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Sedimentological Analysis of Spatial Variations in Seagrass Blue Carbon Deposition

1. **Project Goals**

The research community currently suggests seagrass meadows extract atmospheric carbon and bury it in sediment more efficiently than other ecosystems, making seagrass meadows the greatest contributor to global carbon sequestration. However, these conclusions are based on research approaches with several significant shortcomings. Measurements are mainly from surface samples (top 10 cm) of seagrass beds that are extrapolated to depth. Shallow samples ignore decomposition and depositional processes that vary in time and space. The main goal of this research project is to develop a depositional model for high-salinity temperate seagrass meadows that captures changes associated with storms and accounts for spatial variability in deposition across the meadow. These seagrass beds are located behind the Outer Banks, NC.

To fulfill these aims, this project will answer the following research questions:

- How does the carbon content of seagrass beds vary with depth and proximity to shorelines and saltmarshes?
- Are seagrass beds composed of multiple depositional units?
- Does the composition and geometry of seagrass depositional units vary across the meadow?
- How do seagrass beds record storm events in depositional units?

2. **Background and Significance**

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Carbon sequestration is important to constrain as we move towards managing carbon budgets and offsetting emissions. Vegetated coastal ecosystems like tidal salt marshes, seagrass beds, and mangroves store large amounts of carbon, and there are initiatives to protect these blue carbon stores. Some researchers have suggested that although the area of these ecosystems are one to two orders of magnitude smaller than terrestrial forests, their long-term carbon sequestration per unit area is much greater than that of terrestrial forests (Mcleod et al. 2011). Carbon burial in North American salt marshes and mangroves is well constrained; however, there is still much to learn about the carbon stores of North American seagrass meadows.

Several major uncertainties hinder accurate applications of marine carbon sequestration efforts (Fourqurean et al. 2012). It has been suggested that a significant fraction of sea-grass production may be preserved in sediment over long time-scales (over 1000 yrs), but limited data is available as evidence for this proposition (Duarte et al. 2010). This oversight stems from the fact that most seagrass blue carbon measures rely on surface sampling of seagrass beds (Figure 1), preventing a strong understanding of the carbon burial mechanisms over the entire time and depth scale of the seagrass unit.

In addition, most seagrass carbon calculations focus on one or two species common in the Mediterranean which are generalized to other sites with differing environmental contexts (Fourqurean et al. 2012; Mcleod et al. 2011). This gap leaves North American seagrass meadows and many temperate seagrass species unaccounted for, including those found in North Carolina. North Carolina has the most seagrass area of any state on the U.S. east coast with 70-80% cover in high salinity areas behind the Outer Banks, yet the lack of information on seagrass carbon sequestration in North Carolina makes it impossible to accurately include this habitat in carbon budgets. Furthermore, incorporating the sedimentological perspective would allow us to look back even further to time scales that have not yet been explored in the context of the carbon sequestration power of seagrass meadows.

The depositional model that we aim to develop will help us understand how thick and old seagrass beds are, how carbon burial varies with depth, and whether carbon stock in seagrass beds can survive burial events associated with storms and bounce back. The latter insight is important for determining whether loss of seagrass cover will lead to loss of all the carbon accumulated in the seagrass bed. Consequently, the geologic perspective will allow us to investigate whether or not these carbon sinks can be a long term solution for carbon sequestration and aid in the fight against climate change. This research would fill an extremely important gap in the understanding needed for the state to reach its goals for offsetting emissions.

3. Methods

Research will be conducted out of the Institute of Marine Sciences in Morehead City, NC. Sample collection will build on sampling previously conducted by the [redacted] Lab as described in the "Preliminary Work" section. The lab collected 300 surface sediment samples and several deep core samples from mixed-species *Zostera* and *Halodule* seagrass beds throughout Core Sound, North Carolina (see sites shown in Figure 1). Samples revealed variability in surface organic carbon deposition across different environmental contexts and established a baseline of carbon concentrations. I will collect two transects of sediment cores (five per transect) across the seagrass beds identified as featuring stacked depositional units during prior data collection (see example of a stacked seagrass sample in Figure 2). Transects will be oriented from the back-barrier shoreline, across the meadow towards the mainland shoreline.

