Spring 5-6-2024

Effects of Urbanization on Eutrophication Parameters in three tidal creeks

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By

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Marine Science

Submitted in Partial Fulfillment of the
Requirements for the Degree of Bachelor of Science
In the HTC Honors College at
Coastal Carolina University

Spring 2024

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Abstract

Marshes and swashes are vital environments as a controlling barrier between land affected by various pollutants and the ocean. Eutrophication and the effects of this process can be detrimental for the areas experiencing it. I am interested in ways areas that have little contact with human interactions compare to areas that are heavily urbanized, and whether either of these locations is at a higher risk for eutrophication. Using spectrophotometry and fluorometry, I analyzed samples collected from the relatively undeveloped and restricted-access locations of Waities Island Beach and Dunn Sound monthly for dissolved nutrients, and chlorophyll. At the time of sampling, I also measured temperature, salinity and oxygen levels using a handheld device. These data were then compared to data collected from White Point Swash and Singleton Swash located in urbanized areas. Based on previous research done on this topic, the more urbanized locations should be more at risk for eutrophication due to their exposure to fertilizers and pesticides. This study showed that the two urbanized marsh creeks showed similar patterns in eutrophication parameters as the relatively undeveloped Dunn Sound, with largely similar patterns through the study time period. Further data analysis and research is needed to identify the reasons behind similarities and differences in these three marsh creeks.

Introduction

Marshes and swashes are vital environments as a controlling barrier between land affected by various pollutants and the ocean. Eutrophication and the effects of this process can be detrimental for the areas experiencing it. Waties Island is the northern-most barrier island in South Carolina, and part of it and the mainland is owned and protected by CCU and is a living laboratory for the university. White Point Swash and Singleton Swash are located in heavily urbanized areas in Myrtle Beach and North Myrtle Beach. Access points to creeks and swashes are in residential areas, hotels, and golf clubs where the land around them would have been heavily treated. This study's focus is on whether or not the urbanization of White Point Swash and Singleton Swash causes those locations to experience greater effects of eutrophication than the protected Waties Island (Beach and Dunn Sound). The parameters of interest are those key to the eutrophication process: macronutrients, chlorophyll and oxygen (Bricker et al. 1999, 2007).

Methods

Study sites

My study sites are shown in **Error! Reference source not found.**.

Waties Island is a limited-access site, part of which is owned and managed by Coastal Carolina University as the Anne Tilghman Boyce Coastal Reserve (CCU, 2024). The sampled stations at Waties Island include a beach station, that provided an ocean control, and Dunn Sound, a tidally flushed tidal creek basin in the marsh behind the barrier island.

White Point Swash and Singleton Swash are small coastal watersheds that empty a mix of marshland, residential areas, golf courses, and urbanized spaces (Smith and Sanger 2015). They are monitored as part of other projects of the CCU Coastal Biogeochemistry group (Dr. A. Hannides, graduate student C. Morton, et al.) for a variety of parameters.

