin Straub for the prestigious fellowship, a year-long program for graduate students interested in national policy issues affecting ocean, coastal, and Great Lakes resources.

Knauss fellows serve in host offices within the federal government's executive or legislative branches. The fellowship honors John A. Knauss, a founder of the National Sea Grant Program.

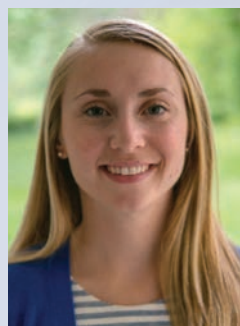
"A Knauss Fellowship is an excellent opportunity to develop career-long personal and professional relationships," says Susan White, executive director of North Carolina Sea Grant. "Our fellows always offer high levels of professionalism, expertise, and enthusiasm for what they do."

North Carolina's fellows have a wide array of interests.

• **Margaret Chory** graduated from Duke University with a master's in environmental management. Chory serves the National Sea Grant College Program as a socioeconomics specialist.

"This placement uniquely will allow me to see firsthand how a large NOAA program like Sea Grant is run," Chory says, "while also experiencing how its initiatives play out on the ground level in the 34-program network."

• **Gabrielle Corradino** pursued her doctorate in biological oceanography at NC State with a focus on nanoplankton. She serves in the NOAA Office of Education as a science education and policy fellow.



Knauss 2020 fellows (top to bottom): Margaret Chory, Gabrielle Corradino, Cheyenne Stienbarger, and Jessamin Straub.

"This next year as a Knauss Fellow is going to push me outside of my research comfort zone and into the world of science policy," Corradino says. "I am looking forward to working with my NOAA office and exploring the process behind policy decisions."

• **Cheyenne Stienbarger** graduated with a master's in marine biology from the University of North Carolina Wilmington. She serves in NOAA's ocean observing and monitoring division.

Stienbarger hopes the Knauss Fellowship will give her an opportunity to embark on something completely new. "Working in a physical oceanography office will certainly satisfy that goal," she says. "I'm excited to be part of a team that uses ocean observations to inform decision-making in communities around the globe."

• **Jessamin Straub** graduated from the University of North Carolina at Chapel Hill with a master's in marine sciences. Straub works with the U.S. Army Corps of Engineers as the advisor to the technical director for Civil Works Research and Development.

"The broad range of projects I'll have the opportunity to work on relate directly to my interests and career goals," she says. "They range from flood-risk management to the U.S. Coastal Research Program, the committee on the Marine Transportation System, and the Engineering with Nature initiative."

These fellows join more than 80 graduate students from

North Carolina who previously served during the Knauss program's 40-year history.

— Danielle Costantini



Merchants Millpond State Park

Six rural North Carolina host sites will showcase the Smithsonian’s “Water/Ways” exhibit in 2020 and 2021 through the North Carolina Humanities Council’s “Museum on Main Street” program. The tour begins in Burnsville in late May, with each participating site and community to announce local programming.

North Carolina’s distinct coastal beaches, mountain rivers, and local lakes play an integral part in shaping the state’s identity. Water/Ways is designed for small-town museums, libraries, and cultural organizations to catalyze community conversations about water’s impact on American culture.

“Creating personal connections with our local waterways is extremely important for supporting active stewardship of these waters,” says Christy Perrin, sustainable waters and communities coordinator for North Carolina Sea Grant and a leader in the N.C. Watershed Stewardship network. “Hopefully visiting the exhibits and related events will inspire people to get out and explore their own local waterways.”

North Carolina Sea Grant and the North Carolina Water Resources Research Institute are among the co-sponsors for Water/Ways.

go.ncsu.edu/Waterways

— Katelyn Vause & Chloe Tenn

OYSTER TRAIL DEBUTS THIS SPRING

What draws you to the coast? Beaches? Fishing? How about shellfish? A team of researchers thinks local oysters and clams have caché enough to support a tourism industry centered on marine aquaculture.

To test that idea, the researchers — from North Carolina Sea Grant, NC State University, and East Carolina University — are investigating the potential of an Oyster Trail to connect tourists with local businesses.

“For example, shellfish farms could offer tours to the public, and restaurants could celebrate local oysters through dinner specials,” says team leader Whitney Knollenberg, of NC State’s Department of Parks, Recreation & Tourism Management.

Essential to the project is understanding the demand for such experiences, as well as the capacity of businesses to support them. To that end, the researchers are conducting focus groups to learn more from candidate Oyster Trail sites — and from the public. North Carolina Sea Grant will announce focus group meetings on NCseagrant.ncsu.edu/news.

“We’ve been in regular communication with Oyster Trail enthusiasts in the Outer Banks,” says team member Jane Harrison,

North Carolina Sea Grant’s coastal economics specialist. “Trail sites are being developed first along the northern coast, namely in Dare County and Hyde County.”

The trail’s Outer Banks debut is slated for May, says Harrison. “Eventually, though, the trail will be available coastwide.”

The trail is administered by North Carolina Sea Grant and the N.C. Coastal Federation, and the Coastal Federation’s N.C. Oyster Blueprint website will host an Oyster Trail online portal. Stay tuned for updates.

NCoysters.org

— Julie Leibach



Marching for Hyde County desegregation

NC MARKS HYDE COUNTY DESEGREGATION

School desegregation came to coastal Hyde County, but not without a fight. The white-controlled Hyde County Board of Education first created a desegregation plan without input from the African American community, which responded with what became known as the “Hyde County Movement.”

A North Carolina Highway Historical Marker commemorates that movement in front of the old Hyde County Courthouse on NC Route 45 in Swan Quarter.

Initially, the all-white board proposed to expand the consolidated whites-only Mattamuskeet School and close two traditionally African American schools. This would have meant extensive travel for African American students, loss of longstanding educational experiences, and potential job losses for African American educators.

African American leaders formed a committee with representation from religious denominations in the county. With help from Golden Frinks, who served with the Southern Christian Leadership Conference, they planned long marches between communities in the county.

Other protests followed that attracted widespread media attention, including a February 1969 march that brought approximately 600 protesters to the state capital.

Eventually, the county adopted a desegregation plan with more inclusive decision-making. It was less expensive and resulted in shorter bus routes.

The Highway Marker program is a collaboration between the N.C. Department of Natural and Cultural Resources and the N.C. Department of Transportation.

— N.C. Department of Natural and Cultural Resources



*Maintaining a way of life
in coastal fishing communities*

COMMERCIAL FISHERS GO TO CAMP

Seventeen of the next generation's commercial fishers came together to network, learn from one another's business operations, and communicate with consumers and policymakers at "Fish Camp" in January.

"Demand for local seafood is increasing, yet the numbers of active commercial fishermen who provide that seafood are decreasing," says Scott Baker, fisheries specialist at North Carolina Sea Grant. "Those who want to succeed in this new era will need solid communication and business skills, as well as a good understanding of the fishery management process."

The three-day workshop covered management and science, business, and safety. Steve Murphey, director of the N.C. Division of Marine Fisheries, and John Nicholson, chief deputy secretary of the N.C. Department of Environmental Quality, held "kitchen-table" conversations. The N.C. Commercial Fishing Resource Fund supported the industry training.

Two staff from UNC-TV's NC Science Now also played key roles, and the Small Business Center at Carteret Community College and the U.S. Coast Guard Auxiliary presented critical information.

"It's a start to maintaining a way of life in North Carolina's coastal fishing communities," says Sara Mirabilio, fisheries specialist at North Carolina Sea Grant and the project lead. "We hope activities like these foster business-savvy, stewardship-minded commercial fishing men and women."

— *Chloe Tenn*

COASTAL TIDINGS

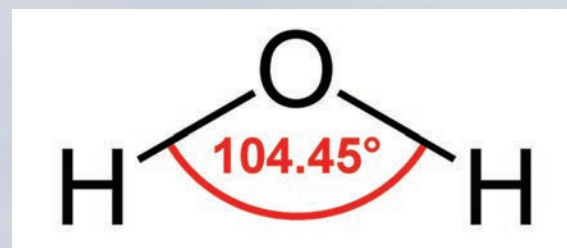
FELLOWSHIP SUPPORTS NC STEM POLICY

North Carolina Sea Grant opened 2020 with a call for applicants for a new fellowship that places graduate students, trained at North Carolina institutions, in science and technology policy roles in state government offices.

"This new NC STEM Policy Fellowship — focused on science, technology, engineering, and mathematics — will provide a unique, in-state, nonacademic career opportunity that may lead to greater retention of these highly trained individuals in state," says Susan White, North Carolina Sea Grant's executive director.

With funding from North Carolina Sea Grant and the Burroughs Wellcome Fund, two fellowships will begin in August. Each fellowship is full-time, working with host offices in the N.C. Department of Commerce's Office of Science, Technology and Innovation, or the N.C. Department of Environmental Quality's State Energy Office.

Each 12-month fellowship includes a



competitive stipend, health care costs, and associated travel and training opportunities, elements that combine for a total value of \$54,500.

"The North Carolina fellows will gain valuable real-world experience and professional development opportunities, working directly with host offices engaged in STEM policy and policymaking processes," says North Carolina Sea Grant fisheries specialist Sara Mirabilio, the fellowship's coordinator. "Host offices also will benefit from access to impartial, science-savvy fellows to help them make critical decisions."

NCseagrant.ncsu.edu/fellowships

— *Chloe Tenn*

MARINE DEBRIS ACTION PLAN TAKES EFFECT

North Carolina Sea Grant and partners recently announced the state's first Marine Debris Action Plan. This multiyear effort will remove litter and prevent its accumulation along North Carolina's coast. The plan complements the Southeast Regional Marine Debris Plan.

"This plan represents the ideas of many people who are familiar with marine debris issues in the state, and it is bringing new energy to this important topic," says Gloria Putnam, North Carolina Sea Grant's coastal resources and communities specialist. Putnam serves on the advisory and implementation committee for the plan, which the North Carolina Coastal Federation spearheaded over a three-year period.

"The practical solutions and research projects in the plan are achievable with relatively modest funding but will need strong and continued engagement from various stakeholders," Putnam adds. "In the long run, the steps on prevention will be the key to success."

In addition to North Carolina Coastal Federation and North Carolina Sea Grant, partners on the project included N.C. Coastal Reserve, N.C. Division of Coastal Management, N.C. Wildlife Resources Commission, Coastal Carolina Riverwatch, and the N.C. Marine Debris Symposium. Beaufort recently became the first N.C. town to endorse the new plan publicly.

NCcoast.org/ActionPlan

— *Katelyn Vause*



Coastal cleanup of marine debris



Debbie Roos / NC State Extension

Native plants like asters attract pollinators, such as the American lady butterfly.

COASTAL LANDSCAPING VIDEO NOW ONLINE

Why is nature-enhancing landscaping becoming more popular?

Because less lawn and more native and pollinator-friendly plants help keep residential landscapes in line with local ecology — and that increases biodiversity. Not only are homeowners more likely to encounter wildlife, there's less grass to mow.

Some landscaping features, such as rain gardens, even remove pollution and reduce downstream harm from stormwater runoff. In addition, the use of "living shorelines" in coastal areas and on waterways can maintain the ecological connections between land and water that many species of plant and animal require,

and homeowners also benefit from highly effective erosion control.

In a free webinar earlier this year, Jane Harrison of North Carolina Sea Grant and Christy Perrin of the North Carolina Water Resources Research Institute explained the Coastal Landscapes Initiative and how to make sustainable coastal landscaping choices.

You can access the video of their webinar and use their information and resources around your home, in your neighborhood, and across your community.

You can also read more about coastal landscaping on page 36.

go.ncsu.edu/CoastalLandscapes

SCIENTISTS PUBLISH NC CLIMATE REPORT

The North Carolina Institute for Climate Studies (NCICS) has released the *North Carolina Climate Science Report*, an independent assessment of observed and projected climate change.

NC State University's Kenneth Kunkel, NCICS's lead scientist for assessments, assembled the team that wrote the report and an advisory panel that provided scientific oversight. The panel included scientists with national and international reputations in their areas of expertise.

The report will inform responses to Governor Cooper's Executive Order 80, *North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy*, including the "N.C. Risk and Resilience Plan," which the Department of Environmental Quality is developing.

For more on Executive Order 80 and the "N.C. Risk and Resilience Plan," see this issue's "Capturing the Culprit" on page 16.

North Carolina Climate Science Report summary: go.ncsu.edu/climate-science

Full report: go.ncsu.edu/climate-science-full



*Sensory Saturday at the
N.C. Maritime Museum at Southport*

MARITIME MUSEUM BECOMES NC'S FIRST CERTIFIED AUTISM CENTER

The North Carolina Maritime Museum at Southport is the state's first Certified Autism Center.

"This is a remarkable achievement for the North Carolina Maritime Museum at Southport and its entire staff," says Joseph Schwarzer Jr., director of North Carolina Maritime Museums. "I couldn't be prouder."

Museum staff and volunteers underwent comprehensive training to earn the Certified Autism Center designation.

"We've done a lot of work with the special needs population in our part of North Carolina," says Katy Menne, the museum's education curator. "We wanted to take that to the next level."

Lori Sanderlin, manager of the Southport museum, says that through their training and collaboration the museum staff has developed methods for providing a safe, welcoming, and accepting environment.

"This process gave us the opportunity to look more deeply at how we are serving everyone who visits the museum," she says.

Their programming includes "Sensory Saturdays," specially designed for people on the autism spectrum. During that time, the museum dims the lights and turns off all audio, as well as providing a craft to incorporate hands-on experiences. The free drop-in program runs the first Saturday of each month from 9 to 11 a.m.

NCmaritimemuseumssouthport.com



THE GREAT

Meredith Ross/VisitNC.com

THE OUTER ALBEMARLE PENINSULA OFFERS SOME OF THE DARKEST SKIES
ON THE U.S. ATLANTIC SEABOARD, WITH SITES FOR UNSURPASSED STARGAZING AND
A NIGHTSCAPE EXPERIENCE FULL OF WILDLIFE AT PLAY UNDER THE MUSIC OF THE SPHERES.

