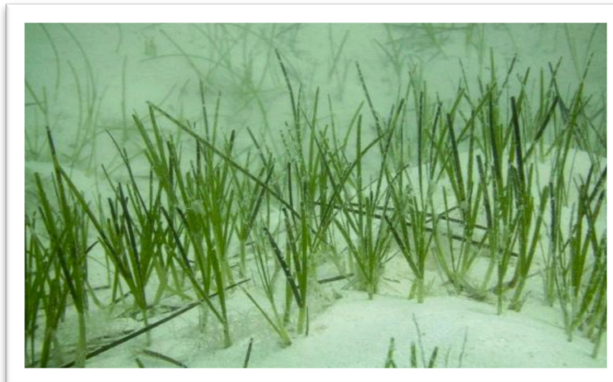
Seagrass Health in Texas

A Comprehensive Monitoring Program

Harte Institute



Florida Museum of Natural History

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Introduction

Seagrasses are one of the most productive ecosystems in the world. Seagrass beds provide many ecosystem services that are valued at $47,000 per acre per year (Constanza et al. 1999). Seagrasses stabilize the shoreline, are places of intense nutrient cycling, and act as a "natural" water treatment facility by removing excess nutrients and heavy metals form the water. In addition, seagrass beds serve as vital habitat and nursery grounds for many species of commercially important fish, crab and shrimp.

Light is the limiting growth factor for seagrasses, and seagrasses require about 25% of the surface irradiance in order to maintain healthy levels of photosynthesis (Dunton et al. 2005). The two major threats to light availability are nutrient loading, which can lead to light absorbing algal blooms, and sediment loading, which can suspend light absorbing particles in the water column. Algal blooms are often caused by excess nitrogen that can enter the system through sewage discharge points or from agricultural and residential fertilizer runoff. Sediment loading is most often caused by erosion, excess impervious cover and deforestation that occur in the watershed upstream of bay or estuary in question. In order to maintain healthy seagrass beds, both nutrient and suspended particle concentrations should be monitored, so that the growth of the seagrass beds is not compromised with insufficient light levels.

In Texas alone, there are over 235,000 acres of seagrass beds (TWPD 1999). These beds not only provide Texas with the ecosystem services previously mentioned, but they also support many fisheries, which provide Texans with jobs. It is in the best interest of the state to maintain healthy seagrass beds; therefore, in 1999, Texas Parks and Wildlife (TPWD) published the

Seagrass Conservation Plan, which calls for a comprehensive monitoring program of over 94% of the state's seagrass beds. In this report, preliminary results are analyzed using ArcGIS for both the Mission Aransas and Corpus Christi Bay seagrass beds.

Study Area

The monitoring program includes over 500 sampling sites in four estuaries: Mission Aransas, Corpus Christi Bay, Upper Laguna Madre and Lower Laguna Madre. These estuaries are characterized by warm, shallow bays that are protected by barrier islands. There are five native Texas seagrass species (*Halodule wrightii, Ruppia maritima, Thalassia testudinum, Syringodium filiforme, and Halophila engelmanii*). In this report, only data from the Mission Aransas and Corpus Christi Bay (Figure 1) are analyzed due to time constraints on data processing.

Methods

Each site was surveyed between August and October of 2011 by a group of graduate research assistants in Dr. Ken Dunton's lab from the Marine Science Institute in Port Aransas, TX. Many biotic and abiotic parameters were measured at each site (Table 1). Not all sites were deep enough to record two light measurements; therefore, light attenuation and percent surface irradiance reflect only the sites deep enough to record two measurements. Light attenuation k values were calculated using the Beer Lambert equation $k = (-\ln(I_z/I_o))/z$, where I_z is the light reading at depth, I_o is the light reading at the surface, and z is the distance between the two sensors in centimeters.

The available data was analyzed using ArcMap 10, and the data was projected in the NAD 1983 coordinate system. A model was built to automate the interpolation of the data (Figure 2). Kriging was the preferred method of interpolation because it yielded the least amount of variance. The interpolations were clipped using the tool, extract by mask, based on a National Hydrography Dataset shape file of both the estuaries.

Results

Abiotic Factors

The Mission Aransas and Corpus Christi Bay estuaries were both shallow and hypersaline (Figures 3 & 4). Salinity increased as you moved south along the coast, and the further you move away from the sites of freshwater inflow. Most of Corpus Christi Bay and parts of the Mission Aransas Estuary were more saline than average ocean water (psu> 35). These bays received little to no freshwater input and experienced extremely high levels of evaporation due to the severe drought in Texas during sampling. All depths within both estuaries were less than 1 meter, which is ideal for seagrass beds since theoretically light should be able to penetrate the full extent of the water column.

The surface water temperature was fairly hot and constant throughout both estuaries ranging from 24 to 36 degrees Celsius (Figure 5). The southern end of Corpus Christi Bay was the hottest area with a maximum temperature of 35.7 degrees Celsius. Temperature data can vary temporally based on the weather of the day sampled and the time of day sampled, therefore, there were probably not significant differences in temperature throughout the two estuaries.

The highest levels of dissolved oxygen were found in the area between Rockport and Ingleside (Figure 6). The oxygen concentrations were lowest in the southern most portion of Corpus Christi Bay. Oxygen production is a sign of a healthy ecosystem and high primary productivity, suggesting healthy seagrass beds.

The pH of both estuaries ranged from just above neutral at 7.18 to slightly basic at 8.53 (Figure 7). pH increased the further south you move and the closer you are to the ocean, since average ocean pH is about 8. 1

Surface light meter readings were taken at every site. Generally, surface light values decreased as you moved south down the coast (Figure 8). Corpus Christi Bay had the lowest light values, while the area between Rockport and Aransas Pass had the highest value of surface light. Since surface light readings vary temporally, it is better to compare the amount of light available to different seagrass beds by looking at % surface irradiance and light attenuation values. These two metrics take into account the clarity of the water, and give a more accurate representation of how much light the seagrass beds are receiving, which is the most critical aspect of the light measurements. The % surface irradiance and light attenuation values were limited since they only reflected data from 33 of the 138 sites sampled due to depth limitations.

The seagrass beds in the Mission Aransas estuary received less light than the seagrass beds in Corpus Christi Bay according to % surface irradiance (Figure 9). The fraction of surface irradiance that penetrated to depth ranged from .66 to .82 for the majority of the northern potion of the study area, while the southern seagrass beds received .83 to .89 of the total surface irradiance. The light values were highest for the area between Aransas Pass and Ingleside.