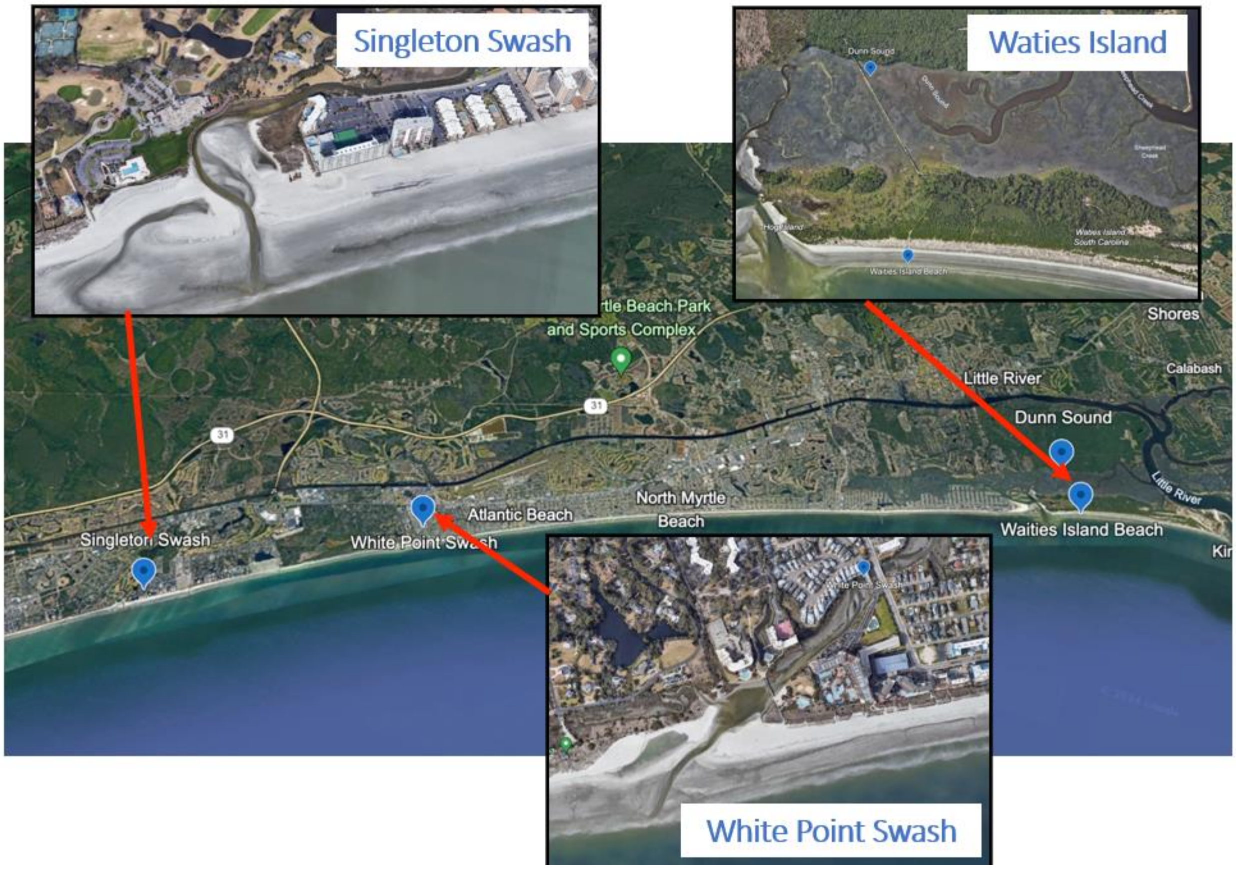

Figure 1 Study sites and stations (image courtesy Google Earth)

Sampling

Between July 2023 and March 2024, water from Waties Island Beach and Dunn Sound was collected and field measurements for the following properties were conducted using a YSI ProDSS multimeter:

- Temperature (^oC),
- Salinity (psu),
- Oxygen concentration (mg/L),
- Oxygen % saturation

Replicate samples were collected and filtered for:

- Dissolved nutrients: nitrate, nitrite, ammonium, and phosphate. These samples were filtered through in-line syringe filters with a pore size of 0.2 μm,
- Chlorophyll. Samples were filtered through GF/F filters.

Data for the same parameters were also collected on the same dates at Singleton Swash and White Point Swash during the aforementioned monitoring projects of the CCU Coastal Biogeochemistry group (Dr. A. Hannides, graduate student C. Morton, et al.).

Sample analysis

Macronutrients

Nitrate was reduced to nitrite and measured spectrophotometrically using the vanadium chloride method (Schnetger and Lehners 2014). Nitrite was analyzed spectrophotometrically using the azo dye method **(**Bendschneider and Robinson 1952, Strickland and Parsons 1972). Ammonium was analyzed by fluorometry (Holmes et al. 1999). Phosphate was analyzed spectrophotometrically using the molybdenum blue method (Murphy and Riley 1962, Hansen and Koroleff 1999).

Chlorophyll

Chlorophyll was extracted from filters using 90 % acetone overnight and measured fluorometrically according to Arar and Collins (1997).

Data analysis

Prior to data analysis, dissolved inorganic nitrogen (DIN) concentration was calculated by adding the concentrations of nitrate, nitrite and ammonium.

Data were graphed and visually inspected:

- By parameter as time-series at all stations,
- As nitrogen species contribution to dissolved inorganic nitrogen per station.

Results

Salinities during the study period at the four stations of the study are shown in Figure 2. Salinities at all marsh sites dropped in a similar pattern throughout the study period, while beach water salinity dropped to a lesser degree at the same time.

Oxygen percent saturation (Figure 3) in the three marsh sites increased during the study period, while it remained constant in beach water. A general increase in oxygen concentration (Figure 4) was observed at all stations throughout the study period.

Time trends in DIN (Figure 5) and phosphate (Figure 6) are similar in two ways:

- Beach water concentrations are generally lower than marsh water concentrations,
- Marsh stations show similar general patterns, with a minimum in fall 2023.

Chlorophyll concentration trends with time (Figure 7) are different from the above because marsh station concentrations are highly variable, while beach water concentrations vary by much less. All show highs in August-September 2023, and Singleton Swash values also peaked in March 2024.

DIN speciation patterns show that Waties Island beach water DIN (Figure 8) is dominated by nitrate and nitrite, while ammonium dominates DIN speciation in marsh water at Dunn Sound (Figure 9), Singleton Swash (Figure 10), and especially at White Point Swash (Figure 11).

