

Weather and Water Quality • Mapping the Future • From Sea to Space • Skedaddling Sea Turtles

# Coastwatch

NORTH CAROLINA SEA GRANT • SUMMER • 2021 • ISSUE 2 • \$6.95

## THE BUTTERFLY EFFECT

*A Winged Crystal Coast Native  
Inspires Stewardship*



## Summer 2021: New Plans and Programs in a New Era

We certainly are looking forward to summer fun outside with family and friends.

Our team also will be reinvigorating North Carolina Sea Grant programming with partners across the state after more than a year of pandemic restrictions. We have missed in-person interactions — and are eager, with ongoing safety measures, to expand our outreach and research with coastal communities, stakeholders, and academic institutions. All this, while keeping an eye on the predicted active Atlantic hurricane season.

It is a busy time, yet one that brings energy and enthusiasm to support NC Sea Grant’s mission to bring science-based information with real-world solutions, enhancing the sustainable use and conservation of ocean and coastal resources to benefit communities, the economy, and the environment.

I commend all of our team members in Raleigh, Wilmington, Morehead City, and Manteo. They have epitomized resilience and reflected a generosity of spirit, along with a sense of optimism and commitment to supporting their families and communities, while also bringing excellence to their work. I am regularly amazed at how adaptive and creative our team has been, along with many partners and collaborators, in delivering virtual programs and seeking on-the-ground solutions to address coastal and watershed challenges.

It’s a very welcome sea change to renew our own programming, and to know our funded researchers are going back out in the field — and the waters. This summer, for instance, will see the ramping up of new projects funded through Community Collaborative Research Grants in partnership with the Kenan Institute for Engineering, Technology, and Science and the NC Water Resources Research Institute. In addition, our second group of NC STEM Policy Fellows will be starting assignments. And, we are busy reviewing proposals for our next round of core research.

We try to embed our commitment to diversity, equity, inclusion, and environmental justice across all our projects, and we also lead particular projects to better understand and respond to conditions in communities that

disproportionately bear burdens. Starting this fall, we’ll investigate the effects of COVID-19 on underserved communities in our state’s coastal counties. The project also will include a special focus on health disparities in coastal North Carolina.

In this issue, you’ll find more prime examples that represent the focus areas of our work: healthy ecosystems, resilient communities, sustainable fisheries and aquaculture, and environmental literacy.

“The Butterfly Effect” is the award-winning Julie Leibach’s lively cover story about the crystal skipper — a conservation legacy for our program and a species worth viewing when you visit N.C.’s central coastal region.

In “Above and Below,” you can read about guest author Alex K. Manda’s groundbreaking work at Pine Knoll Shores and the Buckridge Coastal Reserve. Manda, a geological scientist at East Carolina University, has conducted a wide array of research on that critical resource we often take for granted on the East Coast: water.

“Mapping the Future” provides a preview of Georgina Sanchez’s innovative flood mapping project at NC State’s Center for Geospatial Analytics, a project she is piloting with student Elyssa Collins and other scientists at NC State and the U.S. Geological Survey. Sanchez, Collins, and their colleagues are modeling the effects of different climate change scenarios on both coastal and inland flooding, and, in turn, they will provide a means for developing badly needed updates to flood maps coast to coast.

There’s lots more in this issue, too. Take it with you to the beach — and check out the rip currents safety information on the back cover before you hit the waves.

Please reach out to me at [snwhite3@ncsu.edu](mailto:snwhite3@ncsu.edu) to share your favorite N. C. beach memories. Also, please share your suggestions for how North Carolina Sea Grant can continue to strive towards more inclusive work within our coastal communities.

— Susan White, Executive Director, North Carolina Sea Grant

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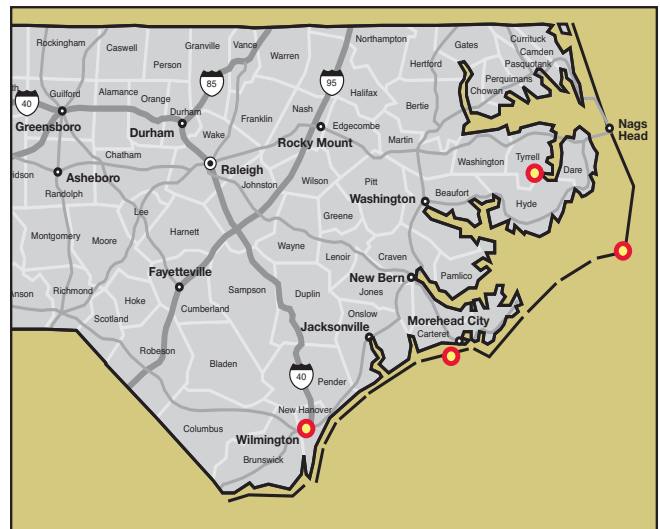
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*Settings for the stories in this issue cover many locations in North Carolina, including these places from north to south on the map: Buckridge Coastal Reserve, Cape Hatteras National Seashore, Pine Knoll Shores, and Wilmington.*





# Coastwatch

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▣ *Front Cover:* Eye to eye with a crystal skipper. Courtesy of the USGS Native Bee Inventory and Monitoring Lab. ▣ *Table of Contents:* The winged Crystal Coast native alights. Courtesy of Carol Price/NC Aquariums.

# Coastwatch

North Carolina Sea Grant • Summer • 2021 • Issue 2

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

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

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

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## OYSTER BLUEPRINT PROVIDES GREEN PLANS FOR INDUSTRY GROWTH

Over 50 contributors across the state have created the *North Carolina Oyster Blueprint for 2021-2025*, an action strategy to advance the restoration, protection, and harvest of oysters.

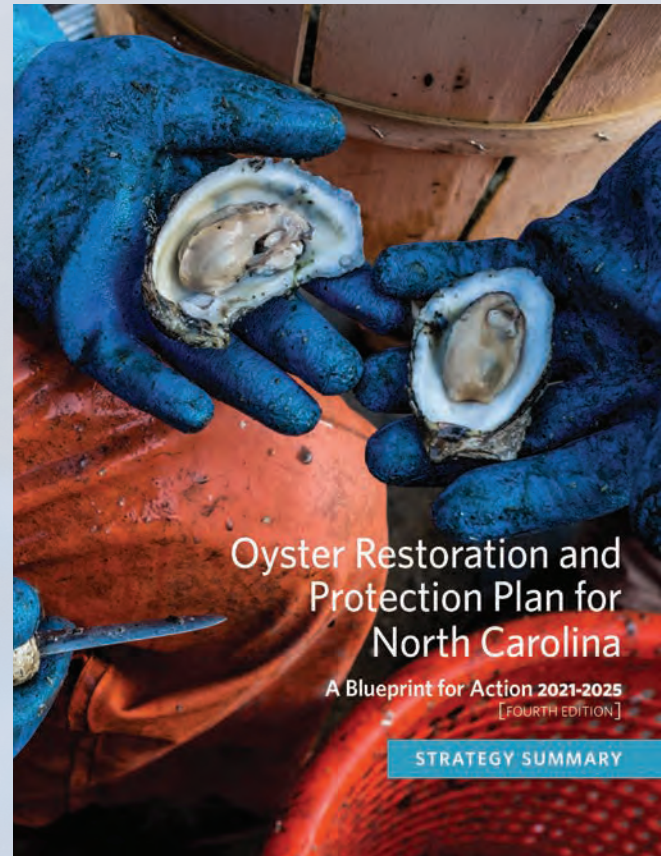
“Our ambitious vision for oysters in North Carolina builds on the *Oyster Blueprint's* solid foundation of successes, and reflects that forward progress,” says Todd Miller, executive director of the North Carolina Coastal Federation. “I’m especially proud of the commitment, cooperation, and creative thinking the many diverse contributors showed in creating this vital plan, even as COVID-19 added new challenges in the last year.”

North Carolina Sea Grant served as a key partner during development of the new *Oyster Blueprint*, continuing the program's long history of work aligned with past and present editions of the *Oyster Blueprint*.

“Several North Carolina Sea Grant extension team members contributed to workgroups that devised the strategies,” says Frank López, North Carolina Sea Grant's extension director. Sea Grant also has funded a variety of research projects supporting the *Oyster Blueprint's* goals.

Restoring oysters offers benefits for water quality, fish habitats, and shoreline protection from storms. Restoring wild oyster populations also can increase the commercial oyster harvest and help farmers who grow their own oysters, contributing jobs and healthy, local food to communities.

However, wild oyster numbers in North Carolina have declined over the last century due to historic overharvesting — as well as the impacts of poor water quality, natural disasters, predation, and disease. The decline mirrors the global loss of an estimated 85% of oyster reefs.



*The new Oyster Blueprint includes a strategic summary.*

*North Carolina Oyster Blueprint for 2021-2025* identifies specific goals for the state. Contributors to the new plans included commercial and recreational fishers, shellfish farmers, state and federal agencies, scientists, tourism officials, restaurant owners, seafood dealers, and environmental nonprofits.

“The latest version of the *Oyster Blueprint* documents the progress and the potential of the oyster industry in North Carolina,” State Senator Norman Sanderson says. “It’s clear that the investments we have made to help the aquaculture industry are paying off. We need to continue to build on that success to create the jobs shellfish can bring to our coastal communities.”

Previous editions of the *Oyster Blueprint* have led to important improvements in the state, including the restoration of nearly 450 acres of oyster habitat, growth in the shellfish aquaculture industry from \$1 million to \$5 million, and a tenfold increase in the number of oyster farms in the state.

• **more:** [go.ncsu.edu/blueprint](http://go.ncsu.edu/blueprint)



Valerie/CC-BY-2.0

## NORTH CAROLINA STATE CLIMATE OFFICE OFFERS DATA ON DEMAND

The North Carolina State Climate Office has a new data request tool that makes it faster and easier to access weather and climate data from across the state. Users only need to activate a free account to access historical weather observations.

With the “Request Builder” and its step-by-step interface, users can select locations of interest, time periods, and other parameters, all from stations providing the most relevant data for each search. Data retrieval only takes seconds.

The “Station Scout” tool uses intuitive, graphical displays to show current conditions, station details, and much more data from hundreds of active weather stations.

The North Carolina State Climate Office will be adding more information to their website, including additional North Carolina-specific activities and climate change education content, findings from research projects, and other tools to help people explore data from around the state.

- **climate data on demand:** [go.ncsu.edu/on-demand](http://go.ncsu.edu/on-demand)

— Allison Fisk



Baxter Miller

## SAFELY SELECTING AND CONSUMING SHELLFISH: FAQs

North Carolina Sea Grant has developed a new web resource for anyone with questions about safely eating shellfish. Consumers can find out where they can buy live shellfish and who is most at risk for shellfish-borne illnesses. They also can learn how to judge the quality of live shellfish, how to transport and store it, and even how to cook it.

- **more:** [go.ncsu.edu/safe-shellfish](http://go.ncsu.edu/safe-shellfish)



Mollie Yacano

NC Coastal Research Fellow Mollie Yacano

## COASTAL RESEARCH FELLOW STUDIES INVASIVE WETLAND GRASS

Mollie Yacano, the recipient of the 2021 North Carolina Coastal Research Fellowship, is investigating the environmental impact of removing Phragmites, a common reed grass that invades coastal wetlands.

“Phragmites has a huge influence on our wetland systems, and its dominance is only growing,” says John Fear, deputy director of North Carolina Sea Grant. “Understanding what happens to the environment as our coastal land managers address ‘Phrag’ will be a great asset to the field.”

Yacano, a Ph.D. student at the UNC Institute for Marine Sciences, is exploring how different methods for controlling Phragmites affect underlying sediments and nitrogen cycling.

“Nitrogen cycling is a key ecological process and an important ecosystem service provided by wetlands,” says Brandon Puckett, research coordinator for the North Carolina Coastal Reserve and National Estuarine Research Reserve Program. “Considering ecosystem services in the management of natural resources, including invasive and non-native species, is critical to making informed decisions.”

Using state-of-the-art drone imagery, Yacano will evaluate both the positive and negative effects of removing the invasive grass.

“Current management practices regarding Phragmites focus on eradication of the plant,” she explains. “Understanding how different eradication approaches impact ecosystem services can help inform policy on whether these eradication measures are in the best interest of both stakeholders and the ecosystem.”

North Carolina Sea Grant and the Coastal Reserve sponsor the fellowship, which supports research in the state’s coastal reserve system.

- **Coastal Research Fellowship:** [go.ncsu.edu/reserve-fellowship](http://go.ncsu.edu/reserve-fellowship)

— Dave Shaw



The Cape Hatteras Lighthouse virtual tour is live.

## NATIONAL PARKS IN NC OFFER NEW PROGRAMS AND DIGITAL OPTIONS

Cape Hatteras National Seashore, Fort Raleigh National Historic Site, and Wright Brothers National Memorial have launched new digital activities for visitors to connect with their national park sites.

The recently released National Park Service’s mobile app, available for free download in the iOS App Store and Google Play Store, provides up-to-date information about all 423 national parks across the country.

The app also includes new audio tours for Cape Hatteras National Seashore, Fort Raleigh National Historic Site, and Wright Brothers National Memorial. These walking tours lead visitors to major highlights and teach listeners about the rich history and natural resources of the three parks.

In addition, the NPS mobile app offers up-to-date information on ranger-guided interpretive programs for the summer season. This summer’s offerings include in-person ranger talks, guided hikes, bicycle tours, and more.

A virtual tour is now available, too, which allows visitors both onsite and around the world to experience a climb up the Cape Hatteras Lighthouse and to explore its 360-degree views. The tour features historic images and educational information as well.