THE GREATEST SHOW ON THE EAST COAST

NEW JOURNEYS INTO THE HEART OF NORTH CAROLINA'S DARKNESS

DAVE SHAW

*THE BUFFER AROUND THE OUTER ALBEMARLE PENINSULA'S
AMAZING NIGHTSCAPES INCLUDES OCRACOE ISLAND.*



Welcome to the “Yellowstone of the East,” where the Gothic South meets the galaxy. Here on the Outer Albemarle Peninsula, you can stare into the soul of the Milky Way, a gash of glitter across the night sky that formed billions of years before our planet. You can watch the moon rise, feathering cirrus clouds of silver and indigo, or follow the night’s new river of light across a black inlet out to the horizon. Here, nighttime cues the cacophony of tundra swans. Your shoes will find solid earth, but the terrain also includes bays, marshes, ghost forests, and pocosins — wetlands built on sandy, peaty soil, saturated with groundwater, and made for boots. This country belongs to wild creatures and critters, to red wolves, alligators, black bears, otters, and manatees.

Bring your telescope, your binoculars, your sense of adventure, and anyone you know who still believes that reality beats virtual reality. Over 2.4 million acres of public lands and waters stretch across the Outer Albemarle Peninsula (OAP) and the surrounding estuaries and barrier islands. Locals live in small towns on the peninsula’s perimeter like Columbia, Stumpy Point, Engelhard, and Swan Quarter, or in crossroad communities like Goat Neck, Alligator, and Gum Neck. This part of the state remains mostly untamable, and, at night, strikingly dark.

All of which makes the peninsula one of the country’s best kept secrets — an expanse of land and sky that offers the rarest of settings. The OAP stages a nightscape that not only awes visitors but that might provide a much-needed boost to ecotourism in northeastern North Carolina.

“When you have a vast area of public wetlands surrounded by expansive estuarine bodies of water, with minimal human activity, the 360-degree vistas of the horizon provide a never-ending parade of night sky magic. Thunderheads illuminate the stage with dramatic lightning, as spectacular cloud displays at day’s end introduce a zenith of planets, constellations, and an astronomical wonderland that is becoming an endangered environment along our coast, because of increasing light pollution.”

THE YELLOWSTONE OF THE EAST

“These are world-class natural resources,” says Stan Riggs. Since the early 1970s, North Carolina Sea Grant has supported numerous research initiatives Riggs has spearheaded, including his latest, the Night-Scape Resource Project. Riggs, now coastal and marine geologist with NC LOW (“North Carolina Land of Water”), is exploring the Outer Albemarle Peninsula after dark.

“It’s truly a magic place,” he says, “once you get off the main highways.”

Riggs first heard the “Yellowstone of the East” description of the peninsula from Mike Dunn, a naturalist and science educator, who worked with Riggs on earlier research. Dunn has led tours for visitors from around the world primarily to two jaw-dropping regions — Costa Rica and Yellowstone Park — and also, at first blush, to seemingly much less exotic eastern North Carolina.

“Mike was right,” Riggs says. “There are plenty of reasons to compare Yellowstone with aspects of the OAP that require more introspection and contemplation. You just have to slow down and understand a little about the natural resources that we have here.”

Riggs’s enthusiasm is catching, especially when he begins cataloging why exactly the Outer Albemarle, like the iconic national park, possesses the potential for ecotourism. The biodiversity within OAP terrain rivals Yellowstone’s, for instance, even among the large animals — black bears, red wolves, porpoises, and sharks versus the famous park’s moose, elk, and grizzly bears — not to mention that the peninsula’s panoramas can compete with any location’s.

In fact, the OAP’s 780 square miles of national wildlife refuges, state parks and reserves, and vast swaths of public game land seem to unfurl endlessly because of an additional 2,900 square miles of publicly owned buffer enveloping it all.

Albemarle Sound to the north, Croatan and Pamlico sounds to the east and southeast, and Pamlico River Estuary to the south surround the OAP. Cape Hatteras and Cape Lookout National Seashores further protect the peninsula to the east, as do the Pea Island and Cedar Island National Wildlife Refuges. To the west, broad stretches of agricultural fields sprawl across the lower Coastal Plain.

“When you have a vast area of public wetlands surrounded by expansive estuarine bodies of water, with minimal human activity, the 360-degree vistas of the horizon provide a never-ending parade of night sky magic,” Riggs says. “Thunderheads illuminate the stage with dramatic lightning, as spectacular cloud displays at day’s end introduce a zenith of planets, constellations, and an astronomical wonderland that is becoming an endangered environment along our coast, because of increasing light pollution.”

INTO THE DARK

Because of the OAP’s immense tracts of protected and unpopulated terrain, these night skies are some of the darkest on the U.S. Atlantic Coast between Boston and Miami.

Riggs recalls when he previously could view the Milky Way from his own back doorstep, a level of visibility astronomers consider necessary both for optimal stargazing with the unaided eye and for exploring the farther reaches of space with binoculars and telescopes. Today, he says, due to light pollution from nearby residential developments, “I can’t see either the Milky Way or the Little Dipper.”

In large part, the conspicuous black sky over the OAP that appears on nighttime satellite maps of the Eastern Seaboard prompted Riggs to document this terrain. Naturalists and astronomers covet such conditions,

Continued



Allie Stewart/USFWS

THE OUTER ALBEMARLE PENINSULA BELONGS TO RED WOLVES, ALLIGATORS, AND MANY OTHER CREATURES, INCLUDING RIVER OTTERS (LIKE THIS ONE, BELOW), AND TUNDRA SWANS (ABOVE, AT LAKE MATTAMUSKEET).



Mike Dunn



INSIDE THE RED CIRCLE, THE OAP REGION'S PRISTINE DARKNESS STANDS IN CONTRAST TO THE EAST COAST'S BRIGHT LIGHTS.

which offer a paradise for both professional and amateur explorers alike — with significant implications for the future economic health of the whole region.

To partner with astronomy experts, his NC LOW joined forces to form the Night-Scape Resource Project with another nonprofit, Greenville's "A Time For Science." The project trained survey teams to journey across the peninsula to catalog night landscapes and soundscapes, as well as the viewsapes of those deep and spacious skies untouched by artificial light.

The teams would visit sites on national wildlife refuges (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter), state parks and reserves (Pettigrew, Somerset Place, and Buckridge), and vast parcels of public game lands (NC Wildlife Resources Commission). But first, there was a caution for everyone who had volunteered for the assignment — scientists, educators, and students alike — about the remote ground they were about to cover.

"The sites with a shoreline are the best. The stage becomes much vaster. Incredible cloud patterns, distant thunderheads with flashing lightning spectacles. Out here, the sunsets and sunrises, and moonrises and moonsets, are among the biggest shows on Earth."

"Most of this land is low, wet, and wild," reads the project's instructional guide. "Do not drive off any paved, graveled, or sand roadway. YOU WILL GET STUCK."

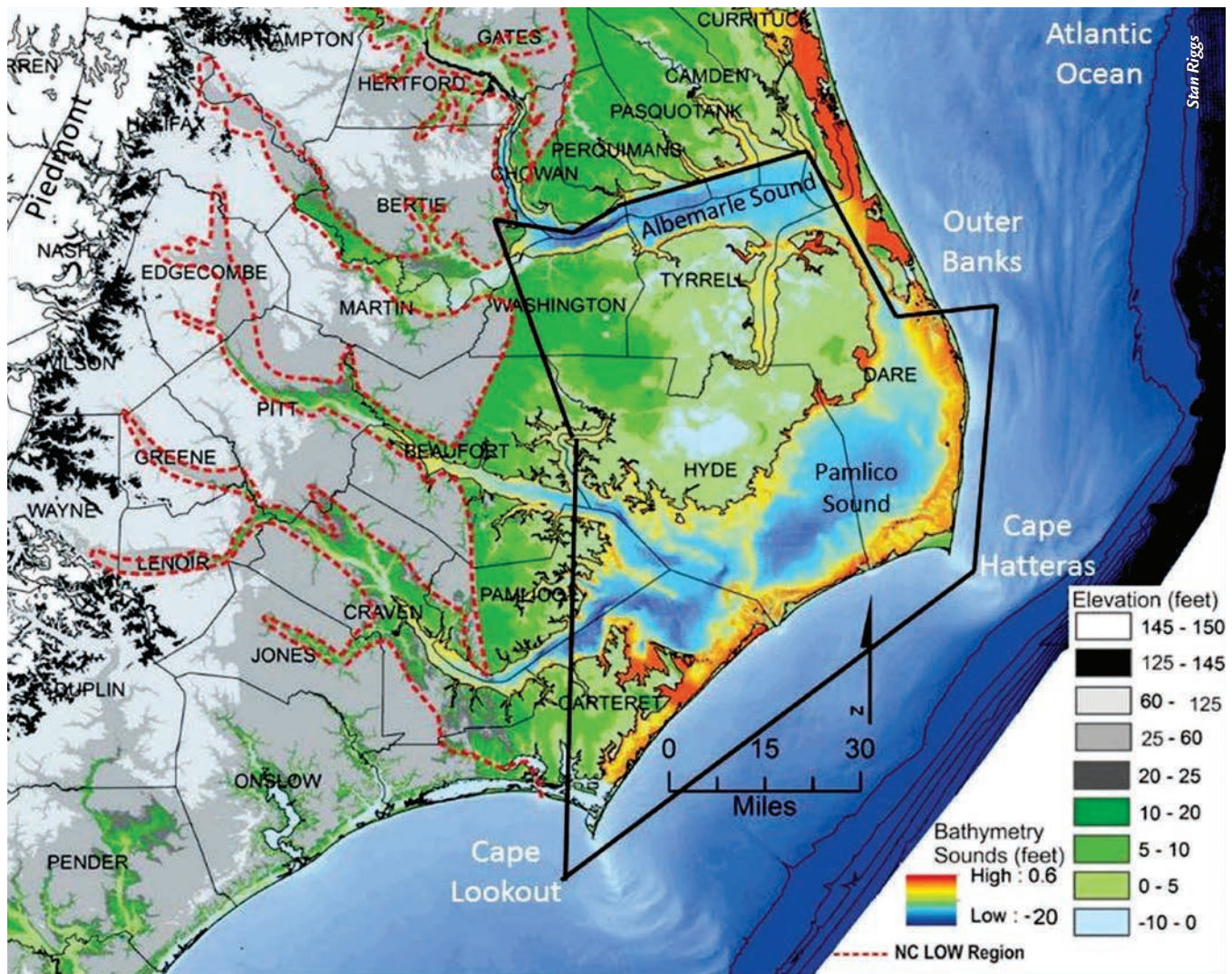
To be sure, venturing off the beaten path on the OAP could lead you into territory Edgar Allen Poe could have borrowed for a literary milieu. Undaunted, though, three adventurous teams fanned out across Tyrrell, Washington, mainland Dare, and mainland Hyde counties to map and develop profiles of optimal sites to experience the nightscape.

Armed with GPS devices, sky-quality light meters, sound meters, and weather instruments, the teams collected data for 11 months, across each season, timing their visits as closely as possible with new and full moons. By the end of the project, they had logged 250 visits to 83 sites, mostly on public land, compiling portraits of each location's darkness, ambient sound, light pollution, nearby environment, accessibility, and even available parking space.

Not only did the project produce comprehensive site profiles, but its data on light pollution possibly could earn the OAP a regional designation as an "International Dark Sky Reserve."

"A majority of our survey sites on the OAP offer starry nights that the International Dark Sky Association's guidelines rate as gold or silver," Riggs says.

The dark sky designation, Riggs adds, along with the accompanying stamp of approval from the International Dark Sky



ABOVE: THE NIGHT-SCAPE RESOURCE PROJECT STUDIED THE QUALITY OF DARKNESS AND MANY OTHER ENVIRONMENTAL FACTORS AT 83 SITES INSIDE THE AREA THAT THE BLACK BORDER ON THIS MAP REPRESENTS.

Association, would enhance the peninsula's visibility, infusing the region's slowly growing ecotourism industry with instant marketability.

Jane Harrison, North Carolina Sea Grant's coastal economics specialist, says tourism on the coast is a key economic driver.

"For Dare County, one in four jobs is in tourism and recreation," she explains. "Hyde, Washington, and Tyrrell counties are looking to grow their tourism economies especially, and night sky ecotours would be a great addition to what they already offer."

In 2015, Harrison says, tourism in Tyrrell County provided less than 2% of the jobs.

THE STARGAZER'S PLAYGROUND

The Yellowstone of the East's appeal is significant and indelible.

"The sites with a shoreline are the best," Riggs says. "The stage becomes much vaster. Incredible cloud patterns, distant thunderheads with flashing lightning spectacles. Out here, the sunsets and sunrises, and moonrises and moonsets, are among the biggest shows on Earth."

"Opportunities for building programs around the nocturnal environment and night sky are unlimited.

Educating the youth, public, and leadership of the Roanoke-Albemarle region is critical for the protection and management of this dark-sky natural resource, but also to capitalize on the potential for developing a sustainable ecotourism for the region's future."

The OAP offers a majestic platform to watch lunar eclipses and rising planets, to unfold a chaise-lounge for shooting stars — especially the seasonal Perseid or Geminid meteor showers — or a place to plant

Continued



USFW

ABOVE: SUNRISES AND SUNSETS AND MOONRISES AND MOONSETS CAPTIVATE VISITORS TO THE ALLIGATOR RIVER REFUGE (HERE) AND ELSEWHERE ACROSS THE OUTER ALBEMARLE PENINSULA.
BELOW: BLACK BEARS ARE COMMON SIGHTS ACROSS THE OAP REGION.



Mike Dunn

your telescope to gaze at supernovas, Saturn's rings, or Jupiter's red spot.

And, of course, out in the heart of all this darkness, our own Milky Way gleams for the naked eye. Most of us no longer can see it from our own back door, with or without a lens. But out on the OAP, that long band of stellar haze crosses the celestial sky faithfully — as faithfully each night as, well, Old Faithful — hinting, like the famous geyser, at the universe's hidden depths.

