Scientist Jud Kenworthy stands among seagrasses in the Back Sound, Carteret County, North Carolina. The state is home to the Eastern Seaboard's largest intact seagrass meadows, which are exceptionally efficient at capturing and storing climate-damaging greenhouse gases. *Jack Igelman/Carolina Public Press*

How North Carolina Incorporated Seagrasses Into Its Blue Carbon Inventory

By measuring coastal carbon storage, the state can advance its climate goals

Overview

Reducing greenhouse gas (GHG) emissions globally will require a multifaceted approach. Conserving, restoring, and managing natural habitats such as forests, grasslands, and wetlands is one strategy that can help moderate emissions and slow the rate of climate change. Coastal wetlands—including salt marshes, scrub-shrub, tidal forested wetlands, and submerged aquatic vegetation (SAV) such as seagrasses—are especially efficient at sequestering (capturing and storing) atmospheric carbon dioxide in their roots and soils. This stored carbon is known as "blue carbon."

North Carolina officials sought to better understand and harness the carbon sequestration benefits of their state's natural habitats, including coastal wetlands. So, beginning in 2021, the state embarked on a process to develop a greenhouse gas inventory (GGI) for its coastal wetlands. The resulting blue carbon GGI, finished in 2023, is among the first in the world to include not only above-water habitats such as salt marshes—often called "emergent wetlands"—but also SAV habitats, particularly seagrass beds.

Researchers from the University of North Carolina at Chapel Hill's Rodriguez Coastal Sedimentology Lab—technician Olivia Key (left, in the water); graduate student Josh Himmelstein (in the boat); and Antonio Rodriguez, principal investigator and associate chair of the university's Department of Earth, Marine, and Environmental Sciences—collect sediment samples from seagrass meadows in Core Sound, North Carolina, which doctoral student Yasamin Sharifi (not shown) will analyze to calculate how much "blue carbon" the vegetation has captured and stored. *Rodriguez Coastal Sedimentology Lab at University of North Carolina at Chapel Hill*

Seagrasses are found along most coastlines in the United States and occur naturally in a range of salinities, from ocean water to estuaries. And because they grow in water-saturated, low-oxygen soil, seagrasses form dense root structures that capture two to five times as much carbon as their aboveground vegetation.[1] These entangled networks create ideal conditions for carbon from other marine sediments to settle in the meadows: As much as 50% of carbon stored in seagrass soils comes from sources other than the seagrasses themselves.[2]

Worldwide, however, seagrasses are under threat from development and degraded water quality, and their degradation or loss can lead to stored carbon being rapidly released back into the environment. In some parts of North Carolina, seagrass beds are declining faster than the global average of 1.5% a year.[3]

Nevertheless, the state still has the most seagrass on the Eastern Seaboard of the U.S., and with the GGI data, it will be better able to conserve those seagrass meadows, restore others, and sequester even more carbon. The state's innovative GGI process and approach for coastal wetlands—particularly the inclusion of seagrass—offer a model for other regions and states interested in incorporating coastal blue carbon into their climate mitigation efforts.

North Carolina's approach

In 2018, North Carolina Governor Roy Cooper issued an executive order that led to the creation of the Natural and Working Lands (NWL) Action Plan two years later.[4] The plan, which represents the state's most comprehensive efforts to date to address its vulnerability to climate change, identifies opportunities to help conserve and manage the state's coastal wetlands and maximize their benefits for carbon sequestration, climate resilience, and the state's economy. Although the plan recognizes coastal wetlands for their significant per-unit-area carbon storage, a lack of available data precluded their inclusion in the state's 2018 GGI update.

Although the United Nation's Intergovernmental Panel on Climate Change (IPCC) has issued guidance for developing GGIs of vegetated coastal wetlands such as seagrasses, most jurisdictions have not included these habitats in their GGIs, largely because of challenges in mapping underwater habitats and a lack of studies of U.S. seagrass carbon.[5] (Even the U.S. Environmental Protection Agency's [EPA's] Inventory of U.S. Greenhouse Gas Emissions and Sinks, commonly known as the national greenhouse gas inventory [NGGI], the country's primary source of greenhouse gas data, does not include seagrasses.[6]) As a result, regions and states aiming to capture the blue carbon in these habitats, including North Carolina, have had to develop their inventories from the ground up.