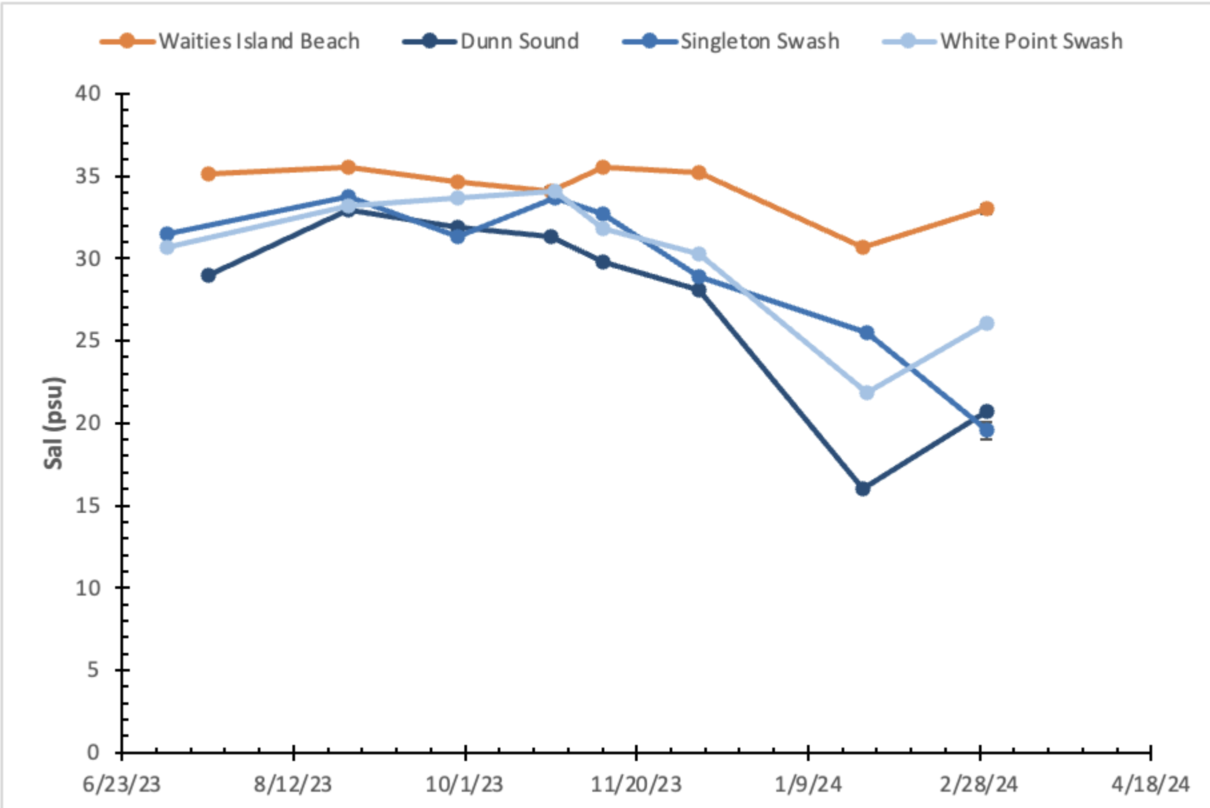

Figure 2 Salinity at the four sites across the time period of data collection. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation. If standard deviation is not visible, it is smaller than the symbols.

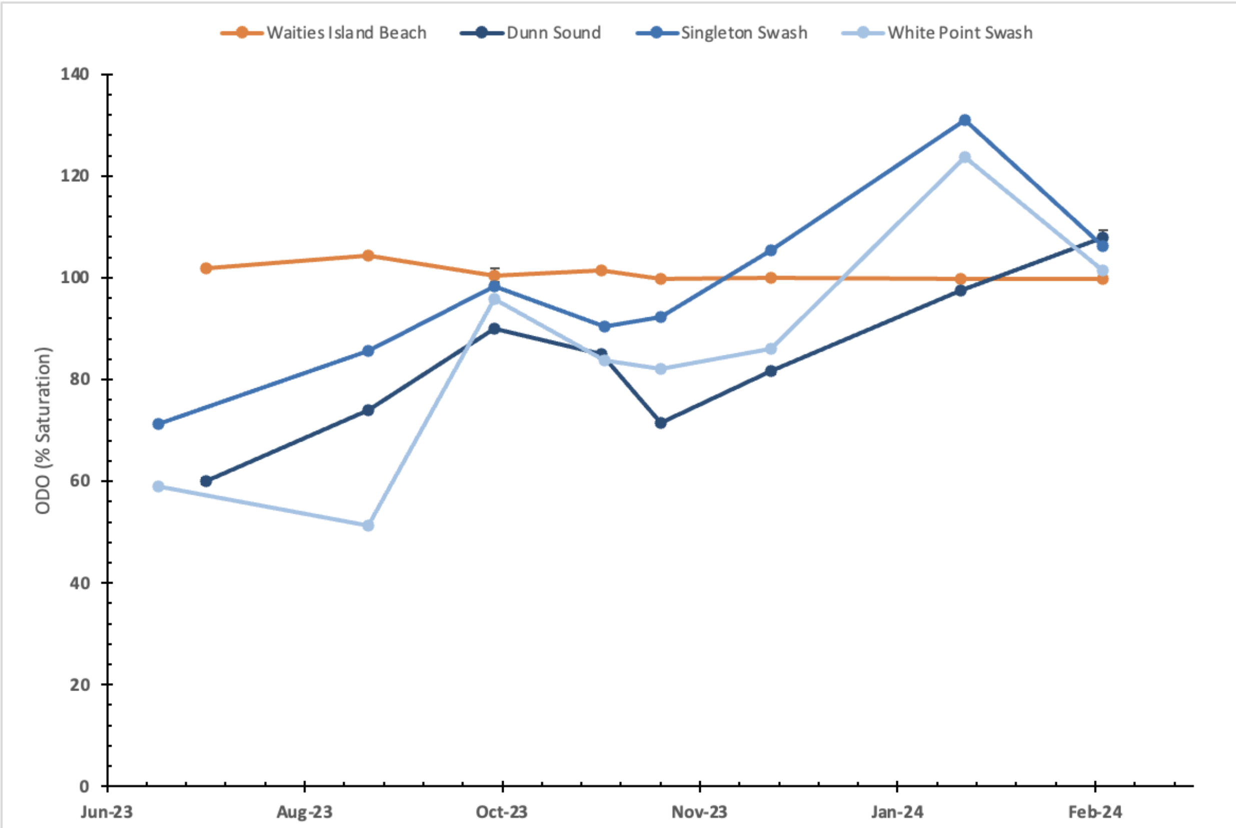

Figure 3 Oxygen percent saturation at the four sites across the time period of data collection. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation. If standard deviation is not visible, it is smaller than the symbols.