"Sweeping through the Milky Way with a telescope reveals a window deep into the center of our galaxy," Riggs says. "Interstellar gas and dust constitute the spiral arm as it cuts through the starry 'cloud.' Within this cloud is a treasure trove of nebulae and star clusters — a stargazer's playground. Here, it's important to see not only with your eyes, but with your mind."

Of course, lifting our chins to the heavens was the original mind-altering experience. From ancient constellations made in the shape of mythological heroes to contemporary literature's marriage of setting and psychology, the night sky has always offered contemplation, inspiration, and awe. One of John Cheever's acclaimed stories, "The Swimmer," depicts a suburbanite's nighttime trek through town, full of youthful vigor as he plunges into his neighbors' pools, flutter-kicking and crawl-stroking his way across one backyard after the other, only to arrive home to find the constellations have changed. Summer's metaphorical skies have become fall's — and just as the seasons have passed, so, too, has much of his life.

NATURE'S REMEDY

In addition to nature's archetypal resonance within us, a record of research as wide as the OAP's dark expanses suggests the very act of beholding the natural world can help alleviate many ills that consume our psychological space — afflictions including stress, depression, and even attention deficit disorder. In fact, science over the past decade has shown that spending time in nature may be especially important for the well-being of children.

In 2018, researchers at NC State and Clemson found that even rural children, amid easily accessible natural settings, are spending more time in front of electronic screens than they spend outside. The study looked at middle school students, in particular, and determined that gaps between time spent on screens and time in the outdoors were widest for girls and African American students.

When the study was published, NC State's Lincoln Larson, co-author of the journal article, said that middle school could be a turning point for children as priorities shifted and their lives became more structured. "This often results in fewer opportunities for outdoor recreation," he explained. "This is a problem, because connection to nature plays a positive role in young people's physical health and psychological development."

For Riggs, the nightscape offers a natural remedy, a valuable alternative for families zigzagging through life with their eyes locked on screens.

"The whole concept is to get people in tune with these hidden resources," he says. "When I take people out on North Carolina's large estuarine water bodies and away from the large urban centers, I tell them to count the number of boats they see. It's rare to see more than a fisherman or two on any given day on most of North Carolina's underutilized estuarine waters."

Accordingly, a large part of the Night-Scape Resource Project's charge is to educate — in effect, to take the sky into the classroom and to draw students into the environment. Riggs and his team have held a series of science teacher education workshops and fieldtrips, and A Time For Science's Brian Baker has taken his portable planetarium into many coastal N.C. schools.

The project also collaborates with the Coastal Studies Institute to host "Star Parties" at Jennette's Pier in Nags Head and the Windsor Middle School in Bertie County, with another slated for April 24 at Jockey's Ridge. Hundreds of eager participants typically attend these events, which include a series of large outdoor telescopes and where "sky time" eclipses "screen time."

"Opportunities for building programs around the nocturnal environment and night sky are unlimited," Riggs says. "Educating the youth, public, and leadership of the Roanoke-Albemarle region is critical for the protection and management of this dark-sky natural resource, but also to capitalize on the potential for developing a sustainable ecotourism for the region's future."

Riggs adds that this ecotourism doesn't depend on clear skies. While spellbinding, the region's unpolluted gateway to the celestial is only part of its hidden magic.

"The best part of stargazing on the OAP often is the environment around you," Riggs says. "Hearing the owls talk to each other, as otters splash in the water. Wolves howl in the distance. And the cacophony of summer amphibians and winter swans and geese. The awesome wind blows through the marsh grasses and causes the waves to lap onshore."

"Sweeping through the Milky Way with a telescope reveals a window deep into the center of our galaxy. Interstellar gas and dust constitute the spiral arm as it cuts through the starry 'cloud.' Within this cloud is a treasure trove of nebulae and star clusters — a stargazer's playground. Here, it's important to see not only with your eyes, but with your mind."

The skies, wildlife, possibilities for photography and kayaking, the potential for an astonishing trail system, even simply the sheer breadth of the terrain to explore — the more you contemplate all that the Outer Albemarle Peninsula offers, the more apt "The Yellowstone of the East" begins to sound.

But the OAP also defies comparison.

"I've lived and worked all over the world," Riggs says. "This region is unique. We've got blackwater streams and swamp forests. The estuaries are drowned river valleys that are bounded by the beaches and capes of the outer barrier islands. And it's all dynamic, subject to high-energy

Continued



THIS COMPOSITE OF
EXPOSURES DOCUMENTED
24 MEMORABLE MINUTES
FROM BROOK VALLEY IN PITT
COUNTY, DURING LAST YEAR'S
FULL LUNAR ECLIPSE.



P. Gempert

storms that cause ongoing changes to the coastal system. It's far more than just a place where astronomers go wow. And it's ours. It belongs to the people." 🌕

This project defined nightscape resources within northeastern North Carolina's coastal system, but local, county, state, and/or federal agencies, with specific rules and regulations pertaining to night visitation, manage these sites. Contact the appropriate office for permission to access specific sites for nightscape viewing.

North Carolina Sea Grant funded the Night-Scape Resource Project through a Community Collaborative Research Grant, in partnership with NC State's Kenan Institute of Engineering, Technology, and Science. North Carolina Space Grant, East Carolina University's Department of Geological Sciences, and ECU's Coastal Studies Institute also provided key support. The project includes: Stanley Riggs, coastal and marine geologist at North Carolina Land of Water and project lead investigator; Karen Clough, NC LOW's community outreach coordinator; Emily Jarvis, executive director of A Time For Science; and Brian Baker, director of astronomy with ATFS. The project has a working partnership with Reide Corbett, oceanographer and executive director of the ECU Coastal Studies Institute, as well as three groups of local volunteers who constituted the field-mapping teams. The project also has developed working partnerships with the U.S. Fish and Wildlife Service (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter National Wildlife Refuges), Pettigrew State Park, and the N.C. Wildlife Resources Commission.

EDITOR'S NOTE: This article heavily relies on Stan Riggs's report, *Night-Scape Resources: Northeastern North Carolina Coastal System*, as well as interviews with and presentations by Stan Riggs. NC State News, Jane Harrison, and other sources also provided information.

- Community Collaborative Research Grants:
go.ncsu.edu/CCRGprogram
- North Carolina Sea Grant funding opportunities:
NCseagrant.ncsu.edu/funding-opps/
- Stan Riggs on "A Brief History of Sea Level Rise":
go.ncsu.edu/a-brief-history

"I've lived and worked all over the world. This region is unique. We've got blackwater streams and swamp forests. The estuaries are drowned river valleys that are bounded by the beaches and capes of the outer barrier islands. And it's all dynamic, subject to high-energy storms that cause ongoing changes to the coastal system. It's far more than just a place where astronomers go WOW. And it's ours. It belongs to the people."



CAPTURING THE CULPRIT

Carbon Sequestration Battle Against Climate

SARAH SPIEGLER

Continued

Jared Kay/VisitNC.com



BY PROTECTING COASTAL ECOSYSTEMS, WE CAN TAKE ADVANTAGE
OF NATURE'S OWN TOOLS FOR CAPTURING CARBON FROM THE ATMOSPHERE —
AND HELP TO SLOW DOWN GLOBAL WARMING.

and the Change

Taylor's Creek, near Beaufort



On January 8, 2016, scientists arrived at Camp Lejeune in Jacksonville, North Carolina, for a day of fieldwork.

Researchers have conducted several studies at Camp Lejeune since 2009 to understand the complex ecosystems that provide the training setting for the largest Marine Corps base on the East Coast. On this day, Carolyn Currin and Nathan McTigue from the NOAA National Centers for Coastal Ocean Science in Beaufort collected a sample of the marsh (a “sediment core”) from 7 feet below ground. Radiocarbon dating later determined the sediment contained carbon that the marsh had stored for almost 2,500 years.

These scientists’ work highlights the critical role of coastal ecosystems in removing carbon from the atmosphere. Last year, Currin and McTigue published a study based on the sediment they collected in 2016, noting that the high rates of carbon buried over time in wetland sediments have “garnered attention as a potential ‘natural fix’ to reduce the concentration of carbon dioxide in Earth’s atmosphere.”

The buildup of carbon in the atmosphere, of course, accelerates global warming — with sizeable consequences. By 2060, the small town of Beaufort in eastern North Carolina, for instance, will experience a foot of sea level rise under NOAA’s lowest sea level projections and potentially as much as 2 to 4 feet as the global climate continues to warm over the next 40 years. Higher temperatures will result in significant challenges for coastal habitats and communities, including many of the places on the North Carolina coast and around the country that are of important cultural, social, ecological, and economic value.

The Carbon Culprit

Carbon, an element found in all living organisms, is the chemical backbone of life, and it is second in abundance only to oxygen in the human body.

The overall amount of carbon on our planet remains relatively fixed, but the way it is stored changes as it cycles through the environment and through living organisms. Oceans, for example, store about 50 times more carbon than the earth’s atmosphere.

Changes in the amount of carbon in our atmosphere, however, result in significant impacts. As greater amounts of carbon dioxide and other greenhouse gases enter the atmosphere, oceans warm and acidify, icebergs melt at a faster rate, and sea levels rise.



TOP: For thousands of years, atmospheric levels of carbon dioxide never rose above the dashed line, but after 1950 they haven’t fallen below it. **BOTTOM:** Scientists drill for a core sample at Camp Lejeune. **RIGHT:** Core samples from the Marine Corps base revealed carbon stored in the marsh for almost 2,500 years.



Carolyn Currin

Our coastal communities experience climate change most severely in the forms of more intense storms, greater rainfall, and rising seas. Hans Paerl at the University of North Carolina at Chapel Hill's Institute of Marine Science in Morehead City published a study last year noting that six of the seven highest precipitation events on record in North Carolina have occurred within the last 20 years. Increasing rainfall and hurricanes such as Floyd (1999), Matthew (2016), and Florence (2018) have brought catastrophic flooding, adverse economic impacts, and ecological damage that has included the increased runoff of pollutants into coastal ecosystems and estuaries.

“Current studies suggest that mangroves and coastal wetlands annually sequester carbon at a rate 10 times greater than mature tropical forests. They also store three to five times more carbon per equivalent area than tropical forests.”

FROM NOAA'S COASTAL BLUE CARBON

Capturing the Culprit: Carbon Sequestration

Studies of Camp Lejeune sediment cores have shown how coastal ecosystems play an important role both in “sequestering” (capturing) and storing carbon.

According to Currin, salt marshes, mangroves, and seagrass beds absorb large amounts of carbon dioxide from the atmosphere and store it underground for extremely long periods of time.

“By using radiocarbon dating,” she says, “we were able to determine that marsh plant material buried at the bottom of a 2-meter deep core was 2,460 years old.”

Currin and her colleagues estimated that carbon has accumulated in the sediment for the past 100 years at a rate almost four times higher than it has for the past 1,000 years. The rate of carbon burial over the lifetime of this marsh typically correlates closely with local sea level rise; thus, the recent increase in stored carbon could be due to accelerated sea level rise in North Carolina.

Of course, North Carolina is replete with vast tracts of salt marshes. Over hundreds of thousands of years, sediment has layered on these marsh ecosystems. As sediment layers continue to build on top of previous layers, carbon remains stored deep within coastal habitats.

Through photosynthesis, marsh plants take in carbon dioxide from the atmosphere and then convert it to plant matter. Because this organic

Continued

plant material becomes buried under sediments, decomposition occurs over thousands of years — in effect, keeping the carbon stored — as compared to forest habitats where decomposition occurs over mere decades. Most of the living organisms in terrestrial forests exist above ground and, thus, break down after death at a faster rate due to much higher exposure to light and oxygen.

Currin says marsh ecosystems are more effective than any other type of habitat in the world — including terrestrial and freshwater ecosystems — at the sequestration and storage process. However, she warns, the accelerated rate of sea level rise might significantly affect carbon storage in coastal ecosystems.

“Although sea level rise brings more tidal water and sediments into the marshes,” she says, “we’re finding that our low marshes in North Carolina are not keeping up with sea level rise, and carbon accumulation will end quickly if the marshes convert to mudflats.”

Even more importantly, as these habitats disappear, they also will release hundreds or thousands of years’ of stored carbon into the atmosphere.

Preserving Marshland

We can try to slow down or adapt to the changes in climate that are already well underway. Preserving and restoring salt marsh habitats and mangrove forests remain an incredibly important piece of the puzzle. However, even if we were to preserve and protect all saltmarshes successfully, these habitats cover insufficient area globally to singlehandedly solve climate change. We won’t be able to salt marsh our way out of this problem.

In addition, as Currin cautioned, rising sea levels could drown marshes, not only ending the capacity of the land to store carbon but also releasing carbon that had already been stored. In fact, a 2019 Special Report on the Ocean and Cryosphere from the United Nations Intergovernmental Panel on Climate Change found that 20 to 90% of



coastal wetlands will disappear by the year 2100.

In North Carolina, however, a new statewide approach could bring important protections to our coast. In 2018, Governor Roy Cooper signed Executive Order 80 (EO80): *North Carolina’s Commitment to Address Climate Change and Transition to a Clean Energy Economy*. By doing so, he also brought recognition to the importance of the state’s coastal habitats. EO80 instructs the state to accomplish specific climate-related goals, such as reducing greenhouse gas emissions to 40% below 2005 levels by the year 2025, integrating climate change mitigation and adaption practices into all cabinet agency programs and operations, and preparing a “Climate Risk Assessment and Resiliency Plan” this year.

Of course, coastal habitats are at the forefront of the battle of land versus rising waters in North Carolina. As part of the EO80 efforts, the Natural and Working Lands (NWL) Stakeholder Group is making recommendations to build ecosystem resiliency, sequester carbon, and provide economic growth through the conservation, restoration, and management of the state’s inland and coastal terrain. To inform the statewide resiliency plan, the Coastal Habitats Subcommittee of the NWL has developed strategies and viable on-the-ground actions that will protect and restore North Carolina’s vital coastal habitats.