Highest light attenuation was recorded near the mouth of Corpus Chirsti Bay, while the lowest levels of light attenuation were recorded farther inland (Figure 10). K values below .69 have been determined to be ideal for seagrass growth (Dunton et al 2005). Therefore, the areas represented in dark and light green should have theoretically been the areas with clear enough water to support healthy seagrass beds.

Chlorophyll a is a good metric to estimate the amount of phytoplankton or algae in the water, which is in turn a good metric to estimate how much nutrient loading, especially nitrogen loading, is affecting the water column. Chorophyll a concentrations were highest in the southern portion of Corpus Christi Bay and just off the coast of Rockport (Figure 11). Chorophyll a absorbs light, therefore, reducing the amount of light available to the seagrass beds below. Even though these measurements do not measure light directly, they can be used to estimate the amount of light available to the seagrass beds. Areas with high chlorophyll a concentrations should have low light availability, while areas with low chlorophyll a concentrations should have high light availability. These estimates are assuming that there is not extensive sediment loading or other factors reducing light availability.

Biotic Factors

The dominant seagrass species were determined for each site (Figure 12). *Haoldule wrightii* (shoal grass) was the dominant species, especially in the sites near the barrier islands. *Thalassia testidinum* (turtle grass) was the second most dominant species, and it was found closer to the shore. There were also several sampling sites without at least 50% seagrass cover, and those sites were classified as bare.

Canopy height was highest in the areas closest to the shore (Figure 13). The canopy height values ranged from 13 centimeters, which was recorded in the southern most part of Corpus Christi Bay to 40 centimeters, which was recorded off the coast of Ingleside. Greater values for canopy height do not necessarily mean healthier seagrass beds, since each of the five species present have different average canopy heights. Despite the differences between species, low values for canopy heights could represent damage from boat scarring or low growth and productivity.

The percent cover of seagrass beds increased as you moved farther from the areas of freshwater inflow (Figure 14). Nutrients and sediment particles, which are transported to estuaries through freshwater inputs, absorb light. If nutrient and suspended sediment concentrations are higher near their source at freshwater inputs, then this might explain why percent cover increased with increased distance from those freshwater inputs. The area within Corpus Christi Bay had the lowest levels of percent cover, which could be a result of runoff from the highly urbanized area surrounding the bay. Overall, the area ranging from Rockport to the mouth of Corpus Christi Bay tended to have the highest percent cover ranging from 66% to 100% cover.

Discussion

Using the percent cover data and assuming that higher levels of percent cover reflect healthier seagrass beds, it appears that the healthiest beds were between Rockport and the mouth of Corpus Christi Bay. It would be expected that these areas of high percent cover would correlate to the areas of highest % surface irradiance and lowest light attenuation k values, if light were indeed the limiting factor in seagrass growth. Using the maps generated in this report, it is difficult to make that correlation. For instance, k values were very high at the mouth of Corpus Christi Bay, yet that was one of the areas with almost 100% seagrass cover. Also, it would be expected that the maps of % surface irradiance and light attenuation values would show very similar pictures. Where % surface irradiance is high, light attenuation coefficients should be low, yet the maps contain many sites where those data points seem to be conflicting. These conflicting characterizations of the light availability suggest that the limited data set used to generate the interpolations was not adequate.

The chlorophyll a concentration map appeared to correlate more closely to the percent cover map than the light reading maps did. Where chlorophyll a concentrations are high, the percent seagrass cover was low; therefore, chlorophyll a concentrations could be a good metric to use to predict seagrass health. Since higher chlorophyll a concentrations reduce % surface irradiance and would increase k values, it would be expected that the chlorophyll a maps would match up with the light maps, which did not happen in this study. Since the chlorophyll a values reflect the light availability, light still may be the limiting factor in seagrass growth, but perhaps there are additional parameters, which have not yet been processed, that also limit seagrass growth.

The next step in this analysis is to incorporate the remaining parameters once they have been processed. This additional data may contain information about additional factors limiting or promoting seagrass growth other than light availability. Once the Mission Aransas and Corpus Christi Bay Estuaries are complete, then the remaining 480 sampling sites from both the Upper and Lower Laguna Madre Estuaries should be analyzed as well. Once all the parameters and study sites have been analyzed, there should be a clearer picture of seagrass health along the entirety of the Texas Coast. If indeed, light does prove to be the limiting factor as hypothesized, it will be imperative to keep a close watch on both chlorophyll a and total suspended solids concentrations to ensure high levels of light availability for the seagrasses. In order to provide more accurate light profiles, new methods should be developed, which allow two light readings to be taken at every site. This improvement in data collection would increase the accuracy of the interpolations for both the light attenuation values and the % surface irradiance, and in turn result is a more accurate characterization of the light available to the seagrass beds. At this point in the analysis, conclusive results about the health of seagrass beds cannot be made since all the parameters have yet to be analyzed and the light data has not proved to be reliable.

Literature Cited

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R.G., Sutton, P. & van den Belt, M. 1997. The value of the worlds ecosystem services and natural capital. Nature, 287, 253-260.

Dunton, K.H., Kopecky, A.L., & Maidment, D. 2005. Monitoring design criteria and biological indicators for seagrass conservation in Texas coastal waters. Final report for regional environmental monitoring and assessment program, EPA.

Texas Parks and Wildlife (TWPD). 1999. Seagrass conservation plan for Texas. TPWD: Resource Protection Division, Austin, TX, USA.