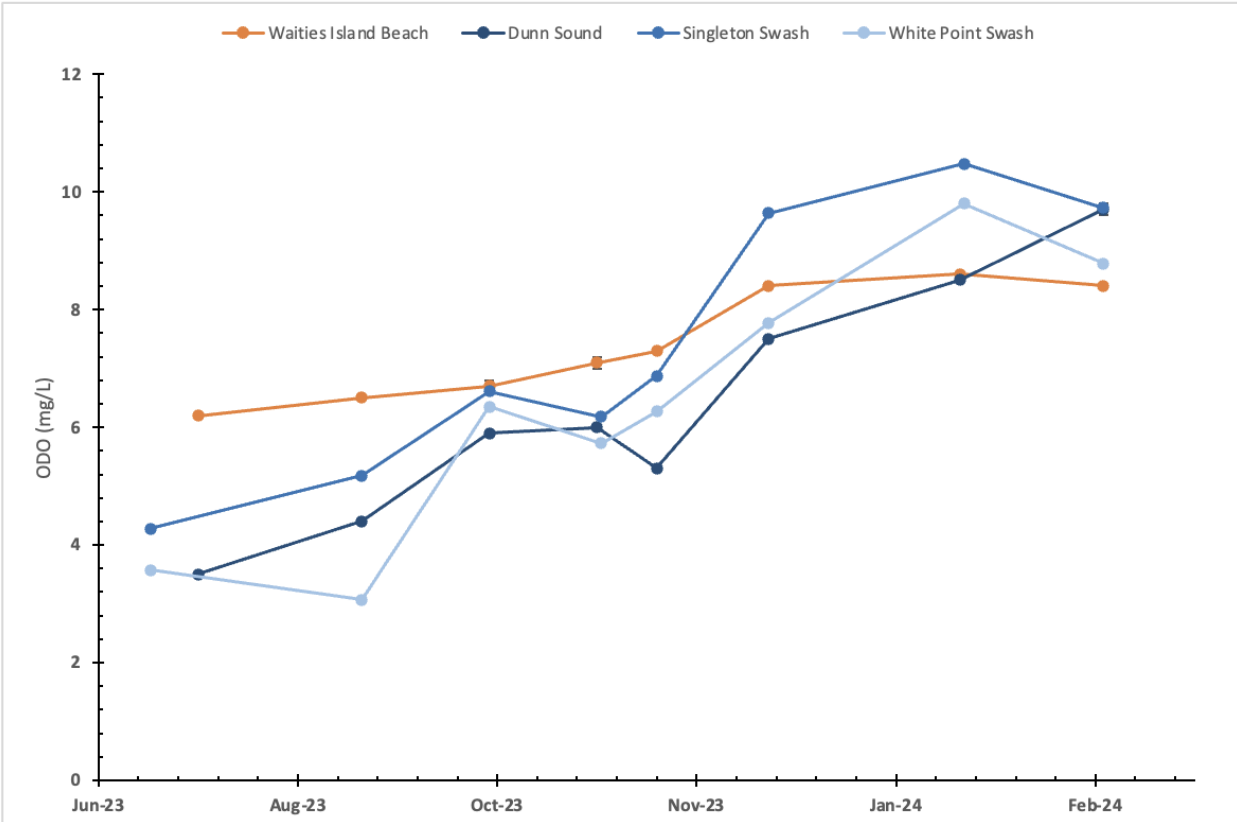

Figure 4 Oxygen concentration at the four sites. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation. If standard deviation is not visible, it is smaller than the symbols.

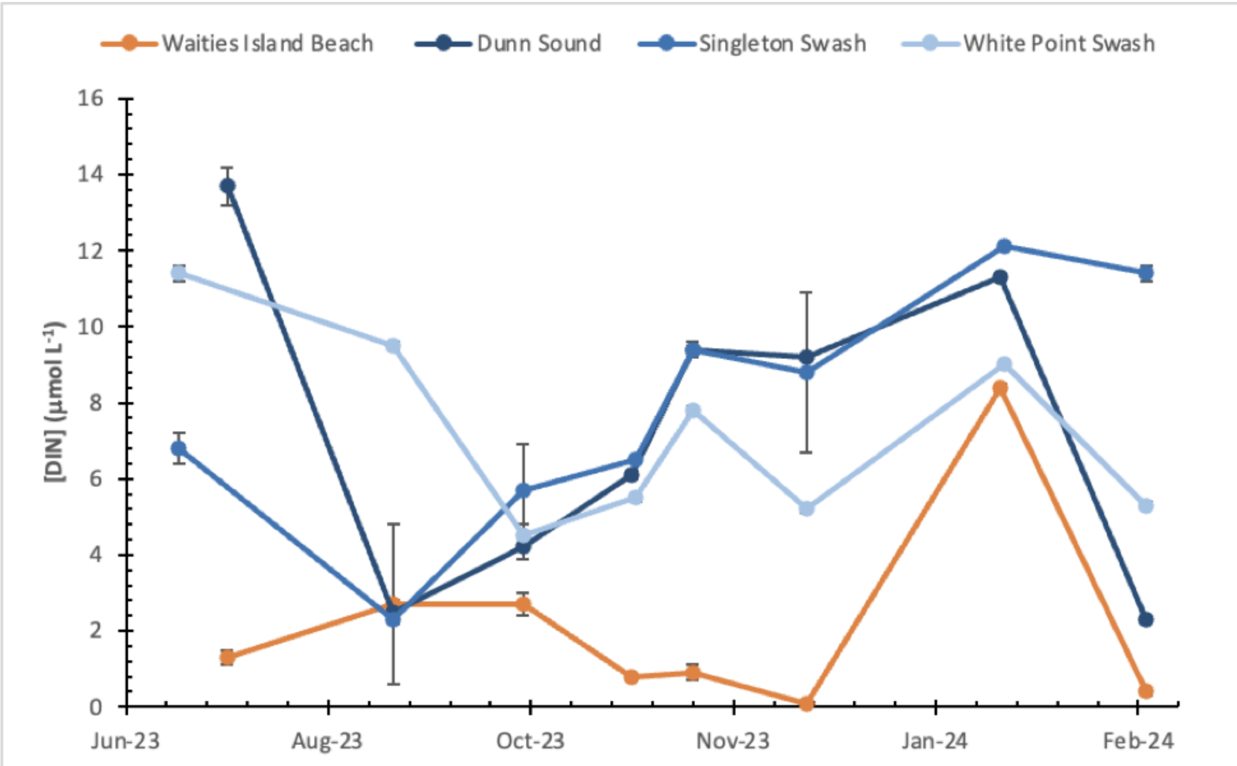

Figure 5 Dissolved Inorganic Nitrogen (DIN) at the four sites across the time period of data collection. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation. If standard deviation is not visible, it is smaller than the symbols.