The subcommittee’s recommendations will include measures that



Left: Fostering North Carolina's healthy coastal ecosystems will better prepare the state to adapt to the challenges of climate change. Above: Camp Lejeune Marines conduct a HALO jump over an airfield. Researchers have conducted studies to understand the complex ecosystems that provide the training setting for the largest Marine Corps base on the East Coast.

A collaborative group of partners from many different organizations serves on the state's Natural and Working Lands Stakeholder Group's Coastal Habitats Subcommittee, which is making recommendations for the N.C. Climate Risk Assessment and Resiliency Plan.

- N.C. Division of Marine Fisheries
- N.C. Division of Coastal Management
- North Carolina Sea Grant
- NOAA National Centers for Coastal Ocean Science
- The Nature Conservancy North Carolina
- Defenders of Wildlife
- Albemarle-Pamlico National Estuary Partnership
- Carolina Wetlands Association
- U.S. Fish and Wildlife Service
- Audubon North Carolina
- Duke University

value coastal habitats both for their carbon sequestration and storage benefits and for the ecosystems services they provide. These ecosystems provide vital habitats for marine life, shoreline protection, opportunities for outdoor recreation and tourism, and a supply of seafood. Fostering these healthy ecosystems will serve to make the state better prepared to adapt to the challenges of climate change.

A multi-pronged approach with diverse partners and solutions, through Executive Order 80 and other efforts, is instructive for how to continue tackling climate change challenges at state, national, and global levels. Many residents in North

Carolina's coastal communities already are thinking about how to work together. The solutions will be complex, and the best approaches will offer equitable and affordable ideas. 

"Tactics to prevent further warming also often help us adapt to the warming that has already happened."

LETTER FROM THE EDITOR, 2019 AUDUBON SOCIETY SPECIAL REPORT ON CLIMATE CHANGE

- Executive Order 80: go.ncsu.edu/80
- Carolyn Currin, Nathan McTigue, and other scientists conducted research at Camp Lejeune as part of the Defense Coastal/Estuarine Research Program (DCERP): go.ncsu.edu/DCERP
- U.N. Special Report on the Ocean and Cryosphere: go.ncsu.edu/UN-report

Sarah Spiegler serves in a dual role as the program coordinator of the N.C. Sentinel Site Cooperative (NCSSC) and as a marine education specialist for North Carolina Sea Grant. She works collaboratively with NCSSC partners to address the impacts of sea level rise on North Carolina coastal habitats and communities. She helps to bridge the gap between science and real-world policy solutions, translating sea level rise and climate change science for managers and local government officials. She also serves on the state's Natural and Working Lands Stakeholder Group's Coastal Habitats Subcommittee.

At the Dawn

The Earthscape

Torrential winds, wild ponies, marauding pigs, and an ever-shifting coast — they all came with one of the best laboratories on the planet for learning how to fly.

LARRY E. TISE

The first successful flight of the Wright Flyer

Continued



of Flight

and Climate of the Outer Banks



“I chose Kitty Hawk because it seemed the place which most closely met the required conditions,” Wilbur Wright wrote his father, Bishop Milton Wright, on September 9, 1900. Inscribing his first letter from North Carolina on the stationery of the Hotel Arlington at Elizabeth City, the elder of the two Wright brothers who invented flight explained why the tiny fishing village on the Carolina coast provided the perfect place for conducting “practical experiments” on what he called “the flying question.”

“At Kitty Hawk, which is on the narrow bar separating the Sound from the Ocean,” he continued, “there are neither hills nor trees, so that it offers a safe place for practice.” Besides, “the wind there is stronger . . . and is almost constant” — sufficient, he believed, to lift from the ground a controlled, man-carrying flying machine.

What he called “the required conditions” at Kitty Hawk had been confirmed to him by both the world’s foremost authority on flight at the time — Octave Chanute — and the U.S. Weather Bureau. Those required elements included several crucial items: sustained winds in one direction of 21 miles per hour; soft sands for many inevitable crashes; remoteness from the prying eyes of big-city newspaper reporters; and reliable transportation access from Dayton, Ohio. No other place known to either Chanute or the Weather Bureau contained all those factors the Wrights sought as their most permanent laboratory for testing several modes of flight.

But neither Wilbur Wright nor his brother Orville had ever flown in an airship or a flying machine, nor even attempted to make any kind of device, other than a kite, that would fly. Nor had they ever seen an ocean — much less the kind of barren, sandy, windswept barrier chain of islands they were about to experience for the first time on the coast of North Carolina. Wilbur described Kitty Hawk as unduly remote — even to the people in Elizabeth City. “No one seemed to know anything about the place or how to get there,” Wilbur told his family.

Eventually, he got passage from Elizabeth City to the place with a local fisherman on a “flat-bottomed,” “half-rotted,” and

“vermin-infested” boat that barely withstood, he thought, the high waves and surging currents of the treacherous waters between the mainland and Kitty Hawk Bay. He was certain that the skipper, one Israel Perry, was incompetent — that the man could neither command his shabby boat properly nor capably ply what Wilbur perceived as the stormy seas of the vast Albemarle Sound. Wilbur thought it almost a miracle that he had survived the dangerous voyage.

Finally arriving on the sliver of sandy and scruffy land between the normally calm Albemarle Sound and the surging waves and tides of the Atlantic Ocean, Wilbur and Orville Wright in 1900 began their experiments. Despite the distance from their orderly Ohio home, the unpredictable patterns of weather, swarming hordes of bloodsucking mosquitoes, roaming armies of hungry pigs, sand-filled shoes and blankets, chilling nor’easters, walloping hurricane-force winds from the south, and every other surprise of raw nature and guileless men, the brothers Wright forged ahead — still unsure about their testing grounds.

“The sand is the greatest thing in Kitty Hawk, and soon will be the only thing.”

— ORVILLE WRIGHT

When he got across the Albemarle Sound to Kitty Hawk on September 11, Wilbur was welcomed as an out-of-state guest and as a temporary boarder at the home of William J. and Addie Tate. The Tates’ small clapboard and wooden-shingle house served doubly as their family residence with their young daughters Irene and Pauline and as the official U.S. Post Office for Kitty Hawk. Being able to perch for three weeks in a local home was a godsend for the young man from Ohio.

His hosts possessed the inherited ways in which coastal people for thousands of years had coped with their unusual

From *Circa 1903: North Carolina's Outer Banks at the Dawn of Flight* by Larry E. Tise.

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Hawks, are better
soarers than Buzzards
but more often resort
to flapping because they
wish greater speed.

A damp day is
unfavorable for
soaring unless there
is a high wind.

No bird soars
in a calm.

The object of the tail
is to increase the spread
of surface in the rear
when the wings are moved
forward in light winds
and thus preserve the center
of pressure at about the
same spot. It seems

redder very little.
In high winds it is
folded up very ~~close~~
narrow.

All soars, but
especially the Buzzard
seem to keep their
fore and aft balance
more by shifting the
center of resistance
than by shifting the
center of lift. Thus
a Buzzard soaring
in the normal po-
sition will be
turned upward by
a sudden gust. It
immediately lowers its
wings often much below
its body. The mo-
mentum of its body
now acting, above

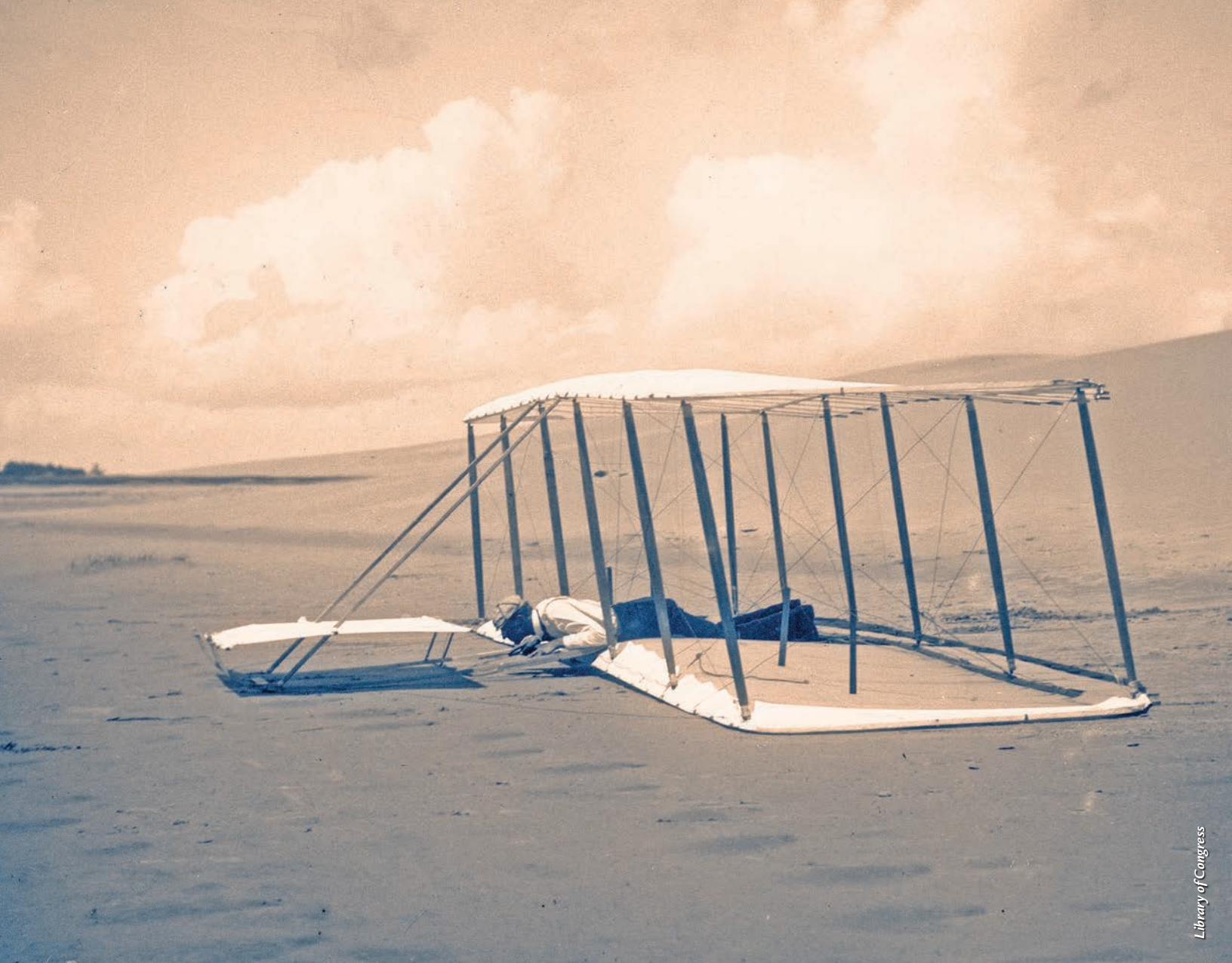
In Wilbur Wright's diary from Kitty Hawk in 1900, he recorded his reflections on birds taking flight from the sounds.

world. It was an environment that was inviting when the weather was fair and hellish when winds and storms and ripping tides lashed across the narrow threads of sand.

During the day, Wilbur worked in the barren yard of the Tate house, cobbling together the first Wright flying machine. In the evenings he sat at supper with the family, hearing about the wild animals that lurked across the scraggly land and the ways humans withstood the persistent assaults of weather, sand, and

biting insects. This initial encounter with the Tates would never be forgotten. The Tates remained lifelong friends and advocates of the Wrights and their pioneering flights on the Carolina coast for the remainder of their lives. Bill, in particular, later styled himself as an official guide to the Wright brothers' Carolina coast and promoted in both North Carolina and Washington, D.C., the creation of a monument marking the most important site of America's first powered flights.

Continued



Although neither Wilbur nor Orville graduated from high school, they were quick learners who adapted rapidly to their newfound coastal environment, which made for this successful glider landing in 1901.

When Orville arrived almost three weeks later, the brothers supped on duck and rabbit and fish — standard local fare in those parts — with the Tates and listened to more coastal lore until October 4, when they ventured on their own into nature. For the next 19 days, the brothers, inexperienced as campers, felt they had mounted a wild and unpredictable steed. They set up a tent on a sandy hill half a mile from the Tate home — roughly halfway between Kitty Hawk, a cluster of houses on the sound side of the banks, and the Kitty Hawk Life-Saving Station on the Atlantic shore side. To their consternation, their tent was blown down repeatedly by winds ranging from 30 to 45 miles per hour.

They took their first flying machine, a smallish device, out and tried to fly it as a kite. That worked well. They then tethered it by ropes to a wooden derrick they had built for testing the craft. But the flying machine was thrashed around and upended whenever they tried to work with it. Although Wilbur built the machine to carry five times his weight, it would not carry him aloft when it was flown as a glider. Adding insult to injury, the machine crashed and was left in a heap of broken rubble when crosswinds threw it into a dune known as “Look Out Hill,” which the brothers renamed the “Hill of the Wreck.”

But all was not lost. When the machine would not lift Wilbur’s 130 pounds, along came a small boy, Tom Tate (a

nephew of Bill Tate). He was “a small chap [70 pounds]...that can tell more yarns than any kid of his size I ever saw,” said Orville. The crude flying machine rose with the diminutive Tate aboard without difficulties.

But when the smallish dunes at Kitty Hawk sometimes lacked the constant winds they sought, the brothers moved four miles southward to the much larger Kill Devil Hills. There, they found both perfect winds and an open terrain more suitable for flight. These large dunes — near no town, but adjacent to the Kill Devil Hills Life-Saving Station — became the locale for all the brothers’ tests in their subsequent trips to the Carolina coast across the next 11 years.

*Despite swarming hordes of
bloodsucking mosquitoes,
roaming armies of hungry pigs,
sand-filled shoes and blankets,
chilling nor’easters, walloping
hurricane-force winds from the
south, and every other surprise of
raw nature and guileless men, the
Wright brothers forged ahead.*

In addition to reckoning with the gusting and swooping winds, the brothers also began to understand the earthscape of the place where they hoped to fly. “But the sand!” exclaimed Orville. “The sand is the greatest thing in Kitty Hawk, and soon will be the only thing,” he prophesied. He and Wilbur could see the results of recent shifts in the sands in the landscape of rotted limbs — once belonging to proud trees — that protruded from the sand.