Figures

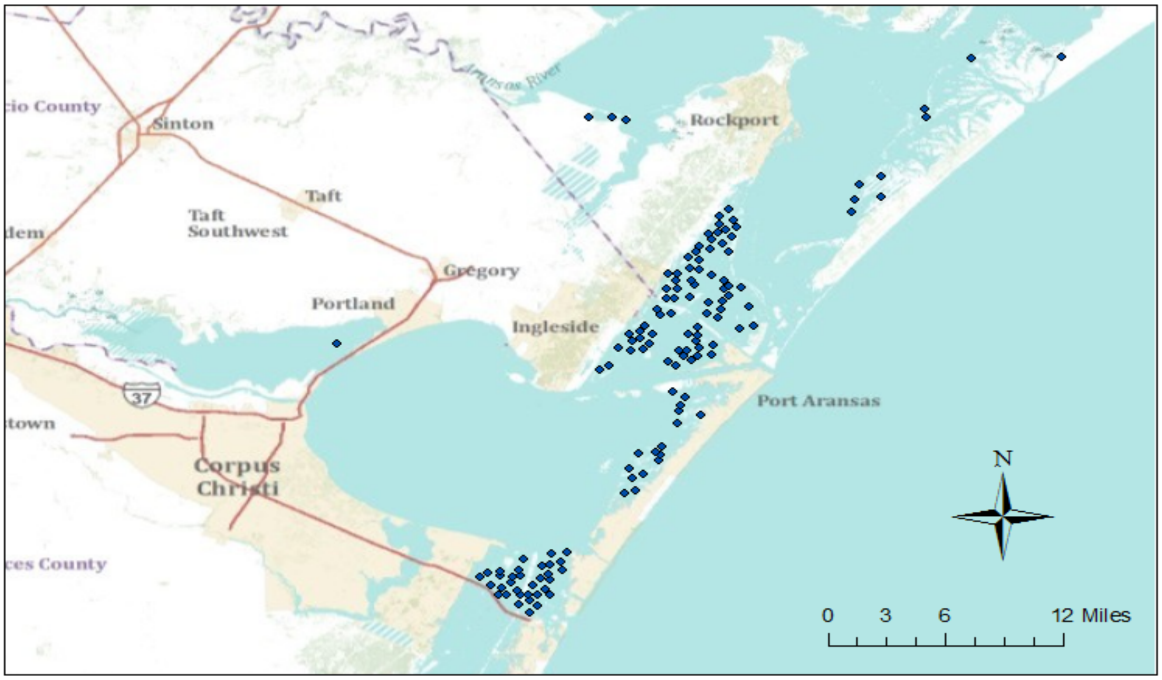


Figure 1: Sampling Sites in Mission Aransas and Corpus Christi Bay estuaries.

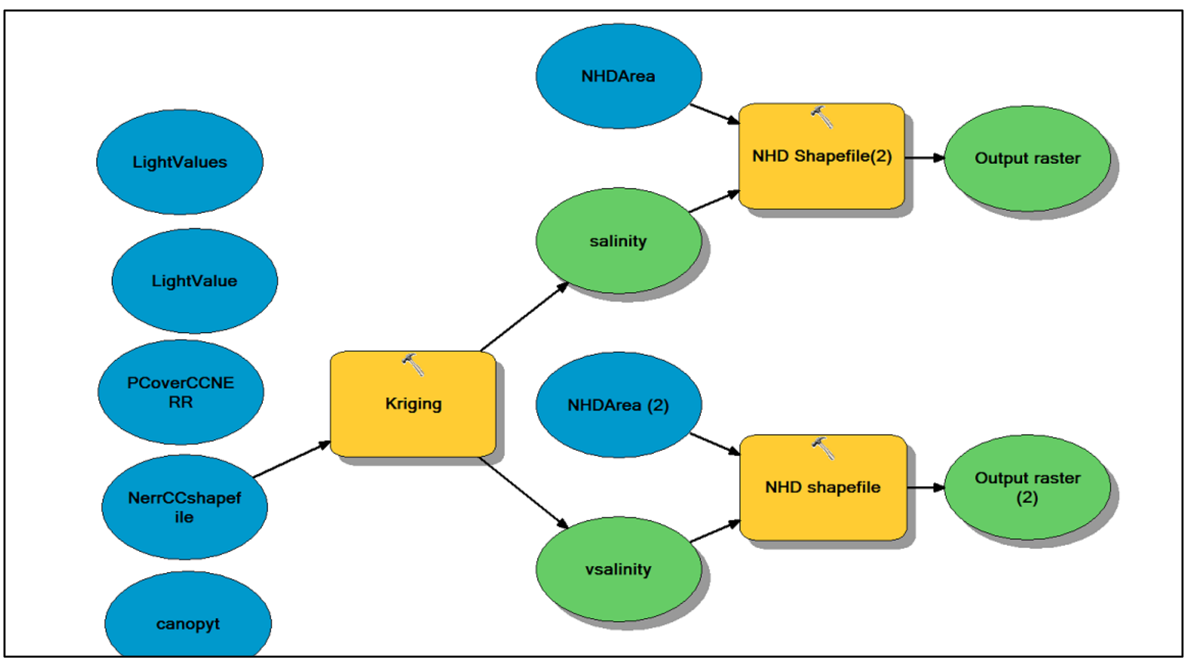


Figure 2: Geoprocessing model built using model builder to perform interpolations of all measured parameters.

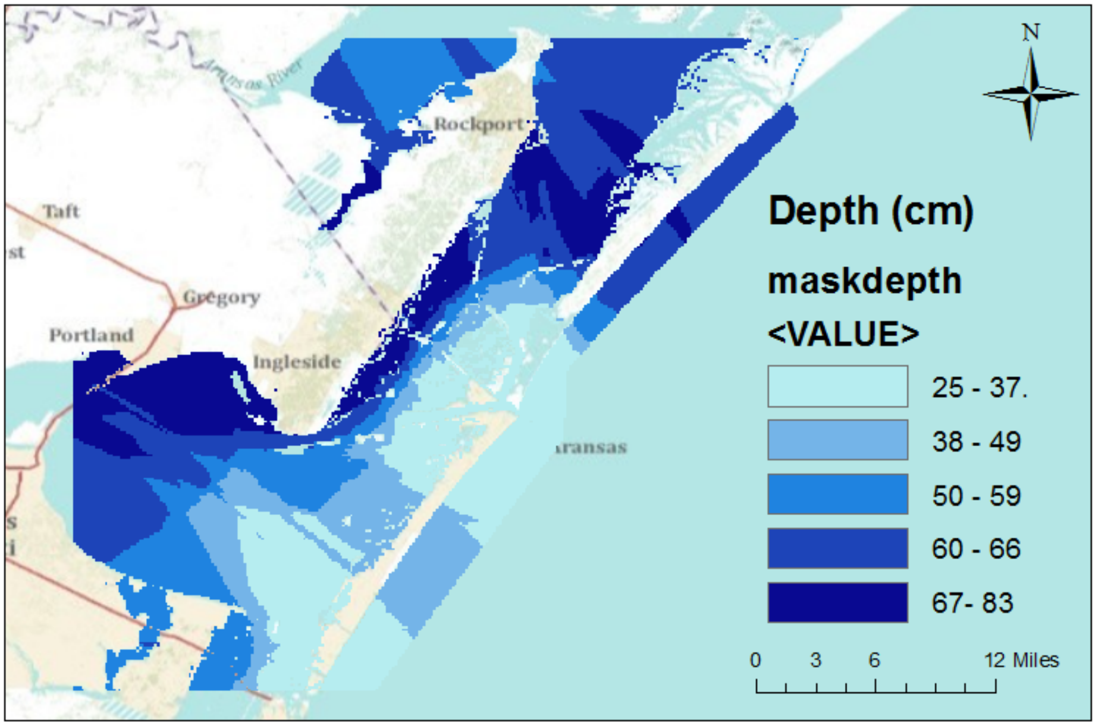


Figure 3: Interpolation of depth (cm).