Thanks to a partnership with Outer Banks Forever, a webcam now also allows visitors to check out the real-time view from atop the 197-foot lighthouse and observe weather and beach conditions.

- **Cape Hatteras Lighthouse virtual tour:**

[nps.gov/hdp/exhibits/caha/tour](https://nps.gov/hdp/exhibits/caha/tour)

- **Cape Hatteras Lighthouse webcam:**

[obxforever.org/obx-national-park-webcams](https://obxforever.org/obx-national-park-webcams)

— from an NPS news release



## NC STATE RESEARCHERS PREDICT ACTIVE HURRICANE SEASON

The 2021 Atlantic hurricane season will bring 15 to 18 named storms in the Atlantic basin, according to researchers at North Carolina State University.

The prediction is higher than the average over the last 70 years, according to Lian Xie, professor of marine, earth, and atmospheric sciences at NC State. Xie, the lead researcher on the study, says the long-term average of named storms is 11.

Of the predicted 15 to 18 named storms, seven to nine may grow strong enough to become hurricanes (compared to the historical average of six), with the possibility of two to three storms becoming major hurricanes.

The Atlantic basin includes the entire Atlantic Ocean, the Gulf of Mexico, and the

Caribbean Sea. The Gulf of Mexico will see an active hurricane season but one more in line with historical averages. Xie predicts three to five named storms forming in the region, two to four of those becoming hurricanes, and one becoming a major hurricane.

Xie’s estimate for the Atlantic basin is similar to a subsequent NOAA forecast, which has predicted a likely range of 13 to 20 named storms, including three to five major hurricanes.

The Atlantic hurricane season runs from June 1 through Nov. 30.

- **Xie’s forecast:** [go.ncsu.edu/active-season](https://go.ncsu.edu/active-season)

- **Coastwatch on hurricanes:** [go.ncsu.edu/coastwatch-hurricanes](https://go.ncsu.edu/coastwatch-hurricanes)

— Tracey Peake



## NC SEAFOOD'S ECONOMIC IMPACT GROWS

New research has found that North Carolina's wild-caught commercial seafood industry provides 5,500 jobs and nearly \$300 million to the state's gross domestic product. Demand for that seafood is strong, with North Carolinians willing to pay more for local fare over foreign products.

"Our results clearly show that, from the docks to the table, North Carolina seafood plays a significant role in our economy," says Jane Harrison, North Carolina Sea Grant's coastal economics specialist.

The findings stem from collaborative work that builds on earlier studies on the economic impact of the state's seafood industry. North Carolina Sea Grant led the project in partnership with Appalachian State University, Duke University, NC State University, and the University of North Carolina Wilmington.

The project included an investigation of numerous seafood attributes that influence purchasing decisions. Harrison, together with Sea Grant's Barry Nash and Appalachian State's John Whitehead, designed a novel experiment to gauge consumer willingness to pay for headed shrimp and flounder fillets.

They found that although price was a major factor, respondents were willing to pay more for seafood from North Carolina and other U.S. sources. In addition, participants were more inclined to buy domestic seafood than seafood bearing "wild-caught" or "sustainably caught" labels.

The N.C. Commercial Fishing Resource Fund Grant Program funded the project.

• **more:** [go.ncsu.edu/NCSeafoodDemand](http://go.ncsu.edu/NCSeafoodDemand)

—Julie Leibach



Jenna Hartley

## STUDENT PRESENTATIONS EVOKE CONCERN ABOUT MARINE DEBRIS

A new study from NC State University and North Carolina Sea Grant has found that voters and local leaders showed greater concern about plastic and other garbage in the ocean after watching student presentations on the subject.

The findings build on previous research that determined educating kids about climate change was linked to an increase in concern in parents. The new findings indicate children can have a broader effect beyond their families.

"Our lab has already established that kids can have an impact across the dinner table, and it's cool to see that they can also have an impact within town halls, too," says the study's lead author Jenna Hartley, a Ph.D. student in the NC State Department of Parks, Recreation, and Tourism Management. "We also saw that kids could help close partisan gaps in how community members view this issue."

The students first completed lessons developed by the Duke University Marine Lab Community Science Initiative on how plastics and other trash reach waterways. Then, the students either made in-person presentations or public service announcement videos that were shared with voters and local political leaders.

In the study, researchers surveyed adults who watched educational events or videos that the students developed — presentations from 2,500 fourth and fifth graders, all told.

Not only did the adults' concern about marine debris increase after watching the children's presentations, but support for marine debris policies also rose.

• **more:** [go.ncsu.edu/plastic-concern](http://go.ncsu.edu/plastic-concern)

—Laura Oleniacz



## CIVIL RIGHTS TRAIL SELECTS HISTORICAL MARKERS

The North Carolina Civil Rights Trail has chosen its first three historical markers. The trail system will highlight sites critical to the Civil Rights Movement in North Carolina.

The N.C. African American Heritage Commission is leading the initiative with

funding from the William G. Pomeroy Foundation and support from Visit North Carolina and the North Carolina Office of Archives & History. The commission will work with communities across the state to designate up to 50 sites for trail markers.

Installation of the markers begins this summer in Cleveland, Hertford, and Lenoir counties:

- New Ahoskie Baptist Church in Ahoskie, North Carolina, where church members led 1960s civil rights efforts. Their work expanded access to public offices, resources, and employment.
- Adkin High School in Kinston, North Carolina, where students walked out in protest of inferior facilities. Their protests eventually led to the construction of new classrooms and a gymnasium.
- Uptown Shelby, North Carolina, marking February 1960 sit-ins, which local high school students led.

The commission has opened a new round of applications through October 2021 for proposals to add markers to the trail.

• **NC Civil Rights Trail:** [aahc.nc.gov/programs/civil-rights-trail](http://aahc.nc.gov/programs/civil-rights-trail)

—Lauren D. Pharr

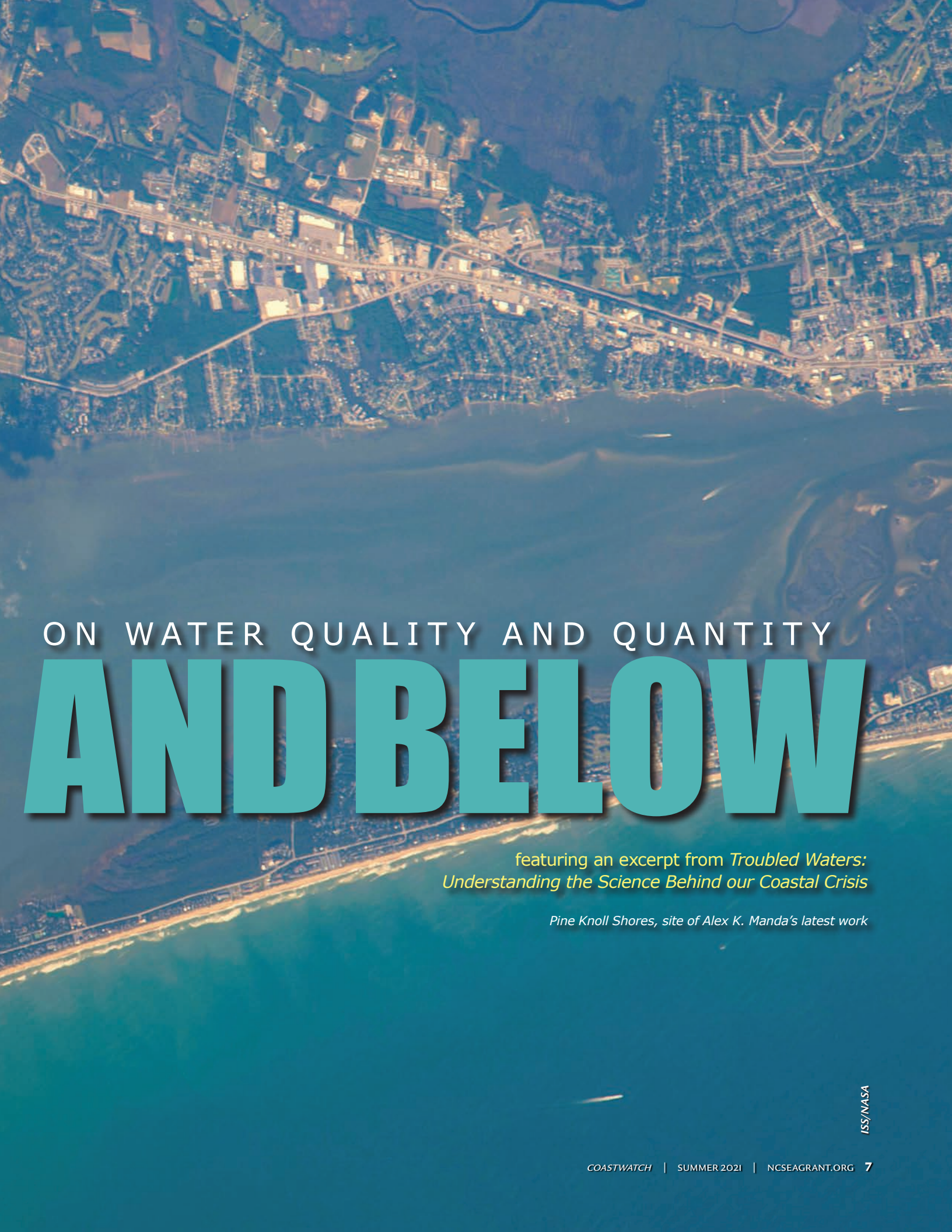
An aerial photograph of a coastal town, likely in North Carolina, showing a mix of residential and commercial buildings, roads, and green spaces. A large, semi-transparent teal shadow is cast over the town, suggesting a low sun position. The ocean is visible in the bottom right corner.

# ABOVE

THE IMPACT OF WEATHER EVENTS

BY ALEX K. MANDA





ON WATER QUALITY AND QUANTITY  
**AND BELOW**

featuring an excerpt from *Troubled Waters:  
Understanding the Science Behind our Coastal Crisis*

*Pine Knoll Shores, site of Alex K. Manda's latest work*



Alex K. Manda (in the red cap, mentoring students in the field) studies a critical resource many people on the East Coast often take for granted: water.

*Alex K. Manda is a geological scientist at East Carolina University. His wide-ranging research interests address a critical resource many people on the East Coast often take for granted: water. His work explores the origins of the water we use, whether water supply can meet demand for generations to come, and what factors determine water availability and quality. He also studies how climate change, population growth, and urban development affect the availability of potable water.*

*Here, he explains studies of two very different weather-related impacts on coastal North Carolina surface waters and groundwater. The first looks at the effect of winds on saltwater intrusion at the Emily and Richardson Preyer Buckridge Coastal Reserve. He then offers a short preview of his new work at Pine Knoll Shores for a North Carolina Sea Grant project designed to mitigate the effects of stormwater flooding after heavy precipitation.*

## WIND, SALT, AND BEARS ON THE INNER BANKS

Several years ago, we investigated saltwater intrusion in a coastal wetland system of the “Inner Banks.” In this region, saltwater intrusion is inundating low-lying lands that are used for agriculture and conservation purposes. Since certain types of vegetation are not tolerant to saltwater, any increase in saltwater content may seriously impact the health of this vegetation.

The first section of this article adapts material from Alex K. Manda’s “A Tale of Two Hydrogeology Problems in Coastal North Carolina” in editor Stephen Culver’s *Troubled Waters: Understanding the Science Behind our Coastal Crisis*, published in 2021 by Springer Nature and reproduced here with permission of SNCSC.



Matt Smith/ECU

For example, in the Emily and Richardson Preyer Buckridge Coastal Reserve, various tree stands of Atlantic white cedar are showing signs of stress, potentially due to saltwater intrusion. According to the North Carolina Forest Service, the state of North Carolina has the largest acreage of Atlantic white cedar in the country. Thus, any loss of Atlantic white cedar will have severe consequences on the ecosystems in which these trees are found.

In other low-lying areas, saltwater is finding its way into agricultural fields, thereby preventing the growth and maturity of certain types of crops (e.g., soybeans, corn, etc.) that are important for the economic well-being of many coastal communities. Saltwater intrusion

therefore threatens to decrease the yields of important cash crops.

To adapt to these environmental changes, farmers might have to find alternate crops to grow, perhaps apply gypsum to their fields, or abandon their farms altogether. Some of these courses of action come at great cost, and thus are likely to cause farmers many sleepless nights. Determining the course of action depends greatly on the mode of saltwater intrusion, as well as the extent of the problem.

