Impacts of Abiotic Factors on Seagrass Growth

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EDA Final Project - Fall 2023

R Markdown

This is an R Markdown document for the final project in EDA. This document explores the impacts of temperature and salinity on linear growth rates and production rates of the seagrass Thalassia testudinum.

Rationale

We chose a data set from the 2022 Johnson, Hanes, and Bolten publication titled "Seagrass growth rates and physical characteristics and measures of water temperature and salinity during a simulated green turtle grazing experiment in The Bahamas, 1999 – 2000." We chose to focus our research in the Bahamas because of the rich marine life in the area. This data set aims to understand how green turtle food consumption practices impact a specific species of seagrass (Thalassia testudinum). We appreciated how thorough this data set was, as it tracked blade width, number of blades per shoot, blade length, shoot density, and even had a leaf index in order to understand how the seagrasses were changing.

We focused on the non-green turtle simulation group of the seagrass. We wanted to see how abiotic factors (temperature and salinity) impacted marine species. This data set also included weekly temperature and salinity sampling, which allowed us to understand if abiotic factors were influencing seagrass growth.

Citation: Johnson, R.A., K.M. Hanes, A.B. Bolten, and K.A. Bjorndal. 2022. Seagrass growth rates and physical characteristics and measures of water temperature and salinity during a simulated green turtle grazing experiment in The Bahamas, 1999 – 2000. ver 1. Environmental Data Initiative. https://doi.org/10.6073/pasta/601ae427b99c240e6df52c0737efbab3 (Accessed 2023-11-25).

Research Questions

1. Does temperature impact production rates of seagrass?
2. Does salinity impact production rates of seagrass?
3. Does temperature impact linear growth rates of seagrass?
4. Does salinity impact linear growth rates of seagrass?

Dataset Information

We first imported the temperature (Temperature-Salinity.csv) and production rates (Seagrass-production-rates.csv) files. We used as.Date() to convert all dates if needed to the right format and filtered each of the files to only include reference data.

```
For the temperature data, we used mutate() to add a mean temperature created from the min_temp and max_

These files were joined using a full_join by the experimental week. NAs were omitted and data was selec
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.3     v readr     2.1.4
## v forcats   1.0.0     v stringr   1.5.0
## v ggplot2   3.4.3     v tibble    3.2.1
```

```
## v lubridate 1.9.3     v tidyr     1.3.0
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
## here() starts at /home/guest/R/Final_Project/BeyerBolgerNoor_Env872_EDA_FinalProject

## [1] "/home/guest/R/Final_Project/BeyerBolgerNoor_Env872_EDA_FinalProject"

## Rows: 792 Columns: 6
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr  (1): treatment
## dbl  (4): plot, interval, exp_week, gr_mass
## date (1): date
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.

## [1] "Date"
```

Exploratory Analysis

```
## `geom_smooth()` using formula = 'y ~ x'

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```

Both Figures 1 and Figures 2 share a remarkably similar relationship and curvature. Given the location of the Bahamas, it makes sense that the weather is coldest in the winter (December to March) and warmest in the summer (June to August). The fact that these figures are so similar suggests that there may be a relationship between mean growth and temperature for the seagrass, but more analysis is needed.

```
## `geom_smooth()` using formula = 'y ~ x'

##
## Call:
## lm(formula = salinity ~ date.x, data = salinity_lineargrowth_processed)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.7296 -0.9014  0.1979  0.7086  1.8548
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -3.546e+01  4.318e+00  -8.213 2.17e-15 ***
## date.x       6.703e-03  3.911e-04  17.140  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.137 on 463 degrees of freedom
## Multiple R-squared:  0.3882, Adjusted R-squared:  0.3869
## F-statistic: 293.8 on 1 and 463 DF,  p-value: < 2.2e-16
```

A linear regression was run to prove this relationship ($p < 2.2e-16$, $R2 = 0.3869$, $df = 463$). This confirms that there is a significant positive relationship between date and salinity. This means that salinity was increasing over time within the study site.

