Environment_Length_Survival_Hatchery

2024-10-26

```
setwd("/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/src/NM")
```

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## 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
```

```
library(ggplot2)
library(gridExtra)
```

```
##
## Attaching package: 'gridExtra'
##
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
library(multcompView) #extract significance letters from Tukey-Kramer test
library(tidyverse)
library(grid)#for ggplot arranging
library(cowplot) #arrange ggplots
```

```
##
## Attaching package: 'cowplot'
##
## The following object is masked from 'package:lubridate':
##
##     stamp
```

```
library(ggpmisc)
```

```
## Loading required package: ggpp
## Registered S3 methods overwritten by 'ggpp':
```

```
##   method                  from
##   heightDetails.titleGrob ggplot2
##   widthDetails.titleGrob  ggplot2
##
## Attaching package: 'ggpp'
##
## The following object is masked from 'package:ggplot2':
##
##     annotate
```

```
library(vegan) #for Mantel tests
```

```
## Loading required package: permute
## Loading required package: lattice
## This is vegan 2.6-8
```

#read in necessary files

```
#this file contains raw lengths of all oysters aged 15-78 days
length <- read.csv("/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/data/latestage_le

#this file has summary statistics on temperature and salinity for the 8 sites (DEBY, LOLA, JR, TX, LA,
envr_summary <-  read.csv("/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/data/envr_

#this file is a matrix of the environmental distances between each site
envr_dist <- read.csv("/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/data/envr_raw_

#this file contains survival rate data for larval oysters up to day 21 post hatching
survival <-  read.csv("/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/data/CViMVP_la
```

Extract survival rates from survival data frame, and reorganize data frame

```
summary(survival)
```

```
##  SpawnTrt_Key       Tank_naming        Group_Day_Key      Group_Day_Label
##  Length:120         Length:120         Length:120         Length:120
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##      Tank           Day_Treatment      Day_analysis            Day
##  Length:120         Length:120         Length:120         Min.   : 0.00
##  Class :character   Class :character   Class :character   1st Qu.: 0.00
##  Mode  :character   Mode  :character   Mode  :character   Median : 6.00
##                                                           Mean   :15.31
##                                                           3rd Qu.:19.00
##                                                           Max.   :78.00
##                                                           NA's   :9
##      Date           Filter_size_µm    Sample_count     Group_count
##  Length:120         Min.   : 35.00   Min.   :     0   Min.   :       0
```

```
##  Class :character   1st Qu.: 35.00   1st Qu.: 10000   1st Qu.:  287000
##  Mode  :character   Median : 48.00   Median : 30000   Median :  602000
##                     Mean   : 85.17   Mean   :100309   Mean   : 2726089
##                     3rd Qu.: 75.00   3rd Qu.:161250   3rd Qu.: 2912500
##                     Max.   :212.00   Max.   :600000   Max.   :15000000
##                     NA's   :38       NA's   :52       NA's   :30
##  Survival_rate_perc Vial_label        Notes
##  Min.   : 0.000     Mode:logical   Length:120
##  1st Qu.: 1.706     NA's:120       Class :character
##  Median : 5.346                    Mode  :character
##  Mean   : 7.880
##  3rd Qu.:11.250
##  Max.   :50.000
##  NA's   :52
```

```
#For survival rates, we only care about survival from day 21 (marked as day_an 15-21), so filter for th
survival_day21 <- survival %>%
  filter(Day_analysis == "15-21") %>%
  filter(Tank_naming != "MVP-LARMIX")

#Exclude any groups with "small" in their label. The length data only considers the eyed oysters.
#use grep function to make a vector of all indices in latestage_len with the phrase "small" in them, ig
small <- grep("small", survival_day21$Group_Day_Label, ignore.case = TRUE)

#make new dataframe WITHOUT any indices saved in small, mean remaining data are everything except small
survival_day21_sub <- survival_day21[-small, ]

#exclude "MVP" from group names to shorten them
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-DEBY"] <- "DEBY"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"]  == "MVP-FL"] <- "FL"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-JR"] <- "JR"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-LA"] <- "LA"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-LOLA"] <- "LOLA"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-ME"] <- "ME"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-NH"] <- "NH"
survival_day21_sub["Tank_naming"][survival_day21_sub["Tank_naming"] == "MVP-TX"] <- "TX"

#select only tank naming and survival rate columns
survival_filter <- survival_day21_sub[, c("Tank_naming", "Survival_rate_perc")]

#rename columns
colnames(survival_filter) <- c("site_name", "percent_survival")
```

#length df organizing

```
#select columns with group, day, and shell length in mm
length <- length[,c("group", "day_an", "shell_length_mm")]