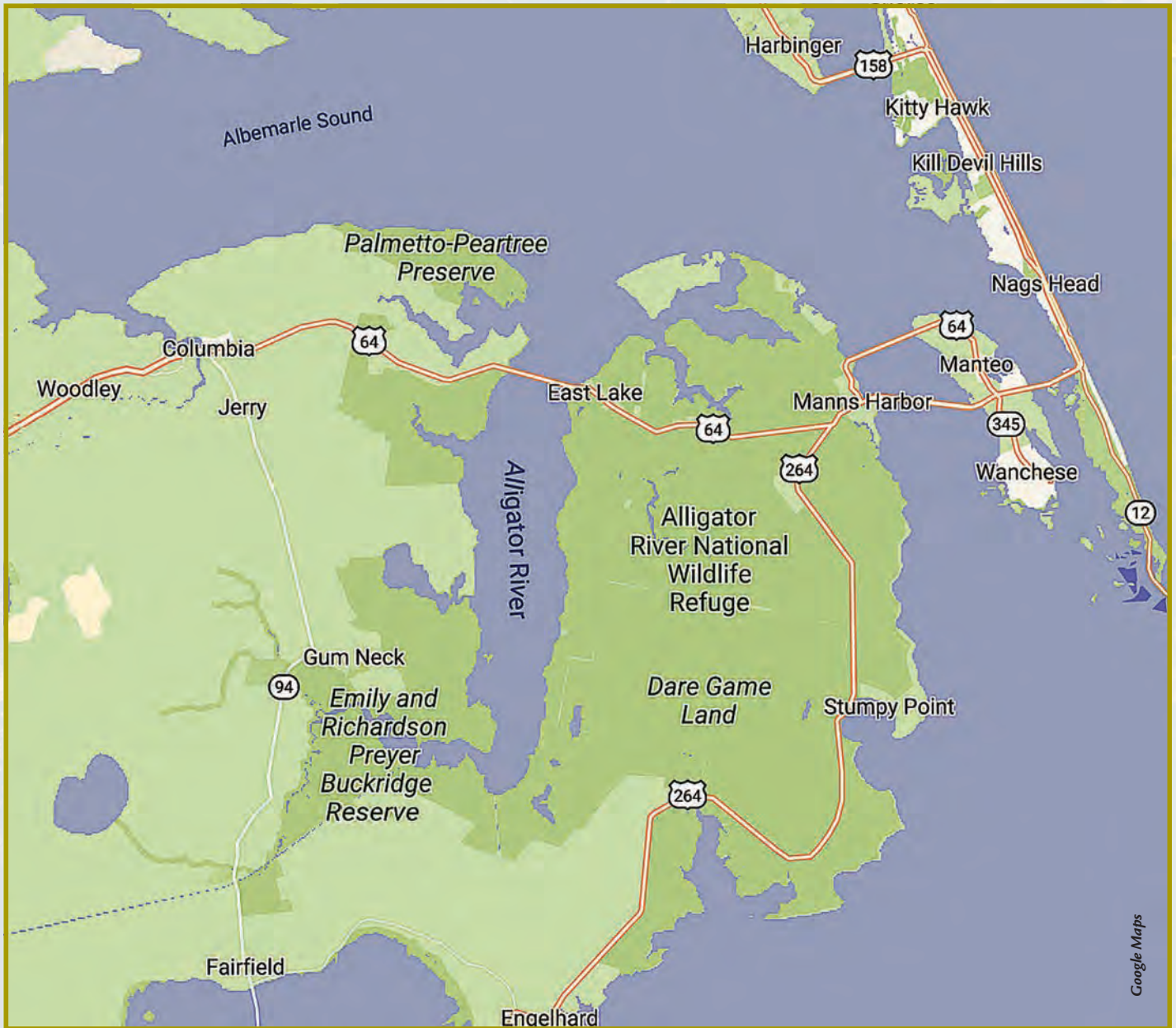
There are several ideas (working hypotheses) that can explain the source of the saltwater. One idea is that the saltwater is migrating inland from the ocean and sounds due to sea-

level rise. As the sea rises, ocean water would not only move farther inland, but the saltwater wedge beneath the coast would also migrate inland.

Although this movement would lead to saltwater sources being near agricultural fields, the process would take years to mature because the rate of relative sea level rise is on the order of several millimeters per year in eastern North Carolina.

Another hypothesis that may explain aquifer/soil salinization is that saltwater intrusion is driven by overwash and storm surge from tropical cyclone activity. Under this process, there is an instantaneous injection of saltwater in inundated fields that then persists in the soil or groundwater for a very long time.

*Continued*



Alex K. Manda and his research team investigated whether wind tides were moving saline water into the Emily and Richardson Preyer Buckridge Coastal Reserve.

Wind tide events are another mechanism by which saltwater can make its way from surface water bodies to agricultural fields. These wind tides may cause the water in channels to overflow into agricultural fields. The wind tides may also prolong the presence of salts adjacent to agricultural fields so that saltwater would then have sufficient time to permeate into adjoining fields, thereby contaminating cropland.

Land subsidence may also cause saltwater intrusion by lowering the land that is adjacent to the sounds or ocean. The impact of this process is that the ocean/sound level would appear to rise relative to the land surface. As a consequence, the ocean would move inland and the saltwater wedge in the subsurface would move inland. Processes that may cause land subsidence in eastern North Carolina may include groundwater pumping from coastal

aquifers in southern Virginia, or the lowering of the land surface as the Earth's crust continues to relax due to the melting of an ice sheet in southern Canada/northern U.S. that occurred about 15,000 to 10,000 years ago.

For this study, we deployed devices (known as loggers) that autonomously record water levels and specific conductivity (used here as a proxy for salinity) in surface water and groundwater

bodies. The idea of the deployment scheme was to place the loggers in such a way that we could capture the height and the conductivity of the water from a potential source (a large human-made canal — the Alligator-Pungo River canal), along a river channel (the Alligator River, adjacent to the Reserve), to finally, a series of small canals in the protected Reserve.

The hypothesis that we were testing for this study was that the saline water detected in the

Reserve originated from the large constructed canal. The saline water then made its way to the Reserve via the Alligator River and small canals. We further hypothesized that the driver for this movement was wind tides. To fully test these hypotheses, we collected weather data in addition to the water quality data and water quantity data.

Installing monitoring wells, deploying loggers and collecting data in the Reserve and surface water bodies was an adventure unto itself. To

understand the interactions between the surface water and groundwater regimes, my research team has installed and instrumented shallow groundwater monitoring stations (i.e., wells deployed in groundwater and surface water) in various locations in the Emily and Richardson Preyer Buckridge Coastal Reserve. These stations are visited periodically to measure or collect water quantity and water quality parameters in the various water bodies.

On one occasion, we needed to retrieve some

*Continued*

*Manda's wide-ranging research interests have provided opportunities for students to gain valuable experience out in the field.*



Alex K. Manda

data for analysis. Since the Reserve is far from Greenville, the location of East Carolina University, and is in a very remote area with plenty of wild animals, such as black bear, various snakes, alligators, and deer, I needed a field assistant to accompany me to the field site. On the day of the field excursion, my field assistant (whom I will call “Katie”) and I planned to spend the whole day at the Reserve to give us enough time to visit all of our well sites.

Early on the morning of the trip, we set about hitching a trailer with an all-terrain vehicle (ATV) to one of my department’s field trucks. We were to use the two-seater ATV to transport ourselves and equipment to the field sites that were on dirt roads far from the main road leading to the Reserve. These dirt roads typically have canals on one or both sides and may have downed trees or mud holes that make travel difficult, particularly after precipitation events.

We got to the field site quite early and were soon at work collecting data from the wells in the northern part of the Reserve. We completed the work in time for lunch, which we had at a pier overlooking the Alligator River. Since we did not want to put the ATV back in the trailer as we relocated to the southern section of the Reserve, we decided to each drive one of the vehicles: I would drive the ATV, and Katie would drive the truck and trailer.

Katie did not know the way to the entrance to the southern part of the Reserve, so I took the lead on the ATV while Katie followed behind me. In a few minutes we were at the intersection of the road leading to the southern sites and the main road. We decided to leave the truck at the intersection so that we could both get on the

*Continued*

*Manda’s work has shown that wind tides are in fact the major drivers of saltwater into the Buckridge Coastal Reserve (right).*



NC Wetlands





Anton Joubert/USFWS

*Black bear sightings on terrain along the Alligator River aren't uncommon (above), but few people had stumbled across bears within the Buckridge Coastal Reserve before Manda and a student researcher had a chance encounter with one.*

ATV to get to the field sites. I beckoned Katie to park behind me, but to my astonishment she decided to drive the truck and trailer across a muddy, soggy shoulder and straight into a ditch!

I got off my ATV to survey the situation. The truck and trailer were truly stuck. I asked Katie to pull forward, to no avail. I asked Katie to pull backwards. No luck either. At this stage, we were left with no choice but to temporarily abandon our fieldwork to seek help from local residents to help pull us out. We drove the ATV to the nearest house where we were directed to another house where guys with a truck and chains could help tow us out.

As luck would have it, we found the right people to help us out of our predicament. Two young men got in their vehicle and came to the truck to help us out of the ditch. In just a few

minutes, the truck was extricated and the two helpful young men were on their merry way. At this point, it was almost dusk and Katie assumed that we would be heading back home without the other data from the southern part of the Reserve. Katie was mistaken!

We jumped onto the ATV and started off for the remaining well sites. A few minutes down the dirt road into the Reserve, Katie pointed at something moving along the road in the distance.

"I think it is a bear," I said.

"A bear? But we don't have any protection!" Katie protested.

"The ATV is sufficient protection," I answered, "as long as we are driving and are on the ATV, we should be fine — on to the field sites!"

Sure enough, it was a bear that we saw. As we approached, it started running towards us on the narrow road.

"The bear is playing chicken with us," I said, "and we are not going to blink!"

We raced towards each other and I started to sweat. About 30 feet away from the ATV, the bear leapt into the canal next to the road.

We continued on to our sites, seeing many bears of different sizes frolicking and playing on the dirt road. I have never seen so many bears in my life. In fact, in all my years working at the Reserve, the total number of bear sightings at the Reserve was only two. We quickly proceeded to the last well sites where I collected my valuable data and then started back to the truck and trailer.



By the time that we got back to the truck, it was dark. With data from the groundwater wells in hand, we loaded the ATV into the trailer and started off back to Greenville. Katie was very glad we were in the truck heading back to civilization. I was just glad we got to collect all the data that we needed for us to test the hypotheses for this particular study.

The results of our study confirmed our original hypothesis that the driver of saline water into the wetlands of the Emily and Richardson Preyer Buckridge Coastal Reserve was wind tides, and indicated that the source of the saltwater intrusion was the large constructed canal. Subsequent study identified the Pamlico Sound as the main source of the saltwater.

Since the region is protected from the ocean by almost uninterrupted barrier islands, astronomical tides have little influence on the daily water fluctuations in the region. Thus, wind tides were the major drivers of saltwater in the region. So, when the wind blows hard from the south, saltwater from the Pamlico Sound is pushed up the Pamlico River, through the Pungo River, along the Alligator-Pungo River canal, and ultimately to the Alligator River where any adjoining canals are overrun by saltwater. These are complicated processes that threaten agriculture in low-lying fields of the Inner Banks.

Our study was located in a part of one Reserve, but saltwater intrusion into agricultural fields occurs in several low-lying coastal counties of eastern North Carolina. Bears might not care about saltwater intrusion, but as coastal populations continue to grow, and as sea level continues to rise, saltwater intrusion problems will continue to be of major interest to humans for the foreseeable future.

## NEW RESEARCH: A CUTTING-EDGE APPROACH TO STORMWATER IN PINE KNOLL SHORES

Stormwater flooding is a major problem in many coastal regions. In the eastern U.S., such as on the barrier islands of eastern North Carolina, stormwater flooding is of particular concern because stormwater flooding events affect the emotional, physical, and financial well-being of seasonal and full-time residents of these coastal communities.

One strategy that has been implemented in other areas to reduce the amount of stormwater flooding involves the use of groundwater pumps to lower the water level beneath the ground. This strategy is based on the idea that the water in the ground can quickly rise to the land surface during heavy rainfall events. If, however, water managers can pump water out of the ground before a rainfall event starts, then more water can infiltrate the ground before the rainwater starts to pond on the ground surface.

If successfully implemented, this technique could reduce the amount of surface water runoff and stormwater flooding. Unfortunately, water managers do not currently have good tools (other than weather forecasts) to help them determine when it would be appropriate to initiate preemptive groundwater pumping strategies in readiness for potential flooding.

We are currently working with the town of Pine Knoll Shores to test a machine learning approach that would provide the water managers in the town with the information and indicators needed to start pumping before a rainfall event. One of the goals of the project is to build a mobile phone application that will use artificial intelligence to predict groundwater levels based on previous and current weather conditions. The

application would then help water managers determine when to turn on groundwater pumps to start lowering the water table based on current groundwater levels, forecasted rainfall amounts, and other information.

If successful, this approach is likely to make coastal communities more resilient by providing coastal water managers with the tools for addressing stormwater flooding. 🌐

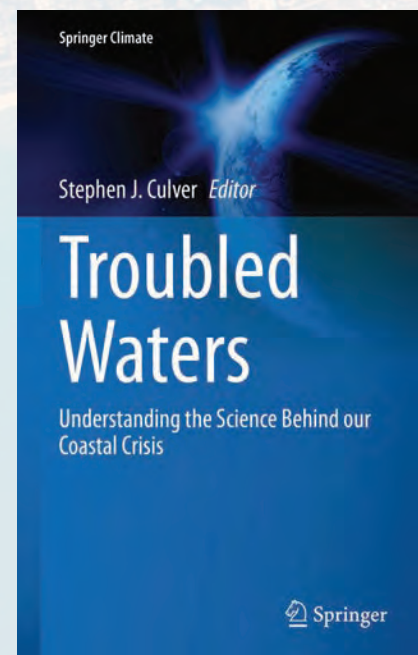
*North Carolina Sea Grant supports Alex K. Manda's machine learning approach to stormwater management as one of several projects addressing the impacts of weather events, among many other topics of importance in our coastal communities.*

[go.ncsu.edu/new-core-funding](https://go.ncsu.edu/new-core-funding)

### Read More

Stephen J. Culver's *Troubled Waters: Understanding the Science Behind our Coastal Crisis*

[go.ncsu.edu/troubled-waters](https://go.ncsu.edu/troubled-waters)



CRYSTAL COAST  
BUTTERFLY  
EFFECT

BY JULIE LEIBACH

# THE BUTTERFLY EFFECT

A NATIVE CRYSTAL COAST SPECIES  
INSPIRES BACKYARD STEWARDSHIP.