```
## `geom_smooth()` using formula = 'y ~ x'
```

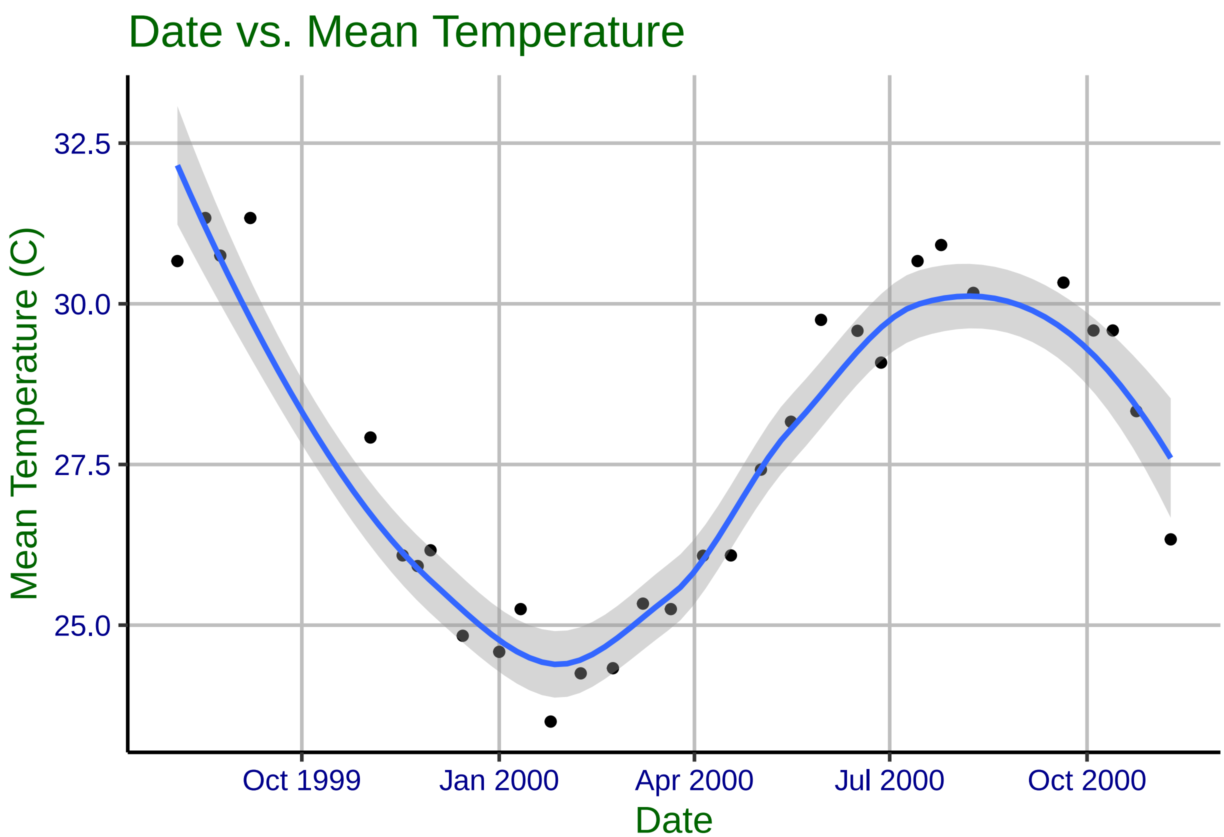


Figure 1: Relationship between date and mean temperature (° C) in the study site region in the Bahamas. Temperature was lowest in February 2000 (23.415 ° C) and highest in July 2000 (31.750 ° C).

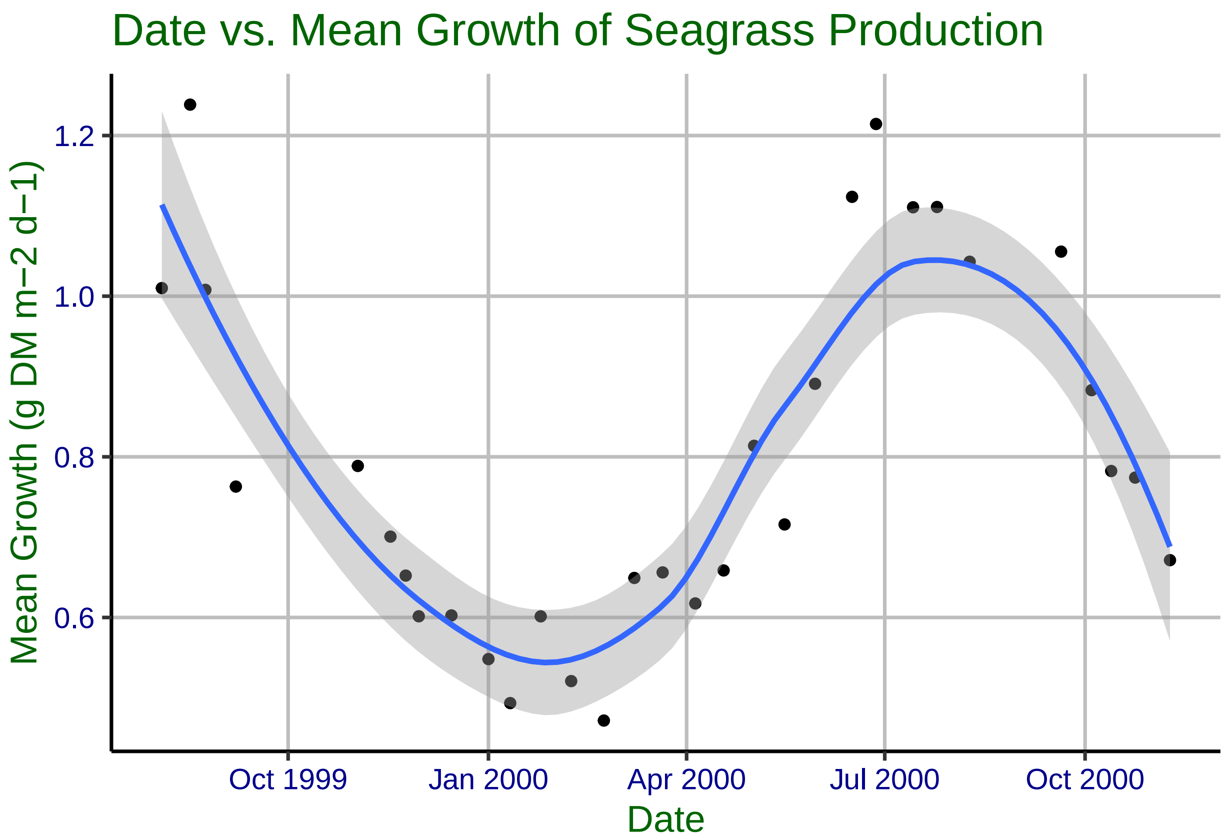


Figure 2: Relationship between date and mean growth rate of the seagrass (in g DM m^{-2} d^{-1}) in the study site region in the Bahamas. Mean growth is highest in August 1999 (1.2384667 g DM m^{-2} d^{-1}) and lowest in February 2000 (0.4716667 g DM m^{-2} d^{-1}).

