Are Climate Change Induced Hurricanes Impacting the Florida Bay Food Web?

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INTRODUCTION/BACKGROUND

The ocean is an important ecosystem due to the dependence on marine life as food for many organisms. However there is one aquatic plant that is the bedrock of the shallow water marine ecosystem, and that is seagrass. Seagrasses provide shelter and food to a variety of aquatic species including small invertebrates, large fish, crabs, turtles, marine mammals and birds *(U.S. Department of Commerce*, 2020*)*. Seagrass thus acts as a focal species for the marine ecosystem which, upon removal, could lead to drastic cascading effects on the aquatic food chain (Figure 1). The increase in hurricane activity as the result of warming waters serves as a potential threat to various species of seagrass that reside in the Atlantic Ocean including turtle grass (*Thallasia testudinum*) and shoal grass (*Halodule wrightii*). Hurricane Theta was identified as the 29th hurricane to hit the East Coast in 2020 alone, marking a record-breaking season of hurricane activity speculated to be the result of increasingly warming waters (Buchanan, 2020*)*. Hurricanes are shown to muddy shallow waters, block sunlight, and uproot plants from the ocean base (Curlett, 2020). It is thus hypothesized that climate change induced hurricanes are leading to a decline in seagrass populations to the point of having detrimental impacts on the shallow water marine ecosystem.

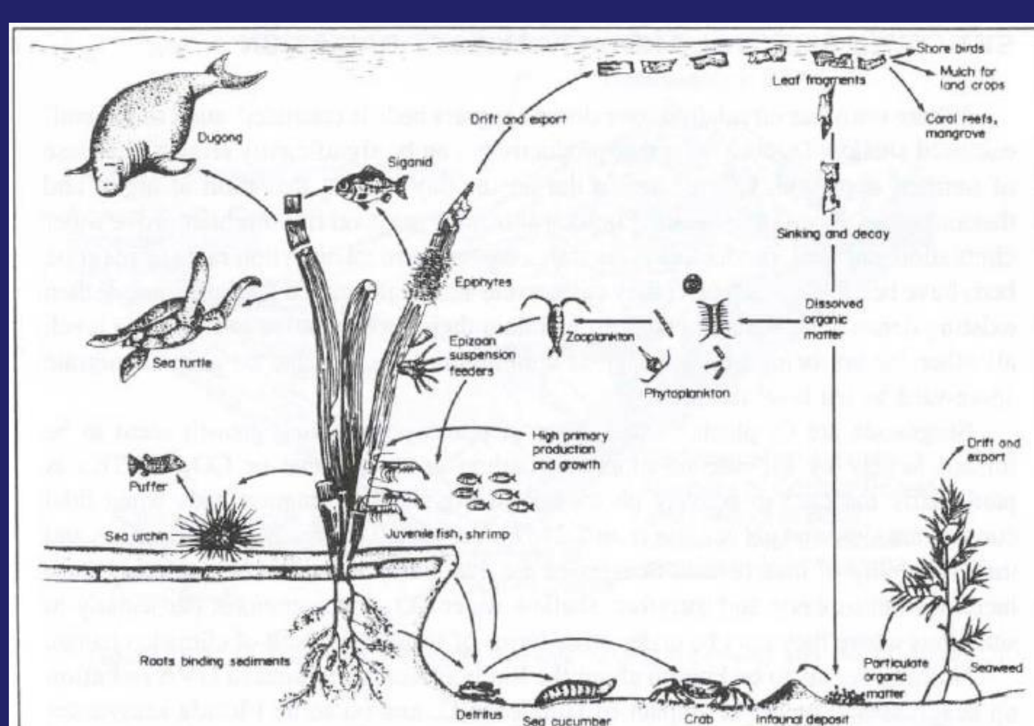

Figure 1. Seagrass serves as a fundamental species in aquatic ecosystems, acting as a food source for turtles and fish, habitat for small invertebrates, and a source of oxygen for aerobic species. Diagram by M.D. Fortes, 1989.

