



NORTH
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Quick Links:

[NOAA Sentinel Site Program](#)

[N.C. Sentinel Site Cooperative](#)

Happy New Year from the NC Sentinel Site Cooperative!

Greetings, partners and stakeholders!

The North Carolina Sentinel Site Cooperative (NCSSC) was established in 2012 as part of a [National Oceanic and Atmospheric Administration \(NOAA\) initiative](#) to provide coastal communities and resource managers with information on the potential impacts of sea level rise on coastal habitats and communities.

NCSSC Partner Featured in Audubon Magazine

Robbie Fearn, center director of the Donal C. O'Brien Jr. Sanctuary and Audubon Center at Pine Island, is featured in the National Audubon Society's Fall 2019 Special Report on Climate Change. [Read more.](#)

NCSSC Hosts Research Sessions at the NC Coastal Conference

The NCSSC was pleased to host old and new partners at the N.C. Coastal Conference this past November in Wilmington. The NCSSC "Research Updates" sessions featured speakers from academia, government agencies and nonprofits. [See the conference program booklet](#), which includes the full agenda, session descriptions and speaker bios. Read more about the NCSSC sessions below.

Archived NCSSC quarterly newsletters are available on the [N.C. Department of Environmental Quality](#) website.

Contact NCSSC coordinator [Sarah Spiegler](#) if you have articles or events that you would like to include in the next quarterly issue.

Research and Updates from the NCSSC

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David Glenn, of the NOAA National Weather Service, speaks at a NCSSC session at the N.C. Coastal Conference. Photo by N.C. Sea Grant.

Erosion and Recovery: Sound-Side Inundation of Cape Lookout National Seashore During Hurricane Dorian

Hurricane Dorian tracked immediately offshore of [Cape Lookout National Seashore](#) (which includes the barrier islands of North and South Core Banks) and Ocracoke Island after devastating the Bahamas in early September, 2019. Dorian briefly made landfall at Cape Hatteras as a Category 1 hurricane on Sept. 6 before moving northeast over the Atlantic Ocean. Winds on the Outer Banks, initially more than 40 m/s (about 90 mph) from the southeast, drove ocean waves and storm surge against the islands and pushed water across Pamlico Sound, resulting in elevated water levels in the sound's northwestern rivers and creeks.

As the storm moved offshore, winds switched to the northeast, and the water in the sound sloshed back, causing a surge against the back side of the barrier islands. Two meters (7 ft) of sound-side flooding was reported on Ocracoke Island, and water levels were likely higher on North Core Banks, which also was inundated from the Pamlico Sound side. Water flowed across the island toward the ocean through gaps in the dunes. [Images captured by NOAA aircraft immediately after the storm show that nearly 100 channels were cut across the dunes and beach.](#) The sand eroded from the island was deposited in tiny deltas in the surf zone.

The [U.S. Geological Survey](#) (USGS) is studying the changes caused by Dorian and the recovery post-storm using new photogrammetric techniques with images taken from a small plane. An initial flight was conducted on Aug. 28, a week before the storm. Researchers completed post-storm flights on Sept. 8, 12, and 13, and Oct. 10. The final flight was made on Nov. 26, a few days after a strong nor'easter battered the Outer Banks. They took photos with a 16-megapixel digital camera linked to a high-quality GPS system that tracks camera location to within about 15 cm (about 6 inches) and recorded about 1,200 overlapping images of North Core Banks during each flight.

After the flights, USGS researchers used the photos to make accurate digital elevation maps and *orthomosaics* — single images created by stitching together many photographs and locating them accurately on the ground with a resolution of about 6 cm (2.5 inches). The elevation maps have vertical accuracies of about 15 cm (6 inches), except in submerged areas, where the technique does not work.

Comparing the elevation maps from each flight allowed the researchers to estimate the volume of sand eroded during the hurricane and the amount of beach recovery during the subsequent months.