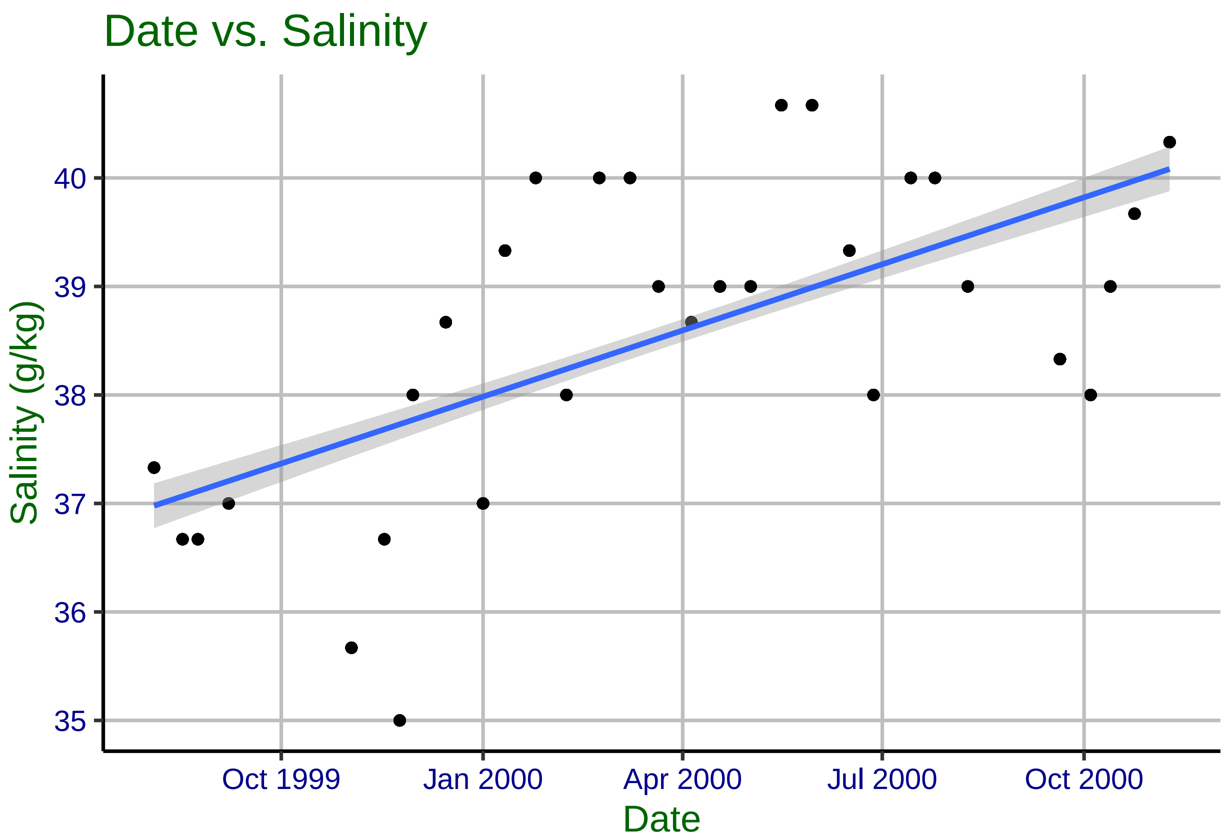


Figure 3: Relationship between date and salinity (g/kg). The lowest salinity was recorded in November 1999 (25.00 g/kg) and the highest was recorded in May 2000 (40.67 g/kg). This suggests a positive relationship where salinity is increasing over the study time.

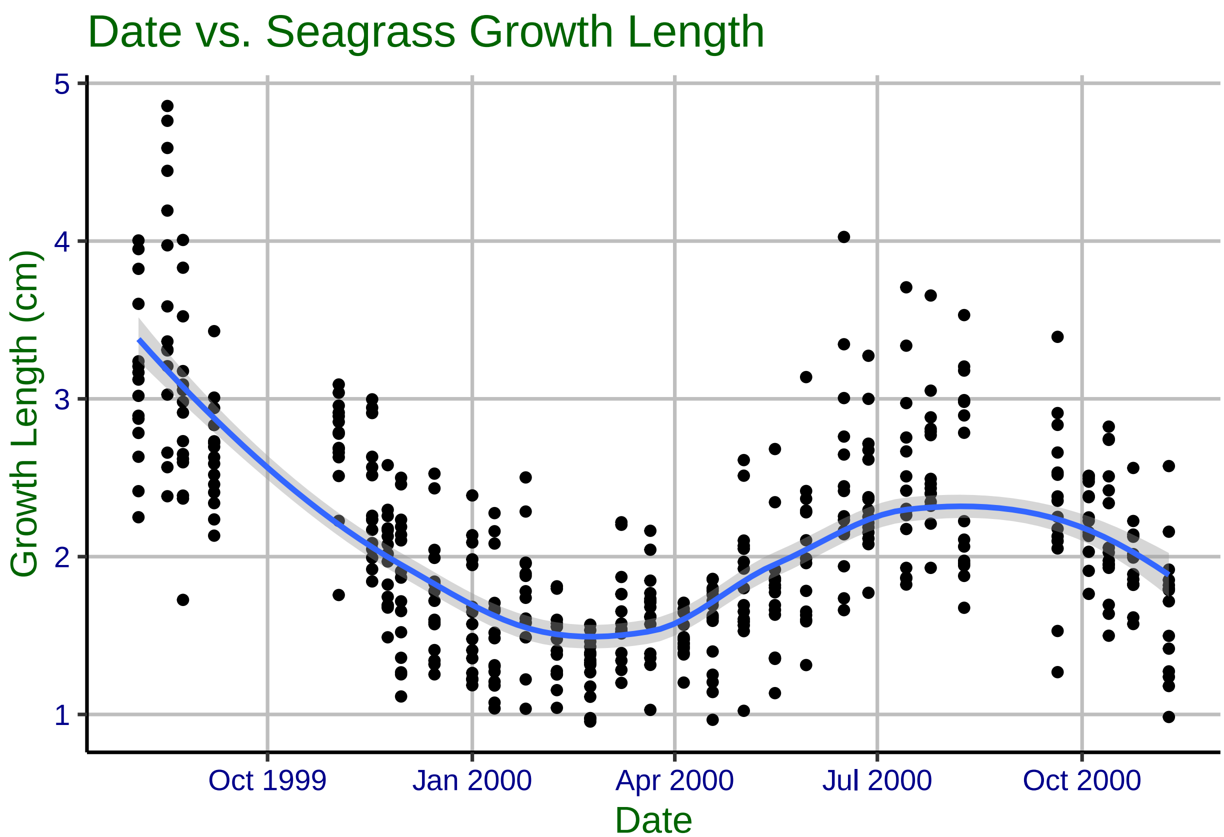


Figure 4: Relationship between date and seagrass growth length (cm) within the study site. The highest amount of growth was recorded in July 1999 (4.856 cm) and lowest amount of growth was recorded in February 2000 (0.955 cm).

Analysis

A linear regression was run on the relationship between mean temperature and seagrass mean growth. As is visible in Figure 3, ProductionRate = 9.6257(temp) + 20.0372. According to this test, temperature significantly positively impacts seagrass production rate ($p < 3.06$ e^{-10}, $R^2 = 0.7504$). This makes sense given our exploratory graphs, where the figures tracking date versus mean temperature and mean growth had incredibly similar shapes. This supports our hypothesis that temperature impacts the linear growth rates of seagrass, given our p-value of less than 0.05.