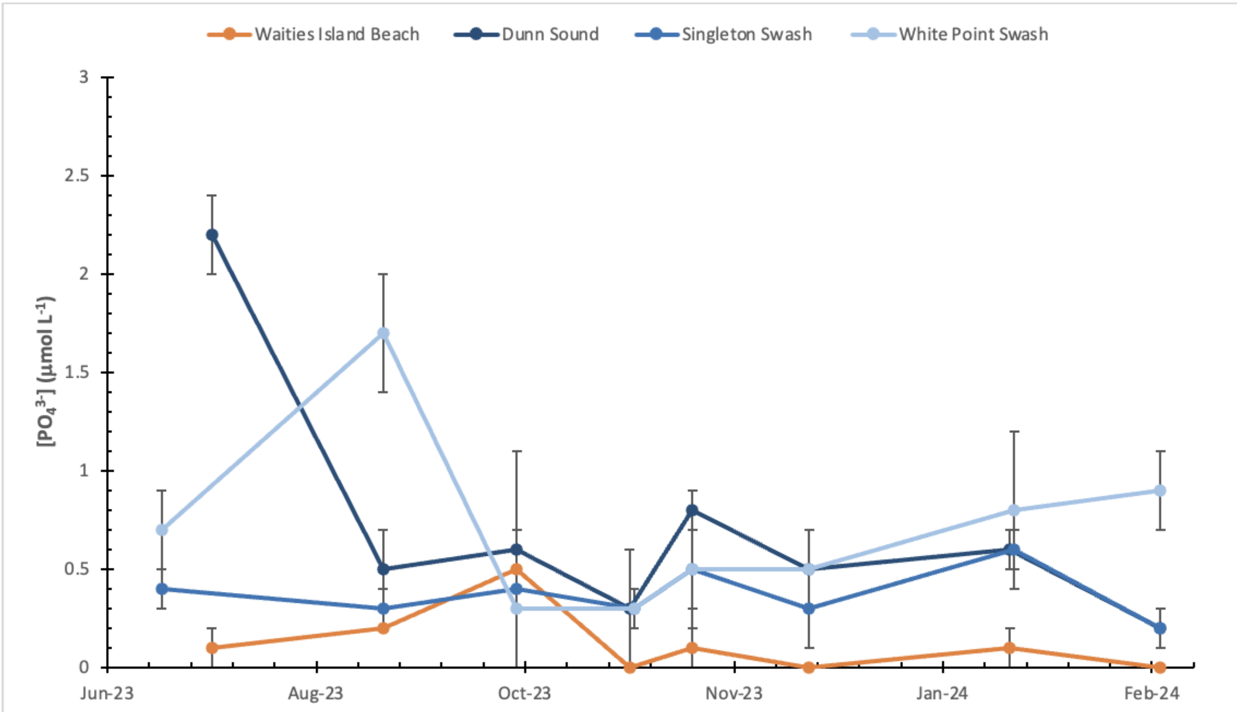

Figure 6 Phosphate concentrations at the four sites. Data points are averaged from replicates collected at each site during that date. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation. If standard deviation is not visible, it is smaller than the symbols.