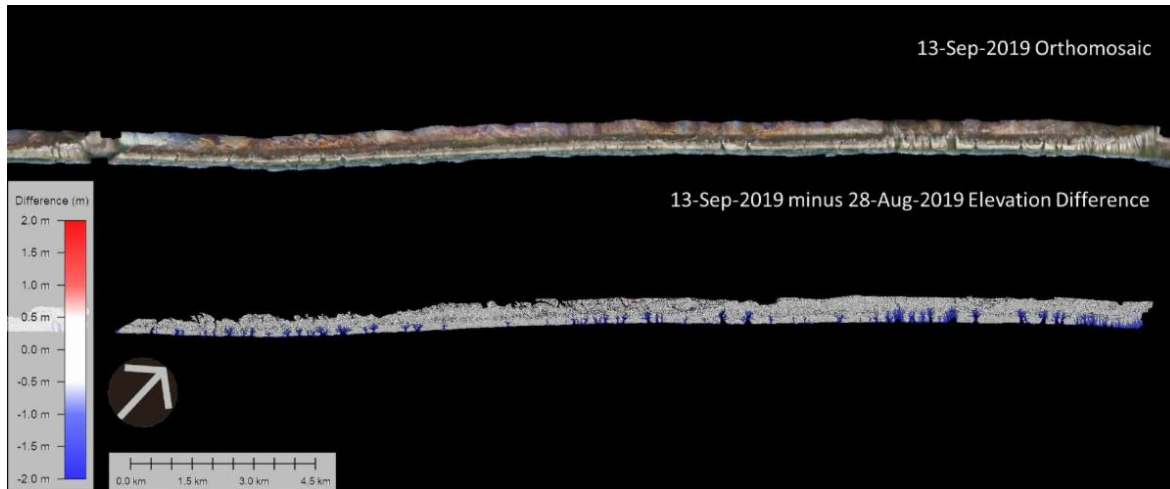


Figure 1. North Core Banks, Cape Lookout National Seashore, North Carolina. Top: orthomosaic of the island showing numerous cuts through the dunes and beach post-Dorian. Bottom: Difference map showing elevation changes between Aug. 28 (before Hurricane Dorian) and Sept. 13 (a week after the storm). Erosion is indicated in blue, areas with little change are shown in gray. Scale bar is 4.5 km long; north is indicated by the arrow.

Huge volumes of sand were lost from North Core Banks to the ocean during the storm. Preliminary results indicate that, island-wide, 98 cubic meters of sand was removed above mean high water (MHW) from the average cross-island profile a meter wide between Aug. 28 and Sept. 12. This loss represents about 16% of the total sand volume in the beach/dune/overwash portion of the island, and about 11% of total island volume above the MHW contour.

Most of the lost sand came from branched channel networks that formed in the locations of previous [washover fans](#), which are layers of sand deposited behind gaps in the dunes by waves during previous storms (Figures 1 and 2). During Dorian, water flowed through these same gaps and changed the depositional fans into erosional drainages (Figure 2). The eroded sand was deposited offshore in small ebb deltas, which are deposits formed when sand-laden streams enter a lake or ocean, and which were quickly reshaped by ocean waves.