*A close-up of a crystal skipper butterfly's head.*



Sam Bland



Michael Waldrop



*“There’s something a little magical about a little brown butterfly that flits around the dunes. This is a real North Carolina treasure.”*

— CAROL PRICE

W

hen Al and Virginia Williams gaze out the back windows of their vacation home in Atlantic Beach, they see the stuff of nostalgia: a large sand dune that Al first encountered as a kid. Both sets of his grandparents had homes in the area, and he spent ample time exploring the environs. “He has fond memories of that one massive dune,” Virginia says.

The sentimental value of that stately sand pile — Virginia estimates that it’s higher than their raised, two-story house — is one reason the couple decided to purchase the dune from a vacation rental company. But they also wanted to preserve the natural landscape beyond their backyard. “It’s quite a pretty dune,” she says. “We certainly didn’t want to see it developed.”

What they didn’t know at the time was that by acquiring the mound they were helping to safeguard habitat vital to another coastal dweller: a native butterfly colloquially called the crystal skipper (*Atrytonopsis quinteri*), one of a family of butterflies known for their darting flight habits.

As far as we know, crystal skippers exclusively live on just a few North Carolina islands, including Bogue Banks, human-made Radio Island to the east, and Bear Island to the west.

Globally rare but locally abundant, the crystal skipper is a state mascot of sorts. “There’s something a little magical about a little brown butterfly that flits around the dunes,” says Carol Price, conservation research coordinator for the North Carolina Aquariums. “This is a real North Carolina treasure.”

Crystal skippers rely on dune vegetation that grows in the swales between beach-fronting sea oats and deeper-set scrub thickets. Adult butterflies sip nectar from various native flowers, such as southern dewberry and species of morning glory. But crystal skipper caterpillars have a more restricted diet: They feed solely on a native grass called seaside little bluestem.

The butterfly “persists in one of the starkest, harshest environments in our coastal ecosystems,” Price says. “It is really a tough place for a butterfly to make a living. And it is not just associated with that habitat — it’s dependent on that habitat.”

Over the past several decades, urbanization along Bogue Banks has fragmented and degraded habitat where seaside little bluestem thrives. Virginia Williams, who briefly lived in Pine Knoll Shores with her family before they moved to

Morehead City in the 1980s, has seen the changes firsthand: “It’s developed incredibly in the last 30 years,” she says.

Despite her long ties to the area, she first learned about the crystal skipper last year, when she met Gloria Putnam, coastal resources and communities specialist for North Carolina Sea Grant. Putnam, Price, and colleagues were in the process of revegetating areas important to crystal skippers; the Williams dune was a prime site for replanting.

The dune enhancement project is integral to a larger, multi-partner effort to better understand and preserve the butterfly — not just for the insect’s sake, but for its ecosystem.

“When it comes to barrier island dunes, we talk about maritime forests and sea oats, but the narrow strip of land in between gets overlooked,” Putnam says. “For me, the crystal skipper can be the ambassador for this important stretch of habitat, helping to capture people’s attention and interest in preserving it.”

## WHAT’S IN A NAME?

Science first brushed with the crystal skipper in 1978, when entomologist Eric Quinter, of the American Museum of Natural History, netted a couple specimens during an expedition along coastal North Carolina. He later passed them on to a Smithsonian entomologist and skipper expert named John Burns.

Burns “immediately recognized the Atlantic Beach specimens as something different,” Michigan State University conservation ecologist Nick Haddad writes in his book, *The Last Butterflies: A Scientist’s Quest to Save a Rare and Vanishing Creature*. Eventually Burns assembled enough convincing evidence to call the insect a new species, publishing his case in the *Journal of the Lepidopterists’ Society* in 2015.

Research conducted in the mid-2000s by NC State University doctoral student Allison Leidner contributed critical insight into what we know about crystal skippers. With funding from North Carolina Sea Grant, Leidner used field and lab techniques to investigate butterfly movement and genetics, with an eye toward addressing their conservation status.

“She put crystal skipper on the map,” says Haddad, who

*Continued*

OPPOSITE, TOP: *Crystal skippers sip nectar from native N.C. plants such as coastal plain dewberry.* OPPOSITE, BOTTOM: *Members of the Coastal Landscapes Initiative revegetated a massive dune behind Al and Virginia Williams’ Atlantic Beach house.*

was Leidner's thesis advisor at NC State at the time. Leidner even coined the butterfly's moniker, drawing inspiration from Bogue Banks's tourist-friendly nickname — Crystal Coast — and from the insect's sugary white wing spots.

Crystal skippers primarily live along a 30-mile stretch from Fort Macon State Park, located on the eastern edge of Bogue Banks, to isolated Bear Island, part of Hammocks Beach State Park. Those two protected areas are species strongholds, offering large tracts of prime habitat.

In contrast, the quality of the intervening habitat has deteriorated or disappeared, primarily from development,



though other big threats include beach nourishment, insecticides, invasive species, major storms and storm surge, and climate change.

But crystal skippers have proven to be remarkably adaptive to their changing environment. Indeed, Leidner found that the butterflies exploit patches of suitable habitat amid development, in effect hopscotching over human-disturbed areas.

Leidner also learned that some natural features can inhibit butterfly dispersal, a finding supported by genetic analysis. Crystal skippers appear to exist in three distinct populations,

*Continued*



ABOVE: Crystal skipper butterflies lay their eggs on only seaside little bluestem. OPPOSITE: The North Carolina Botanical Garden led an effort to collect and propagate seeds from seaside little bluestem (*Schizachyrium littorale*) growing in Fort Macon State Park.



Courtesy of N. C. Aquarium at Pine Knoll Shores



Emma York Matzloff/N. C. Botanical Garden

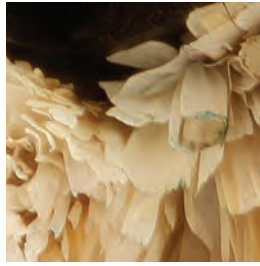


Carol Price/NC Aquariums



Gloria Pittman





*“When it comes to barrier island dunes, we talk about maritime forests and sea oats, but the narrow strip of land in between gets overlooked.”*

— GLORIA PUTNAM

she says. Two inhabit Bogue Banks, divided by maritime forest. An inlet separates the third population on Bear Island.

Ultimately, her findings suggested that “natural features, like ocean and maritime forests, were probably greater barriers to butterfly movement than development,” Leidner says. She cautions, however, that unabated urbanization could change the stakes.

“From my research, we really saw that habitat connectivity is important. But probably what’s even more important is just the amount of land available to the butterfly.”

### LOCATION, LOCATION, LOCATION

On Bogue Banks, “development is extensive and progressing,” Haddad writes in his book. “The only way to increase the butterfly’s global population here is to engage people in low-cost conservation and restoration, especially on the dunes in front of their beach houses.”

That approach resonates with Sea Grant’s Putnam and the N.C. Aquarium’s Price, who have been leading a project to revegetate sites along Bogue Banks with seaside little bluestem and nectar plants as part of the Coastal Landscapes Initiative.

Four locations were chosen in part based on vegetation surveys done several years ago by NC State student Ian Grace. The new planting builds on dune enhancement efforts

completed just before Hurricane Florence relentlessly drenched the state in September 2018. “We saw that there was a loss of plant material following Hurricane Florence,” Price says.

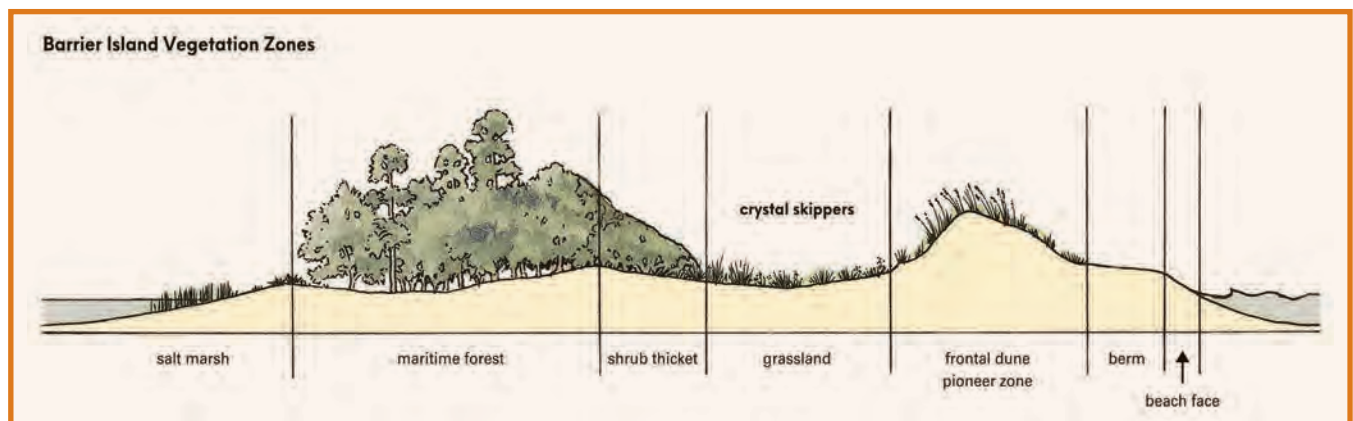
For expertise, Putnam turned to the North Carolina Botanical Garden at the University of North Carolina at Chapel Hill. Known for its native plant conservation efforts, the garden oversaw an effort to gather seeds from seaside little bluestem and nectar plants growing at Fort Macon State Park. Then garden staff propagated the seeds into plugs for planting.

Gathering seeds from known crystal skipper habitat was key, says N.C. Botanical Garden conservation ecologist Mike Kunz. “We want to use local plants because they are adapted to, and have coevolved with, the local ecosystem and all of its parts,” he says.

For instance, the bloom time of a nectar plant collected far outside of the skipper’s range might not jibe with the butterfly’s natural cycles. Given that adult skippers only appear twice a year — one brood emerges from April to mid-May, and a second from mid-July to late August — synchrony is essential.

Genetic diversity is, too. “We don’t want to just go collect a whole bunch of seeds from a couple of seaside little bluestem plants right on the side of the parking lot,” Kunz says. “We want to make sure we cover a whole range of ‘micro habitats,’ right? So, tops of the dunes, down the sides, in the lower areas.”

*Continued*



ABOVE: *Crystal skippers* rely on dune vegetation that grows in swales between sea oats and shrub thickets.

OPPOSITE, TOP: *Morning glory* species are among the nectar plants that *crystal skippers* use. OPPOSITE, BOTTOM: Volunteer *Georgia Minnich*, who recently retired from the N.C. Aquarium at Pine Knoll Shores, plants seaside little bluestem in the Williams dune.

Adapted from an illustration by David Williams for *The Dune Book*



Sam Bland



*"I think we have a responsibility to protect and steward these areas. This is a butterfly's home; this is also your home."*

— ALLISON LEIDNER

All told, the team installed 1,500 seaside little bluestem and 500 nectar plants over two planting sessions, which took place in October 2020 and this past March. "The cooperation and collaboration on this have been a lot of fun to be involved with and really cool to see," Kunz says.

For her part, Leidner, who now works in the National Aeronautics and Space Administration's Earth Science Division, is pleased to hear about the efforts. "When we look at conservation, we need to look holistically," she says. Revegetating crystal skipper habitat supports a host of other organisms within that ecosystem — including humans who benefit from the storm buffer that healthy dunes provide.

"I think we have a responsibility to protect and steward these areas," Leidner adds. "This is a butterfly's home; this is also your home."

## SEEDS OF CHANGE

Now that she's aware of the crystal skipper, Virginia Williams keeps an eye out for the lively specks. "I'm very excited to have them in the backyard," she says. "If I knew where to get seaside little bluestem, I'd plant some more."

The grass is hard to find in retail outlets, but Putnam is making inroads. She recently connected the N.C. Botanical Garden with master gardener Karen Mulcahy, who operates a native plant nursery called Above the Briery from her home north of Kinston. "Trying to enhance and restore environments is really appealing to me," Mulcahy says.

The garden shipped her a package containing seaside little bluestem and various nectar plant seeds, along with propagation instructions. If her experiment goes well, Mulcahy plans to sell her native beauties at coastal farmers markets.

For the crystal skipper team, conservation doesn't

stop with planting. Since May, Price has been overseeing two NC State students as they conduct butterfly and vegetation surveys funded by the U.S. Fish and Wildlife Service. The purpose is twofold: to gauge crystal skipper abundance, and to get a better picture of which nectar plants adult butterflies use.

Price hopes the experience will inspire more environmental stewardship. "I think there's value in using this as a way to teach the young conservationists of the future," she says. "This is what it takes, this is what it looks like, when you're trying to save a species." 🌱

*Retail nurseries in North Carolina may request seaside little bluestem and nectar plant seeds from Emma York Marzolf, conservation grower at the North Carolina Botanical Garden, by emailing [eyork@unc.edu](mailto:eyork@unc.edu).*

*Learn about Karen Mulcahy's native plant nursery at [facebook.com/AbovetheBriery](https://facebook.com/AbovetheBriery).*

## DESIGNING WITH NATURE

The Coastal Landscapes Initiative is a multi-partner effort to address landscaping at every stage of the process, from planning and design to installation and

management. The group has published a variety of digital and print resources, including a handy native plant guide, an interactive map of model gardens, and design templates for home gardeners and landscapers alike. Find them all at [go.ncsu.edu/CoastalLandscapes](https://go.ncsu.edu/CoastalLandscapes).



OPPOSITE: A crystal skipper on common toadflax.

A lush green forest scene with a wooden fence and a body of water in the foreground. The text 'MAPPING THE FUTURE' is overlaid in the center. 'MAPPING' is in a light green outline font, and 'THE FUTURE' is in a solid teal font.