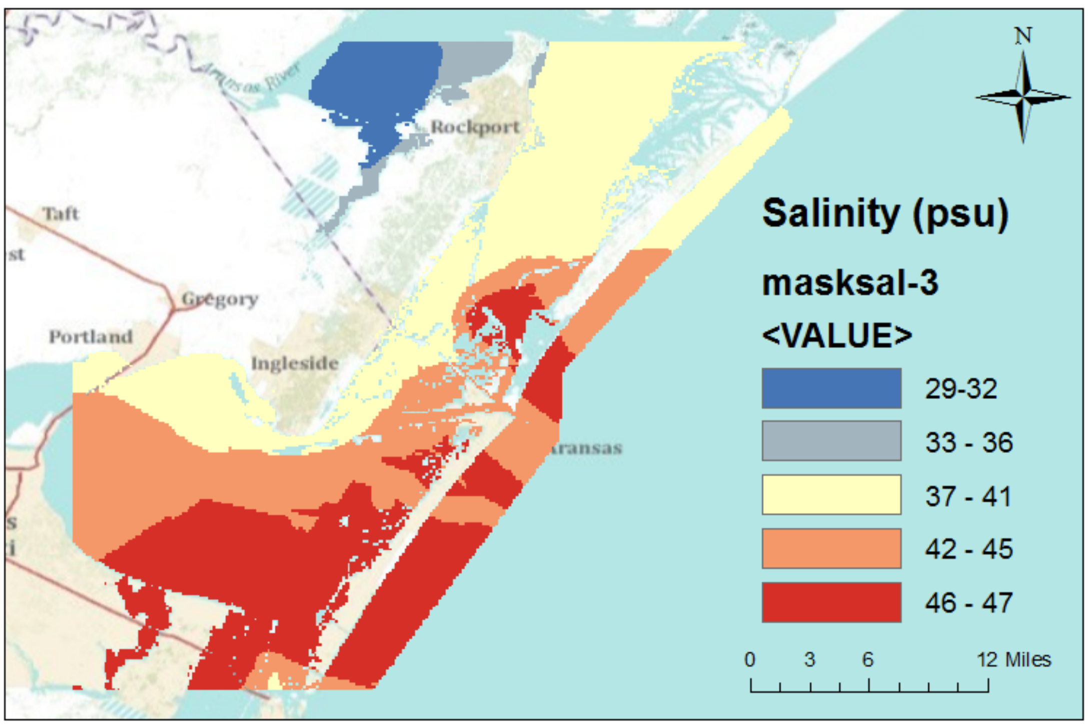


Figure 4: Interpolation of salinity (psu).

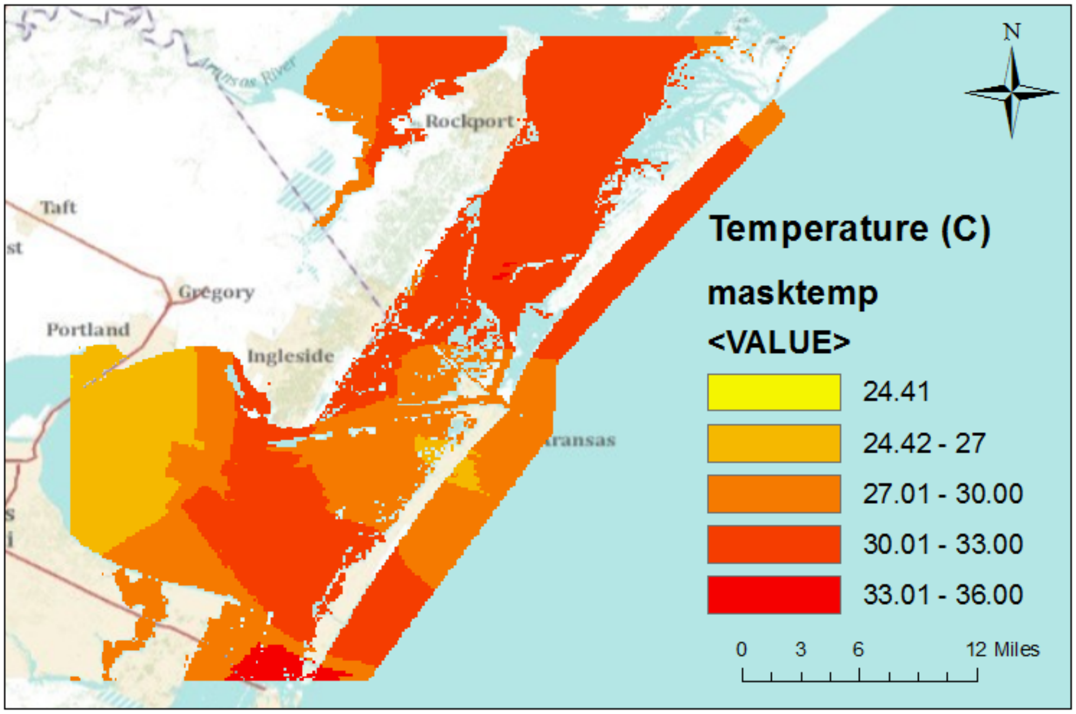


Figure 5: Interpolation of temperature (C).