```
## `geom_smooth()` using formula = 'y ~ x'
```

```
## Warning: Removed 38 rows containing non-finite values (`stat_smooth()`).
```

```
## Warning: Removed 38 rows containing missing values (`geom_point()`).
```

A linear regression was run and showed there was not a significant relationship. The p-value is 0.6956 and r^2 is -0.02894.

```
## `geom_smooth()` using formula = 'y ~ x'
```

A linear regression was run to prove this relationship ($p < 2.2e^{-16}$, $R^2 = 0.4335$, df = 463). This confirms that there is a significant positive relationship between temperature and seagrass linear growth. This means that seagrass linear growth increases as the temperature increases within the study site.

```
## `geom_smooth()` using formula = 'y ~ x'
```

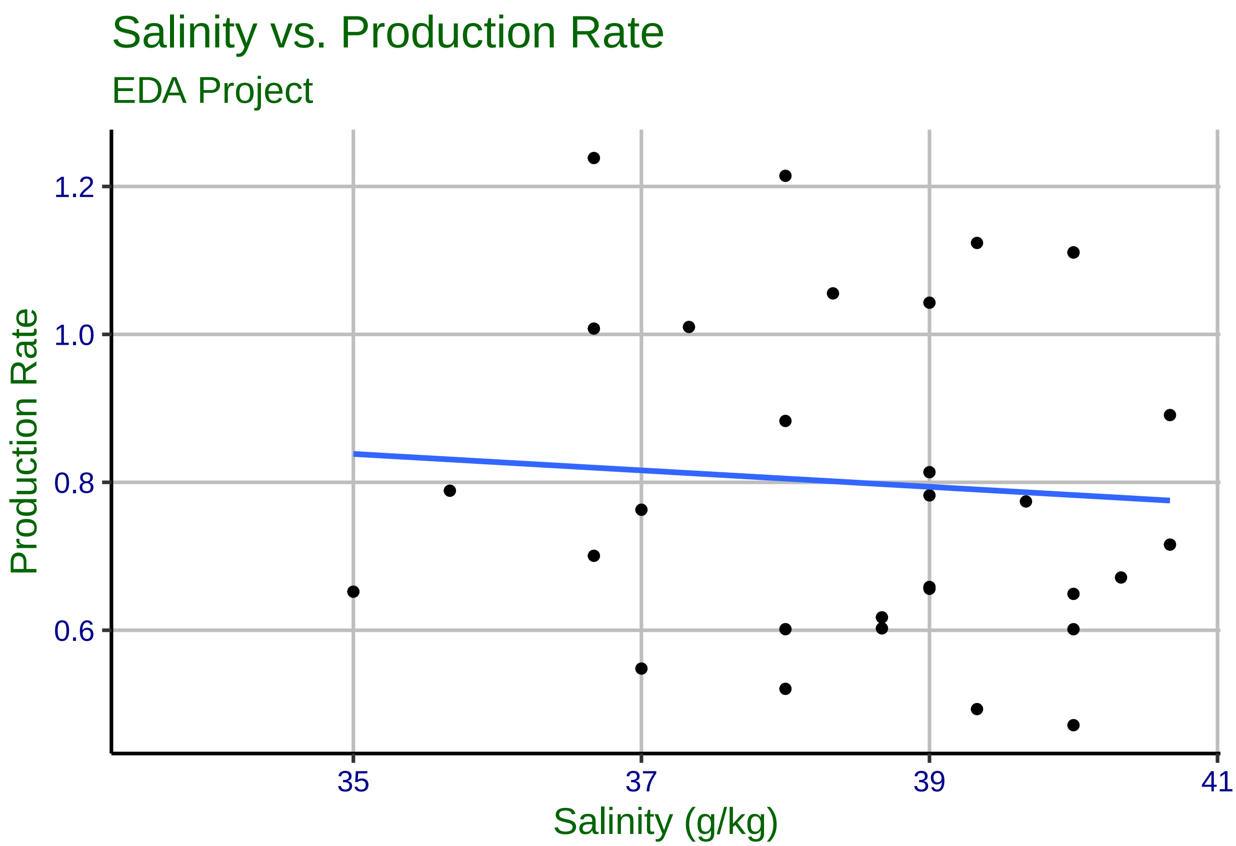


Figure 5: Relationship between salinity (g/kg) and seagrass production rates (g DM m^{-2} d^{-1}). The graph shows that there does not seem to be any relationship between the two variables.

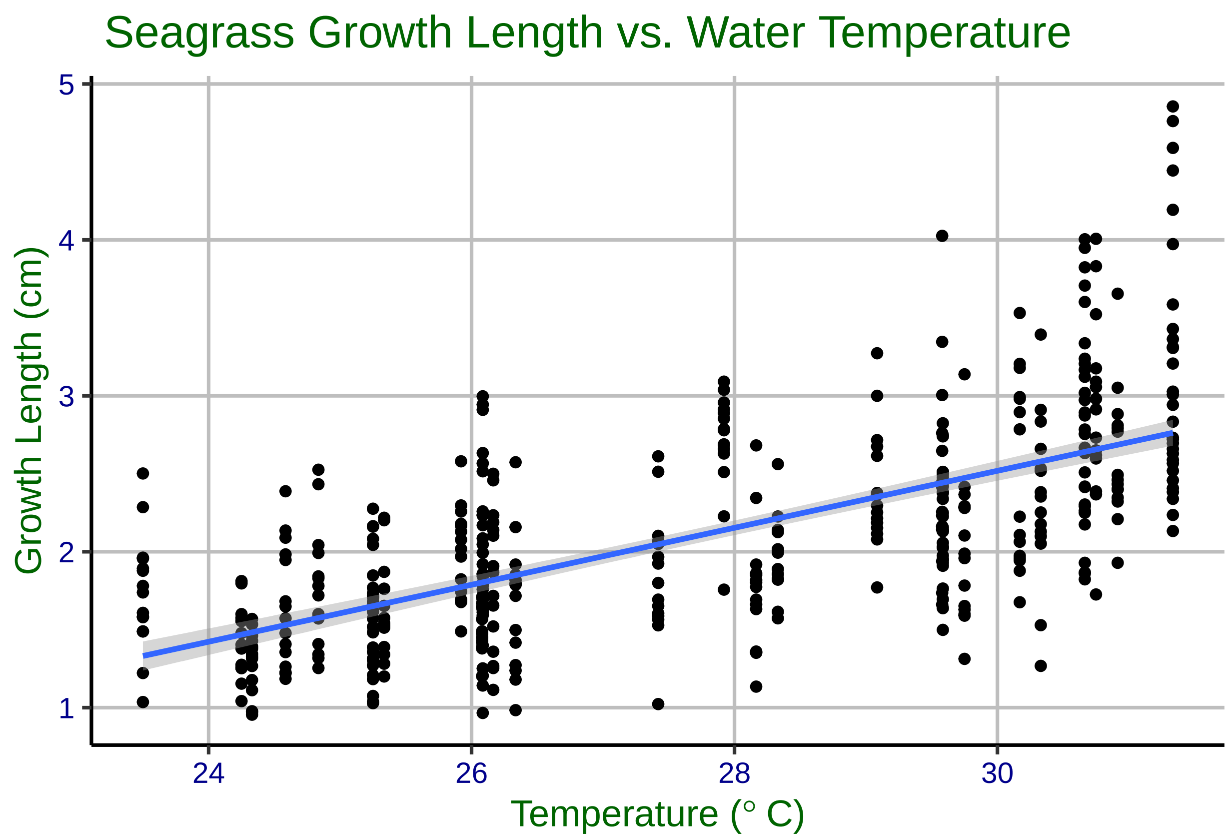