# MAPPING THE FUTURE

BY ANDREW MOORE



# CLIMATE CHANGE AND FLOODING IN COASTAL NORTH CAROLINA

AS SEAS RISE AND STORMS STRENGTHEN, NEW MODELING  
WILL HELP COMMUNITIES ASSESS HEIGHTENED FLOOD RISKS.



Leif Skogfors/FEMA

FLOODING IS THE MOST COMMON TYPE OF NATURAL DISASTER IN THE U.S., AND AREAS ACROSS THE COAST AND INLAND REMAIN SUSCEPTIBLE. ASHEVILLE, 2004, AFTER HURRICANE FRANCES.

**D**URING THE EARLY MORNING HOURS OF SEPTEMBER 14, 2018, THE EYEWALL OF HURRICANE FLORENCE CROSSED ONTO THE SHORE OF WRIGHTSVILLE BEACH WITH 90 MPH WINDS. OVER THE NEXT FEW DAYS, THE STORM PRODUCED RECORD-BREAKING RAINFALL ACROSS THE STATE AND CATASTROPHIC FLOODING THAT CAUSED 42 FATALITIES, AS WELL AS MORE THAN \$16 BILLION IN DAMAGE TO NEARLY 75,000 STRUCTURES.

Extreme weather events like Florence have always posed a threat to North Carolina and other parts of the southeastern United States. But as climate change accelerates, these storms are becoming more intense, increasing the likelihood and seriousness of flooding in many of the region’s urban and coastal areas.

“Over the past two decades, climate change has increased the frequency and severity of flooding beyond anything we’ve seen in history,” says Georgina Sanchez, a research associate at the Center for Geospatial Analytics in NC State’s College of Natural Resources. “It’s imperative that we understand how flood risk is likely to change in the future, given anticipated environmental changes.”

With funding from North Carolina Sea Grant, Sanchez and Elyssa Collins, a doctoral student at the Center for Geospatial Analytics, are collaborating with other researchers at NC State and the U.S. Geological Survey (USGS) on modeling that simulates the effects of climate change on flooding. The maps that Sanchez and her team are developing will help land-use planners across the state and country visualize and anticipate flooding hotspots, and, in doing so, potentially avoid property damage and loss of life.

“Flood maps are a vital component of community resilience,” Sanchez says. “We use them to determine which areas have a high risk of flooding and where to develop. But most flood maps underestimate risk. Communities can’t effectively plan for flooding if they don’t have flood maps that reflect the effects of climate change — including how sea level is rising and precipitation patterns are changing.”

## RISING SEAS AND STRONGER STORMS

Flooding is the most common type of natural disaster in the U.S., mostly occurring when excessive rainfall over an extended period of time causes a river or stream to exceed its natural capacity. It can also occur when rainfall overwhelms urban drainage systems.

Cities are especially vulnerable to flooding as development converts naturally vegetated areas into parking lots, roads, and other impervious surfaces, says Charles Stillwell, a USGS hydrologist at the South Atlantic Water Center in Raleigh and a project collaborator.

“When it rains over a natural landscape, most of the water is absorbed by trees and soils,” Stillwell says. “But when those natural landscapes are converted into impervious surfaces, there are fewer trees and soils available to absorb the water. As a result, more water flows into the streams more quickly, which leads to more frequent and severe flooding.”

In North Carolina and across the southeastern U.S., many coastal communities have experienced increased flooding over the last few decades and will continue to do so as the rising temperatures associated with climate change shift rainfall patterns and exacerbate extreme weather events, especially hurricanes.

The Atlantic hurricane season officially runs from June 1 through November 30. When these storms make landfall, they can unload heavy and sustained rainfall that can overwhelm nearby rivers and drainage systems. They can also produce strong winds that push large volumes of ocean water ashore — an effect known as storm surge.

Size, speed, and track determine the amount of rainfall — and damage — a hurricane produces. Unfortunately, as the world’s oceans continue to absorb more than 90% of the increased atmospheric heat generated by greenhouse gas emissions, the intensity and duration of hurricanes are increasing.

A recent analysis published by the National Oceanic and Atmospheric Administration found that climate change has increased the likelihood of a hurricane developing into a Category 3 storm or higher by about 8% since 1979. And to make matters worse, scientists warn that climate change could eventually cause hurricanes to slow down, which would extend their progression over land and allow them to drop more rain.

But hurricanes aren’t the only source of flooding, Stillwell says. As a result of the added water from melting ice sheets and glaciers, as well as the expansion of seawater as it warms, global sea level has risen by about 8 inches since 1800. The increase in volume is pushing storm surges farther inland and worsening tidal flooding, which occurs when seasonal high tides temporarily inundate low-lying areas with seawater.

“Rising sea levels, compounded with storm

surge and heavy rainfall, increase the risk of flooding in coastal communities,” Stillwell explains. “These communities are so far downstream that there is nowhere else for the water to go.”

Climate change models project that global sea level rise will continue to accelerate, which will cause frequent road closures, reduced stormwater drainage capacity, deterioration of infrastructure, and intrusion of saltwater into drinking water, among other impacts. In fact, by the end of the 21st century, the impacts of sea level rise could cost the global economy an estimated \$14.2 trillion in lost or damaged infrastructure.

## FLOOD MAPS WITH FLAWS

To help mitigate flood damages, many communities across the country participate in FEMA’s National Flood Insurance Program. It allows property owners in these communities to purchase protection against losses from flooding. It also requires insurance for existing homes and buildings located in the 100-year floodplain.

Communities that participate in the

National Flood Insurance Program must adopt and enforce floodplain management regulations that meet or exceed the minimum standards and requirements, which include limitations on new development in the floodplain or a minimum elevation at which some houses must be built or raised.

When implementing land-use regulations and flood insurance requirements, communities rely on flood maps prepared by FEMA. Fortunately, after decades of delays, the agency finally updated its maps in March. Before that, the maps had been outdated by up to 30 years, according to Collins.

Still, despite the update, the flood mapping process is time-consuming, research-intensive, and expensive, Collins says. As a result, FEMA has only developed flood maps for 61% of the contiguous U.S., leaving thousands of vulnerable communities without the appropriate information to guide development and other land-use planning activities.

In addition, many of FEMA’s existing flood maps don’t account for ongoing and future climate or land-use change.

“Climate and land cover influence the

*Continued*

MANY COMMUNITIES HAVE EXPERIENCED INCREASED FLOODING OVER THE LAST FEW DECADES AND WILL CONTINUE TO DO SO AS THE RISING TEMPERATURES SHIFT RAINFALL PATTERNS AND EXACERBATE WEATHER EVENTS. VANCEBORO, 2010, AFTER TROPICAL STORM NICOLE.



Tim Burkitt/FEMA

hydrological flow of an area, so changes need to be continuously reflected in flood maps in order to accurately depict the extent of a 100-year flood,” Collins says.

FEMA’s flood maps also oversimplify risk by utilizing static, categorical boundaries for the 100-year floodplain, according to Sanchez. Currently, properties even just a foot outside of the floodplain are considered at low risk of flooding.

Research shows, however, that these properties have a much higher risk of flooding than projected. In 2016, more than 75% of homes in North Carolina whose owners applied for a federal disaster assistance block grant after Hurricane Matthew were located *outside* FEMA-defined floodplains.

“This categorical representation of flood risk encourages development right outside the floodplain, where property owners can avoid more strict regulations, and this tends to mislead developers and prospective

homeowners about their true flood risk,” Sanchez says. “With our simulations, we get a more resolved understanding of risk and how different properties and communities could be affected by flooding now and in the future.”

Beginning in October, FEMA will incorporate additional flood risk variables — flood frequency, flood type, and property characteristics — into the mapping process as part of a new program called Risk Rating 2.0. But to better prepare communities for climate change, researchers like Sanchez and Collins are also creating new risk assessment models.

### A NEW MODEL: STREAMFLOW PROJECTIONS AND DIGITAL TERRAIN

In a novel approach, Sanchez, Collins, and their collaborators are combining streamflow projections for rivers across the

contiguous U.S. with a digital terrain model known as HAND (Height Above Nearest Drainage) to create simulations that depict how annual flooding probabilities are likely to change over the next century under a range of climate scenarios.

Since the Industrial Revolution, the burning of fossil fuels for electricity, heat, and transportation has emitted larger concentrations of greenhouse gases into the atmosphere. Although greenhouse gas emissions cause climate change and its negative effects, such as increased flooding, scientists still aren’t exactly sure how much emissions will increase in the future.

To account for this uncertainty, the research team will compare the flood probability results of different levels of greenhouse gas emissions using more than 30 global climate models.

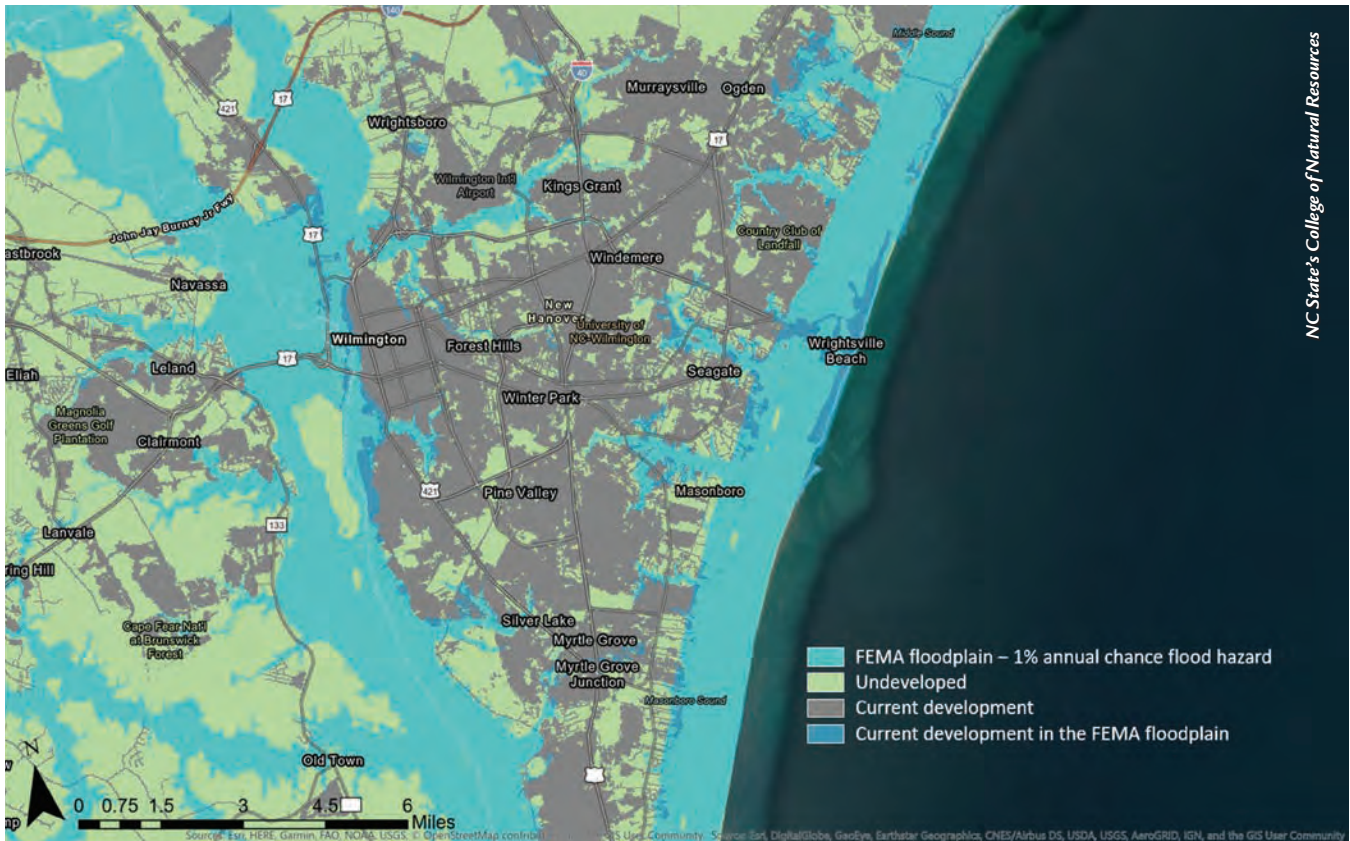
“When evaluating the impacts of climate change, it is important to consider



NC State’s College of Natural Resources

GEORGINA SANCHEZ (RIGHT) AND ELYSSA COLLINS (LEFT) AT THE CENTER FOR GEOSPATIAL ANALYTICS ARE DEVELOPING STATE-OF-THE-ART FLOOD MAPPING THAT ACCOUNTS FOR DIFFERENT CLIMATE CHANGE SCENARIOS.





SANCHEZ AND COLLINS ARE GENERATING ANNUAL FLOOD PROBABILITIES FOR WATERSHEDS SURROUNDING WILMINGTON AND PLAN TO ESTABLISH A MODELING FRAMEWORK TO DEVELOP SIMULATIONS FOR ENTIRE REGIONS AND SUB-REGIONS ACROSS THE U.S.

both moderate and high emissions scenarios in order to show the effects of unmitigated climate change,” Collins says. “A higher emissions scenario will likely result in more frequent flood events.”

The research team plans to simulate flooding for each day between 2021 and 2100 and will then aggregate the daily simulations into annual flooding probabilities. Sanchez says the resulting simulations will ultimately offer a computationally efficient and cost-effective framework for flood mapping.

Currently, Sanchez and Collins are generating annual flood probabilities for watersheds surrounding Wilmington as a proof of concept, and they plan to establish a replicable and scalable modeling framework to develop simulations for entire regions and sub-regions across the country.