“The sea,” he observed, “has washed and the wind [has] blown millions and millions of loads of sand up in heaps along

the coast, completely covering houses and forest.” One night a “45 mile nor’easter” struck their camp and “took up two or three wagon loads of sand from the N.E. end of our tent and piled it up eight inches deep on the flying machine we had anchored about fifty feet southwest.” While this was happening, the sides of their tent snapped repeatedly, sounding “exactly like thunder.”

While the Wright brothers marveled at the moving landscape of their test grounds, a young geology professor at the University of North Carolina in Chapel Hill, Collier Cobb, attempted to explain the ebb and flow of sands on the barrier island chain for the *National Geographic Magazine* in 1906. According to Cobb, the advancement of sands and the formation of great new dunes around 1900 was the result of years of people denuding the pine forests that had flourished on the Carolina banks for eons.

“This movement of the sand was started just after the Civil War by the cutting of trees next to the shore for ship timbers,” he wrote. He found that an entire fishing village on Hatteras Island had been buried by sand near a spot known as “The Great Woods” — where “not a stick of timber stands upon it today.” Cobb’s assessment of the changes was the best guess in an era that lacked essential data on the rise and fall of oceans that would be available to scientists a century later. (For the current science behind the state’s shifting coastline, see “A Brief History of Sea Level Rise in North Carolina” in the Winter 2019 issue of *Coastwatch*: go.ncsu.edu/sea-level-rise.)

Aside from the constantly shifting sands, one of the other fundamental modifications in the shape of the Carolina coast was the never-ending creation and melting away of inlets from, and thereby outlets to, the Atlantic Ocean across its barrier islands. The island chain experienced by the Wright brothers in 1900 looked nothing like the coast that had been encountered by the explorers sent to the same region by Sir Walter Raleigh 300 years earlier.

Whereas the Atlantic’s salty waters had spilled into the sounds through porous inlets twice daily with the rise and fall of every tide, the disappearance of these water channels transformed the upper banks region of North Carolina — the Albemarle Sound — into a gigantic freshwater sea. As one of the largest freshwater habitats in America, the Albemarle became a lush environment for the growth of wide spans of the

Continued

grasses beloved by migrating fowl. In the process, this inland sea became a perfect laboratory where the Wright brothers could study the behavior of soaring and swooping birds in flight. The seasonal shifts of millions of duck, geese, and other migratory birds from Canadian to South American habitats made the inner side of the Carolina's barrier islands one of the richest sites for the targeting of waterfowl in the Americas.

Another result of the closing of the inlets was a modification in the fish and shellfish culture of coastal Carolina. The transformation of the Albemarle Sound into a freshwater environment meant that its population of shad, herring, and striped bass exploded. Every February through April thereafter millions upon millions of these and other freshwater species could be harvested without depleting the abundance.

As one of the largest freshwater habitats in America, the Albemarle became a lush environment for the growth of wide spans of the grasses beloved by migrating fowl — a perfect laboratory where the Wright brothers could study the behavior of soaring and swooping birds in flight.

But the disappearance of salt water north of Roanoke Island also meant that these waters could no longer produce oysters. Indeed, when North Carolina in 1887 had commissioned a study of its coastal waters for the purpose of expanding the cultivation of oysters, its principal scientist excluded the entire Albemarle Sound region from its survey of existing oyster beds. But the presence of an abundant resource of fish and other sea life, ready to be harvested, was one of the defining characteristics of

coastal Carolina at the turn of the 20th century.

While the opening and closing of inlets along the Carolina coast had a profound effect on the natural habitat of the region, by the first years of the 20th century the presence or absence of these natural openings between sound and sea had little effect on the lives and habits of coastal Carolinians.

As residents of one of the most constantly changing environments on the American coast, lifelong habitués of the region adapted to the changes. Sharing information on changing channels for boating and fishing, locals adjusted to the moving barrier islands, the relocation of fish and shell beds, and access to the Atlantic for saltwater fishing. There was no need in 1900 to build highways or bridges or to operate a fleet of ferries to convey vehicles from island to island. The daily experience of coastal residents was a water-based lifestyle and existence. Everyone proudly possessed a boat.

Although neither Wilbur nor Orville graduated from high school, they were quick learners who adapted rapidly to their newfound coastal environment. They became accustomed to seeing cattle and wild ponies roaming across some of the grassy expanses around Kitty Hawk. They expected to encounter from the outset the sudden appearance at their camp of marauding pigs perpetually rooting for edibles not yet consumed by human beings.

As the Wrights lofted their experimental flying machines into the complicated flux of air over Kitty Hawk, they also became experts in the acquisition and use of meteorological information. As keen observers of climate, they made daily calculations on wind, barometric pressure, and temperatures. They saw the mighty power of winds, storms, and furious seas that could move mountains of sand across the thin Carolina barrier islands. They saw trees that had been humbled by constant winds bowing away from the torrential blasts of air. They endured both hurricanes and tropical storms as they learned to turn nature on the continental fringe into an asset for inventing flight.

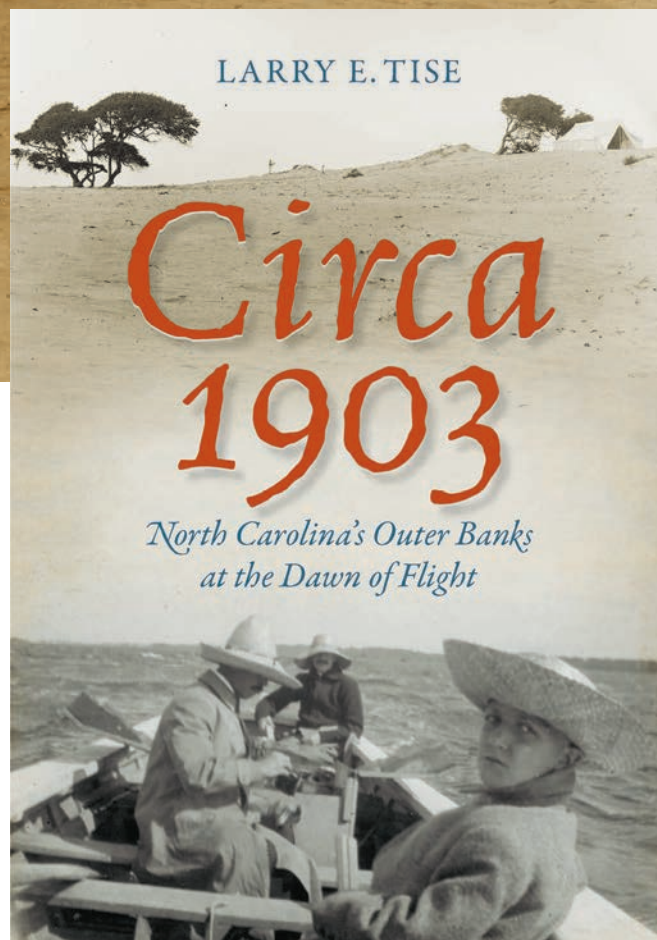
When storms were not brewing, they noted more pleasant spectacles of their ocean environment.

"The sunsets here are the prettiest I have ever seen," observed Orville. "The clouds light up in all colors in the background, with deep blue clouds of various shapes fringed with gold before. The moon rises in much the same style, and lights up this pile of sand almost like day."

The Wright Brothers' initial campground sat outside Kitty Hawk in 1900. They would return to the Outer Banks for years to take advantage of one of the best places on Earth for flying.

Finding a kinship with his newly discovered natural workshop, Wilbur wrote his sister Katharine somewhat nostalgically as he and Orville left the coast for the first time in 1900: "We have said 'Good bye Kitty, Good bye Hawk, good bye Kitty Hawk, we're gwine to leave you now.'"

With what they had learned about this fragile but volatile coast, about the people who lived there, and, most importantly, about themselves, they would be able to return for years, better prepared to take advantage of one of the best places on Earth for flying. 🌐



To order *Circa 1903: North Carolina's Outer Banks at the Dawn of Flight*, visit go.ncsu.edu/circa1903.

Lessons in Mariculture

go.ncsu.edu/MaricultureLessons

ZOOM IN ON AQUACULTURE

LAST FALL, NORTH CAROLINA SEA GRANT PUBLISHED A COLLECTION OF FREE LESSON PLANS ON MARINE AQUACULTURE, OR “MARICULTURE.”

Designed for high schoolers, the activities cover a wide range of topics, such as aquaculture’s origins and the benefits of shellfish to the ecosystem.

“This curriculum is here to hopefully help teachers — earth and environmental science and marine science teachers, in particular — integrate aquaculture resources into their classroom,” says Amy Sauls, a science teacher at Swansboro High School and lead writer on the lesson plans. “Aquaculture, especially of North Carolina oysters and clams, is a quickly growing industry that our students need to know about.”

Lesson 4, republished here, offers a flavor of what you can expect from these resources. Through a creative slideshow focusing on the blue crab, this lesson encourages students to think about the biology and ecology of various aquaculture species.

“Teach a kid to fish,” quips Sauls. “How about how to grow clams, oysters, or blue crabs?”

Find more lesson plans at go.ncsu.edu/MaricultureLessons.

—Julie Leibach



Spawning female blue crabs are recognizable by yellow-orange, brown, or black egg masses.

David Sadtler/CCBY 2.0

OVERVIEW

This activity exposes students to North Carolina aquaculture species at multiple scales. First, students will take a big-picture look, exploring a species’ habitat needs and the effects of human activity on its environment. Then they will examine the organism at smaller and smaller scales to better understand the organism’s life cycle and adaptations.

The blue crab (*Callinectes sapidus*) will serve as a model species, given its important role in marine aquaculture in the state. Indeed, soft-shell blue crabs, along with Eastern oysters (*Crassostrea virginica*), are the top N.C.

marine aquaculture species by volume and by economic value.

Students also will have the opportunity to research other organisms to compare similarities and differences in life stages, habitats, biological needs, and aquaculture potential.

- **Grade Level:** 9-12
- **Duration:** 2 class periods

SCIENCE STANDARDS

Bio.1.2.2

Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

Bio.2.1.2

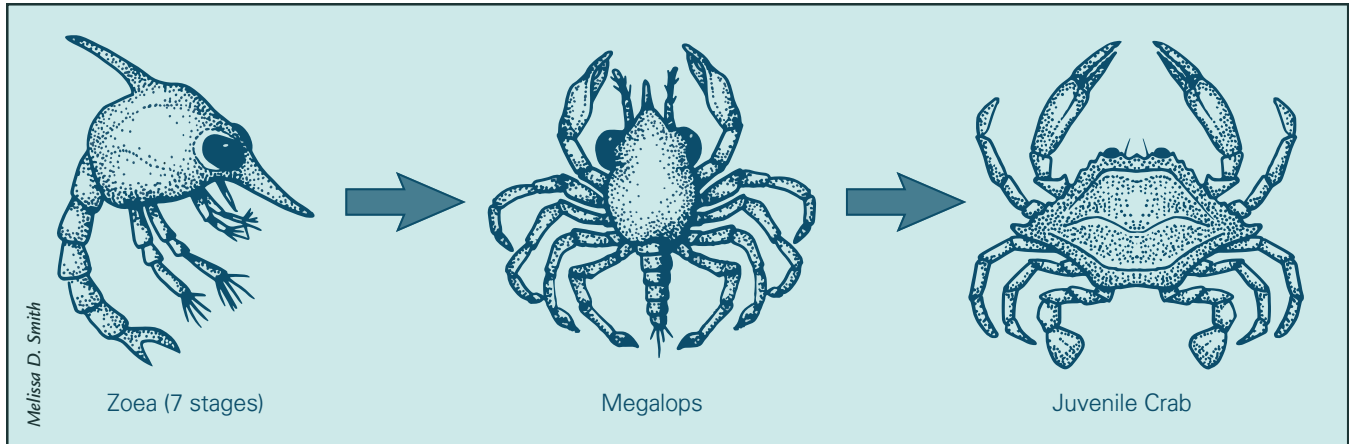
- Analyze the survival and reproductive

LESSON 4

OBJECTIVES

By the end of this lesson, students will be able to:

1. Describe the life stages of an aquaculture species and recognize its habitat needs and other ecological requirements at each stage.
2. Compare and contrast the ecological needs of species produced through aquaculture.
3. Explain the role of zooplankton and phytoplankton in the food web.
4. Explain the ways that different organisms reproduce can help or hinder their suitability as aquaculture species.



success of organisms in terms of behavioral, structural, and reproductive adaptations.

Bio.2.2.2

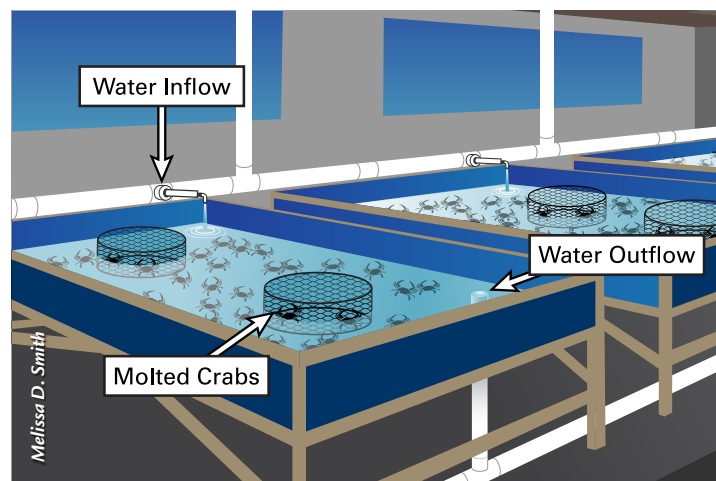
- Explain how the use, protection, and conservation of natural resources by humans impact the environment from one generation to the next.