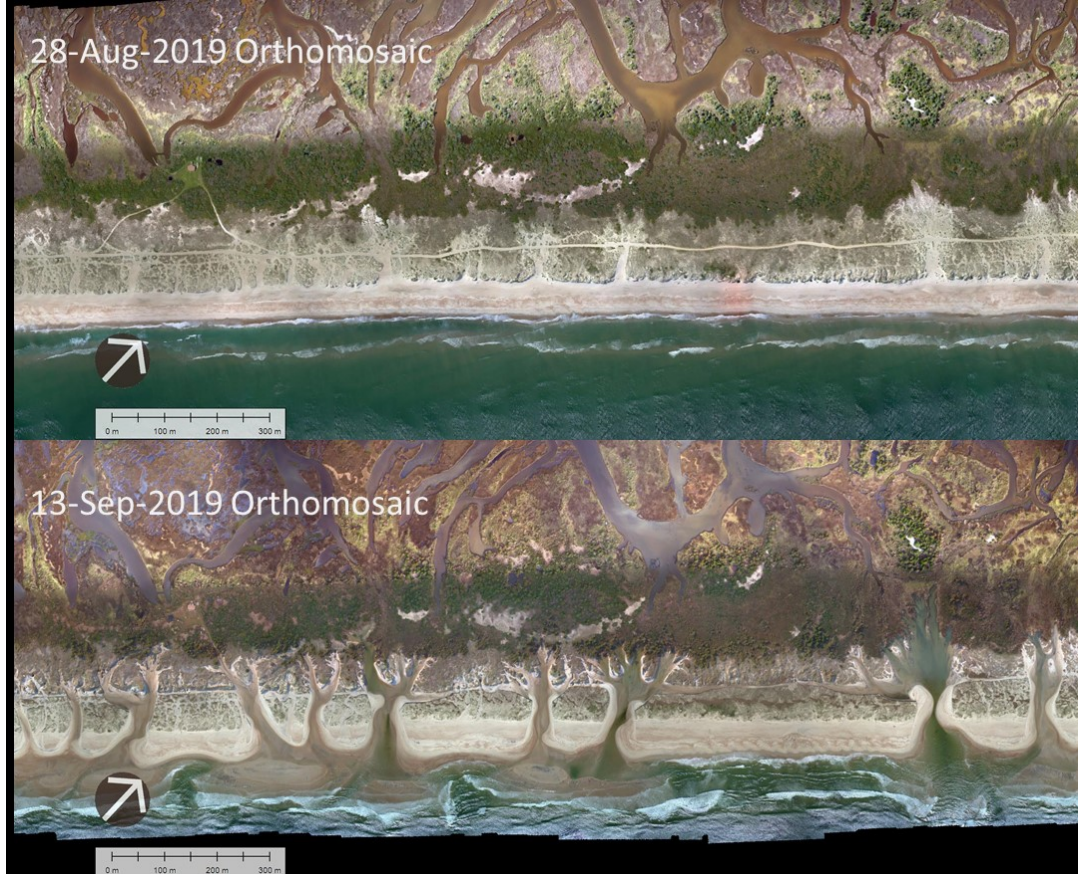


Figure 2. Orthomosaics of a section of the North Core Banks shoreline. Top: before Hurricane Dorian. Bottom: after the storm, showing erosional cuts through the dunes and beach, and initial recovery of the beach as offshore sand bars begin to migrate shoreward to connect to the beach. Scale bar is 300 m long; north is indicated by the arrow.

Beach recovery began almost immediately after the storm as waves built small sand spits into and across the newly cut channels. By Oct. 11, the berm in front of the island was nearly intact again, enclosing numerous inland ponds and low spots in the former channels networks. A powerful nor'easter in mid-November generated waves that overtopped this berm and partially filled these ponds and low spots with sand (Figure 3). That storm also eroded the beach and the front side of some dunes, leaving a steep beach face. Overall, only a small fraction (<5%) of the eroded sand has been redeposited above MHW.

The eventual filling of the ponds and low spots on North Core Banks with sand will require significant amounts of storm-induced [overwash](#). USGS researchers speculate that the low spots may persist for years before being filled, and that these changes may alter habitat distributions and flooding vulnerability of Cape Lookout National Seashore.