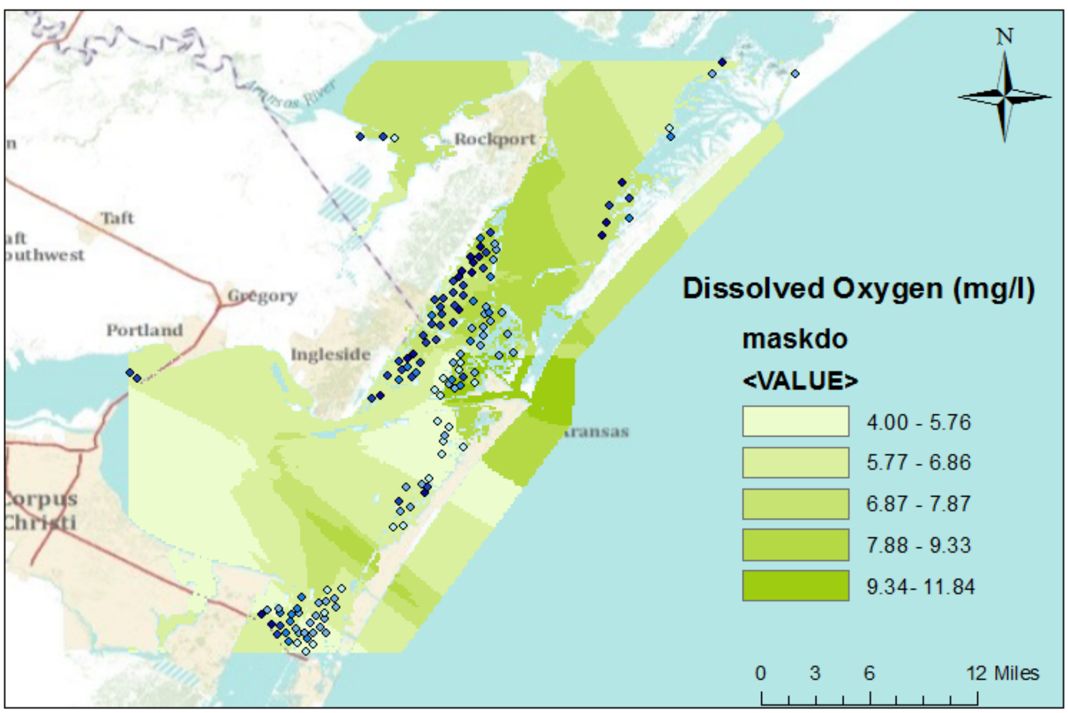


Figure 6: Interpolation of dissolved oxygen (mg/l).

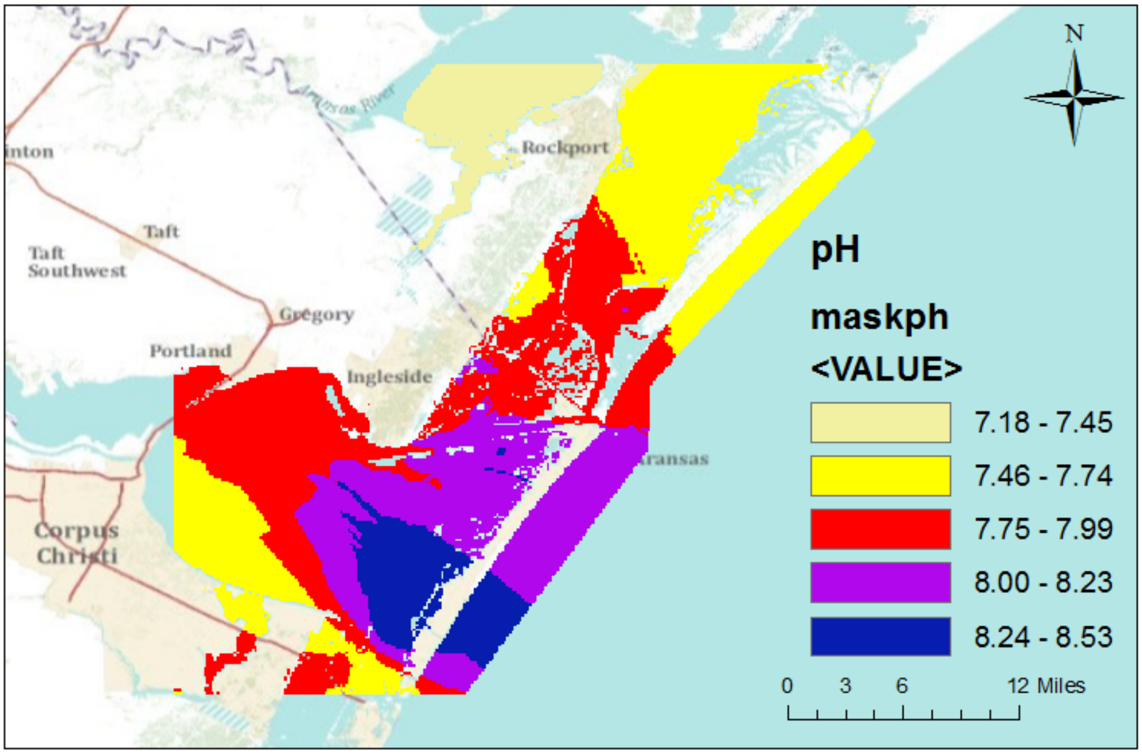


Figure 7: Interpolation of pH.

