Which environmental parameter is the best predictor of seagrass cover?

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# TABLE OF CONTENTS

1.0 Introduction .......................... 1  
  1.1 Problem Formulation ................. 2  
2.0 Methods ................................ 3  
  2.1 Data Collection ....................... 3  
  2.2 Data Processing ....................... 3  
  2.3 ArcGIS Processing .................... 3  
3.0 Results & Discussion ................ 7  
  3.1 Temperature OLS ..................... 7  
  3.2 Salinity OLS ......................... 8  
  3.3 PH OLS ................................ 8  
  3.4 Chlorophyll a OLS ................. 9  
  3.5 Comparing R-squ .................... 10  
  3.6 Discussion ......................... 11  
4.0 Data Presentation ................... 13  
5.0 References ......................... 17
1.0 INTRODUCTION

Seagrass is a fully submerged angiosperm that is found in shallow parts of the sea, typically in bays and near coastlines (Duarte, 1991). However, their geographic distribution is limited to areas with somewhat low wave energy and tidal prisms (Koch & Beer, 1996; Short et al., 2001; Stevens & Lacy, 2012). Like many flora and fauna in the world, several factors inhibit seagrasses from fully extending into their vast fundamental niche, such as temperature, salinity, pH, and turbidity (Short et al., 2001). These factors can also influence their density.

Although many species of seagrass can tolerate a wide range of temperatures (McMillan, 1984), their photosynthetic capacity is limited to an optimum range of temperatures, following the P-I curve, which applies to many photosynthetic biota (Jones, et al., 2014). The P-I curve famously demonstrates that the rate of photosynthesis decreases when it’s too hot or too cold. Therefore, seagrasses thrive in the optimum range of temperatures (Bulthuis, 1987).

Salinity tolerance in seagrasses typically varies among species, but overall, they can tolerate a wide range of salinities (Short et al. 2001). However, hyposaline and hypersaline environments can have detrimental effects on their biological processes (Touchette, 2007). For example, a common species in North and Central America, Thalassia testudinum, has shown low density and low survival rates in areas overwhelmed with freshwater flow from man-made canals (Lirman & Cropper, 2003). On the other end of the spectrum, a study on the Texas coast showed that seagrass cover increased after efforts were made to reduce salinity in the hypersaline Laguna Madre (Quammen & Onuf, 1993).

Climate change is altering the ocean in several ways, one of the ways being acidification. However, seagrass has shown resilience when faced with low pH levels (Garrard et al., 2014). It is hypothesized that with more carbon dioxide in the ocean, seagrass can improve their photosynthetic capacity, and potentially thrive in these conditions (Zimmerman et al., 1997). Thus, it is possible that seagrass cover can be positively influenced by low pH levels.

Chlorophyll is a pigment, and chlorophyll concentration in seawater is associated with phytoplankton presence, which contributes to particles in the water column via biological processes (Timms & Moss, 1984). This has led researchers to believe that there is a correlation between chlorophyll concentration and turbidity (Chen et al.,...
2009). Increased turbidity is an issue for seagrass because it inhibits light availability (Short et al., 2001). Because chlorophyll a concentration is linked to turbidity, it is possible that there is an inverse correlation between chlorophyll a concentration and seagrass density, where seagrass density is highest when chlorophyll a concentration is low. However, this relationship has not been established in scientific literature yet.

Ultimately, is important to look at seagrass cover because density can be an indicator for seagrass health, as well as ecosystem health (Wood & Lavery 2000). Many studies show that there is a correlation between high seagrass cover and biodiversity (McCloskey & Unsworth, 2015; Smith et al., 2011). Therefore, this project explores the relationship between seagrass cover and environmental parameters, temperature, salinity, pH, and cholorphyll a in the Corpus Christi Bay.

### 1.1 Problem formulation

Question: Which environmental parameter is the best indicator of seagrass cover?

Hypothesis: Chlorophyll a will be the best predictor because of its association with turbidity.

The results will be quantified by using the Ordinary Least Squares (OLS) regression tool in ArcGIS. This tool uses statistics to produce an R-squared value, which will show if an independent variable (temperature, pH, etc.) is a good predictor of a dependent variable (seagrass cover). The R-squared values will be compared for each OLS, where the highest value is the best predictor.
2.0 METHODS

2.1 Data collection

The seagrass and environmental data for this project was acquired from the Texas coast, near Port Aransas. This is an ongoing project conducted by students in Dr. Ken Dunton’s lab (UT-MSI). The location references were downloaded from other sources (Figure 1).