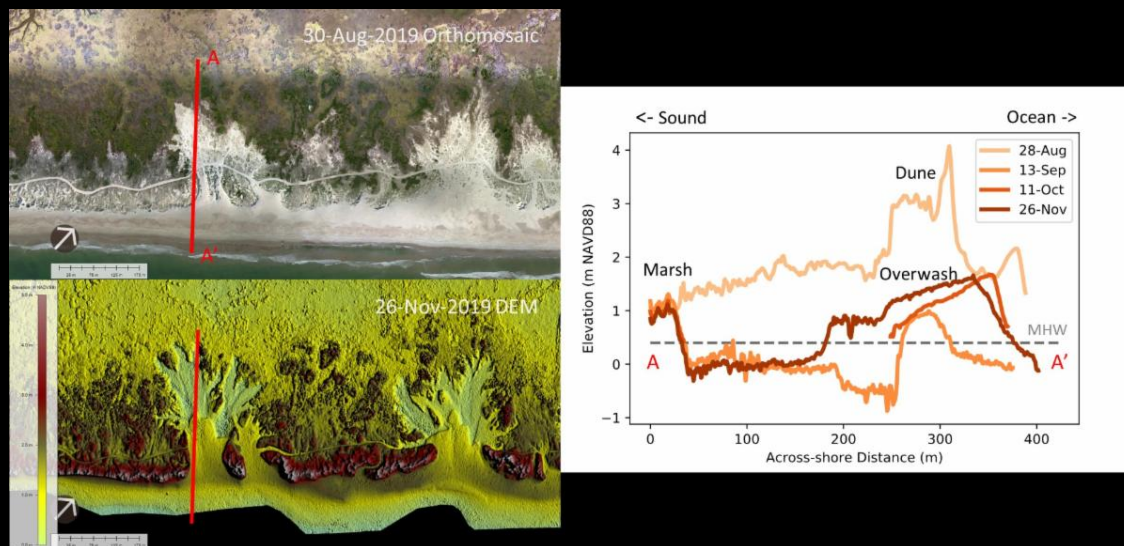


Figure 3. Details of changes at another location on North Core Banks. Top left: pre-storm orthomosaic. Bottom left: post-storm digital elevation map from Nov. 26, about 10 weeks after Hurricane Dorian and a week after a large nor'easter. Right: cross-shore profiles from along the red line shown in the left images. These four profiles are compared to the mean high water elevation (MHW; gray dashed line). The four profiles show pre-storm data with a 4-m dune crest (highest profile); the post-Dorian 13-Sep erosion (lowest profile); the construction of a berm in the 11-Oct profile (data missing below the dashed MWH line); and the subsequent partial infilling of the eroded basin and low spots with overwash after the November nor'easter (darkest profile).

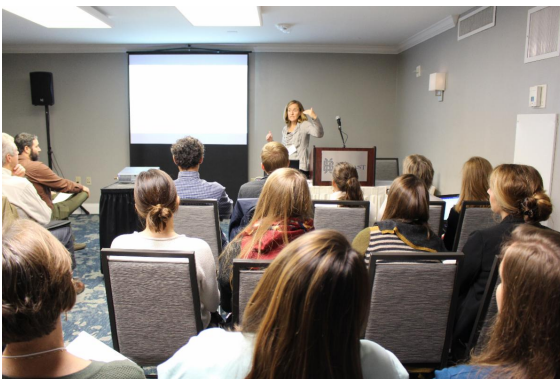
This work is being conducted by Chris Sherwood, Jon Warrick, Jenna Brown, Andy Ritchie and Christine Kranenburg of the US Geological Survey (USGS), and Wayne Wright of C.W. Wright Consulting, with support from the USGS Coastal/Marine Hazards and Resources Program and congressional funds from the 2019 Disaster Relief Act. We thank our partners at the National Park Service for field observations. This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information has not received final approval by the U.S. Geological Survey (USGS) and is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

For more information, please contact [Christopher R. Sherwood](#), U.S. Geological Survey, Woods Hole Coastal/Marine Science Center, Woods Hole, MA.

NCSSC Research Updates at the NC Coastal Conference

The N.C. Sentinel Site Cooperative (NCSSC) invited current and new partners to attend the “NCSSC Research Updates” sessions at the [2019 N.C. Coastal Conference](#), hosted by N.C. Sea Grant in Wilmington on Nov. 19, 2019. The sessions provided updates on research related to sea level rise and opportunities for engagement with the cooperative.

The NCSSC provides coastal communities and resource managers in North Carolina with information on the potential impacts of sea level rise on coastal habitats and communities. The need for an update on research and monitoring efforts related to sea level rise and coastal resilience in North Carolina was expressed by participants at the [2017 NCSSC Partners Meeting](#). In 2018, the NCSSC expanded to encompass the [20 N.C. counties included under the Coastal Area Management Act \(CAMA\)](#), as well as Jones and Martin counties. The location of the conference in Wilmington was an opportunity for the NCSSC to reach new partners in the broader geography.



Jenny Davis, of NOAA National Centers for Coastal Ocean Science (left), and Michael Itzkin, of the University of North Carolina at Chapel Hill (right), speak to the audience at the NCSSC session at the N.C. Coastal Conference. Photos by N.C. Sea Grant.

During the conference sessions, speakers showcased recent research by NCSSC partners that encompassed interdisciplinary, collaborative efforts to monitor change in N.C. habitats and

communities. Participants learned how research and monitoring can be used by resource managers and coastal decision-makers to better address the impacts of sea level rise and flooding in North Carolina. They also learned about the importance of partnerships in collaborative research efforts.

Topics covered included marsh response to sea level rise in North Carolina; the impact of storms and sea level rise on dune formation on N.C. barrier islands; people's perceptions of sea level rise in coastal North Carolina; the impact of storms, sea level rise and flooding on water quality; involvement of coastal decision-makers in the collaborative research process and the use of NCSSC research results to increase science communication and reach a broader audience.



Carter Smith of the Duke University Marine Lab and a 2018 NCSSC graduate fellow, speaks at a NCSSC session at the N.C. Coastal Conference. Photo by N.C. Sea Grant.