In 2021, North Carolina officials involved in the NWL plan appointed a blue carbon work group to enact the recommendations. The work group modeled the state's seagrass inventory on the IPCC's "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands" and the NGGI to ensure consistency with national reporting and to make inclusion of the states' data easier for EPA officials when they update the NGGI to add seagrasses.[7]

Brandon Puckett, then a research coordinator for the North Carolina National Estuarine Research Reserve (NERR), conducts seagrass research in the Rachel Carson Reserve in the NERR, which is located in Carteret County. *E. Woodward/North Carolina NERR, via Flickr*

Although the state's coastal habitat mapping provided the most up-to-date information on the extent of seagrass beds, it still lacked data on low-salinity SAV and carbon storage rates. To compensate, the work group included only high-salinity SAV in the inventory and used the IPCC's "default values" for carbon storage, which are globally accepted aggregated data that can be substituted when regional or state-specific information is not yet available.[8] Additionally, the work group convened two workshops with seagrass mapping and blue carbon experts from federal and state agencies, academic institutions, and nonprofits to develop methods for dealing with other missing or inexact data.[9]

Those efforts yielded information from various other sources, including:

- Habitat mapping and extents.
    - North Carolina Division of Marine Fisheries.[10]
    - Albemarle-Pamlico National Estuary Partnership.[11]
    - Aerial photographic surveys digitized for geographic information systems.[12]
    - Habitat region overlays from the North Carolina Coastal Habitat Protection Plan (CHPP), a science-based blueprint for coordinating conservation and restoration of coastal habitats across state and federal agencies.[13]
- IPCC default net carbon accumulation rate.[14]
- IPCC soil carbon default values.[15]

Developing the GGI

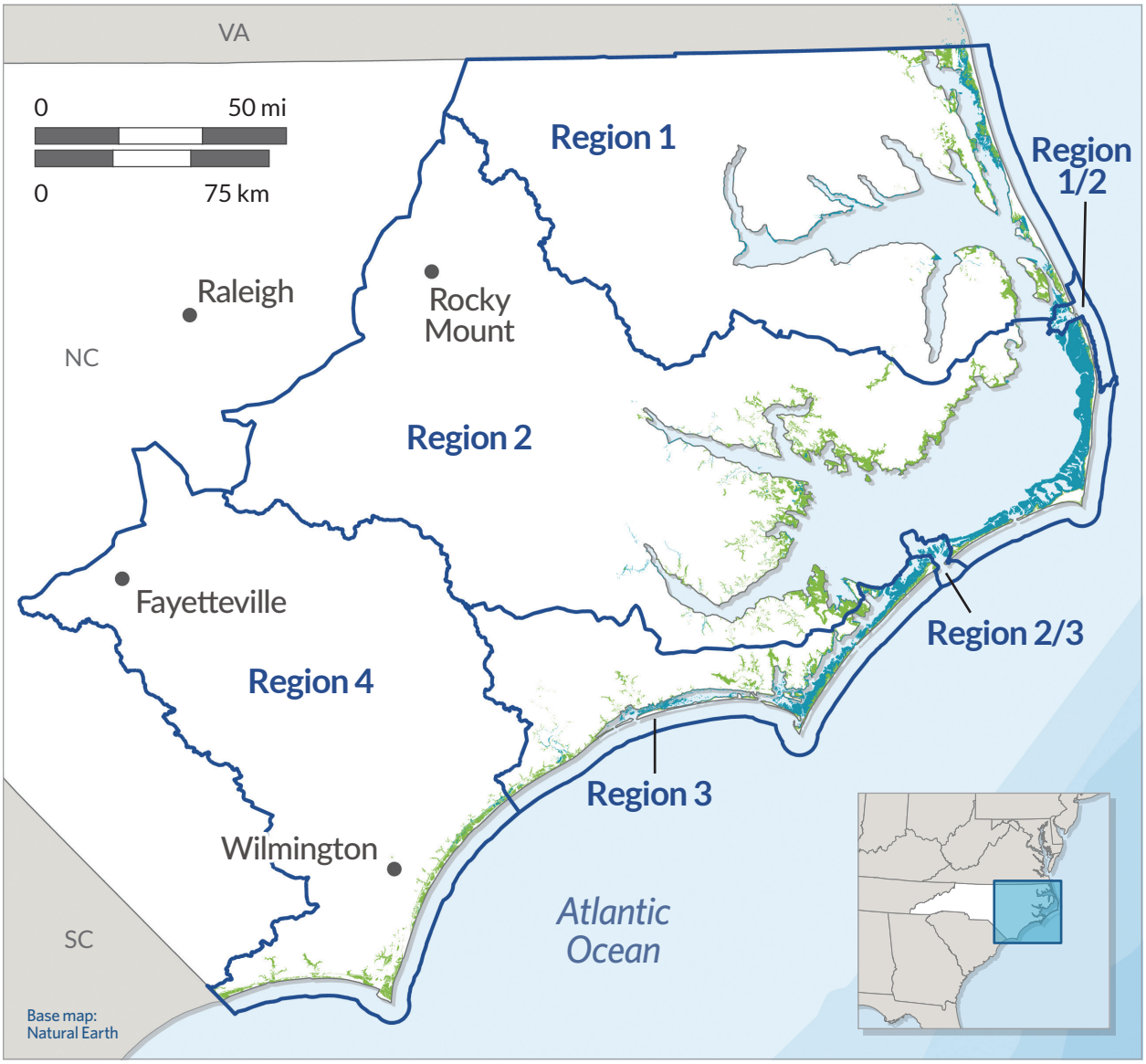
After identifying the necessary data sources, the work group created North Carolina's first GGI for seagrasses by:

1. **Estimating the total extent of seagrass habitats by year.** The team overlayed geographical regions from the CHPP onto state seagrass maps from 2007 to 2013 and used the data between survey dates to provide an estimate for years where data was missing.
2. **Estimating carbon emissions and removals.** Using default carbon dioxide emission and removal rates established in the 2013 IPCC wetlands supplement, the work group first estimated the annual carbon dioxide emitted and captured by the state's seagrass meadows and then multiplied those estimates to calculate the seagrasses' approximate carbon dioxide emissions and removals at five-year intervals.
3. **Accounting for uncertain estimates.** The team also calculated minimum and maximum values to indicate the range of uncertainty for emissions and removals.

Figure 1

North Carolina Uses Coastal Habitat Protection Plan Regions to Calculate Captured and Stored Carbon

State's coastal habitat types and protection plan regions



Sources: United States Fish and Wildlife Service, "Download Seamless Wetlands Data by State," https://www.fws.gov/program/national-wetlands-inventory/download-state-wetlands-data; North Carolina Department of Environmental Quality, "NC SAV Mosaic" (1981-2021), https://data-ncdenr.opendata.arcgis.com/datasets/nc-sav-mosaic-1981-to-2021/explore

Outcomes and next steps

The work group finalized North Carolina's seagrass GGI in September 2023. It showed that seagrasses along the state's coast stored more carbon than they emitted between 2007 and 2021 but also that annual removals of carbon had slightly decreased over that period because of the loss of seagrass acreage. In 2021, the state's seagrasses sequestered approximately 55.14 kilotons of carbon dioxide equivalent in the soils alone, comparable to removing roughly 12,270 automobiles from the state's roads for one year.[16]

The seagrass inventory will be incorporated into the next update of North Carolina's statewide GGI, which is scheduled to be released in January 2024.

The seagrass GGI process and results also uncovered research gaps and needs that the state can address in future updates, including:

- How reliable are estimates of seagrass cover for years that lack specific data?
- What is the best way to address low-salinity SAV in a GGI, given uncertainties in mapping, carbon accumulation rates, and the effects of methane—a naturally occurring but potent greenhouse gas, which tends to increase as salinity decreases?
- Can carbon accumulation rates and stocks be reliably predicted using metrics, such as seagrass cover and abundance?
- What are the effects of sea-level rise on seagrass carbon accumulation and storage?
- What is the fate of historic carbon storage when seagrass coverage is lost?
- What seagrass protection and restoration investments will have the best return on investment in terms of carbon accumulation and storage?