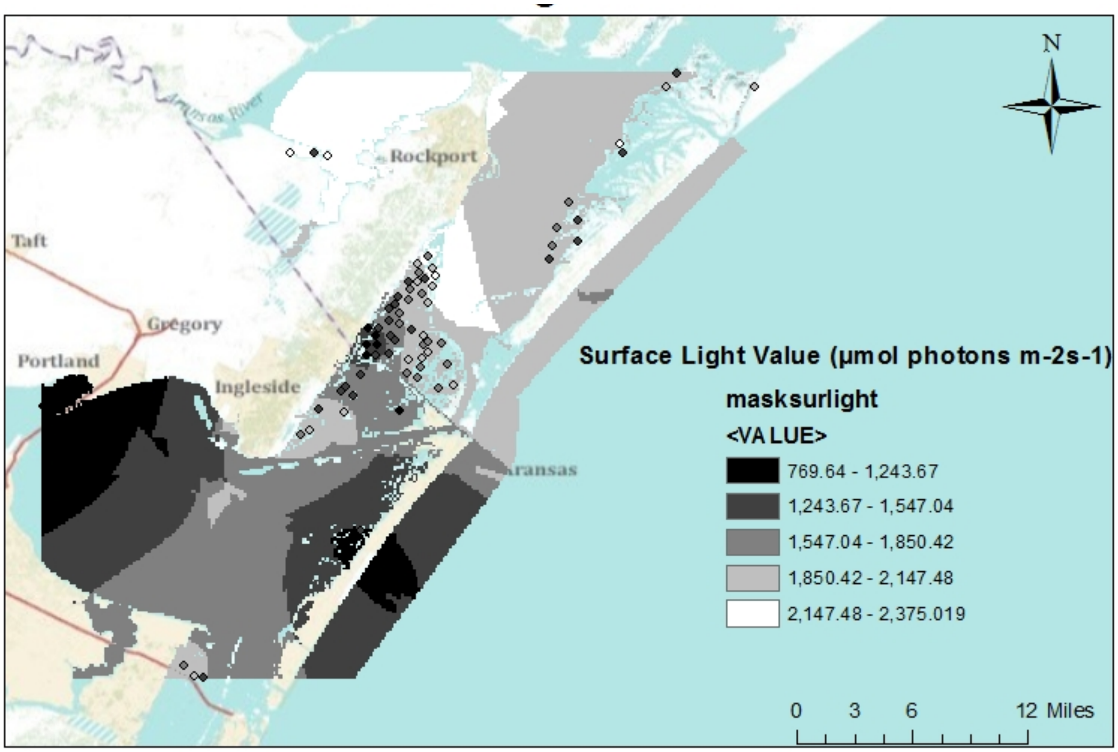


Figure 8: Interpolation of surface light values (um of photons m-2s-1)

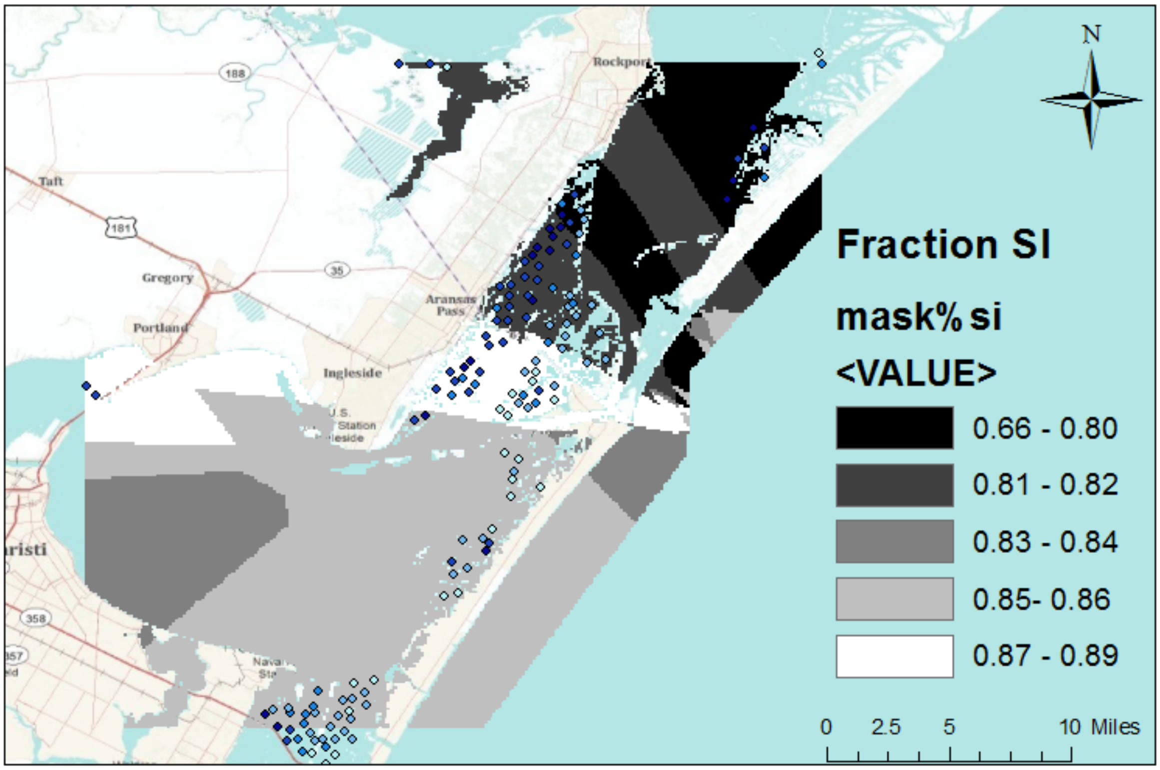


Figure 9: Interpolation of % surface irradiance.