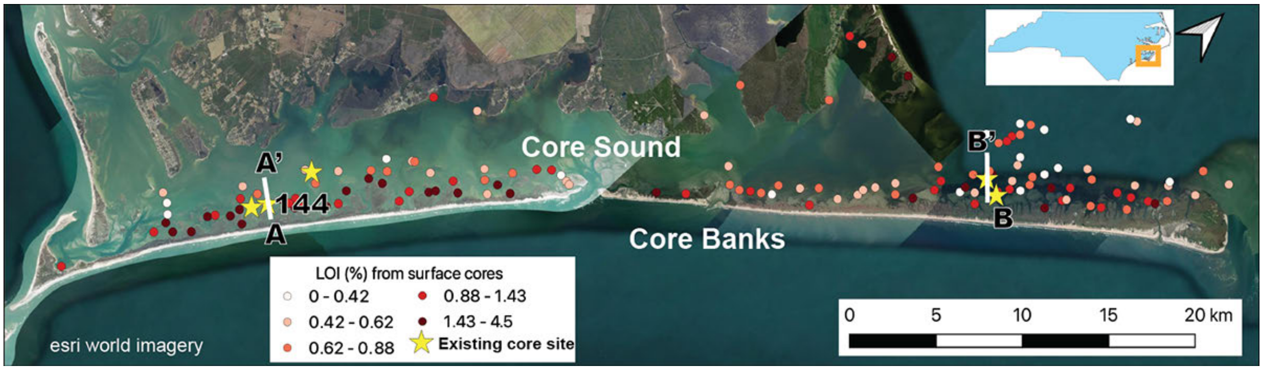

Figure 1. Study area map showing locations of existing samples and proposed core transects A-A' and B-B'. The circles mark the location of 300 surface samples used to constrain spatial variations in percent organic matter. Preliminary cores marked with stars were collected to constrain the sedimentology and stratigraphy of a seagrass unit and form the basis of this study. Cross sections will be created from the five cores I collect at each transect.

Cores (3-m in length) will be obtained from a small motorboat using the vibracoring method and core locations surveyed using a Trimble RTK GPS system. Cores will be opened along their long axis using a circular saw, described, and photographed. Opened cores will be subsampled at 2-cm intervals for percent organic matter using loss on ignition methods and for grain size using a Cilas particle size analyser. Cross sections will be drafted in Illustrator using NAVD88 as the datum on which to hang the cores. I expect that the cores will capture multiple stacked seagrass units, as shown in Figure 2 and deeper units will pinch out at some distance away from the barrier island.

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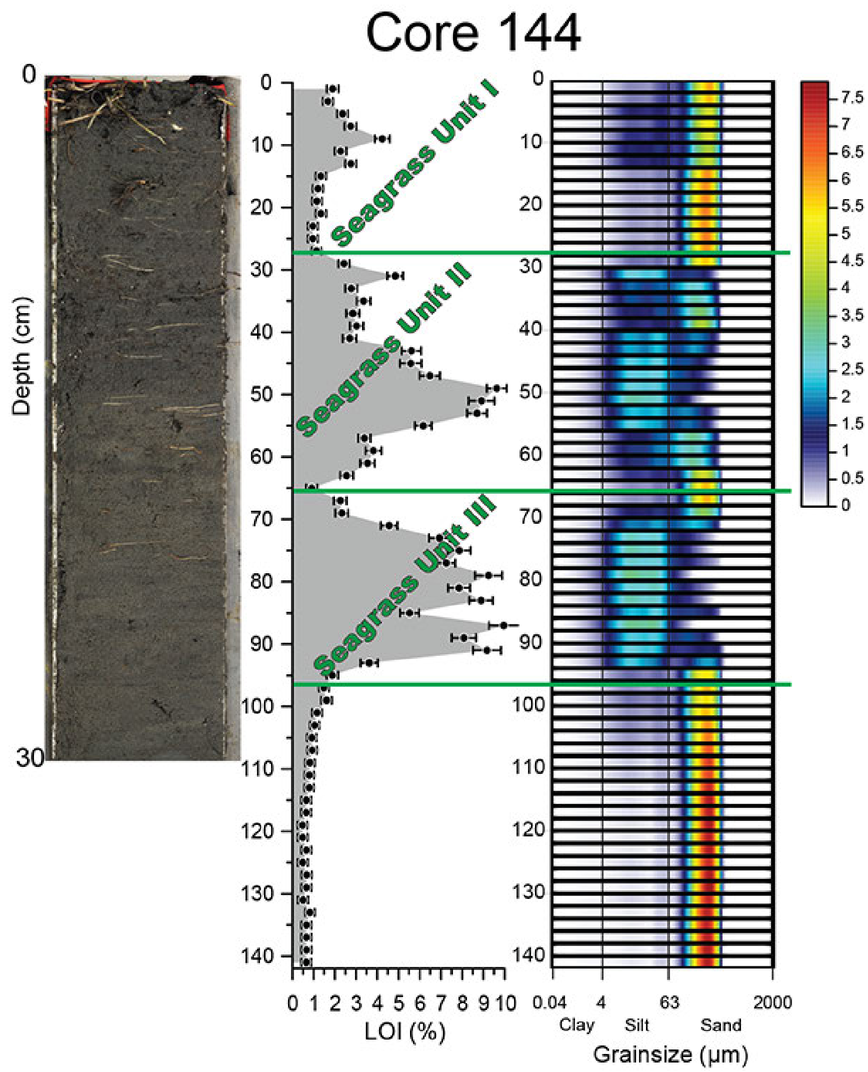