<table>
<thead>
<tr>
<th>Data description</th>
<th>Source</th>
<th>Spatial reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass data</td>
<td>Collected by Dr. Ken Dunton’s lab (UTMSI)</td>
<td>WGS 1984</td>
</tr>
<tr>
<td>Texas polygon</td>
<td>GEO 327G course, exercise 1 file folder</td>
<td>WGS 1984</td>
</tr>
<tr>
<td>Basemap reference</td>
<td>World ocean base reference</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 1. Summary of data sources.*

2.2 Data processing

Before the seagrass and environmental data could be imported to ArcGIS, several steps had to be taken. First, the large dataset had to be categorized by location, where the area of interest (Corpus Christi Bay) was isolated and organized further. Next, the DESIRED environmental parameters were included for each site (Figure 2). Once the relevant data was separated and properly arranged, it was converted to a CSV file so it could be added to the map.

*Figure 2. An example of the csv file for this project.*

2.3 ArcGIS processing

1. Open a blank map and add data.
   a. Click the arrow next to the add data button (Figure 3) → add the World Oceans Basemap.
Figure 3. The add data button and arrow for the dropdown menu are circled in red.

b. Set the spatial reference in the table of contents to WGS 1984.

c. Create a folder connection (folder called “classproject”)

d. Add the Texas shapefile- go to ArcCatalog and navigate to the “txtrct” shapefile in the lab 1 folder → drag the file into the map → it will appear in the table of contents, make sure the coordinate system is correct (WGS 1984- UTM Zone 14)

e. Add the csv file- open the dropdown menu for the “add data” function(Figure 2) → add x/y data → navigate to the seagrass csv file → set spatial reference to WGS 1984 → click ok (it will appear in the table of contents)

2. Export data

a. Right click on the seagrass csv in the table of contents → go to data → export data (Figure 4) → call the layer “seagrass” and save it to the classproject folder → specify the filetype to “shapefile” → click ok → a window will pop up asking if you want to add this file as a new layer on the map- click “yes”

Figure 4. Exporting the csv file.

3. Change symbology
a. Right click on the seagrass shapefile in the table of contents → go to properties → click the symbology tab → click “quantities- graduated colors” → change the value field to “%cover” (this will create 5 ranges of values for percent cover) → choose the green light to dark color ramp, where light green is low density and dark green is high density (Figure 5) → click ok

![Symbology for seagrass cover](image)

Figure 5. Symbology for seagrass cover.

4. Change environmental data into rasters (IDW)
   a. Temperature- open the IDW spatial analyst tool → set the input point feature to the seagrass shapefile → in the z value field, select “temperature” (keep the defaults for everything else) → save the file to the classproject folder → click ok
   b. Salinity- repeat the same steps for temperature, but change the z value field to “salinity”
   c. pH- repeat the same steps for temperature, but change the z value field to “pH”
   d. Chlorophyll a- repeat the same steps for temperature, but change the z value field to “chla”

5. Statistics- Individually perform an ordinary least squares (OLS) regression for each variable.
   a. Temperature- open the OLS spatial statistics tool → set the input feature class to the seagrass shapefile → select temperature in the explanatory variable box → specify where you want the OLS feature class and output report file to be save (the classproject folder) → click ok
   b. Salinity- repeat the same steps for temperature, but change the explanatory variable to “salinity”
   c. pH- repeat the same steps for temperature, but change the explanatory variable to “pH” (Figure 6)
d. **Chlorophyll a** - repeat the same steps for temperature, but change the explanatory variable to “chla”

![Image of OLS interface]

**Figure 6. OLS for pH.**

6. Create layouts (Figures 16, 17, 18, & 19) and analyze the OLS reports
3.0 RESULTS & DISCUSSION

The individual OLS regressions performed in ArcGIS generated reports for each environmental parameter. This allowed me to compare R-squared values, and see which variable was the best predictor of seagrass density in the Corpus Christi Bay.

3.1 Temperature OLS

An OLS was conducted to test if temperature was a good predictor of seagrass cover. The overall regression was not statistically significant ($R^2 = .006566$), [F(df= 1,79)= .522146], p= .472058. The OLS tool generated a report with visual representations of this relationship (Figures 7 & 8). In conclusion, temperature accounted for .66% of variation in seagrass cover, therefore, it is not a good predictor of seagrass density in the Corpus Christi Bay.

Figure 7. Scatterplot of seagrass cover and temperature.