#filter out LARMIX from group
length_filter <- length %>%
  filter(group != "LARMIX")

#keep only data from days 15-21
```

```r
length_21 <- length_filter %>%
  filter(day_an == "15-21")

length_78 <- length_filter %>%
  filter(day_an == "78")

#find mean shell lengths of each group on each day
means_mm_21 <- aggregate(shell_length_mm ~ group, FUN = mean, data = length_21)
colnames(means_mm_21) <- c("site_name", "mean_length_mm_21")

means_mm_78 <- aggregate(shell_length_mm ~ group, FUN = mean, data = length_78)
colnames(means_mm_78) <- c("site_name", "mean_length_mm_78")
```

#remove extra columns from environmental data frame

```r
#remove extra site label and standard deviations from envr_summary
envr <- envr_summary[,-c(2,6,10)]

summary(envr)
```

```
##       X             Mean_Annual_Temperature_C Mean_max_temperature_C
##  Length:8           Min.   :15.33             Min.   :23.46
##  Class :character   1st Qu.:16.86             1st Qu.:26.35
##  Mode  :character   Median :17.83             Median :28.65
##                     Mean   :19.09             Mean   :28.54
##                     3rd Qu.:22.33             3rd Qu.:30.98
##                     Max.   :23.11             Max.   :33.17
##  Mean_min_temperature_C Mean_Annual_Salinity_ppt Mean_max_Salinity_ppt
##  Min.   : 1.758         Min.   :10.46            Min.   :16.88
##  1st Qu.: 3.192         1st Qu.:14.87            1st Qu.:23.69
##  Median : 3.784         Median :18.99            Median :27.90
##  Mean   : 5.121         Mean   :20.02            Mean   :27.25
##  3rd Qu.: 7.481         3rd Qu.:23.01            3rd Qu.:30.54
##  Max.   :10.387         Max.   :32.35            Max.   :37.20
##  Mean_min_Salinity_ppt
##  Min.   : 0.9688
##  1st Qu.: 5.0596
##  Median : 9.3657
##  Mean   : 8.5100
##  3rd Qu.:12.6328
##  Max.   :15.4224
```

```r
#rename cols
colnames(envr) <- c("site_name", "Mean_Annual_Temperature_C", "Mean_max_temperature_C", "Mean_min_tempe

#add sampling site latitudes. Note that these latitudes ARE NOT the same as the latitudes of where envi
envr$lat <- c(37.249107, 37.98030, 37.1501163, 28.096000, 29.239925, 30.440030, 43.053746, 44.01330)
```

#Join data frames

```r
surv_length_envr <- left_join(envr, means_mm_21, by = "site_name") %>%
  left_join(means_mm_78, by = "site_name") %>%
  left_join(survival_filter, by = "site_name")

write.csv(surv_length_envr, "/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/data/Surv
```

```r
#compare mean length on day 21 to mean annual temp, mean annual salinity, and latitude

length21_temp_lm <- lm(mean_length_mm_21 ~ Mean_Annual_Temperature_C, data = surv_length_envr)
summary(length21_temp_lm)
```

```
##
## Call:
## lm(formula = mean_length_mm_21 ~ Mean_Annual_Temperature_C, data = surv_length_envr)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0153946 -0.0062781  0.0004731  0.0080888  0.0131565
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 0.3281427  0.0261835  12.532 1.58e-05 ***
## Mean_Annual_Temperature_C -0.0008187  0.0013556  -0.604    0.568
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01122 on 6 degrees of freedom
## Multiple R-squared:  0.0573, Adjusted R-squared:  -0.09982
## F-statistic: 0.3647 on 1 and 6 DF,  p-value: 0.568
```

```r
#extract p-value (.568)
length21_temp_pval <- summary(length21_temp_lm)$coefficients[,4]
length21_temp_pval <- unname(length21_temp_pval[2])


length21_sal_lm <- lm(mean_length_mm_21 ~ Mean_Annual_Salinity_ppt, data = surv_length_envr)
#extract p-value (.411)
length21_sal_pval <- summary(length21_sal_lm)$coefficients[,4]
length21_sal_pval <- unname(length21_sal_pval[2])

length21_lat_lm <- lm(mean_length_mm_21 ~ lat, data = surv_length_envr)
summary(length21_lat_lm)
```

```
##
## Call:
## lm(formula = mean_length_mm_21 ~ lat, data = surv_length_envr)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.015881 -0.005571  0.001032  0.007308  0.013481
##
## Coefficients:
```