MOTIVATION

Florida Bay is a 2,200km^2 water body that is home to two primary species of seagrass, turtle grass (*Thallasia testudinum*) and shoal grass (*Halodule wrightii*). Florida Bay is a focus point of study as it is home to a diverse array of species including the endangered Florida manatee (*Trichechus manatus latirostris*), sea turtles (*Caretta caretta*), and smalltooth sawfish (*Pristis pectinata*). These endangered species rely on seagrass to perform photosynthesis to oxygenate the aquatic ecosystem, provide refuge from predators and act as a primary food source. Within the last few years, there was recorded to be a decline of 40,000 acres of turtle grass in Florida Bay alone which lead to a cascade effect of declines in populations of consumers including pinfish, mojarra, mullet, and toad fish (*U.S. Department of Interior*, 2015). This rapid decline in turtle grass thus has the potential to cause detrimental impacts to the great variety of species that are heavily reliant on seagrass for their survival. Florida Bay has additionally been a focal point of experiencing the effects of increased hurricane intensity in the Atlantic. We therefore speculate that this drastic decline in seagrass is the result of increased hurricane activity which causes the direct uprooting of seagrass rhizomes from the ocean floor and the burying of seagrass species from displaced sediment (Byron & Heck, 2006). Studying the resiliency of various species of seagrass might lead to new methods of mitigating the impact of hurricanes. Gathering data on species abundance allows us to deduce which species are at a higher risk of extinction and thus efforts can be taken to reduce this risk.

HYPOTHESIS

It is hypothesized that there is a relationship between increased hurricane activity and the abundance of seagrass which acts as a focal species for the marine food web.

PREDICTIONS

We predict that the frequency of hurricanes will have an impact on the abundance of seagrass species and therefore impact the health of shallow water ecosystems. The more hurricanes occurring in a season and the more intense the storms are, the lower recorded seagrass abundance. Lowered seagrass populations will decrease habitat health since many organisms depend on these seagrass species. We predict that turtle grass will be the most resilient species of seagrass, as it will be able to withstand hurricane-caused trauma. Due to its deep root structures, this species is less likely to be ripped up by changing currents or debris carried back out to sea. Similarly, the shoal grass will be the least resilient in its ability to withstand hurricane damage as it has a shallower root system (Reynolds, 2018). In addition to damage caused by uprooting, we believe increased dirt and debris swept up by the ocean will also harm the seagrass populations. Seagrasses depend on light for photosynthesis, and thus, light availability limits the areas in which they can grow (*NOAA*, 2020). When more hurricanes cause an increased amount of damage on land, and sweep the trash and debris from this damage into the ocean, less light will reach the ocean floor and limit seagrass attempting to grow there. This is another reason we believe the turtle grass will be more resilient. Its deeper root system allows this species to grow taller and would help it reach more sunlight than some of the shorter species that would struggle to gain enough light in cloudier, debris-filled waters. While turtle grass is less likely to be damaged, it also shows slower recovery. shoal grass, on the other hand, is a colonizer species and, while less resilient, will repopulate an area at a faster rate. This will give shoal grass a more rapid decline and recovery than turtle grass (Reynolds, 2018; Figure 2). Both species are likely to decline during the months of May through November, as this is the typical hurricane season.