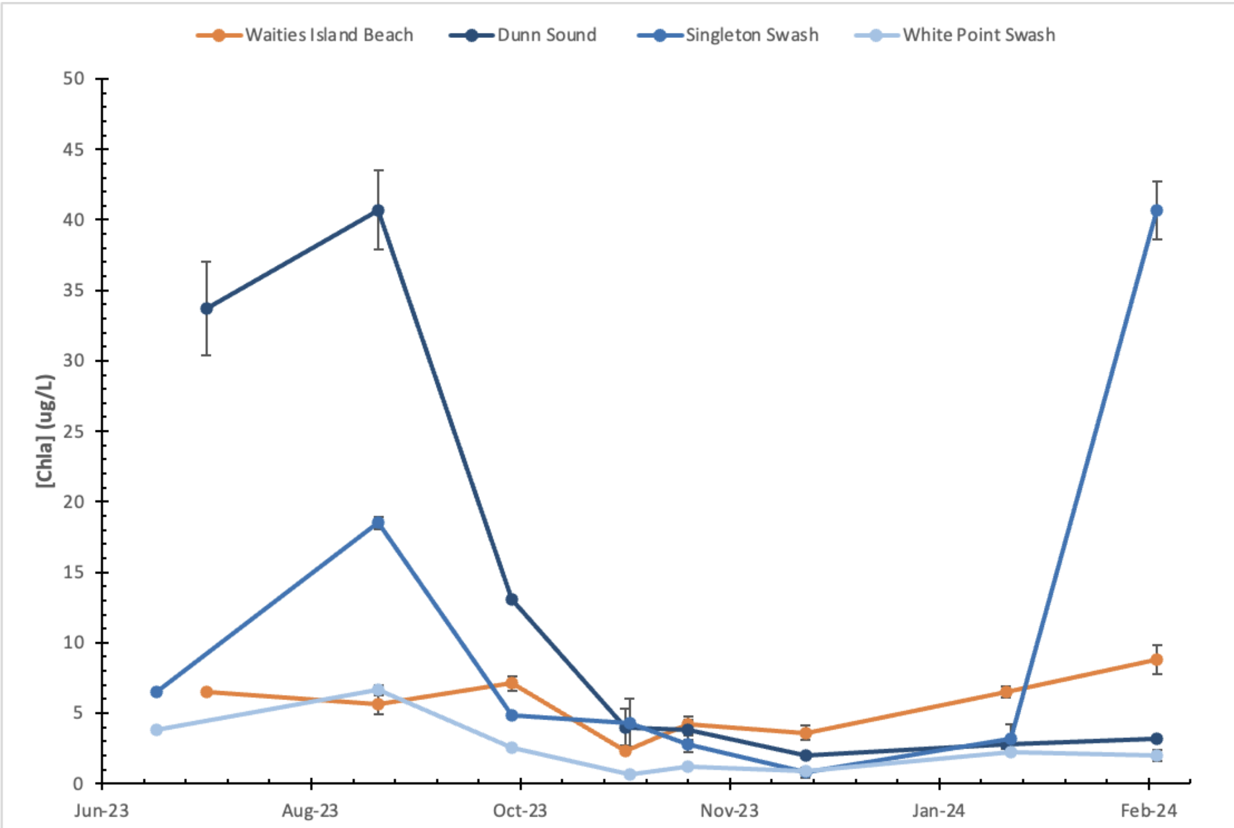

Figure 7 Chlorophyll concentrations at the four sites. Data points are averaged from replicates collected at each site during that date. Data points are averaged from replicates collected at each site during that date. Error bars indicate one standard deviation If standard deviation is not visible, it is smaller than the symbols.

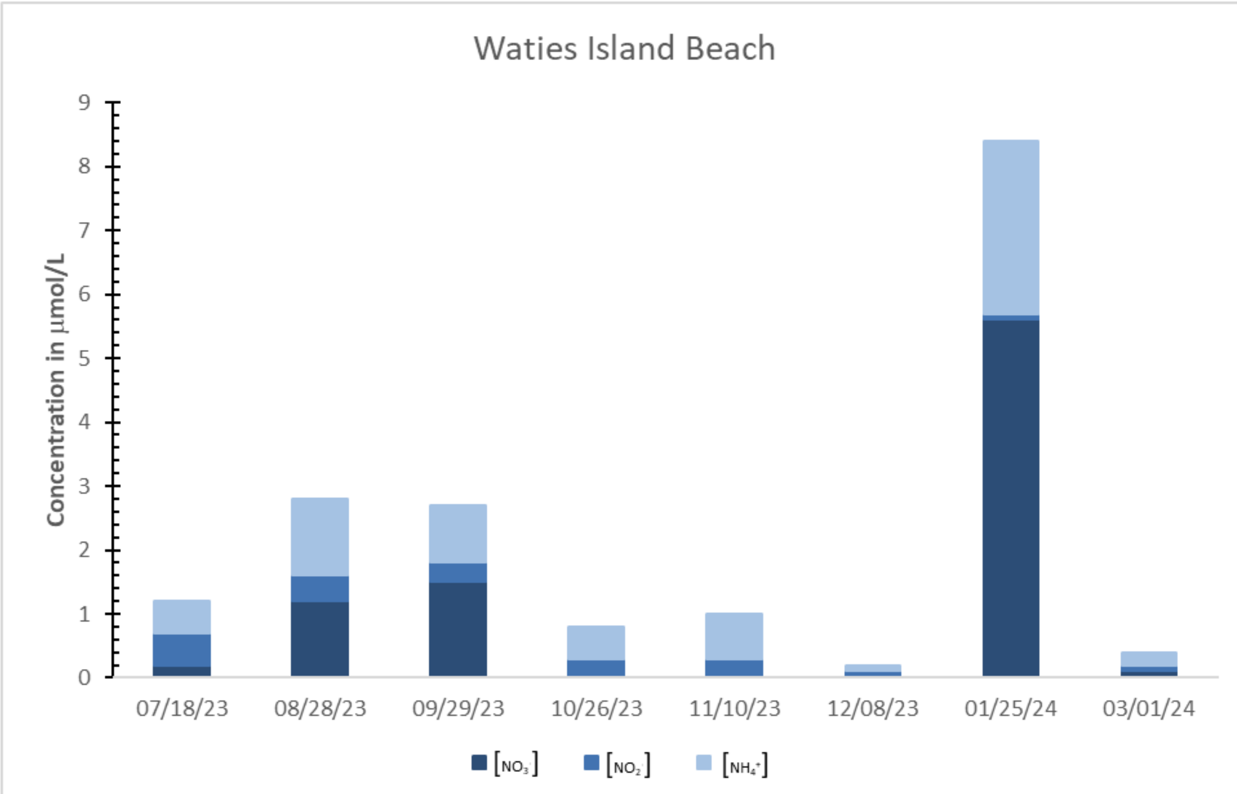

Figure 8 Contribution of each nitrogen species to DIN in Waties Island Beach collected across the time period of data collection. Data points are averaged from replicates collected at each site during that date.