```
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.3003121  0.0255685  11.745  2.3e-05 ***
## lat         0.0003398  0.0007034   0.483    0.646
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01134 on 6 degrees of freedom
## Multiple R-squared:  0.03745,    Adjusted R-squared:  -0.123
## F-statistic: 0.2334 on 1 and 6 DF,  p-value: 0.6461
```

```
#extract p-value (0.646)
length21_lat_pval <- summary(length21_lat_lm)$coefficients[,4]
length21_lat_pval <- unname(length21_lat_pval[2])

#compare percent survival to mean annual temp, mean annual salinity, and envr distance from DEBY
surv_temp_lm <- lm(percent_survival ~ Mean_Annual_Temperature_C, data = surv_length_envr)
summary(surv_temp_lm)
```

```
##
## Call:
## lm(formula = percent_survival ~ Mean_Annual_Temperature_C, data = surv_length_envr)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.0024 -0.5082  0.1592  0.3649  0.9948
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -3.04143    1.87564  -1.622   0.1560
## Mean_Annual_Temperature_C   0.29084    0.09711   2.995   0.0242 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8037 on 6 degrees of freedom
## Multiple R-squared:  0.5992, Adjusted R-squared:  0.5324
## F-statistic:  8.97 on 1 and 6 DF,  p-value: 0.02416
```

```
#extract p-value (0.024)
surv_temp_pval <- summary(surv_temp_lm)$coefficients[,4]
surv_temp_pval <- unname(surv_temp_pval[2])

surv_sal_lm <- lm(percent_survival ~ Mean_Annual_Salinity_ppt, data = surv_length_envr)
summary(surv_sal_lm)
```

```
##
## Call:
## lm(formula = percent_survival ~ Mean_Annual_Salinity_ppt, data = surv_length_envr)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.3035 -0.9805  0.2219  0.6144  1.4024
##
## Coefficients:
```

```
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)                4.18142    1.14239    3.66   0.0106 *
## Mean_Annual_Salinity_ppt -0.08341    0.05382   -1.55   0.1721
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.073 on 6 degrees of freedom
## Multiple R-squared:  0.2859, Adjusted R-squared:  0.1669
## F-statistic: 2.402 on 1 and 6 DF,  p-value: 0.1721
```

```
#extract p-value (0.172)
surv_sal_pval <- summary(surv_sal_lm)$coefficients[,4]
surv_sal_pval <- unname(surv_sal_pval[2])

surv_lat_lm <- lm(percent_survival ~ lat, data = surv_length_envr)
summary(surv_lat_lm)
```

```
##
## Call:
## lm(formula = percent_survival ~ lat, data = surv_length_envr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.97500 -0.76479  0.03013  0.54583  1.11282
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  7.45699    2.00449   3.720  0.00985 **
## lat         -0.13775    0.05514  -2.498  0.04664 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8887 on 6 degrees of freedom
## Multiple R-squared:  0.5098, Adjusted R-squared:  0.4282
## F-statistic: 6.241 on 1 and 6 DF,  p-value: 0.04664
```

```
#extract p-value (0.0466)
surv_lat_pval <- summary(surv_lat_lm)$coefficients[,4]
surv_lat_pval <- unname(surv_lat_pval[2])

#compare length at day 78 to mean annual temp, mean annual salinity, and envr distance from DEBY
length78_temp_lm <- lm(mean_length_mm_78 ~ Mean_Annual_Temperature_C, data = surv_length_envr)
summary(length78_temp_lm)
```

```
##
## Call:
## lm(formula = mean_length_mm_78 ~ Mean_Annual_Temperature_C, data = surv_length_envr)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.1777 -0.5723 -0.0590  0.8314  3.9262
##
## Coefficients:
```

```
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 17.1980     5.7027   3.016   0.0235 *
## Mean_Annual_Temperature_C  -0.1900     0.2953  -0.644   0.5436
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.443 on 6 degrees of freedom
## Multiple R-squared:  0.06458,    Adjusted R-squared:  -0.09132
## F-statistic: 0.4142 on 1 and 6 DF,  p-value: 0.5436
```

```
#extract p-value (0.543)
length78_temp_pval <- summary(length78_temp_lm)$coefficients[,4]
length78_temp_pval <- unname(length78_temp_pval[2])


length78_sal_lm <- lm(mean_length_mm_78 ~ Mean_Annual_Salinity_ppt, data = surv_length_envr)
#extract p-value (0.983)
length78_sal_pval <- summary(length78_sal_lm)$coefficients[,4]
length78_sal_pval <- unname(length78_sal_pval[2])

length78_lat_lm <- lm(mean_length_mm_78 ~ lat, data = surv_length_envr)
#extract p-value (0.962)
length78_lat_pval <- summary(length78_lat_lm)$coefficients[,4]
length78_lat_pval <- unname(length78_lat_pval[2])
```