“These simulations aren’t intended to replace FEMA’s flood maps,” Sanchez says “rather to provide another option for land-use planners and developers to effectively estimate future flood risk and damage as the environment changes.”

COLLABORATORS ON THE PROJECT INCLUDE ROSS MEENTEMEYER, DIRECTOR OF THE CENTER FOR GEOSPATIAL ANALYTICS AND THE GOODNIGHT DISTINGUISHED PROFESSOR OF GEOSPATIAL ANALYTICS IN NC STATE’S DEPARTMENT OF FORESTRY AND ENVIRONMENTAL RESOURCES; HELENA MITASOVA, ASSOCIATE DIRECTOR FOR GEOVISUALIZATION AT THE CENTER FOR GEOSPATIAL ANALYTICS AND PROFESSOR IN NC STATE’S DEPARTMENT OF MARINE, EARTH, AND ATMOSPHERIC SCIENCES; AND ADAM TERANDO, RESEARCH ECOLOGIST AT THE USGS SOUTHEAST CLIMATE ADAPTATION SCIENCE CENTER.

- **Coastwatch on Climate Change and Sea Level Rise** [go.ncsu.edu/coastwatch-climate](http://go.ncsu.edu/coastwatch-climate)
- **North Carolina Sea Grant’s Funding Opportunities** [go.ncsu.edu/sea-grant-funding](http://go.ncsu.edu/sea-grant-funding)
- **EPA Climate Change Indicators in the United States: Ocean Heat** [go.ncsu.edu/epa-ocean-heat](http://go.ncsu.edu/epa-ocean-heat)
- **Department of Homeland Security OIG 2017 Report: FEMA Needs to Improve Management of Its Flood Mapping Programs** [go.ncsu.edu/dhs-flood-maps-report](http://go.ncsu.edu/dhs-flood-maps-report)
- **Preparing for Future Storms, NC Is Working Around One Bad Source of Data: FEMA Flood Maps** [go.ncsu.edu/preparing-for-future-storms](http://go.ncsu.edu/preparing-for-future-storms)
- **Georgina Sanchez** [go.ncsu.edu/georgina-sanchez](http://go.ncsu.edu/georgina-sanchez)
- **Elyssa Collins** [go.ncsu.edu/elyssa-collins](http://go.ncsu.edu/elyssa-collins)
- **Charles Stillwell** [go.ncsu.edu/charles-stillwell](http://go.ncsu.edu/charles-stillwell)
- **Ross Meentemeyer** [go.ncsu.edu/ross-meentemeyer](http://go.ncsu.edu/ross-meentemeyer)
- **Helena Mitasova** [go.ncsu.edu/helena-mitasova](http://go.ncsu.edu/helena-mitasova)
- **Adam Terando** [go.ncsu.edu/adam-terando](http://go.ncsu.edu/adam-terando)

*NASA Helicopter Water Survival Training.*



*Josh Valcarlos/NASA*



# FROM SEA TO SPACE

## ASTRONAUT ZENA CARDMAN'S LOVE FOR SCIENCE IS OUT OF THIS WORLD

THIS MARINE SCIENTIST  
TURNED ASTRONAUT  
NOW SERVES IN A NASA  
PROGRAM DESIGNED  
TO LAND THE FIRST  
WOMAN ON THE MOON,  
AND SHE'S ELIGIBLE  
FOR MISSIONS TO MARS.

BY KATIE MOSHER

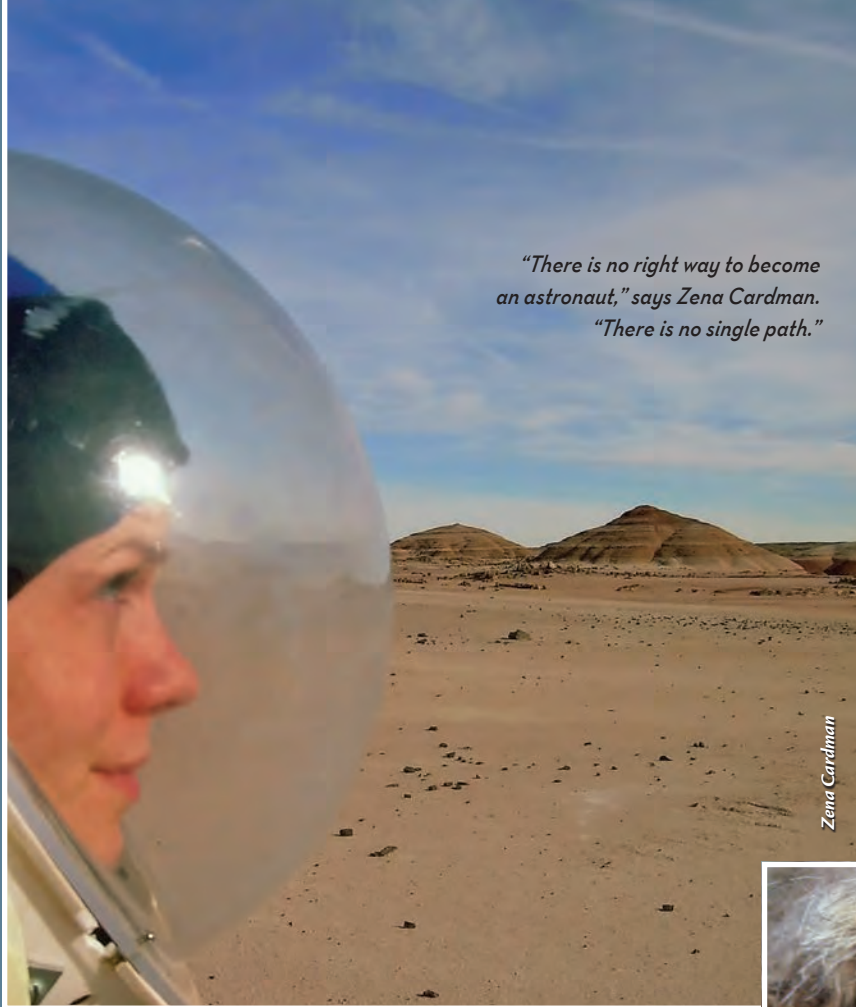
**N**ASA astronaut Zena Cardman may not yet know when or where she will fly her first space mission, but research experiences she had as an undergraduate were the first steps on her career path. Although Cardman has shifted her goals skyward, her educational interests began in marine and aquatic environments – in North Carolina and beyond.

“I sort of made a habit of studying the slimy, the underground, the most bizarre life on earth, whether that’s in a deep-sea hydrothermal vent or underground in caves,” she said in her keynote address at the 2021 NC Space Symposium. About a dozen former and current NC Space Grant scholars presented at the event on topics ranging from engineering and computer science to astronomy and life sciences.

*Continued*



David DeHoyos/ASCAN Training Photo



*“There is no right way to become an astronaut,” says Zena Cardman. “There is no single path.”*

Zena Cardman

and biogeochemical cycling in cave systems. There, she also received Pennsylvania Space Grant Graduate Research Fellowships.

In early 2020, she graduated with the first class of astronauts under the Artemis program, which aims to land the first woman and next man on the moon by 2024. She is now eligible for spaceflight, including assignments to the International Space Station, Artemis missions to the moon and, potentially, missions to Mars.

“You can watch a couple of my classmates launch hopefully as early as this fall, and then next year in 2022,” she said. “We’ll see what happens for the rest of us. But there’s so much going on at NASA right now — it’s a great problem to have not knowing which vehicle you’ll be flying on, or when.” 🌐

As an undergraduate, Cardman benefited from a research mission on Axel Heiberg Island, which is in the Canadian High Arctic, at about 80 degrees latitude north. “I was there not so much to soak in the landscape, but really there to study this environment as an analog for what other planets might be like, what kinds of life might be hosted on a planet like Mars,” she explained.

Cardman earned her bachelor’s degree in biology in 2010 from the University of North Carolina at Chapel Hill, where she also earned honors in poetry and minors in marine science, creative writing, and chemistry. She then earned a master’s degree in marine science at UNC-Chapel Hill, including pursuing her research interests at the UNC-CH Institute for Marine Sciences in Morehead City.

“There is no right way to become an astronaut,” Cardman said in a recent interview. “There is no single path. I realized during that time that I love the operational side of research and the teamwork aspect as much as the science itself. The chance to work for NASA and astronaut corps — and be a researcher, be a scientist, but as a part of something much larger than anything I could do on my own — was really appealing.”

Jobi Cook, NC Space Grant’s associate director, has known Cardman since those early days.

“Zena was the recipient of five NC Space Grant awards that supported her NASA-affiliated research efforts in some of the most extreme environments on Earth, from the Arctic to the Antarctic,” Cook said. “We’re proud to have helped set her career journey.”

In addition to the polar regions, NASA-supported research has taken Cardman to Hawaii, Idaho, and British Columbia. She even has sailed with the Sea Education Association as assistant engineer.

“I was supported so often by the Space Grant — and I feel like it has affected the course of my life in a really profound way,” Cardman noted.

Cardman was selected for NASA’s 2017 Astronaut Candidate Class. At that time, she was a National Science Foundation Graduate Research Fellow at Penn State University, investigating microbial metabolism



Zena Cardman

NC Space Grant hosts the annual NC Space Symposium, which celebrates students, alumni, and partners who offer insights about career pathways. The 2021 virtual event featured current and former NC Space Grant-funded students, including alumni with positions now at NASA, Elevate Farms, United Launch Alliance, and GVT LLC. The event closed with a career panel for students and early-career professionals.

- Watch videos from the NC Space Symposium, view student posters, and learn more about this year’s event: [go.ncsu.edu/symposium2021](http://go.ncsu.edu/symposium2021)
- NC Space Grant: [NCspacegrant.org](http://NCspacegrant.org)

Carteret County



NC State University Photos

# The Anglers Who Are Best at What They Do — And More

*The Latest Science for Anglers*

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

## HOW IS OVERFISHING AFFECTING SOUTHERN FLOUNDER?

*Acoustic tracking and conventional tagging provide crucial information to plan for the sustainability of the species.*

- *Research Need*

Southern flounder support valuable commercial and recreational fisheries in North Carolina, but the stock has experienced high harvest rates since the 1990s and currently is overfished. Fisheries managers have implemented

minimum size limits, gear restrictions, and seasonal closures with the goals of reducing harvest and rebuilding the stock.

Stock assessments require information on fishing and natural mortality to evaluate whether management goals are working. Our objective was to provide the first direct estimates of natural mortality for southern flounder using acoustic tracking technology, while also providing updated estimates of fishing mortality from conventional tagging.

- *What did they study?*

We combined acoustic telemetry and

conventional tagging to estimate both fishing and natural mortality for southern flounder in North Carolina.

We tracked the movements of 271 southern flounder implanted with acoustic transmitters in the New River estuary from 2014 to 2016. We estimated natural mortality using information from fish movements within the estuary, while recaptures and reporting of external tags from these same fish also provided information on fishing mortality.

Our acoustic receiver network additionally allowed us to detect fish migrating out of the New River estuary during the fall, the period

when mature fish emigrate from coastal bays and rivers to spawn in offshore waters. Detections of these migration events allowed us to separate migration from mortality.

Additional data provided by the North Carolina Division of Marine Fisheries' southern flounder tagging program allowed us to estimate fishing mortality rates for tagged fish across the state.

- *What did they find?*

Seasonal patterns of fishing mortality were consistent across North Carolina and, in particular, in the New River estuary. Elevated harvest rates of southern flounder began in late spring and continued through December each year.

Our estimates of fishing mortality indicate that overfishing might still occur but also show a general pattern of lower harvest rates than during previous periods of overfishing.

Natural mortality of southern flounder was a significant contributor to the total annual

mortality rate, and our natural mortality estimates were in general agreement with previous estimates from predictive models.

Emigration from the New River estuary was high and accounted for more than 40% of southern flounder. Separating emigration from mortality was critical to improving the accuracy of our mortality estimates.

- *What else did they find?*

The telemetry study demonstrated that migration is highly seasonal. Approximately 99% of the southern flounder in our study left the estuary between October and December. Updated information on the timing of southern flounder migration could allow fishery managers to set seasonal closures of the fishery, providing greater protection for mature fish that migrate offshore to spawn.

- *Anything else?*

The most recent stock assessment for southern flounder determined that harvest rates

are still above management goals and stock size is still below these goals. Our estimates of mortality and emigration should provide managers with benchmarks to evaluate future stock assessments and inform options for achieving a sustainable southern flounder fishery.

— by *Trevor Scheffel*, data coordinator at the Atlantic Coastal Cooperative Statistics Program in Arlington, Virginia

## WHERE ON THE EAST COAST DO SALTWATER ANGLERS ENCOUNTER THE MOST SPECIES OF FISH?

*Based on interviews with anglers, North Carolina offers a more diverse array of species than any other state but one on the Atlantic seaboard.*

If you're a fan of fisheries facts, stats, and trivia, you may have enjoyed a previous *Hook, Line & Science* piece that used data from the annual publication *Fisheries of the United States* to determine which coast (the Gulf of Mexico or the Atlantic) was responsible for the largest saltwater catch by anglers. We're continuing that fisheries trivia with this article.