EE.2.2.1

- Explain ways to mitigate detrimental human impacts on the lithosphere and maximize sustainable use of natural resources.
- Explain the effects of human activity on shorelines, especially in development and artificial stabilization efforts.

VOCABULARY

- larva:** early, immature form of an animal whose development to maturity involves metamorphosis
- plankton:** small and microscopic organisms found drifting or floating in the sea or in fresh water, consisting chiefly of diatoms, protozoans, small crustaceans, and the eggs and larval stages of larger animals
- megalops:** a free-swimming larval stage in the development of a crab that follows the zoea stage; a crab at this stage has large eyes, little claws, and legs
- molt:** loss of plumage, skin, hair, or an old shell as a regular feature of an animal's life cycle
- recirculating aquaculture system:** tanks used to raise aquatic organisms in which the



TOP: Early life stages of a blue crab

BOTTOM: A soft-shell crab recirculating aquaculture system

water in the system is treated and reused through biological and mechanical filtration

- taxonomy:** orderly classification of plants and animals according to their presumed natural relationships

- zoea:** a crustacean's first larval form after hatching from its egg; a small, transparent organism that swims at, or near, the surface of the sea

- zooplankton:** plankton consisting of small animals and the immature stages of larger animals

BACKGROUND

Blue crabs are crustaceans, meaning that adult crabs have hard shells and jointed legs. It takes 12 to 18 months for crabs to fully mature. They develop through several stages until they reach the adult shape many of us recognize.

The blue crab starts its life as a

microscopic larva called a zoea that drifts through the water eating zooplankton and plant materials. This period lasts 30 to 45 days.

Eventually the blue crab reaches the megalops stage, when it grows a soft exoskeleton and starts to look more crab-like. It sheds that skin after six to 20 days. At that point it is a juvenile crab that looks like a miniature version of an adult crab.

In order for a mature crab to grow, it periodically sheds its hard shell through

a process called molting. A soft, pliable crab emerges and expands its soft, new shell. A crab that has just shed its hard shell is known as a soft-shell crab and is a common aquaculture product in North Carolina. Soft-shell crab producers must monitor blue crabs closely in order to harvest them directly after molting. Within only a few hours of shedding its shell, the crab will again return to its hardened state.

Soft-shell crab production is a type of short-term farming, because it consists of removing crabs from the wild and holding them until they molt. Soft-shell crabs can be produced in indoor or outdoor recirculating aquaculture systems, such as the shallow tanks depicted in the illustration. These shedding tanks are simple troughs or shallow tables that hold running water that is pumped from a brackish water

Continued

supply. Water filtration maintains proper water quality. Molting crabs are separated by mesh enclosures to protect them during this vulnerable life stage.

Blue crabs are part of a complex food web and have evolved numerous adaptations to find food and avoid being eaten. They are omnivores and opportunists in their eating habits. They eat both plants and animals, including bivalves like soft-shell clams; other crustaceans, such as shrimp; fish and marine worms; and anything else they can find, including dead plants and animals. They even eat younger blue crabs!

In turn, many organisms eat blue crabs. Eel, drum, spot, striped bass (rockfish), Atlantic croaker, and catfish all eat crabs when they are in the zoea and megalops stages. Some sharks and cownose rays eat the larger adult crabs, as do Kemp's ridley sea turtles. Humans also eat blue crabs. In fact, blue crabs are the number-one seafood harvested in North Carolina by volume and monetary value. Fishers deploy crab pots, typically from a boat, to catch crabs.

Blue crabs have a number of other adaptations that make them successful in the marine environment. For example, females produce a large number of eggs — as many as 750,000 to 8 million at a time. This reproductive strategy ensures that at least some eggs will survive, even if others are eaten.

Blue crabs are habitat generalists, meaning that they can exploit different habitats. For instance, they can thrive in high salinity ocean water as well as in inland waters with low salinity. Blue crabs are known as osmoconformers, meaning that they can adapt to the salinity of their environment by adjusting the salt content of their cells through a process called osmosis.

Like many other arthropods — a phylum that also includes insects and spiders — blue



To grow, a blue crab periodically sheds its hard shell through a process called molting.

crabs can regenerate a lost appendage through molting. They can grow a new full-sized leg or claw after two to three molts.

- **Materials:** Download the Zoom In PowerPoint presentation at go.ncsu.edu/ZoomIn. The presentation uses photos to illustrate blue crab ecology, biology, and harvesting methods.

ACTIVITY

1. The teacher will show students, without much explanation, the Zoom In PowerPoint presentation. At each slide, the teacher will ask the students what they see. As the slides progress to show smaller scales, the teacher can discuss food webs, as well as adaptations that the crabs have evolved in order to eat and avoid being eaten.

The teacher will then facilitate a discussion on:

- **The N.C. coastline:** What lives there?
- **Adaptations of the blue crab:** How does it survive?
- **Blue crab aquaculture:** Is the blue crab suitable for production in North Carolina? How so or why not?
- **Sourcing seafood:** What role do humans play in protecting marine species and ensuring a sustainable seafood supply?

2. Students will create a Zoom In PowerPoint or booklet of another N.C. aquaculture species (e.g. Eastern oyster, hard

clam, sunray Venus clam, freshwater prawn, rainbow trout, black sea bass), similar to the blue crab PowerPoint.

Students will present their PowerPoint or booklet to another student and explain what they learned about the species, including its taxonomy, biotic and abiotic requirements, life cycle, and suitability for aquaculture. The student pairs should create a list of similarities and differences between one of their chosen species and the blue crab.


Next, the teacher will facilitate a group discussion about the similarity and difference lists. Are any of the similarities or differences related to species taxonomy, for example? Which species are of the same phylum, class, order, or family? The teacher also will ask students to describe which characteristics of their organism could hinder its use in aquaculture, and which characteristics are conducive to aquaculture.

EXTENSION

Each student will explain the findings about their aquaculture species to an adult — for example, another teacher, parent, or adult friend — and have the adult sign off that the student completed the assignment.

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2. Blue Crab Unit. Albemarle-Pamlico National Estuary Partnership. (Blue crab fact sheet starts on page 21.)
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4. Oesterling, M.J. Soft crabs in closed systems: A Virginia success story. Virginia Institute of Marine Sciences.

Direct links to the references are available with the online version of Lesson 4 at go.ncsu.edu/Lesson-4. 



Off Shackleford Banks Island, Carteret County.

The Surf Zone, Summer Spawning, and Seafood Sleuths

BY SCOTT BAKER AND SARA MIRABILIO

from the popular blog series on the latest science for anglers

WHAT FISH SPECIES LIVE IN THE SURF ZONE?

At Wrightsville Beach, 84 different fish species use the surf zone.

• *Research Need*

The surf zone is an important region for fish communities and anglers alike. Some fish are known to inhabit the surf zone throughout all of their life stages, such as particular species of silversides and other bait fish. Others — such as spot and red drum — use the surf zone as waypoints between deep ocean habitats and estuaries. The surf zone also serves as important nursery habitat

for the young of many species, including recreational favorites like Florida pompano and flounder.

This popular environment is surprisingly understudied. For example, in North Carolina we have had little established information on full fish communities that inhabit the surf zone.

How many fish species live in or use the surf zone? How long do they stay there? How does the diversity of the fish community change across seasons?

• *What did they study?*

Researchers from the University of

North Carolina Wilmington investigated the surf zone fish community at Wrightsville Beach to determine which species inhabit the area and when they are present. The researchers repeatedly collected fish using long-haul seine nets at seven sites along the beach and identified and counted the number of fish collected from each pull.

• *What did they find?*

The research team identified 84 different species caught in the surf zone at Wrightsville Beach over 11 years. Of the total number caught, 10 species made up 95% of

Continued

the total catch, meaning that a few species use this habitat in much greater numbers than others. This finding suggests that the surf zone may represent an important habitat for these species.

- *What else did they find?*

These researchers also found that the total number of fish in the surf zone peaks in the warm summer months, as does the diversity of the fish community. In June through August, a typical angler at Wrightsville Beach is likely to find more fish and more species in the surf.

- *So what?*

As our understanding of the surf zone fish community increases with findings like these, we can begin to highlight fish species that rely on the surf zone for important stages of their lives. Many of the fish species that live in the surf in their early stages eventually move into offshore waters and represent important recreational and commercial fisheries. It is important to understand how these fish use the surf zone (for instance, as a nursery for their young or as a permanent home), so that we can ensure careful management and protection of this habitat and these fish.

— Summary by Jackson Bialek

WILL COBIA RETURN TO THEIR SUMMER SPAWNING HABITAT?

Electronic tagging reveals the answer.

- *Research Need*

Cobia are a moderately-sized open-ocean fish that recreational anglers love to catch for their aggressive fight and excellent table fare. Researchers have identified two genetically distinct populations along the U.S. coastline: the Atlantic stock and Gulf of Mexico stock.

Much of the data used to delineate these stocks came from fish tagged in the southern portion of their range. Additionally, a genetic study found differences between inshore and offshore cobia in North Carolina and Virginia.

But was the accepted boundary

between the Atlantic and Gulf populations valid? Were there additional differences among cobia within these areas?

- *What did they study?*

Researchers at NC State investigated movement patterns of tagged cobia to see if the species were homing to inshore or offshore areas during spawning months. The researchers surgically implanted 98 tags in cobia captured in North Carolina and Virginia. They also established an acoustic receiver array between Cape Lookout and Cape Hatteras and extending east to the continental shelf break to listen for the tagged fish.

- *What did they find?*

During late spring to early fall, researchers detected 45 of 54 cobia tagged in 2018. The bulk of these fish were inshore in Chesapeake Bay, with a smaller number detected in offshore ocean waters between North Carolina and Delaware.

- *What else did they find?*

As water temperatures dropped below about 68°F, cobia began migrations to overwinter locations. During winter, a few cobia were detected at outer continental shelf sites off North Carolina, and approximately



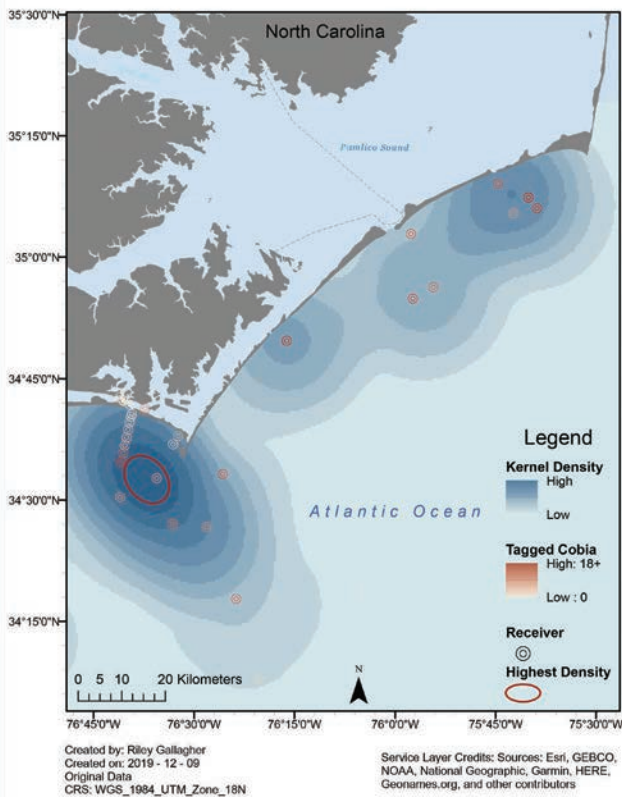
Jackson Bialek



Jackson Bialek

Researchers identified 84 different species in the surf zone at Wrightsville Beach. Typically, the total number of fish peaks during the summer.

Cobia Detection Density Map



one quarter of cobia were detected south of the current stock boundary in the known “mixing zone” between Cape Canaveral in Florida and the Georgia-Florida state line.

As water temperatures warmed above 68°F in the spring, cobia began moving northward and westward. In summer 2019, 31 out of 32 cobia returned to their 2018 locations.

• So what?

These findings provide strong evidence that cobia show a tendency to return to a particular area. The research confirmed understandings of where the boundary lies between cobia populations and may explain genetic differences between inshore and offshore cobia.

Future research will determine if there are differences between inshore and offshore cobia that warrant different management strategies.

— Summary by Riley Gallagher

DO YOU HAVE WHAT IT TAKES TO BE A SEAFOOD SLEUTH?

Citizen scientists collected seafood samples to help determine seafood mislabeling — and they did it as well as the experts.

• Research Need

If you’ve paid any attention to the national and global seafood news over the past decade, it should come as no surprise that seafood mislabeling can be a common problem. A growing body of work suggests that between 19% and 30% of seafood is mislabeled globally. Research demonstrates that

often cheaper or less desirable species are illegally substituted for the items sold.

The traditional method for gathering seafood samples for DNA identification involves scientists both collecting and processing the data and following strict procedures. But sometimes the desired study design doesn’t match what scientists actually can do within the constraints of manpower, funding, and geography.

Oceana, a conservation organization, conducted one of the largest studies of its kind to evaluate seafood mislabeling in the U.S. marketplace from 2010 to 2012. Those results have been reported extensively: 33% (421 of 1,243) of seafood samples collected across the country were mislabeled.

One of the unique aspects of the Oceana study was that the organization mobilized its members across the country in a grassroots effort to serve as citizen-scientist data collectors.

• What did they study?

Investigators first perfected a simple sampling kit that the public could use to collect and submit seafood samples for DNA testing.

Investigators then used an email database of 55,346 Oceana members in 11 major U.S. metropolitan areas to announce the seafood fraud detection project and recruit citizen scientists. Volunteers selected two samples from multiple species available at grocery stores, retail markets, and restaurants in their area. Participants received no compensation for purchasing the seafood, and the sampling procedure for DNA analysis required them to save only a small raw or cooked portion. The research project paid for the DNA analysis.

• What did they find?

One thousand fifty-eight of members signed up to be “seafood sleuths,” and each received a seafood test kit in the mail. Volunteers recorded information as the scientists had requested. Approximately 33% of the seafood sleuths returned 631 samples, nearly half of the samples collected for the entire study.