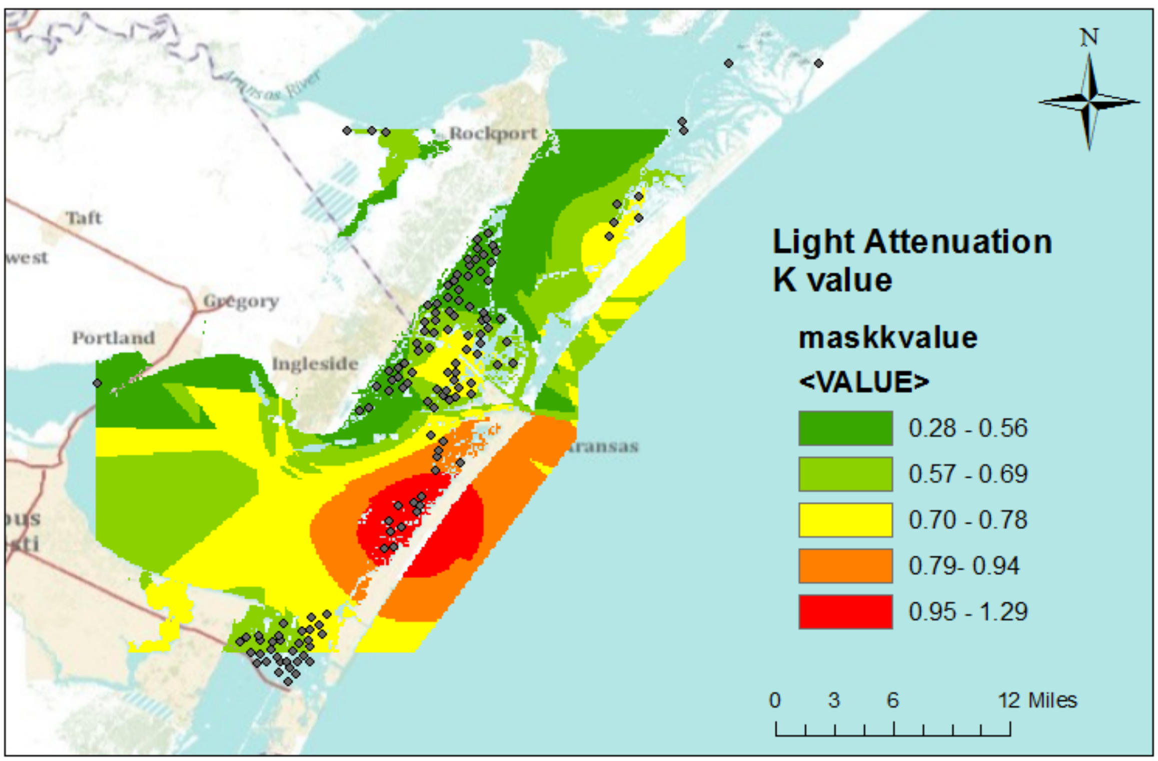
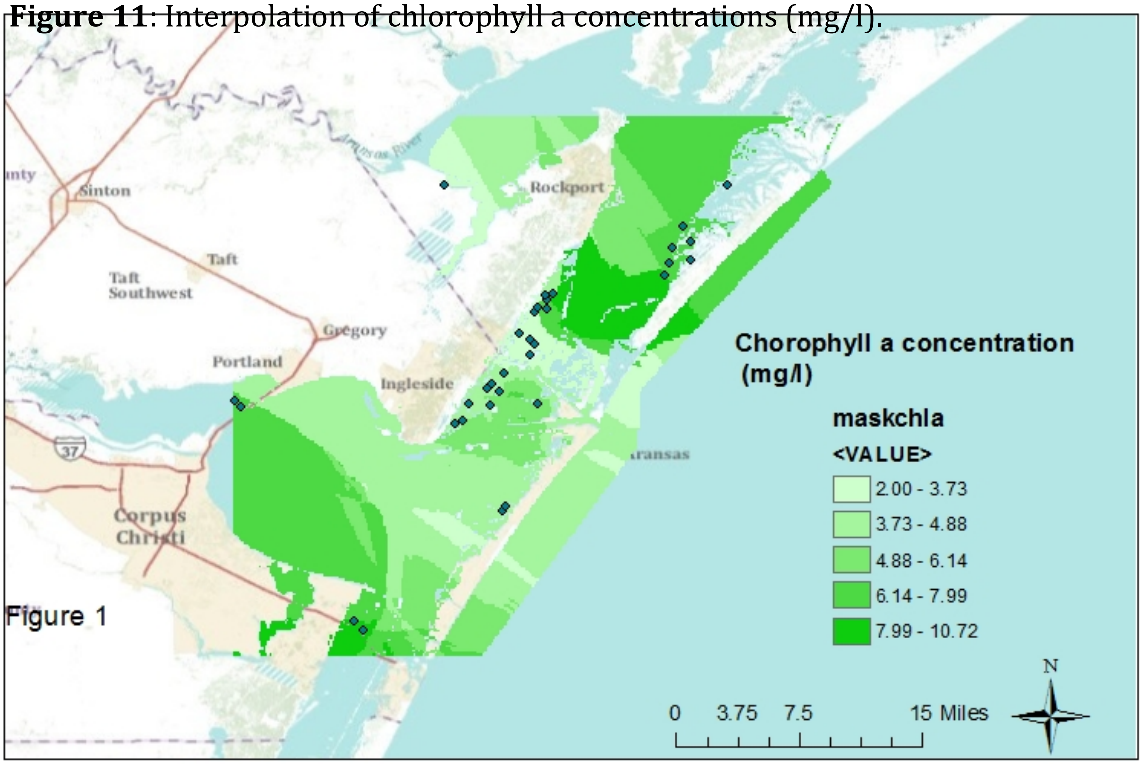


Figure 10: Interpolation of light attenuation k values (m-1).

Figure 11: Interpolation of chlorophyll a concentrations (mg/l).



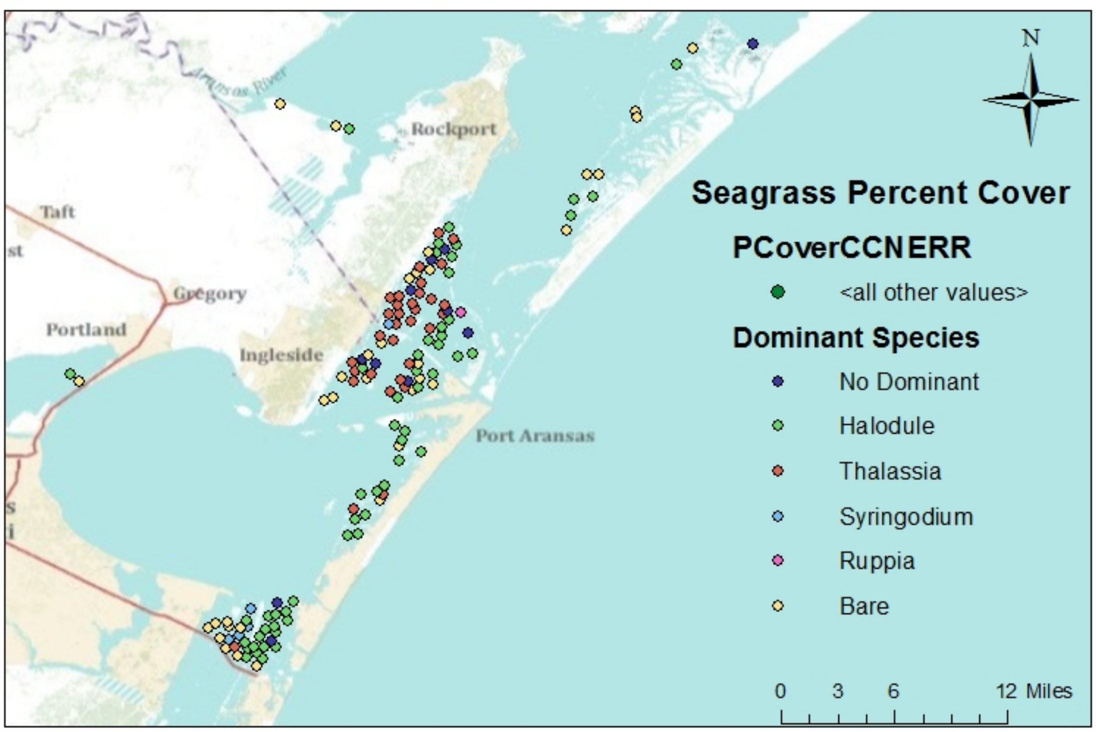


Figure 12: Dominant species (% cover> 50%) listed by sampling site.