Figure 8. Residual plot of the relationship between seagrass cover and temperature.
### 3.2 Salinity OLS

An OLS was conducted to test if salinity was a good predictor of seagrass cover. The overall regression was not statistically significant ($R^2 = .028746$, $F(df=1,79)= 2.338135$, $p=.130241$). The OLS tool generated a report with visual representations of this relationship (Figures 9 & 10). In conclusion, salinity accounted for 2.8% of variation in seagrass cover, therefore, it is not a good predictor of seagrass density in the Corpus Christi Bay.

![Figure 9. Scatterplot of seagrass cover and salinity.](image)

![Figure 10. Residual plot of the relationship between seagrass cover and salinity.](image)

### 3.3 pH OLS

An OLS was conducted to test if pH was a good predictor of seagrass cover. The overall regression was not statistically significant ($R^2 = .001131$, $F(df=1,79)= .089461$, $p=.765654$). The OLS tool generated a report with visual representations of this relationship (Figures 11 & 12). In conclusion, pH accounted for .11% of variation in seagrass cover, therefore, it is not a good predictor of seagrass density in the Corpus Christi Bay.
Figure 11. Scatterplot of seagrass cover and pH.

Figure 12. Residual plot of the relationship between seagrass cover and pH.

3.4 Chlorophyll a OLS

An OLS was conducted to test if chlorophyll a was a good predictor of seagrass cover. The overall regression was not statistically significant ($R^2 = .000789$), $[F(df= 1,79)= .062354]$. $p= .803465$. The OLS tool generated a report with visual representations of this relationship (Figures 13 & 14). In conclusion, chlorophyll a accounted for .08% of variation in seagrass cover, therefore, it is not a good predictor of seagrass density in the Corpus Christi Bay.
3.5 Comparing $R^2$ values

Although none of the R-squared values showed a strong relationship between the independent variables and seagrass cover, some values were higher than others (Figure 15).

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$R^2$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity</td>
<td>.028746</td>
</tr>
<tr>
<td>Temperature</td>
<td>.006566</td>
</tr>
<tr>
<td>pH</td>
<td>.001131</td>
</tr>
<tr>
<td>Chlorophyll a</td>
<td>.000789</td>
</tr>
</tbody>
</table>

*Figure 15. Independent variables and $R^2$ values in descending order.*
3.6 Discussion

Seagrass density is important to study because it can indicate ecosystem health (Wood & Lavery 2000). The purpose of this project was to explore associations between environmental parameters and seagrass density to answer the research question: which environmental parameter is the best predictor of seagrass cover? The hypothesis was proven incorrect, chlorophyll a was not the best predictor of seagrass cover. In fact, it was the worst predictor. Salinity was the best predictor, but the regressions showed that none of the environmental variables (temperature, salinity, pH, chlorophyll a) had a relationship with seagrass cover. This may be due to the small sample size, or associations between independent variables. For example, 2 or more of the variables may be correlated, such as salinity and temperature, so a multiple regression analysis may produce a strong R-squared value. Further research may include adding or combining more environmental parameters.
4.0 DATA PRESENTATION

Figure 16. Map of seagrass cover and its relationship with temperature in the Corpus Christi Bay. Seagrass cover is divided into 5 ranges indicated by points of varying shades of green. The temperature data is displayed as a raster that was created using the IDW tool in ArcGIS. In the top left corner is a zoomed out perspective of the study area, the red rectangle corresponds to the larger map on the right.
Figure 17. Map of seagrass cover and its relationship with salinity in the Corpus Christi Bay. Seagrass cover is divided into 5 ranges indicated by points of varying shades of green. The salinity data is displayed as a raster that was created using the IDW tool in ArcGIS. In the top left corner is a zoomed out perspective of the study area, the red rectangle corresponds to the larger map on the right.
Figure 18. Map of seagrass cover and its relationship with pH in the Corpus Christi Bay. Seagrass cover is divided into 5 ranges indicated by points of varying shades of green. The pH data is displayed as a raster that was created using the IDW tool in ArcGIS. In the top left corner is a zoomed out perspective of the study area, the red rectangle corresponds to the larger map on the right.
Figure 19. Map of seagrass cover and its relationship with chlorophyll a in the Corpus Christi Bay. Seagrass cover is divided into 5 ranges indicated by points of varying shades of green. The chlorophyll a data is displayed as a raster that was created using the IDW tool in ArcGIS. In the top left corner is a zoomed out perspective of the study area, the red rectangle corresponds to the larger map on the right.
5.0 REFERENCES