Investigators used multiple approaches and confirmed that data the citizen scientists collected was comparable to data the trained scientists collected.

The citizen-science approach also provided a more informed and engaged online membership, who continued to take action to advance seafood fraud policies with policymakers long after the completion of the study. The project likely contributed to the creation of the Seafood Import Monitoring Program, which today requires catch documentation and traceability for select species brought into the United States.

• Anything else?

The U.S. Food and Drug Administration keeps track of seafood items sold (or thought to be sold) in U.S. establishments. This list contains scientific and common names of 1,957 individual species. go.ncsu.edu/seafood-list

— Summary by Scott Baker

HookLineScience.com



Coastal Landscaping: THE NEXT BLUE ECONOMY SECTOR?

Consumer behavior will play a significant role.

BY JANE HARRISON

INTRODUCTION

By committing to the blue economy, the coastal landscaping industry can be profitable while also enhancing the ocean and coastal environment. Landscape designers and contractors, nursery managers, and home, or DIY, landscapers all have a role to play.

This paper, part of North Carolina Sea Grant's Blue Economy Information Series, explores landscaping preferences and practices of coastal residents living in Elizabeth City, North Carolina, and provides recommendations for environmentally friendly landscaping.

COASTAL LANDSCAPING

The blue economy is defined as a sustainable ocean and coastal economy, which emerges when economic activity is in balance with the long-term capacity of ocean and coastal ecosystems to support that activity and remain resilient and healthy. The coastal landscaping industry has the potential to contribute to the blue economy, depending on consumer behavior.

Nature-enhancing landscaping is trending nationwide. For instance, reduction of water-

intensive lawns is becoming common in drought-prone areas. Living shorelines, which incorporate natural materials like oyster shells, also are cropping up more often. These areas create habitat by maintaining connections between upland, intertidal, and aquatic areas while providing shoreline erosion control.

Recent studies have shown that in the southeastern United States, the use of native plants by landscape architects and contractors has increased, as has customers' interest in those species¹. Native and pollinator-friendly plants used in residential landscaping support local ecology. More biodiversity means we're more likely to encounter wildlife.

RESIDENTIAL LANDSCAPING MOTIVATIONS

Numerous factors influence how residents tend to their yards and gardens. Appreciation for nature is a significant driver for many gardeners. Environmental factors, such as soil type, temperature, and prior plantings, also affect residents' decisions. Social and cultural factors — such as demographics, societal values, and aesthetic preferences — play a major role, too. Desires

for privacy, shade, and tidiness influence landscaping behavior as well.

While enjoying nature is a key reason for spending time in the yard, residents don't always consider how their landscaping practices affect the surrounding environment. A recent study found that more than 75% of North Carolina residential landscapes are lawn². Monocultures of nonnative turf grass typically dominate residential landscapes, providing minimal benefits to wildlife. Excessive fertilizer and water use to maintain lawns also adversely affect water quality and quantity.

On the other hand, studies show that N.C. residents actually crave plants beyond turf, such as trees, shrubs, native grasses, vines, ferns, and flowering perennials. Many residents prefer to balance turf with other types of plantings, according to studies of North Carolina homeowners^{3,4}. Those plants can serve multiple functions. Coastal residents are especially interested in plantings that can withstand flooding and severe storm events⁴.

Residents adjust their landscaping preferences based on new knowledge. For example, a recent survey in Raleigh revealed

how learning the beneficial relationships between native plant and bird species can change residents' proclivities⁵. After learning about the role that native plants play in supporting bird populations, fewer respondents preferred landscapes composed primarily of turf. More preferred diverse native plantings.

Formal rules and ingrained customs affect landscaping decisions, for better or for worse. At the neighborhood scale, codified and enforceable rules may be enacted by local

government authorities and homeowners' associations (HOAs). For example, municipalities often consider dense growth of tall weeds and grass to be a public nuisance. HOA covenants can require a fixed number of trees or certain species of plants on a lot.

Personal beliefs and social pressures can be far more influential than formal rules, however. Studies on social norms indicate a preference for manicured landscapes over "disorderly" naturalistic ones^{6,7}. Such "messy" yards, though, can be artfully tamed

through regular maintenance such as edging and pruning.

Another factor affecting landscaping decisions is market supply. Numerous studies show market demand exists for various environmentally friendly landscaping practices^{8,9}. Marketing and supply may need to catch up. Emphasizing the eco-friendly features of products can be an effective marketing strategy that delivers a price premium. The way in which plants are

Continued



Jane Harrison



Martin LaBar/CC BY-NC 2.0



Rob Thurman/CC BY 2.0



Jane Harrison

CLOCKWISE FROM TOP LEFT: • This Elizabeth City yard includes a mix of native and nonnative species. • Butterfly weed attracts insect pollinators. • A stormwater pond behind this Wilmington resident's house features native flowering perennials. • Highbush blueberry shrubs can create an excellent hedge.

displayed or labeled at stores — for example, placement on a pollinator-friendly display table — can inform customers of the plants' ecological benefits.

Yet, because larger plant nurseries and garden centers serve regional markets, they often don't tailor their supply to local conditions. Smaller growers and retail outlets have an important niche to fill by providing plants well adapted to a particular place. Similarly, local landscaping designers and installers can accommodate unique environments, but they must be educated on local conditions and suitable plants.

Finally, demographic features — such as differences in race, ethnicity, and income — drive landscaping decisions. Lower-income households have fewer resources to devote to yard care, while higher-income households may be the most reluctant to counter social norms. A study looking at homeowner perceptions in Raleigh indicated that middle-class households were the most likely to use native plantings over turf³. That same study also showed that African American residents, regardless of income level, were more likely to prefer turf grass in their own and in neighbors' yards. More research pertaining to understudied groups is needed to explore the reasons for such trends.

SPOTLIGHT ON ELIZABETH CITY

In the summer of 2019, a team led by North Carolina Sea Grant conducted interviews and yard tours with 21 coastal residents in Elizabeth City to explore common yard maintenance and gardening practices and preferences¹⁰. Residents provided insight into how they manage their yards and select plants, and described maintenance challenges.

Interviewees matched the profiles of gardeners nationwide, which skew toward an older and wealthier demographic. For example, the highest spending on gardening is among Baby Boomers, married households, those with annual incomes of more than \$75,000, and college graduates¹¹.

Open-ended questions revealed what motivates interviewees to care for their yard; their reasons for selecting a plant; and their engagement in environmentally friendly landscaping activities (see Figure 1).

The top three factors that influenced

yard care were (1) "other people's opinion of yard" (2) "enjoyment of yard" (3) "desire to make yard attractive." Given the influence of neighbors' opinions, any large-scale changes in residential landscaping would likely require a collective shift at the neighborhood level.

The following quotes, from three different interviewees, showed the power of social contagion:

Interviewee A: "I'll plant a rose bush in my yard, like my neighbor."

Interviewee B: "I see crepe myrtles everywhere, so they must do well."

Interviewee C: "We talk to other people, see what they are growing. We are not plant-smart, so need some counsel."

The top three factors influencing plant selection were (1) ease of maintenance; (2) plant color; and (3) suitability to an area (see Figure 2). Said one interviewee: "I do not consider whether the plant's native. I want to know: Will it grow here? That's the question."

Rather than focusing on the benefits of native plants to pollinators, emphasizing their adaptability and minimal maintenance needs may increase their use on a larger scale.

Most interviewees noted several environmentally friendly activities they engage in related to yard care and maintenance (see Figure 3). The top activities reported were (1) limiting chemicals; (2) selecting native plants; and (3) avoiding and controlling invasive species.

Although the majority of interviewees reported limiting fertilizers, pesticides, and herbicides, they noted using a chemical treatment on occasion. Most interviewees did not use lawn treatments. Rather, they applied pesticides and herbicides in select spots.



ABOVE: An alternative to hardened bulkheads (top) are living shorelines, which provide erosion control and habitat.

SUSTAINABLE COASTAL LANDSCAPING

For the coastal landscaping industry to become a blue economy sector, it must tailor its offerings to current consumer behavior. The research conducted in Elizabeth City illustrates the myriad preferences and pressures that residents consider when landscaping.

The following recommendations will help guide coastal residents interested in adopting environmentally friendly practices:

- Choose native and noninvasive plants well-suited to coastal conditions.
- Use a mix of plant types that benefit ecological health.
- Reduce turf and adopt a lawn alternative that creates wildlife habitat.
- Water and fertilize strategically to maintain water quantity and quality.
- Rejuvenate soil to enhance soil health.
- Manage storm water to improve water quality.
- Maintain stormwater ponds for water quality and beauty.

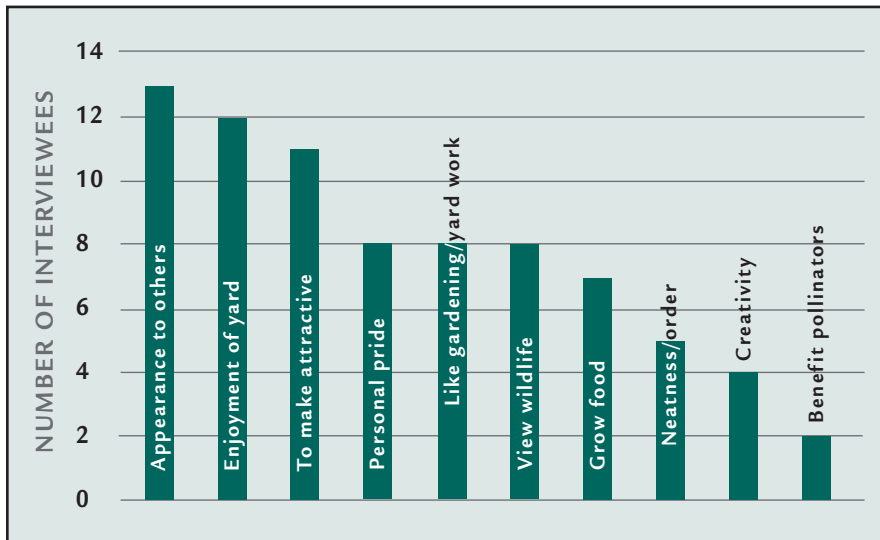


FIGURE 1. Motivations to Care for Yard

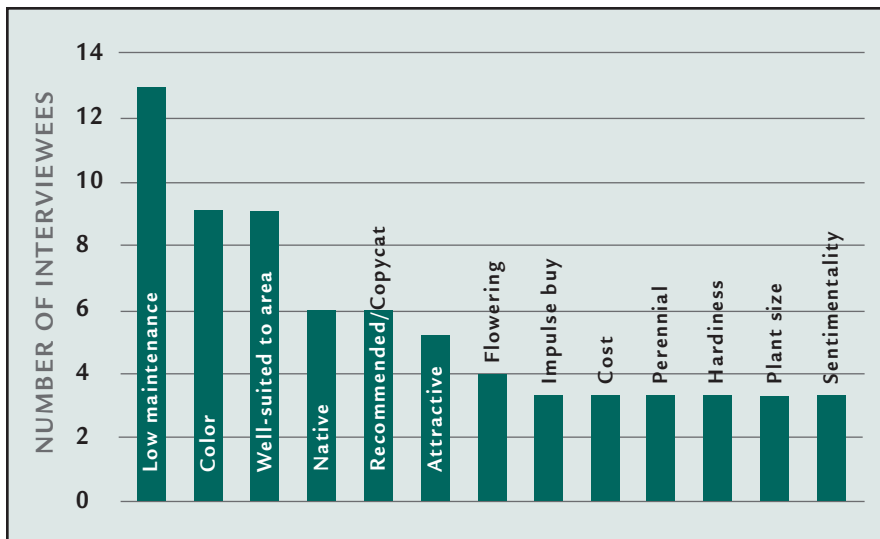


FIGURE 2. Reasons for Plant Selection

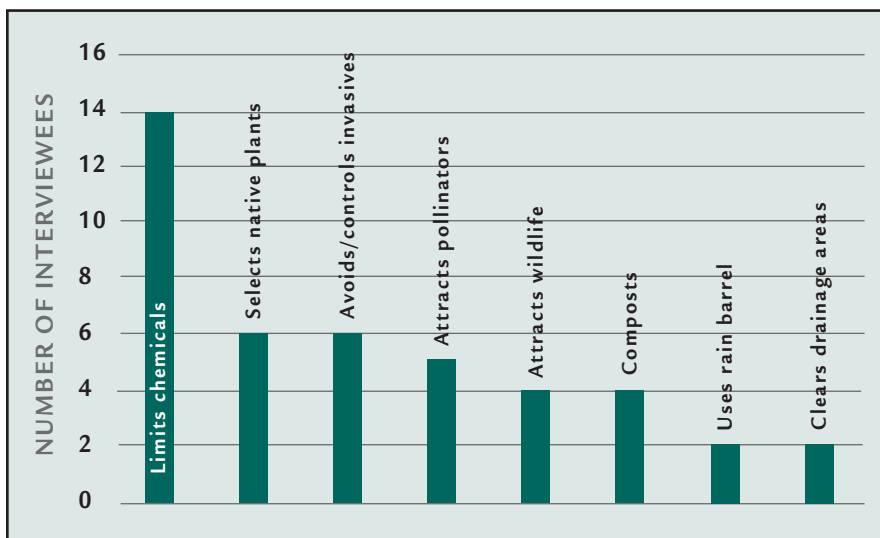


FIGURE 3. Environmentally Friendly Activities

- Consider nature-enhancing alternatives when replacing deteriorating bulkheads.
- Install living shorelines to protect property and provide habitat for wildlife.
- Select storm-ready trees to protect your home.
- For help, seek out experts, such as county cooperative extension specialists and master gardeners.