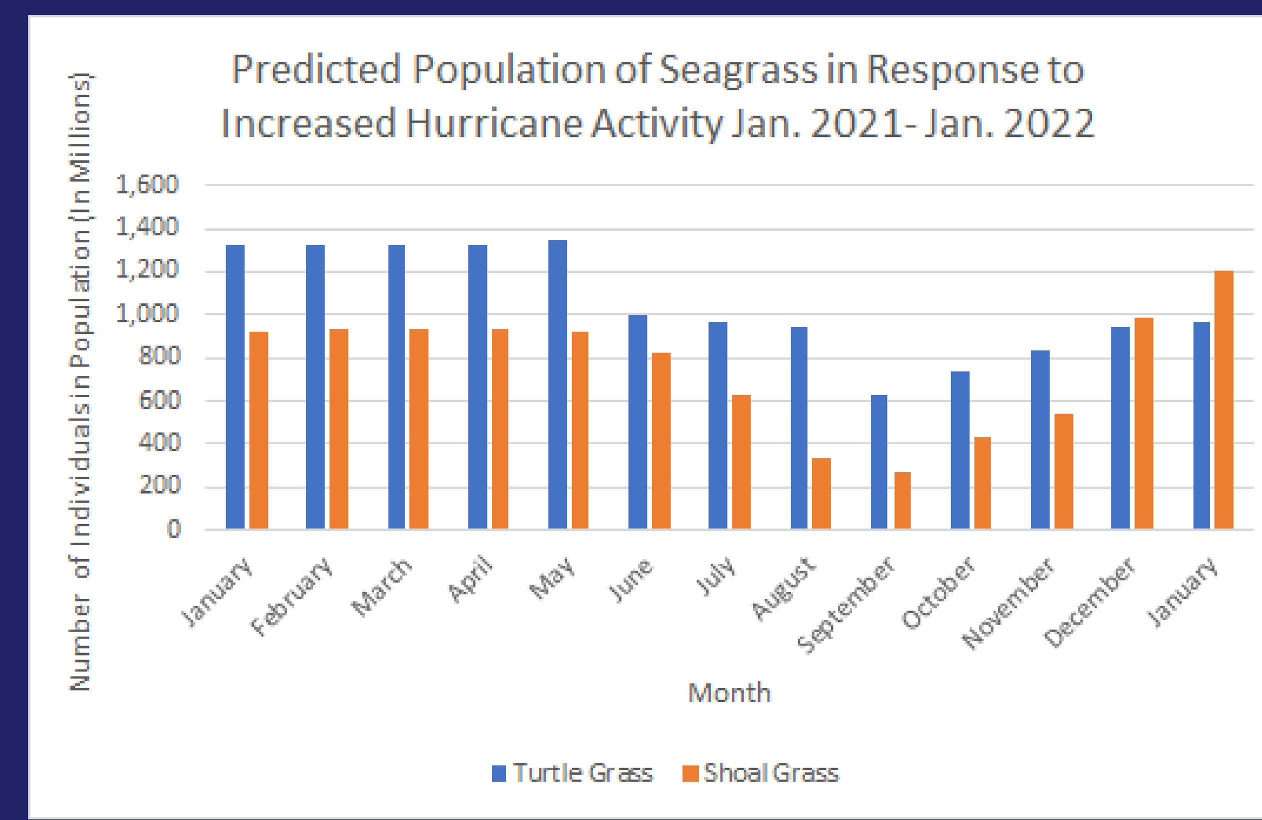

Figure 2. Predicted response of two species of seagrass populations shoal grass (*Halodule beaudettei)* and turtle grass (*Thalassia testudinum)* to hurricane activity from January 2021-January 2022. Population abundance will be measured using a quadrat system and determining how many individuals of each species are present in a given .5m x .5m quadrat plot.

EXPERIMENTAL DESIGN

Utilizing an aerial view of Florida Bay, we will randomly select 50 points using Google Earth Engine (Figure 3). Each waypoint will be navigated to by scuba divers where a .25m^2 quadrat will be placed (Figure 4). The number of shoots of each species present (*Thallasia testudinum* and *Halodule wrightii)* within each quadrat will be recorded and utilized to derive the species density and resulting population size using the equation: N (population size) = Density x 2,200km^2(Area of Florida Bay). This process will be repeated once each month for a year, from Jan. 2021 – Jan. 2022 using the same coordinates as the sampling points.

To monitor storm surges in the Florida Bay region, we plan to partner with the U.S Geological Survey (USGS). The USGS has placed 125 storm-tide sensors along the coast of Florida from which wave height, and storm tide duration are updated every 30 seconds (*USGS*, 2019). The collected data is then made available in real time to the public through the USGS Flood Event Viewer. We will utilize the available data to record hurricane activity in Florida Bay from Jan. 2021- Jan. 2022. We will then overlay this data with the resulting seagrass population data to serve as an indicator of whether the active hurricane season months show a significant decline in the two species of seagrass.