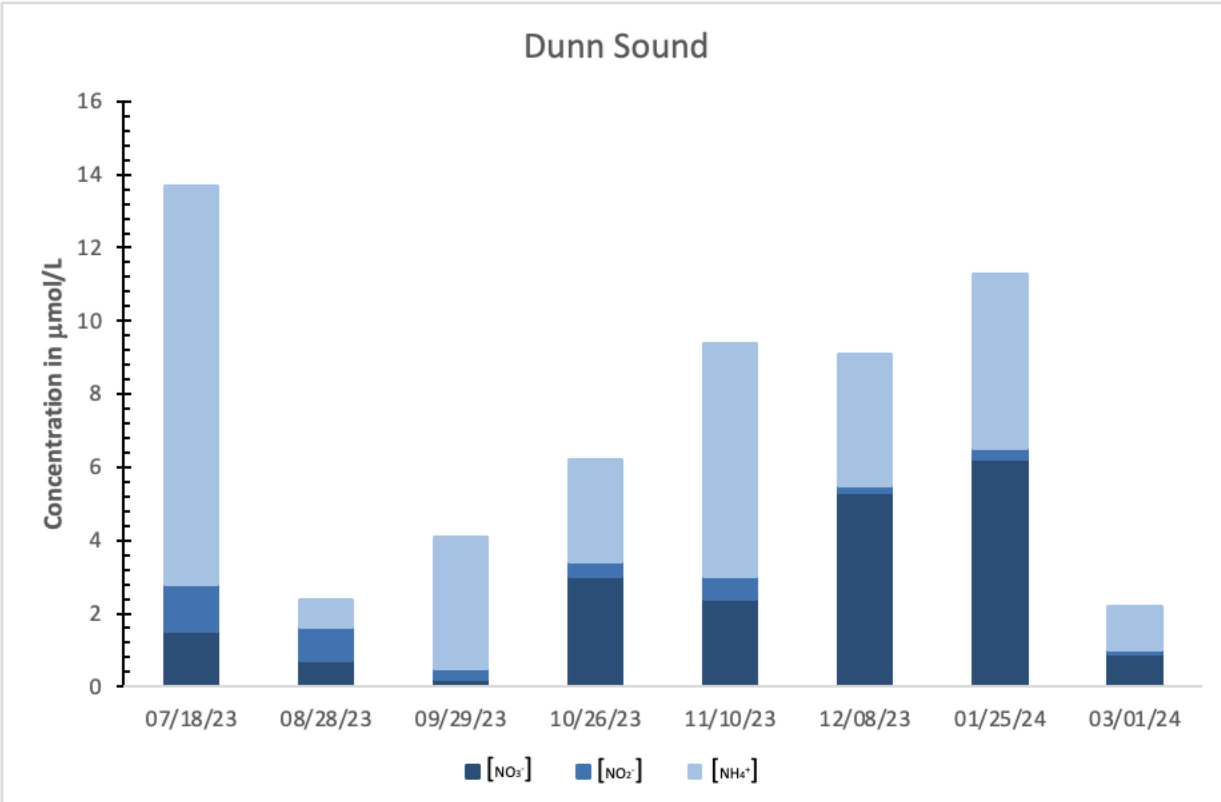

Figure 9 Contribution of each nitrogen species to DIN in Dunn Sound collected across the time period of data collection. Data points are averaged from replicates collected at each site during that date.

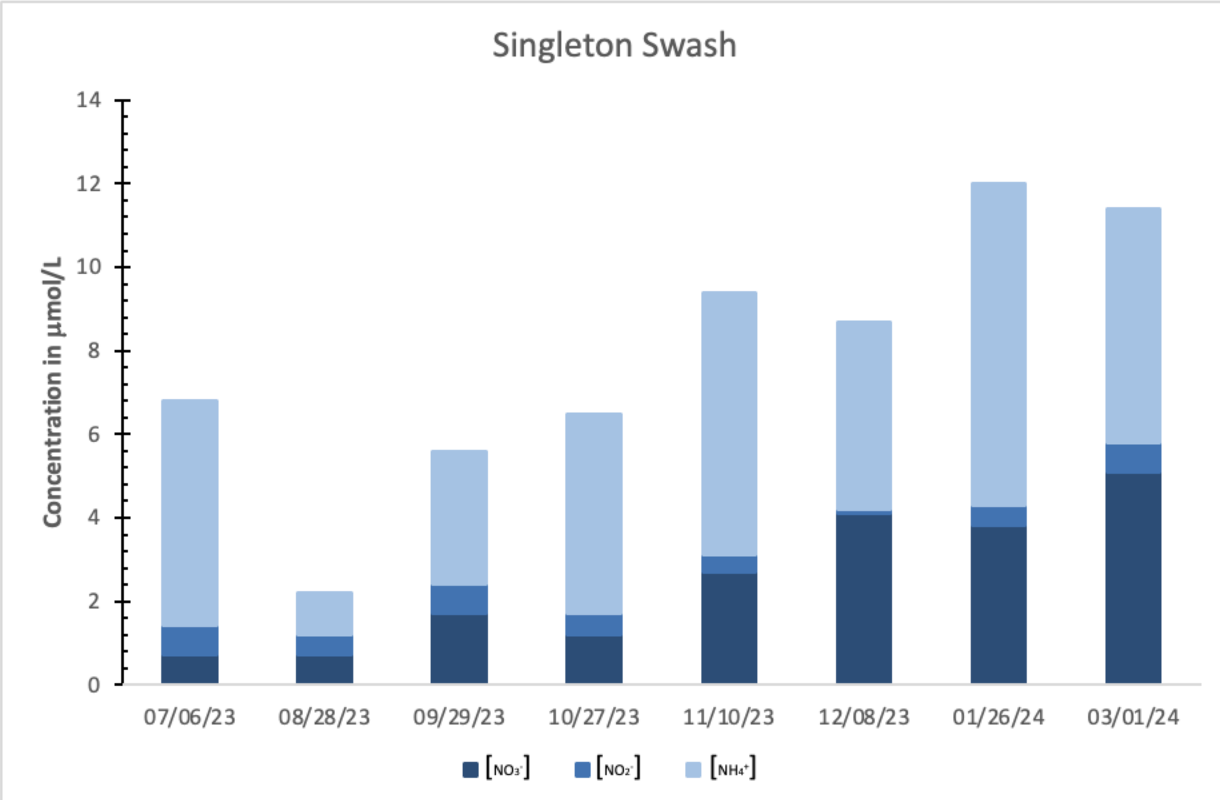

Figure 10 Contribution of each nitrogen species to DIN in Singleton Swash collected across the time period of data collection. Data points are averaged from replicates collected at each site during that date.