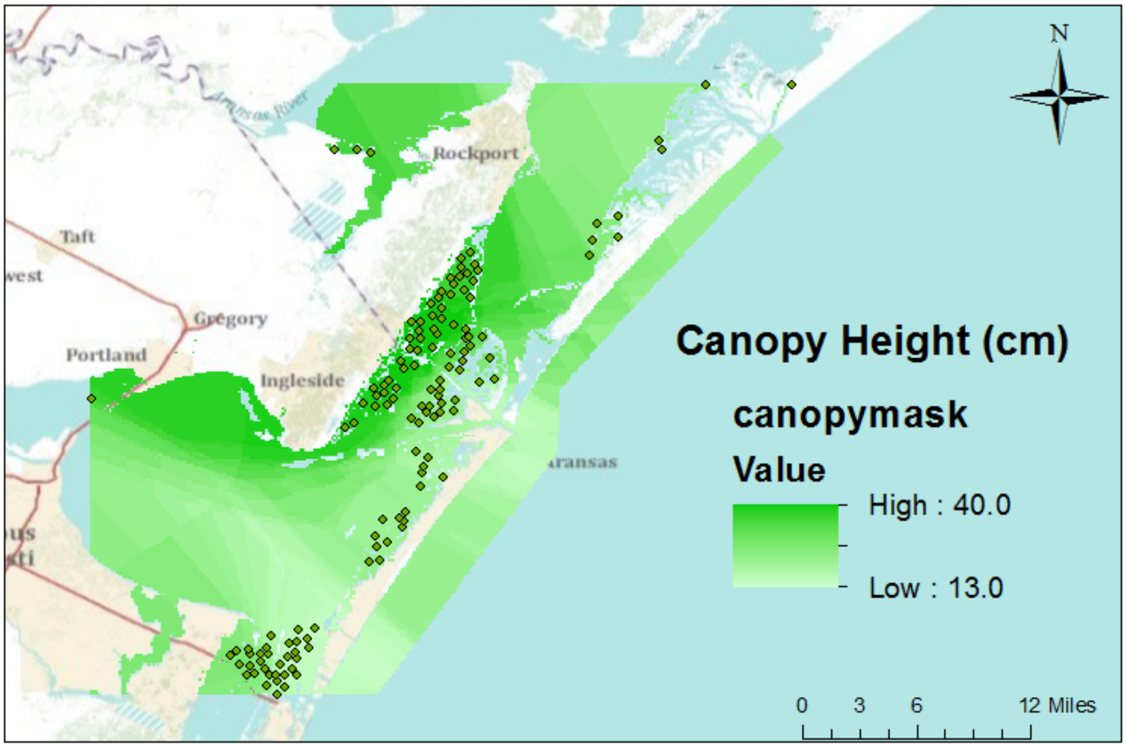


Figure 13: Interpolation of canopy height (cm).

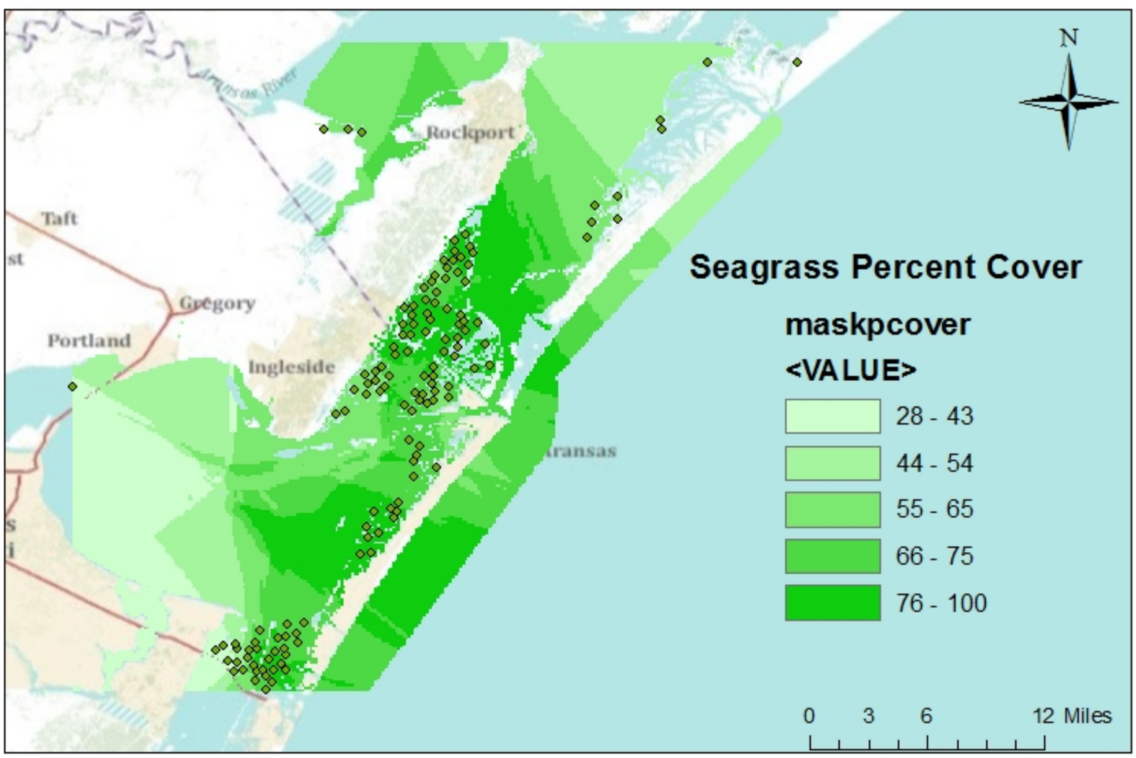


Figure 14: Interpolation of percent cover.

Table

Abiotic Factors	Biotic Factors
Salinity	**Percent Cover**
Temperature	**Species Composition**
Light	**Canopy Height**
pH	Seagrass Biomass
Surface Irradiance	Root:Shoot Ratios
% Surface Irradiance	Shoot Density
Chlorophyll a	
Light Attenuation	
Dissolved Oxygen	
Total Suspended Solids (TSS)	
Ammonium	
Nitrates	
Stable Isotope Analysis	

Table 1: Abiotic and biotic parameters measured at all sites. Bolded parameters were processed and ready in for analysis in this report.