The NCSSC would like to thank speakers Sarah Spiegler (NCSSC coordinator), Jenny Davis (NOAA National Centers for Coastal Ocean Science), Brian Boutin (The Nature Conservancy), Michael Itzkin (UNC-Chapel Hill), Justin Ridge (Duke University Marine Lab), Carter Smith (Duke University Marine Lab), David Glenn (NOAA National Weather Service), Hans Paerl (UNC-Institute for Marine Sciences), and Michael O'Driscoll (East Carolina University) who provided research updates addressing the impacts of sea level rise on marshes, land, people and water quality in North Carolina.

Over 75 people participated in the NCSSC sessions, and over 30 new partners signed up for the NCSSC Quarterly newsletter. To be added to the list, please email NCSSC coordinator [Sarah Spiegler](#). The NCSSC would also like to thank session moderators Carolyn Currin (NOAA National Centers for Coastal Ocean Science), Nathan Hall (UNC-IMS), Justin Ridge (Duke University Marine Lab) and Sarah Spiegler (N.C. Sea Grant), and the [NOAA Southeast and Caribbean Regional Collaboration Team](#) for providing funding.

The NCSSC presentations in pdf format can be found [here](#).

NC King Tides Project Flies with SouthWings Before and After Hurricane Dorian

The NC King Tides project flew with the nonprofit organization [SouthWings](#) in September and October, 2019. SouthWings, based in Asheville with satellite offices in New Orleans, Louisiana, and Annapolis, Maryland, coordinates flights over environmentally sensitive areas. They don't charge partners for the flights, and all the pilots volunteer their time, aircraft and fuel costs.

The [NC King Tides Project](#) asks citizens to take photographs of high water level events in their communities, and also provides outreach and education to research, community and school groups related to sea level rise, coastal inundation and flooding events.



Aerial views of the N.C. Rachel Carson Reserve during the King Tide on Sept. 2, 2019, before Hurricane Dorian. The top photo shows Middle Marsh in the reserve and Beaufort Inlet. The bottom photo shows the reserve and downtown Beaufort. Photos by Sarah Spiegler, in partnership with SouthWings.

Christine Voss (UNC-IMS) and Sarah Spiegler (N.C. Sea Grant), representing the NC King Tides Project, coordinated the flights with SouthWings. Staff from the N.C. Division of Marine Fisheries, N.C. Coastal Federation and UNC-IMS also participated in the flights.

SouthWings volunteer pilots Stuart Bailey and William Kahn took passengers up to photograph high water levels on Sept. 2, before Hurricane Dorian, and after the hurricane on Oct. 1. Both flights were conducted during King Tide events and captured images of Cape Lookout National Seashore, Cape Hatteras National Seashore, Ocracoke Village, Beaufort and Morehead City.

Read the [story](#) in Coastal Review Online about the flights with SouthWings prior to Hurricane Dorian.



The top photo from Sept. 2, 2019, shows Bogue Banks from the ocean side. The bottom photo, from Oct. 1, 2019, shows some of the new inlets cut from Hurricane Dorian at Cape Lookout National Seashore. Photos taken during King Tides by Sarah Spiegler, in partnership with SouthWings.



Cape Fear River Watch also flew with SouthWings during the King Tide after Hurricane Dorian. These photos feature aerial views of downtown Southport (top) and Carolina Beach (bottom) on Oct. 1, 2019. Photos courtesy of Cape Fear River Watch, in partnership with SouthWings and volunteer pilot Art Falk.

Marsh Resilience Summit Hosted by the Chesapeake Bay Sentinel Site Cooperative

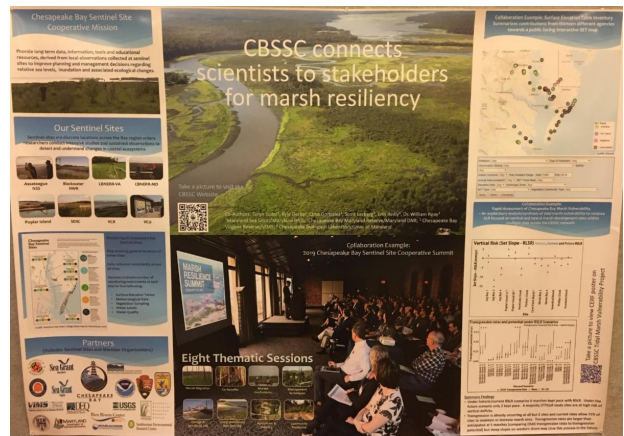
The Chesapeake Bay Sentinel Site Cooperative (CBSSC), with support from Maryland Sea Grant, hosted the first [Marsh Resilience Summit](#) on Feb. 5 to 6, 2019, in Williamsburg, Virginia. Over 200 people, including community members, scientists and coastal managers, discussed the latest science, challenges and opportunities related to increasing marsh resilience in the face of sea level rise. They also highlighted pressing research needs.