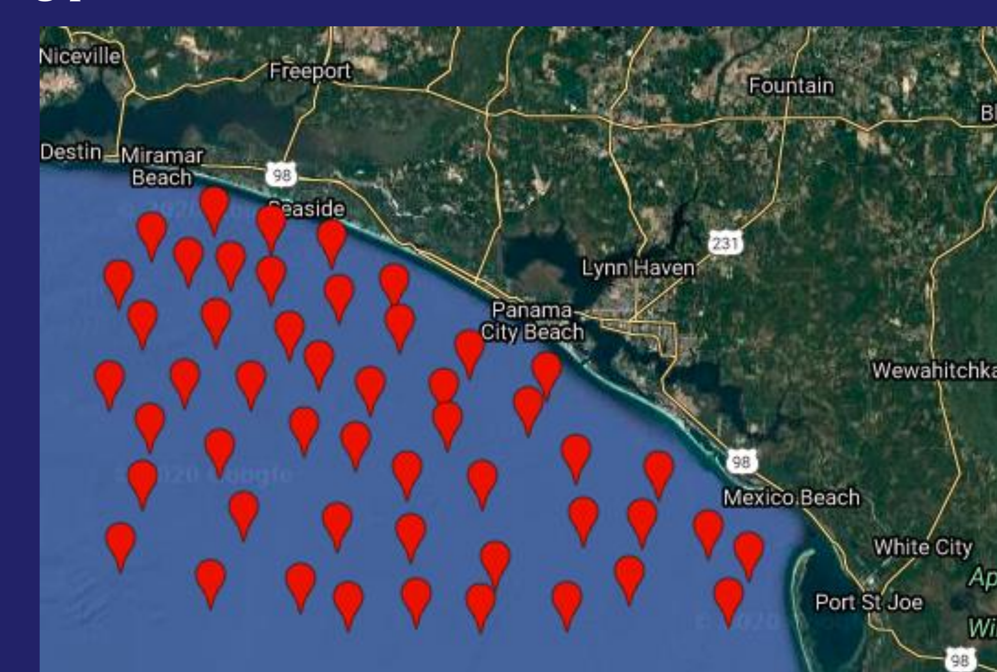

Figure 3. 50 sampling waypoints will be randomly generated using Google Earth Engine.

Figure 4. A .25m^2 quadrat will be used at each coordinate to determine the seagrass density and ultimately calculate the estimated population size of each seagrass species in Florida Bay. Photo by *Solutions to Avoid Red Tide – START*, 2017

INTENDED ANALYSIS

The independent variables, month of the year and seagrass species, are categorical variables while the dependent variable, the population size of seagrass, is continuous. Upon data collection and analysis, we will utilize a two-way Analysis of Variance (ANOVA) as our experiment involved two categorical independent variables (Months and Seagrass Species). Utilizing this form of analysis, we will be able to deduce whether months of statistically higher hurricane activity show a negative correlation with the population of seagrass in Florida Bay. This will also allow us to gather data on the resiliency of turtle grass in comparison to shoal grass and their population declines and rebounds. Our analysis will be limited to the Florida Bay area and thus will not be representative of the entire population of seagrasses on the coast of Florida. Florida Bay is an extensive water mass and thus is subdivided into regions from which we will be randomly collecting samples. Thus, we will have data from Catfish Key Basin, Johnson Key Basin, Pelican Key Basin, Whipray Basin, Sid Key Basin, Rabbit Key Basin, Twin Key Basin, Rankin Lake, Buoy Key, Garfield Bight, Rankin Bight, and Santini Bight *(U.S Department of Interior*, 2015*)*.

EXPECTED BENEFITS

This research will give us better insight as to which seagrass species are more resilient. This can help us make a plan to protect some of the more vulnerable species, or help us choose a species which is most likely to be successful should we find the need to replant large populations of seagrass. This research will also give us a better overall understanding of shallow water ecosystems in the Florida Bay area. Our data collected on seagrass abundance and hurricane frequency/intensity can be used by researchers studying other species and aspects of shallow water ecosystems on the Florida coast to learn more about this environment's food web and interconnected species. It will also help raise awareness of the importance of minimizing climate change impacts in order to prevent more intense hurricanes and maintain healthy shallow water ecosystems. It will help motivate more individuals to lessen their impact on the environment and gain a stronger understanding of the consequences our actions have. Our study will help us gain crucial knowledge while inspiring further research and discoveries.

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