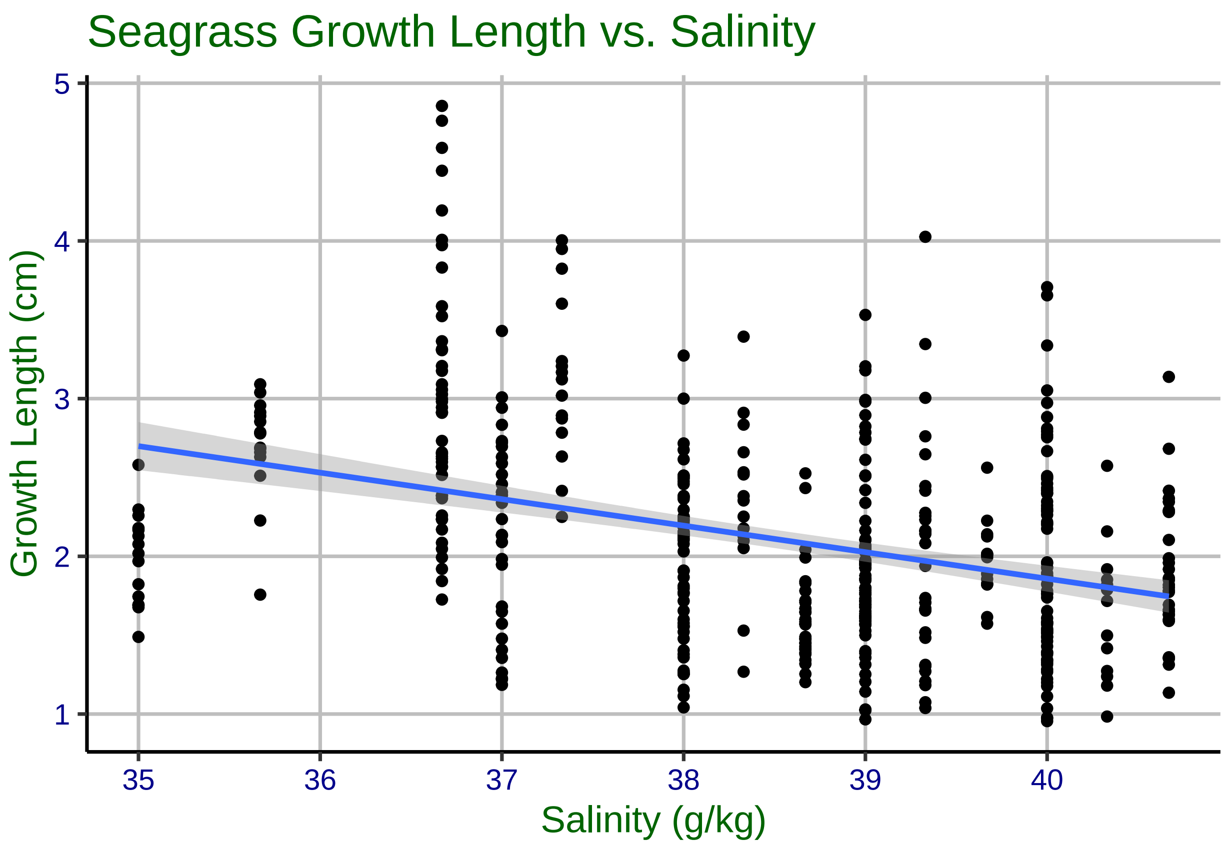


Figure 6: Relationship between seagrass growth length (cm) and water temperature (° C). This suggests a positive relationship where as temperature increases, growth length also increases.



A linear regression was run to prove this relationship ($p = 1.256e^{-15}$, $R^2 = 0.1273$, df = 463). This confirms that there is a significant negative relationship between seagrass linear growth and salinity. This means that seagrass linear growth decreases as the salinity increases within the study site.