- *Research Need*

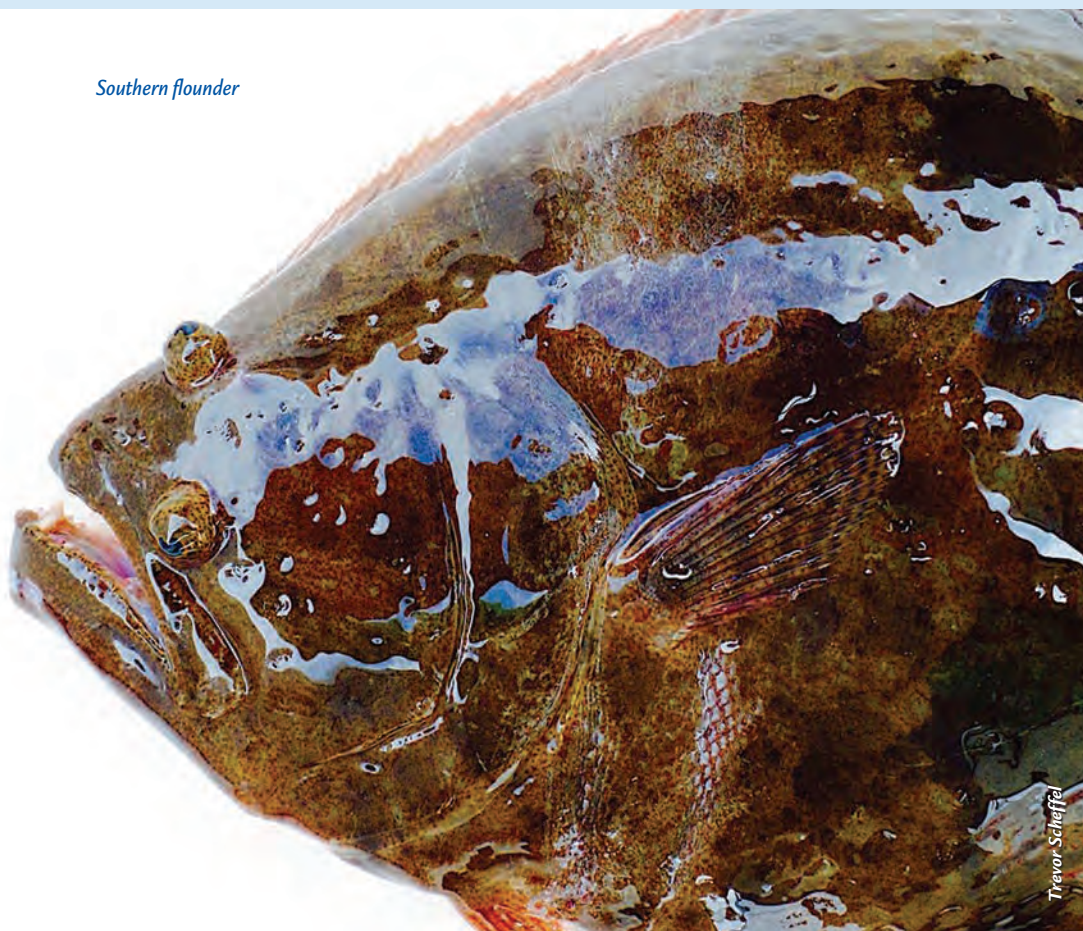
Staff with the North Carolina Division of Marine Fisheries (DMF) interview thousands of saltwater anglers each year on the docks or as they return from fishing trips. One goal of those interviews is to put eyes on the fish that anglers keep in order to accurately identify fish as part of the Marine Recreational Information Program (MRIP).

I've always wanted to know which state along the Atlantic Coast has the highest number of unique species or species groups, but this information isn't readily available.

To find the answer, I submitted a data request to DMF staff about the unique species saltwater anglers encountered on the 14 East Coast states from 2015 to 2019. This included kept

*Continued*

*Southern flounder*



*Trevor Scheffel*



NC State University Photos

and released fish, either observed at the dock or reported by fishers.

• *What did they find?*

Saltwater anglers along the 14 East Coast states encountered 509 unique species or species groups from 2015 to 2019.

The states with the most species in saltwater angler catch were Florida (398), North Carolina (258), and South Carolina (190). The states with the fewest species in the catch were Maine (60), New Hampshire (62), and Connecticut (87).

Florida possibly has an unfair advantage because the data includes species encountered on both the Atlantic and Gulf of Mexico coasts.

• *Anything else?*

Numerous factors influence the species count by state. But if we look at the latitude of each state and the length of Atlantic shore coastline, we can begin to see some interesting trends.

Notably, anglers encounter more species as latitude decreases (as we move toward the equator) and as coastline increases (which

provides more available habitat).

So if you fish in coastal North Carolina waters, you'll have a great chance to encounter something new or perhaps unusual — more to think about next time you get a bite on your hook.

— by Scott Baker

WHAT KINDS OF ANGLERS ARE THE BEST AT WHAT THEY DO?

*Surprising research suggests that differences among anglers don't matter much when we look at how many fish they actually catch.*

When it comes to surf fishing, it's hard to beat the coastline of North Carolina. Little data is available on onshore fishing, however, while the number of anglers continues to increase.

Let's look at a study from the French Riviera that tries to quantify the angler population and related implications for management. Like North Carolina's coastline, the region has a highly diverse group of anglers, from locals to seasonal fluxes of

tourists, who bring new fishing practices and different levels of awareness about rules and regulations.

• *Research Need*

A lack of data makes monitoring and assessment difficult in many recreational fisheries. State, regional, and federal partners use in-person, telephone, and mail surveys to measure the number of trips saltwater anglers take and the number of fish they catch, but estimating total recreational effort is a statistical challenge.

Fishery policies traditionally were based on stock status indicators such as Catch Per Unit of Effort, for which "effort" is the amount of time and fishing gear in the water. (Catch Per Unit of Effort directly relates to stock abundance.) The diversity of angler practices and behaviors may influence angling efficiency and raises the question of the validity of using Catch Per Unit of Effort to set policies in marine recreational fishing.

• *What did they study?*

From November 2017 to October 2018,



a research team visited the Natural Marine Park of the Gulf of Lion in France, the second largest marine park in the Mediterranean Sea. They first counted the number of recreational fishers, and then selected a subset to participate in a 20-minute interview.

The questionnaire focused on a wide range of variables covering socioeconomic data and fishing methods. They also asked anglers about the size and species of their catch.

By analyzing this large dataset, the researchers were able to describe the composition of the onshore fishing population, its fishing strategies, and the impact of both on Catch Per Unit of Effort.

- *What did they find?*

Over the study period, the research team counted 795 marine recreational fishers within the park and interviewed 212 of them. All

anglers surveyed, in the end, were men. Most were between 50 and 59 years of age with little (1 to 5 years) to intermediate (11 to 20 years) fishing experience.

The majority of surveyed anglers fished occasionally (less than 30 times per year) and for leisure more than for catches. They fished most often in the morning (24%) and especially in summer (49%).

The majority of surveyed anglers fished from shore only (74%), as few owned or rented a boat. Nearly half of the surveyed anglers cast from dikes (49%), although surfcasting from the beach also was common (44%). They chose their fishing spot principally based on tranquility or accessibility.

Most anglers (57%) were locals, and in this fishery, most anglers (77%) ended the day empty-handed. Only 12% caught one target species or more. Most anglers (92%) also practiced catch-and-release.

The average expenditure was 100 to 500 euros (approximately \$120 to \$600) to harvest 0 to 10 kilograms (22 lbs.) of fish per year.

A large majority of surveyed anglers (74%) perceived a decline in the numbers of fishes, which they linked to commercial fishing (51%) and water pollution (25%). In addition, 60% of fishermen admitted that they did not know which species were protected inside the park or the minimum legal catch sizes for the main species they targeted.

- *So what?*

The total Catch Per Unit of Effort didn't differ overall among types of anglers across these groups: "Vacationers," "Occasional Local Fishermen," "Experienced Local Fishermen," and "Local Lure Fishermen."

When and where anglers fished, as well as how they responded to management measures, did differ across groups.

In addition, the researchers only noted differences by group in Catch Per Unit of Effort for four species.

Findings seem to support continued use of Catch Per Unit of Effort in onshore marine recreational fishing as a relative indicator for stock status, regardless of the kind of anglers in the area. 🌊

— by Sara Mirabilio

read the full studies and more at  
[HookLineScience.com](https://HookLineScience.com)

New Hanover County





Vanda Lewis

• Asian Curried Shrimp



Vanda Lewis

• Mahi-Mahi with Tropical Glaze

# Savory Summertime

VANDA LEWIS AND JOYCE TAYLOR

**M**ARINER'S MENU, NORTH CAROLINA SEA GRANT'S POPULAR ONLINE SEAFOOD GUIDE, FEATURES BLOGGER AND PHOTOGRAPHER VANDA LEWIS'S PICTURES WITH RECIPES THE LATE JOYCE TAYLOR DEVELOPED. ENJOY THESE SPECIAL TREATS THIS SUMMER.

## ASIAN CURRIED SHRIMP

- 1 pound large shrimp, peeled and deveined
- 4 tablespoons soy sauce
- 1 tablespoon dry sherry
- 1/3 cup chopped shallots
- 2 teaspoons curry powder
- 1/2 teaspoon dark brown sugar
- 3 tablespoons canola oil

In a small bowl, toss shrimp with soy sauce and sherry. Marinate 20 minutes, stirring occasionally.

Heat oil in a medium skillet or wok. Add shallots and sauté. Mix in curry powder and sugar.

On high heat and using a slotted spoon, add shrimp and stir-fry until done (about 6-8 minutes).

## MAHI-MAHI WITH TROPICAL GLAZE

- 1 1/2 pounds mahi-mahi fillets, cut into serving-size pieces
- 1/2 cup pineapple juice
- 1 1/2 tablespoons butter, melted
- 1 tablespoon fresh lime juice
- 1/4 teaspoon lime zest
- 1/2 teaspoon Tabasco sauce
- 1/4 teaspoon fresh ginger, finely chopped
- 1/4 teaspoon garlic, minced
- 1/2 tablespoon fresh basil, finely chopped
- 1/4 teaspoon salt
- 1/4 teaspoon black pepper, freshly ground
- 2 tablespoons dark rum
- 1 tablespoon cornstarch

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

In a small saucepan, combine pineapple juice, butter, lime juice, lime zest, Tabasco, ginger, garlic, basil, salt, and pepper. Heat, and simmer for 4 minutes. Stir in rum, and heat for 2 minutes.

Remove 2 tablespoons of sauce to a small bowl. Blend in cornstarch, and add back to the sauce. Cook over low heat, stirring

constantly, until thickened enough to spread.

Place fish on a lightly greased broiler pan, skin sides down. Brush with sauce mixture. Cook about 8 to 10 minutes or until done. Brush again with glaze about halfway through cooking time. Keep remaining sauce hot.

Remove to a serving dish. Spoon remaining sauce over fish.

### EASY GRILLED SOFT-SHELL CRABS

- 8 soft-shell crabs, cleaned
- 1/2 cup butter, melted
- 1/2 teaspoon salt
- 1/2 teaspoon black pepper, freshly ground
- 1/2 teaspoon Tabasco sauce

Preheat the grill to medium high.

Combine butter, salt, pepper, and Tabasco. Cool. Brush both sides of crabs with the mixture.

Place crabs, topsides down, over hot coals. Close grill and cook until shell turns bright red, about 2 1/2 to 3 minutes. Turn and repeat on the other sides.

Serve with tartar sauce, if desired.

Check your local fish markets for soft-shells, especially around the full moon!

### TRIGGERFISH WITH SHALLOT BUTTER

- 1 1/2 pounds triggerfish fillets, skinless
- 2 tablespoons canola oil
- 2 tablespoons butter
- salt
- black pepper, freshly ground
- flour

Prepare shallot butter (see below) and set aside.

Heat oil in a skillet to 375° F. Add butter and melt. Lightly salt and pepper fish, then dredge lightly in flour. Place in skillet, and sauté until lightly browned (about 4 to 5 minutes). Turn the fish over and repeat, cooking until done. Serve with shallot butter.



• *Easy Grilled Soft-Shell Crabs*



• *Triggerfish with Shallot Butter*

#### **Shallot Butter**

- 1/2 cup butter, softened
- 2 tablespoons shallots, finely chopped
- 1 teaspoon fresh tarragon, chopped
- 1 teaspoon fresh basil, chopped
- 1/4 teaspoon salt

- 1/4 teaspoon white pepper, freshly ground

In a small bowl, combine butter, shallots, tarragon, basil, salt, and pepper. Spread over warm fish. 🍴

Visit the Mariner's Menu online seafood guide: [MarinersMenu.org](http://MarinersMenu.org).



Ken Blevins/StarNews

Oak Island in 2020, after Hurricane Isaias

# AGAINST WIND AND WATER

AS CLIMATE CHANGE BRINGS MORE INTENSE HURRICANES AND HIGHER SEAS THAT THREATEN THE SHAPE AND SURVIVAL OF COASTAL COMMUNITIES, HOMEOWNERS STILL HAVE OPTIONS THAT CAN HELP TO REDUCE THE RISK OF PROPERTY DAMAGE.

BY ALLISON FISK

*Allison Fisk has served as a science communicator with North Carolina Sea Grant during the past year. She graduated with her master's in technical communication from NC State in May.*

**R**ECENT STORMS HAVE BROUGHT COSTLY IMPACTS FROM WIND, RAIN, AND STORM SURGE. According to NOAA, damages totaled \$11 billion after Hurricane Matthew,

\$24 billion after Florence, and \$1.6 billion after Dorian. As climate change heats the Atlantic and brings rising seas, scientists project a continued increase in the frequency of intense storms and flooding.

Frank López, North Carolina Sea Grant's extension director, says a wide array of strategies can help coastal residents buffer the effects of wind and water.

“Storm-resilient construction and nature-

based approaches can serve to buy time and resist some of the present impacts of climate change, like increasing storm frequency and intensity,” López says. “Other impacts like sea level rise and tidal flooding will require coastal communities to evaluate where development occurs, siting of infrastructure and critical facilities, and how they can commit to holding the line against these climate forces.”