Figure 2. Preliminary core showing three stacked seagrass units. The core photo is of the upper seagrass unit. Plot shows loss on ignition (LOI) profile of subsamples from the core, a proxy for organic carbon present in the core over depth. This core will be part of Transect A-A'. See Figure 1 for location.

Timeline	Activities
May 16-June 15	Field data collection and lab analyses (open the cores, photograph and describe them, subsample).

June 16-July 15	Run loss on ignition and grain size on core samples and interpret the data found.
July 16-August 15	Prepare figures, write a project summary, create a powerpoint presentation and a poster.

4. Preliminary Work and Experience

Preliminary sampling for this overarching project was begun by the [redacted] Lab in the summer of 2021, in partnership with the Albemarle-Pamlico National Estuary Partnership (APNEP), including local stakeholders at NOAA, NC SeaGrant, and the NC Division of Marine Fisheries. Additional cores were then collected from Core Sound based on the variability in surface carbon deposition revealed through initial sampling. Two of those long cores revealed stacked seagrass units. This summer, I will build on these preliminary sampling efforts by exploring the research questions detailed above.

Along with this preliminary data, I have 2 years of relevant prior lab experience: I did mineralogy work on the 365 Million Years project with Dr. [redacted] at Appalachian State, and I currently hold a position in Dr. [redacted] Isotope Geochemistry Lab on campus where I prepare samples and run strontium column chemistry. I have taken GEOL 200 (The Solid Earth), 201 (Earth's Surface), and 303 (Sedimentology and Stratigraphy) at UNC, and GES 1101 (UNC equivalent of GEOL 101) and GES 2250 (UNC equivalent to GEOL 202). These research experiences and courses have equipped me with the necessary skills for collecting and processing the sediment samples for this study.

5. **Final Products and Dissemination Plan**

In addition to the project summary and powerpoint presentation for SURF, research will be communicated in the short-term by preparing and presenting a scientific poster and will eventually be included in a larger peer-reviewed paper examining the role seagrass plays in the carbon cycle. The poster will be presented at UNC's 25th Annual Celebration of Undergraduate Research and the EMES Department's PerkinElmer Undergraduate Research Symposium, both in the spring of 2024.

6. **IRB/IUCAC Statement**

No human or animal subjects will be used as part of this study; therefore, IRB or IUCAC approval will not be needed

7. **Total Word Count: 1,191 words**

References

Duarte CM, Marbà N, Gacia E, Fourqurean JW, Beggins J, Barrón C, Apostolaki ET. 2010. Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. Global Biogeochemical Cycles. 24(4):n/a-n/a. doi:10.1029/2010gb003793.

Duarte C. 1991. Allometric scaling of seagrass form and productivity. Marine Ecology Progress Series. 77:289–300. doi:10.3354/meps077289.

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Fourqurean JW, Duarte CM, Kennedy H, Marbà N, Holmer M, Mateo MA, Apostolaki ET, Kendrick GA, Krause-Jensen D, McGlathery KJ, et al. 2012. Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience. 5(7):505–509. doi:10.1038/ngeo1477. https://www.nature.com/articles/ngeo1477.

Kennedy H, Beggins J, Duarte CM, Fourqurean JW, Holmer M, Marbà N, Middelburg JJ. 2010. Seagrass sediments as a global carbon sink: Isotopic constraints. Global Biogeochemical Cycles. 24(4):n/a-n/a. doi:10.1029/2010gb003848.

Lavery PS, Mateo M-Á, Serrano O, Rozaimi M. 2013. Variability in the Carbon Storage of Seagrass Habitats and Its Implications for Global Estimates of Blue Carbon Ecosystem Service. Valentine JF, editor. PLoS ONE. 8(9):e73748. doi:10.1371/journal.pone.0073748.

Mcleod E, Chmura GL, Bouillon S, Salm R, Björk M, Duarte CM, Lovelock CE, Schlesinger WH, Silliman BR. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Frontiers in Ecology and the Environment. 9(10):552–560. doi:10.1890/110004.