Despite these questions, North Carolina's work highlights the importance of protecting seagrasses and other coastal wetlands, as well as the role conservation and restoration can play in advancing state climate goals. North Carolina's efforts give other coastal states a model for developing estimates of the carbon stored in their seagrass habitats that maximize the values of wetlands GGIs for land-use managers and scientists, even in the absence of perfect data.

Resources for states

- The Pew Charitable Trusts: Pew Launches Blue Carbon Network to Help States Address Climate Change (https://www.pewtrusts.org/en/research-and-analysis/articles/2022/04/29/pew-launches-blue-carbon-network-to-help-states-address-climate-change)
- U.S. Climate Alliance and World Resource Institute's Natural and Working Lands Guide for States (https://static1.squarespace.com/static/5a4cfbfe18b27d4da21c9361/t/604652f0d82ffb5074df3b3d/1615221491785/Guide+to+NWL+Inventory+Improvements.pdf)
- Restore America's Estuaries: A National Blue Carbon Action Plan (https://estuaries.org/wp-content/uploads/2022/02/Blue-Carbon-National-Action-Plan-Final.pdf)
- The Blue Carbon Initiative: Blue Carbon Manual (https://www.thebluecarboninitiative.org/manual)
- Office of Coastal Management: Blue Carbon Fast Facts (https://coast.noaa.gov/states/fast-facts/blue-carbon.html)
- The Pew Charitable Trusts: Eelgrass and Kelp Play Vital Role in Coastal Ecosystems, Communities—but Face Diverse Threats (https://www.pewtrusts.org/en/research-and-analysis/data-visualizations/2022/eelgrass-and-kelp-play-vital-role-in-coastal-ecosystems-communities-but-face-diverse-threats)

Endnotes

1 K. Meyer and A.C. Moya, "Seagrass Meadows Some 9,000 Miles Apart Show Strength of Nature-Based Solution to Climate Change," The Pew Charitable Trusts, June 27, 2023, https://www.pewtrusts.org/en/research-and-analysis/articles/2023/06/28/seagrass-meadows-some-9000-miles-apart-show-strength-of-nature-based-solution-to-climate-change.

2 Ibid.

3 D. Field, J. Kenworthy, and D. Carpenter, "Extent of Submerged Aquatic Vegetation: High Salinity Estuarine Waters" (Albemarle-Pamlico National Estuary Partnership, 2021), https://apnep.nc.gov/documents/files/metric-report-extent-submerged-aquatic-vegetation-high-salinity-estuarine-waters/open.

4 North Carolina Department of Environmental Quality and North Carolina Department of Natural and Cultural Resources, "North Carolina Natural and Working Lands Action Plan" (2020), https://files.nc.gov/ncdeq/climate-change/natural-working-lands/NWL-Action-Plan-FINAL---Copy.pdf.

5 Intergovernmental Panel on Climate Change, "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands" (2014), https://www.ipcc-nggip.iges.or.jp/public/wetlands/.

6 U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2019" (2021), https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2019.

7 Intergovernmental Panel on Climate Change, "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories."

8 Ibid.

9 Participating organizations were: U.S. Department of Agriculture; U.S. Environmental Protection Agency, Region 1; NOAA National Centers of Coastal Ocean Science; North Carolina Department of Environmental Quality; Albemarle-Pamlico National Estuary Partnership; North Carolina Coastal Federation; The Pew Charitable Trusts; University of North Carolina at Chapel Hill, Institute of Marine Sciences; Florida International University; University of Virginia; North Carolina State University; Silvestrum Climate Associates; and The Smithsonian Institution.

10 North Carolina Department of Marine Fisheries, North Carolina Marine Fisheries Spatial Interface, https://fisheries-ncdenr.opendata.arcgis.com/.

11 Field, Kenworthy, and Carpenter, "Extent of Submerged Aquatic Vegetation."

12 Ibid.

13 North Carolina Department of Environmental Quality, "North Carolina Coastal Habitat Protection Plan" (2021 Amendment), https://www.deq.nc.gov/marine-fisheries/coastal-habitat-protection-plan/north-carolina-coastal-habitat-protection-plan-2021-amendment/open.

14 Intergovernmental Panel on Climate Change, "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories."

15 Ibid.

16 U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," accessed April 2023, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

For more information, please visit: pewtrusts.org/USBlueCarbon

The Pew Charitable Trusts

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