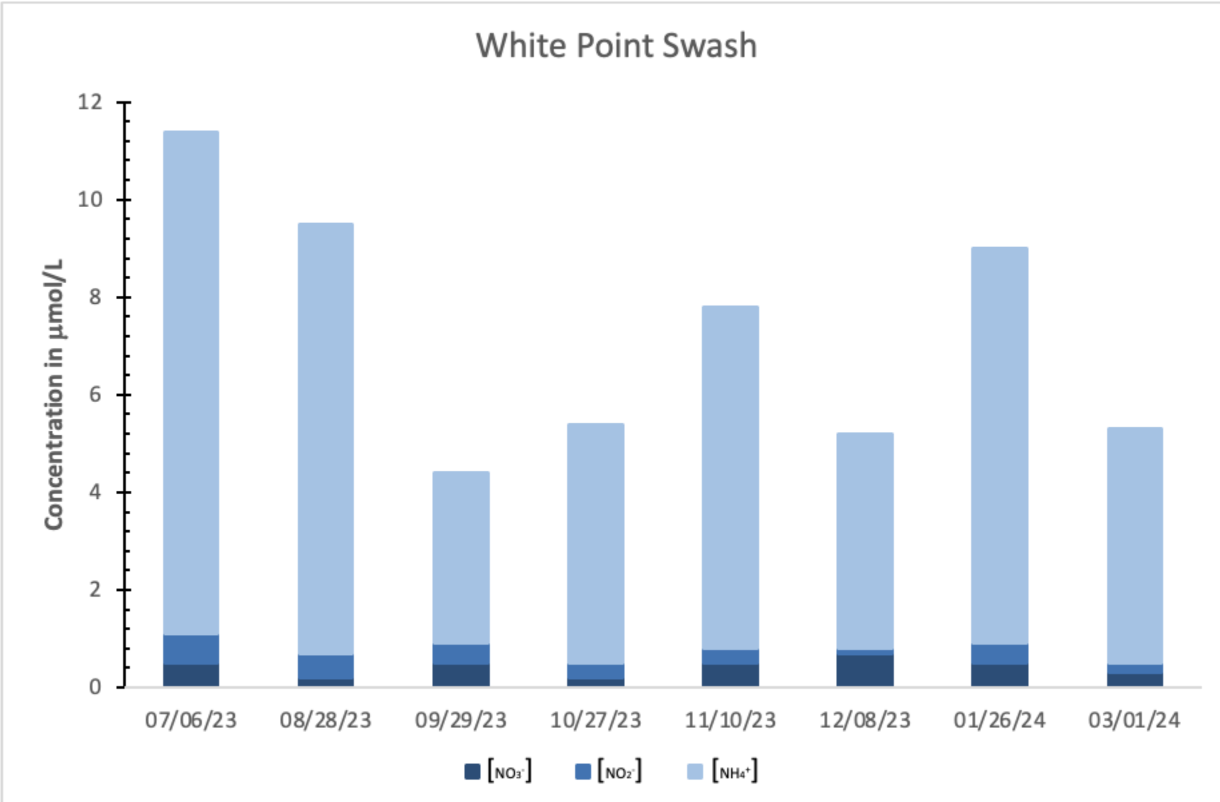

Figure 11 Contribution of each nitrogen species to DIN in White Point Swash collected across the time period of data collection. Data points are averaged from replicates collected at each site during that date.

Discussion

General patternsAll of the sites during the study period (July 2023- March 2024) followed the same general trends:

- Salinities dropped throughout this period, especially at marsh sites,
- Oxygen concentration increased,
- Macronutrient concentrations (DIN, phosphate) dipped in fall 2023,
- Chlorophyll dipped in late fall and winter.

Differences can be summarized as follows:

- Marsh water salinities dropped during the study period much more than beach water,
- Oxygen saturation remained fairly constant around 100 % in beach water, while it increased across marsh sites,
- Beach water macronutrient concentrations were lower than marsh water concentrations,
- Chlorophyll concentrations were highly variable at marsh stations compared to beach water, with Singleton Swash peaking in March 2024,
- Beach water DIN is dominated by the more oxidized forms of nitrate and nitrite, while the most reduced form, ammonium, dominates in the marsh stations. This is expected from the general oxidation conditions of surf-impacted beach water compared to the more stagnant and shallow marsh creek water, which will be under the influence of the reduced sediments underlying it (Hannides et al. 2019).

Next steps

This study identified patterns in the main eutrophication-relevant parameters of oxygen, macronutrients and chlorophyll. Next steps would include the following:

- Continue sample collection throughout a full seasonal cycle over a year,
- Compare the data to estuarine eutrophication standards (Bricker et al. 1999, 2007),
- Conduct further data analysis and research to see what is different between the three marsh stations that may cause similarities and differences between them.

Acknowledgments

I would like to thank Dr. Hannides for his support and contributions to this project. I would also like to thank Christianna Morton for her help in the field. My research was supported with a Gupta College of Science Research Fellows award and the HTC Honors College. Monitoring at White Point Swash and Singleton Swash is partially funded by grants to Dr. Hannides by Horry County, the City of North Myrtle Beach, and the Township of Briarcliffe Acres.

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