The compilation of presentations and guided discussion questions centered on the impacts of changing marsh landscapes on natural and developed communities. The Marsh Resilience Summit Proceedings are now available [here](#).

Participants valued hearing about current research and education efforts as well as discussing new collaborations and research directions. An overarching theme was a need for even greater engagement among researchers, government agencies, land-managers, policy-makers, NGOs and other organizations to begin to break down barriers and identify opportunities for coastal resilience projects.

The summit consisted of eight themed sessions:

- Marsh Migration
- Environmental Market Mechanisms and Other Conservation Policy Opportunities
- Linking Wetland Conservation and Community Resilience
- Co-Benefits of Marsh Conservation
- Lessons Learned from Management Techniques and Restoration
- Dredge and Beneficial Use
- Lessons Learned on Living Shorelines and Thin Layering
- Marshes, Agriculture, and Industry



Article About NC Surface Elevation Tables Earns Excellence in Communications Award

NCSSC coordinator Sarah Spiegler won second place in feature writing from the [N.C. Association of Government Information officers](#) for her article about Surface Elevation Tables (SETs) in North Carolina. The article, "[Land Versus Sea](#)," appeared in the Summer 2019 issue of N.C. Sea Grant's *Coastwatch* magazine.



Lisa Baron, of the National Park Service, takes SET measurements at Cape Lookout National Seashore. Photo courtesy of NOAA Beaufort Lab.

Audubon North Carolina Receives Grants

Audubon North Carolina recently received grants from the

National Fish and Wildlife Foundation and the N.C. Clean Water Management Trust Fund for marsh restoration and resilience planning on Currituck Sound. Goals of the project include increasing community resilience to flooding, sea level rise, storms and other coastal challenges while protecting habitat for birds and wildlife.

Read more [here](#).



Publications and News Features

Audubon Magazine: "[The Fight to Save Pine Island](#)," Fall 2019

Chesapeake Bay Sentinel Site Cooperative: "[2019 Marsh Resilience Summit Proceedings](#)," 2019

Ocean and Coastal Management: "[Variables shaping coastal adaption decisions to armor, nourish, and retreat in North Carolina](#)," Jan. 1, 2020

The News & Observer: "[Here's what might be keeping your NC community from preparing for climate change](#)," Jan. 27, 2020

The New York Times: "[Florida Keys Deliver a Hard Message: As Seas Rise, Some Places Can't Be Saved](#)," Dec. 4, 2019

The New York Times: "[Marine Labs on the Water's Edge are Threatened by Climate Change](#)" Jan. 7, 2019

The Star Tribune: "[Historic US Towns endured wars, storms. What about sea rise?](#)," Dec. 5, 2019

USGS: "[Study Finds Knowledge Gaps on Protecting Cultural Sites from Climate Change](#)" Dec. 19, 2019

Funding Opportunities

National Sea Grant, *deadline Feb. 21*

- [John A. Knauss Marine Policy Fellowship](#)

North Carolina Sea Grant, *deadline March 2*

- [NC STEM Policy Fellowship](#)

Upcoming Events

[Scientific Research and Education Network \(SciREN\) Coast Event](#), Pine Knoll Shores

- Feb. 27, at the N.C. Aquarium at Pine Knoll Shores

[N.C. Water Resources Research Institute Annual Conference](#), Raleigh

- March 18 to 19, at the Jane S. McKimmon Center at NC State University; register [here](#)

[Drones in the Coastal Zone workshop](#), Beaufort

- March 31 to April 2, at the Duke University Marine Lab and NOAA Beaufort Lab; register [here](#)

[Coastlines and people Open data and MachinE learning sprint \(COMET\)](#), Kitty Hawk

- May 11 -to 15, at the Hilton Garden Inn; apply [here](#) by February 15

NOAA Office for Coastal Management, [A Framework for Ecosystem Services Projects training](#), Beaufort

- May 12, at the NOAA Beaufort Lab; register [here](#)

The NOAA Sentinel Site Program leverages existing research and monitoring resources to ensure resilient coastal communities and ecosystems in the face of changing conditions. The program's place-based approach focuses on issues of local, regional and national significance that impact habitats and species managed by NOAA and surrounding coastal communities.