Educational resources on these topics can be found at: go.ncsu.edu/CoastalLandscapes

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Springtime Sensations

BY VANDA LEWIS
AND JOYCE TAYLOR

MARINER'S MENU, ONE OF THE FASTEST GROWING SITES FOR SEAFOOD RECIPES ON THE WEB, FEATURES BLOGGER AND PHOTOGRAPHER VANDA LEWIS'S POSTS OF RECIPES THE LATE JOYCE TAYLOR DEVELOPED. LEWIS SELECTED THESE FAVORITES FOR SPRINGTIME AND BEYOND. MarinersMenu.org

BROILED GROUPE WITH DIJON MAYONNAISE

- 1 1/2 pounds grouper fillet, cut into serving-sized pieces
- 3 tablespoons melted butter
- salt
- freshly ground black pepper

Prepare Dijon mayonnaise (recipe below) and refrigerate.

Place fish on lightly greased broiler pan.

Brush with melted butter. Lightly salt and pepper.

Broil about 4 inches from heat until done, about 8 to 10 minutes.

Place on serving dish and serve with Dijon mayonnaise.

Dijon Mayonnaise

- 1/2 cup mayonnaise
- 1/2 tablespoon Dijon mustard
- 1 tablespoon dry white wine
- 1/2 teaspoon minced garlic
- 1/4 teaspoon Tabasco sauce
- 1/8 teaspoon freshly ground white pepper

In a small bowl, combine mayonnaise, mustard, wine, garlic, Tabasco, and pepper.

DEEP-FRIED SOFT CRABS

- 8 soft-shell crabs
- 1 cup milk
- 1 cup flour
- 1/2 teaspoon salt

- 1/2 teaspoon freshly ground black pepper
- 1/4 teaspoon cayenne pepper
- oil for frying

Place crabs in shallow dish. Pour milk over them and leave for 15 minutes.

In another shallow dish, combine flour, salt, pepper, and cayenne.

Lift crabs from milk to drain. Dredge in flour mixture. Cook in hot oil, 375°F, a few at a time, until golden brown, about 5 minutes.



Broiled Grouper with Dijon Mayonnaise



Deep-Fried Soft Crabs



Crab Cakes with Fresh Basil and Thyme

- 1/2 cup mayonnaise
- 1 egg, beaten
- 1 cup French bread crumbs to blend into crabmeat
- 1 cup French bread crumbs for coating
- oil for frying

Remove any shell or cartilage from crabmeat. Place meat in medium bowl.

Melt butter in medium sauce pan. Sauté onion and celery until tender. Remove from heat. Stir in basil, thyme, cayenne, salt, and Tabasco.

Blend in mayonnaise, egg, and bread crumbs. Gently blend into crabmeat, being careful not to break the meat apart.

Shape into six or eight patties. Dredge lightly in 1 cup of dry crumbs.

Fry in 3 tablespoons of hot oil, 350°F, until golden brown on one side, about 4 minutes. Turn and repeat on other side. Drain on paper towels.

SHRIMP AND CRAB STUFFED POTATOES

- 1 cup shrimp, cooked and chopped
- 1 cup backfin crabmeat
- 6 small baking potatoes
- canola oil
- 6 tablespoons melted butter
- 1/2 cup heavy cream
- 1/4 cup sour cream
- 1 cup mozzarella cheese, freshly grated
- 1/2 cup green onion, including tops, minced
- 1/2 teaspoon nutmeg
- 1/2 teaspoon salt
- 1/2 teaspoon freshly ground white pepper
- paprika

Scrub potatoes with brush. Rub lightly with canola oil. Bake at 400°F until done, about 40 to 60 minutes.

While potatoes are baking, cook shrimp in lightly salted water. Peel and cut into pieces about 1/4 inch.

When potatoes are cool to touch, cut in half lengthwise. Carefully scoop out pulp, leaving a firm shell about 1/4-inch thick.

Combine pulp, butter, heavy cream, sour cream, cheese, onion, nutmeg, salt, and pepper. Mix until smooth.

Stir in shrimp. Gently mix in crabmeat, being careful not to break crab pieces apart.

Stuff shells with mixture. Sprinkle lightly with paprika. Bake at 400°F until heated through, about 15 minutes. 🍴



Shrimp and Crab Stuffed Potatoes

CRAB CAKES WITH FRESH BASIL AND THYME

- 1 pound backfin crabmeat
- 3 tablespoons butter
- 1/4 cup chopped onion
- 1/4 cup chopped celery
- 2 tablespoons chopped fresh basil
- 2 tablespoons chopped fresh thyme
- 1/8 teaspoon cayenne pepper
- 1/2 teaspoon salt
- 1/4 teaspoon Tabasco sauce

Order Joyce Taylor's book *Mariner's Menu: 30 Years of Fresh Seafood Ideas* at go.ncsu.edu/Recipe-Book.



*“A picture may be worth a thousand words,
but a soundscape is worth a thousand pictures.”*

– BERNIE KRAUSE, SOUNDSCAPE ECOLOGIST AND FOUNDER OF WILD SANCTUARY



An Underwater Soundscape Is Worth a Thousand Pictures

The Surprising Implications of Eavesdropping on Fish

BY OLIVIA CARETTI

Olivia Caretti, a National Science Foundation Graduate Research Fellow in the Marine Ecology and Conservation Lab at NC State, serves on Dave Eggleston's research team. North Carolina Sea Grant's core research funding supports Eggleston's "Evaluating Cultch Oyster Reefs as Essential Fish Habitat" project. At the N.C. Coastal Conference in November, Caretti received first place honors for her poster presentation about using acoustics to assess oyster reef restoration.

WE OFTEN THINK OF THE UNDERWATER ENVIRONMENT AS A QUIET AND STILL PLACE. HOWEVER, MOST OF THE OCEAN IS FULL OF NOISES FROM BIOLOGICAL, GEOLOGIC, AND HUMAN ACTIVITY.

Like humans, underwater animals use sound to communicate, navigate, and search for food — and the underwater environment is full of signals associated with these behaviors. What can we learn by eavesdropping on these conversations?

For my research, I am tapping into this natural set of behaviors to learn about how fish and invertebrates interact with their habitat — specifically how they use restored oyster reefs. Passively listening to animals in their natural environment provides a nondestructive and unique way to monitor this, especially in estuarine systems where water is murky and where animals are constantly on the move and difficult to sample.

Our team at NC State collected two years of acoustic recordings on restored oyster reefs in the Pamlico Sound. We coupled our recordings with habitat surveys to understand how fish responded to changes in their oyster reef habitat.

From our acoustic data, we can determine what species are present on

restored oyster reefs, when they are present, and how they are using their habitat. For example, oyster toadfish make two different types of calls depending on their behavior. Males make the “boatwhistle” call only during spawning season, while they use the “grunt” call for day-to-day communication.

Moreover, acoustics have allowed us to identify spawning information about several important estuarine fish species. We have identified the exact date when such species as oyster toadfish, speckled trout, silver perch, and red drum begin spawning on restored oyster reefs in Pamlico Sound. We also can see how fish-calling activity changes in response to local weather patterns. With a longer dataset, we even could look at how spawning activity for certain species may shift in response to climate change.

We also have seen the soundscape of restored oyster reefs change over time. Sounds from reef-dwelling species — such as oyster toadfish, red and black drum, snapping shrimp, and crabs — have become more common as reefs developed after construction. We even can see how different species make up the community on reefs in different locations and built with different materials. All this information can be extremely useful for informing goals and designs of oyster restoration projects.

Longer term acoustic monitoring could

provide information on the recovery of habitats from large disturbances, such as hurricanes or “fresh-hit” events from intense inland flooding. Acoustic monitoring could show how quickly fish returned to reefs following a major storm. Essentially, changes in a habitat’s sound composition could indicate changes in habitat health and suggest its resilience.

Estuaries are dynamic habitats, and short-term changes in the environment can be difficult to monitor with traditional, intermittent sampling methods. Acoustics can track these short-term changes, as well as longer-term shifts, extremely well by providing an almost continuous record of information.

Just by listening, we can learn valuable information about the fish living beneath the sea, and this information can be crucial for conservation and restoration decisions. Listening to fish can uncover an entirely new perspective of our watery world. 🎧

- *the toadfish boatwhistle call (audio):*
go.ncsu.edu/boatwhistle
- *Olivia Caretti's "What Can Researchers Learn by Eavesdropping on Fish?":*
go.ncsu.edu/eavesdropping-on-fish
- *Olivia Caretti's interview with WUNC radio:*
go.ncsu.edu/Caretti-on-WUNC
- *North Carolina Sea Grant's core research funding:*
go.ncsu.edu/new-core-funding

ABOVE AND LEFT: Olivia Caretti (here) and her colleagues have identified the exact dates when several fish species begin spawning on restored oyster reefs in North Carolina's Pamlico Sound.



Yener Ulus is investigating how mercury changes from its inorganic form — which is less likely to transfer to animals or people — to a more toxic form when saltwater begins invading freshwater wetlands

MERCURY ON THE RISE

Will sea level rise affect toxic mercury levels in coastal wetlands?

MAYA HOON

AS SEA LEVELS CONTINUE TO RISE WITH EACH PASSING YEAR, RESEARCHERS INCREASINGLY ARE FOCUSING THEIR ATTENTION ON HOW THE CHANGE MAY IMPACT COASTAL WETLANDS. While there is an abundance of research on the effects of sea level rise on the coast, few studies have addressed how rising seas might affect deposits of mercury, an environmental pollutant.

Yener Ulus, a Ph.D. student in environmental health sciences at the University of North Carolina at Greensboro, is tackling the question of mercury's impacts on freshwater coastal wetlands. With

support from a joint North Carolina Sea Grant – Water Resources Research Institute graduate research fellowship, he is investigating how mercury changes from its inorganic form — which is less likely to transfer to animals or people — to a more toxic form when saltwater begins invading freshwater wetlands.

“We already know there is mercury pollution,” Ulus says. “But we don’t know what this perturbation would look like with sea level rise, hurricanes, storm surges, and floods.”

Mercury is present in almost every waterbody and is one of the most common pollutants in North Carolina’s freshwater fish. Thus,

it potentially threatens the health of people consuming those fish. However, *the form* of mercury dictates the *level of threat* that this pollutant poses to ecosystems and to human health.

When saltwater invades freshwater wetlands, it can carry abundant sulfate into these systems, which sets off a chain reaction in the wetland.

“There are sulfate-reducing bacteria that use the sulfate,” Ulus explains. “As a byproduct it converts inorganic mercury into organic mercury — which we call methylmercury, the most toxic form. This methylmercury is in the water, sediment, the plankton, small insects, fish, and eventually humans who eat the fish.”

INTO THE FIELD — AND HURRICANE DORIAN

When he gathers samples to study, Ulus and his team must drive five hours from Greensboro to his wetland study sites in Dare and Tyrrell counties. He dedicates up to five more hours to collecting sediment, water, and biota samples, then makes the return drive back to his lab. Even when Hurricane Dorian made its way to North Carolina’s coasts, he visited his sites for samples prior to the storm surge, while local towns were evacuating.

“One week after the hurricane passed, we went back to collect samples,” he says. “So, basically that gave me a chance to see how methylmercury will vary when you have excessive amounts of sea water intrusion from storm surge.”

According to Ulus, those results were “amazing.” There was, indeed, an increase in methylmercury.

With a clearer picture of the methylmercury levels in the water and sediment at his wetland sampling sites, Ulus is beginning to address how the food chain, in turn, might reflect these levels. He hopes to sample more biota from his wetland sites to understand how methylmercury moves through the food web, which he believes is essential for understanding how the toxin may affect human communities.

BLUE HERONS, BEARS, AND SPREADING THE WORD

Ulus grew up in Arsuz, Turkey, a small green town near the Mediterranean Sea that relies on fishing and farming.

“I wanted to be the person who saves the environment,” he says, “while also being a good influence to those around me.”

He takes his research outside of his lab and field sites to spread awareness about mercury pollution in coastal areas. As a volunteer with UNCG’s Science Everywhere program, he teaches students from kindergarten to high school about mercury as a pollutant.

In Tyrrell County, one of the poorest counties in North Carolina and the location of one of his sampling sites, Ulus says many people don’t know about mercury.

“So, one of my purposes is to explain what’s going on in their own community about mercury pollution,” he explains. “Because most of them have no idea about that.”

He contacted the town manager in Columbia, North Carolina, on the Albemarle-Pamlico Peninsula, about the need to inform town officials and residents about mercury pollution.

Ulus also presented his research in Poland at the 14th International Conference on Mercury as a Global Pollutant. In addition, he has presented and discussed his findings with government representatives and communities in his home country.

For Ulus, protecting human health is paramount, but he also emphasizes the obligation to protect and preserve wildlife and natural beauty.

“We should provide a good environment for any wildlife,” Ulus says. “When I go [to my wetland sampling sites] I see the blue herons — they are flying. Or I see the bears! This is our treasure, you know?” 🐻

Watch Yener Ulus at UNCG’s “Three-Minute Thesis” event. His presentation earned honors in the People’s Choice category:

go.ncsu.edu/3-minute-mercury

North Carolina Sea Grant fellowships:
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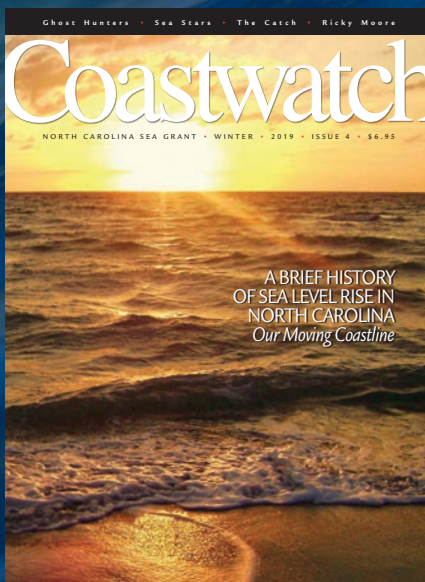


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Thank You!

North Carolina Sea Grant would like to thank the people who have provided support to our program over the past year. Generous donors again have helped us carry out our mission — which, of course, included four more editions of the award-winning *Coastwatch* magazine.

In particular, we'd like to thank **Natalie Hamrick**, **Karen LaMontagne**, and **Philip Mertz** for their donations.

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