Among the approaches that can help homeowners reduce the risk of storm damage now is the FORTIFIED program. Spencer Rogers, North Carolina Sea Grant’s coastal construction specialist, says the program also can bring homeowners annual savings of 5% to 22% on wind insurance premiums.

“Installing wind-resistant features can protect buildings and potentially save homeowners money,” Rogers says. “Options to receive insurance rate credits for these protections are available through private

insurance companies and state-mandated wind pools.”

The first of several increasing discounts comes with a FORTIFIED roof that requires an added water-resistant layer under your roofing, along with potential upgrades in how the roof is attached to the rest of the house.

“Following the FORTIFIED program makes homes more resilient and durable, helping homeowners protect what is priceless during a disaster,” says Cheryl Piner, an engineer and FORTIFIED evaluator. She says that the underlayer beneath the shingles on FORTIFIED roofs helps to prevent damage from high winds knocking off shingles and then allowing rainwater into the house.

“I witnessed extensive damage to homes on Topsail Beach after Hurricane Florence,” Piner says. “The homes were effectively flooded from water coming in from the roof, which then required full gutting and rebuild for the

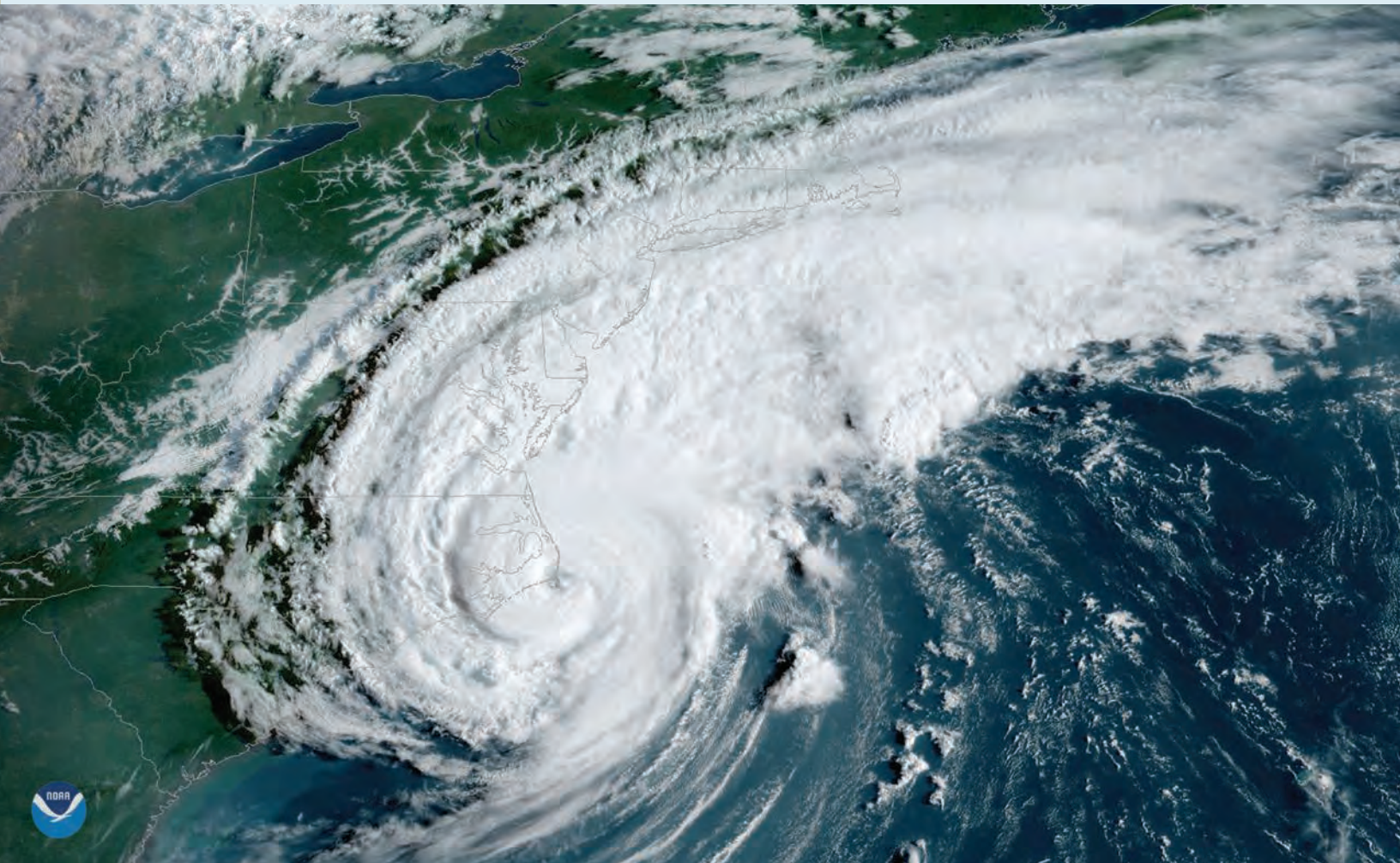
interior of the homes.”

FORTIFIED roof inspectors verify modifications before the insurance incentives kick in. The cost for the evaluations and inspections as a FORTIFIED roof is installed is about \$600. Rogers says the up-front cost is relatively small, though, compared to the cost of damage — and, he adds, the insurance companies offer incentives that pay toward this cost.

### A BETTER ROOF ON THE OUTER BANKS

Barrier island resident Sara Mirabilio received a letter in April 2019 from the North Carolina Insurance Underwriting Association (NCIUA), better known as “the state wind pool,” inviting homeowners to apply for a first-come-first-serve grant for replacing roofing with a FORTIFIED Roof.

*Continued*





Habitat partnered on a FORTIFIED home construction with Katherine Montwieler (front row, far left) and UNCW's Women Build team (shown here on an earlier project).

"My roof was 17 years old, and I already was considering replacing it," says Mirabilio, a fisheries specialist based on the Outer Banks with North Carolina Sea Grant.

After she applied for a grant, Mirabilio received \$6,000 toward the \$8,500 cost of the FORTIFIED roof for her 1,172-square-foot home. Although that roof was more expensive than a standard roof replacement, with the grant she paid less overall.

"I love my new roof," Mirabilio says. "You can't even see where the old vents were. It was cheaper with the grant, I got an insurance discount, and it's a better roof."

For six years, Mirabilio will get an insurance discount for her FORTIFIED roof. She receives a residential windstorm mitigation credit of over \$90 per year from the NCIUA, the policy she had at the time of the install. After switching to another insurer, Mirabilio continues to receive a wind loss reduction credit of just over \$90.

In 2021, some N.C. coastal homeowners have qualified for a new grant program for FORTIFIED roofs.

### FORTIFIED HABITAT

FORTIFIED Roofs aren't only available for existing homeowners but for new builds, too.

Twenty years ago, Habitat for Humanity partnered with Nationwide Insurance to build the highest level FORTIFIED for Safer Living Home. In addition, Cape Fear Habitat has been using water-resistant roofing methods since 2008, even before the FORTIFIED discounts became available, helping protect over 150 homes.

This kind of building is not new to North Carolina or Habitat for Humanity, and, in fact, it fits with Habitat's process of sturdy construction.

"Houses built by Habitat for Humanity are durable, because those homes typically are built by teams of volunteers who like to drive nails," Rogers says. "Structural wind resistance is most often controlled by the connections, such as nails or screws — and more volunteers use more fasteners."

In 2019, Spencer Rogers suggested the University of North Carolina Wilmington Women Build team, led by Katherine Montwieler, work with Habitat on a FORTIFIED home build.

Rogers arranged for the materials to do the roofing work as a demonstration, and Piner donated her time for the required FORTIFIED evaluations for the Women Build team.

Montwieler's Women Build team raised about \$5,000 for Habitat for Humanity in 2018 and \$4,000 in 2019. She says she saw the new construction as an opportunity to show "the campus and the wider audience the great work we can do together."

With Habitat and UNCW Women Build teaming on construction, and with Piner's evaluation, the house received a FORTIFIED Roof certificate, qualifying its resident for wind insurance premium discounts.

Not only do these provisions help to make homes more durable during the hurricane season, but also year-round from tornadoes,

severe thunderstorms, and nor'easters.

"The program also helps homeowners lower the overall cost of their community's recovery after a disaster," Piner says. "Studies have shown every \$1 spent on disaster mitigation saves \$4 in community disaster recovery expenses."

North Carolina Sea Grant has helped to train building evaluators, roofers, and contractors on the FORTIFIED requirements. Rogers also provides information to homeowners about the insurance incentives available to them — including those discounts on wind insurance premiums that can save up to 22% annually.

He also offers this simple advice: "Ask your insurance agent for details." 📞

### MORE

- **2021 Memo from Spencer Rogers on "Insurance Premium Incentives for Wind-Resistant Construction"**  
[go.ncsu.edu/wind-memo](https://go.ncsu.edu/wind-memo)
- **Video of Testing of a FORTIFIED Home vs. a Regular Home**  
[go.ncsu.edu/fortified-test](https://go.ncsu.edu/fortified-test)
- **Critical Steps to Avoid Roof Damage from Tornadoes and Hurricanes**  
[go.ncsu.edu/avoid-damage](https://go.ncsu.edu/avoid-damage)
- **NOAA on Cost of Hurricanes Matthew, Florence, and Dorian**  
[go.ncsu.edu/hurricane-pricetag](https://go.ncsu.edu/hurricane-pricetag)
- **FORTIFIED's Incentives**  
[go.ncsu.edu/incentives](https://go.ncsu.edu/incentives)



# SKEDADDLING SEA TURTLES

## *How Loggerheads React to Hurricanes*

NOT ONLY DO THE TURTLES DIVE LONGER AND CHANGE LOCATIONS,  
BUT THEIR NEW BEHAVIORS LINGER AFTER THE STORM HAS PASSED.

BY SARA MIRABILIO

**H**URRICANES WREAK HAVOC ON COASTAL MARINE ECOSYSTEMS. They destroy coral reefs, mix up the water column, redistribute bottom sediments, and increase pollution through stormwater runoff.

Although we know hurricanes also can cause fish to leave nearshore estuaries and coastal ocean environments for deeper water, we have few examples of sea turtle behaviors during large storm events.

All loggerhead sea turtle populations are among the endangered or threatened species protected under the Endangered Species Act, and while interactions with fisheries are the biggest threat to loggerheads, degradation of nesting habitats and changes in the environment also affect these populations.

A decade ago, NOAA Fisheries scientists and partners placed satellite tags on 26 loggerhead sea turtles from southern Massachusetts to Cape Hatteras. As Hurricane Irene moved through the region two months

afterward, the research team could examine whether the satellite-tagged turtles changed their dive behaviors and patterns of movement. The tags also recorded oceanographic conditions.

Of the 26 turtles, 18 were in the eye of Hurricane Irene. During the storm, all but three of the turtles moved northward, presumably traveling with the surface currents to conserve energy. The few turtles that remained in their foraging area during the storm dove for longer durations — sometimes over an hour, or more than twice the loggerheads' typical dives.

After the storm, all the turtles that had moved north during the hurricane moved back south. Ten stopped at the foraging area they had occupied before the storm, while the others kept on going — one nearly 84 miles. Southward migration is normal for loggerhead sea turtles, but the timing here was much earlier than normal seasonal movement.

At least two weeks after Irene, the loggerheads' diving times still hadn't returned to pre-storm durations.

We don't know precisely why the loggerhead turtles reacted to the hurricane as they did. Was it the sound from increased winds, shifts in barometric pressure, altered currents, other factors, or some combination of variables?

However, this research clearly did demonstrate that sea turtle movements and their dive behaviors both change during an extreme weather event. As the East Coast experiences rising intensity in ecosystem disturbances, including hurricanes, effective management will become more difficult if and when animals become displaced. 🌪️

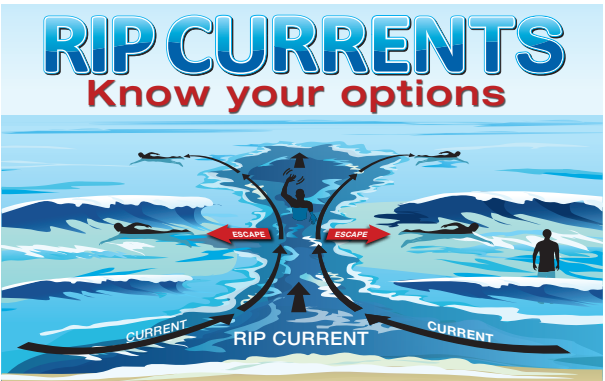
- **the full study:** [go.ncsu.edu/skedaddle](http://go.ncsu.edu/skedaddle)
- **how hurricanes cause gray triggerfish to evacuate:** [go.ncsu.edu/triggerfish-leave](http://go.ncsu.edu/triggerfish-leave)

*This post originally appeared in North Carolina Sea Grant's popular Hook, Line & Science series.*  
[HookLineScience.com](http://HookLineScience.com)



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**RIP CURRENTS**  
 Know your options

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


**IF CAUGHT IN A RIP CURRENT**

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

**SAFETY**

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

More information about rip currents can be found at the following websites:  
[weather.gov/safety/ripcurrent/](http://weather.gov/safety/ripcurrent/)  
[usla.org](http://usla.org)



## SPREAD THE WORD. SAVE A LIFE.

Download this safety poster, print it out, and put it up. And share the link: [go.ncsu.edu/be-safe](http://go.ncsu.edu/be-safe)

## TEACH

Use free educator resources to enrich student learning.


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

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

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