```
temp_lat_corr <- cor.test(surv_length_envr$Mean_Annual_Temperature_C, surv_length_envr$lat)
temp_lat_corr #significant correlation between temp and lat, cannot include both in multiple regression
```

```
##
##  Pearson's product-moment correlation
##
## data:  surv_length_envr$Mean_Annual_Temperature_C and surv_length_envr$lat
## t = -8.8851, df = 6, p-value = 0.0001132
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.9936754 -0.8088184
## sample estimates:
##       cor
## -0.9640364
```

```
#multiple regression
surv_temp_sal_lm <- lm(percent_survival ~ Mean_Annual_Temperature_C + Mean_Annual_Salinity_ppt, data = s
summary(surv_temp_sal_lm) #both explanatory variables significant, whole model significant
```

```
##
## Call:
## lm(formula = percent_survival ~ Mean_Annual_Temperature_C + Mean_Annual_Salinity_ppt,
##     data = surv_length_envr)
##
## Residuals:
##        1        2        3        4        5        6        7        8
## -0.41864 -0.34440  0.61996  0.27276 -0.47766 -0.02476  0.68693 -0.31417
```

```
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -1.30130    1.44748  -0.899  0.40985
## Mean_Annual_Temperature_C   0.28004    0.06744   4.153  0.00889 **
## Mean_Annual_Salinity_ppt   -0.07660    0.02800  -2.736  0.04099 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5571 on 5 degrees of freedom
## Multiple R-squared:  0.8395, Adjusted R-squared:  0.7753
## F-statistic: 13.08 on 2 and 5 DF,  p-value: 0.01032
```

```
length21_temp_sal_lm <- lm(mean_length_mm_21 ~ Mean_Annual_Temperature_C + Mean_Annual_Salinity_ppt, da
summary(length21_temp_sal_lm) #neither explanatory variable significant, model not significant
```

```
##
## Call:
## lm(formula = mean_length_mm_21 ~ Mean_Annual_Temperature_C +
##     Mean_Annual_Salinity_ppt, data = surv_length_envr)
##
## Residuals:
##          1          2          3          4          5          6          7
## -0.0039705  0.0070959 -0.0008724 -0.0125143  0.0115745  0.0042660 -0.0145993
##          8
##  0.0090201
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 0.3176148  0.0300787  10.559 0.000132 ***
## Mean_Annual_Temperature_C -0.0007533  0.0014013  -0.538 0.613937
## Mean_Annual_Salinity_ppt   0.0004635  0.0005818   0.797 0.461836
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01158 on 5 degrees of freedom
## Multiple R-squared:  0.1635, Adjusted R-squared:  -0.1712
## F-statistic: 0.4885 on 2 and 5 DF,  p-value: 0.6401
```

```
length78_temp_sal_lm <- lm(mean_length_mm_78 ~ Mean_Annual_Temperature_C + Mean_Annual_Salinity_ppt, da
summary(length78_temp_sal_lm) #neither explanatory variable significant, model insignifcant
```

```
##
## Call:
## lm(formula = mean_length_mm_78 ~ Mean_Annual_Temperature_C +
##     Mean_Annual_Salinity_ppt, data = surv_length_envr)
##
## Residuals:
##       1       2       3       4       5       6       7       8
##  1.0415  3.8777 -0.2769  0.1329 -1.0801  0.8543 -4.1905 -0.3589
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)               17.367666   6.952154   2.498   0.0546 .
## Mean_Annual_Temperature_C -0.191080   0.323889  -0.590   0.5809
## Mean_Annual_Salinity_ppt  -0.007467   0.134480  -0.056   0.9579
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.676 on 5 degrees of freedom
## Multiple R-squared:  0.06516,    Adjusted R-squared:  -0.3088
## F-statistic: 0.1742 on 2 and 5 DF,  p-value: 0.845
```

```
#put multiple regression output table in results
```

#adjust p-values

```
p_values <- c(length21_temp_pval, length21_sal_pval, length21_lat_pval, surv_temp_pval, surv_sal_pval, s

p_adj <- p.adjust(p_values, method = "BH")

p_values
```

```
## [1] 0.56802380 0.41097924 0.64610781 0.02416428 0.17214151 0.04664046 0.54362971
## [8] 0.98297176 0.96196115
```

```
p_adj
```

```
## [1] 0.8307100 0.8307100 0.8307100 0.2098821 0.5164245 0.2098821 0.8307100
## [8] 0.9829718 0.9829718
```

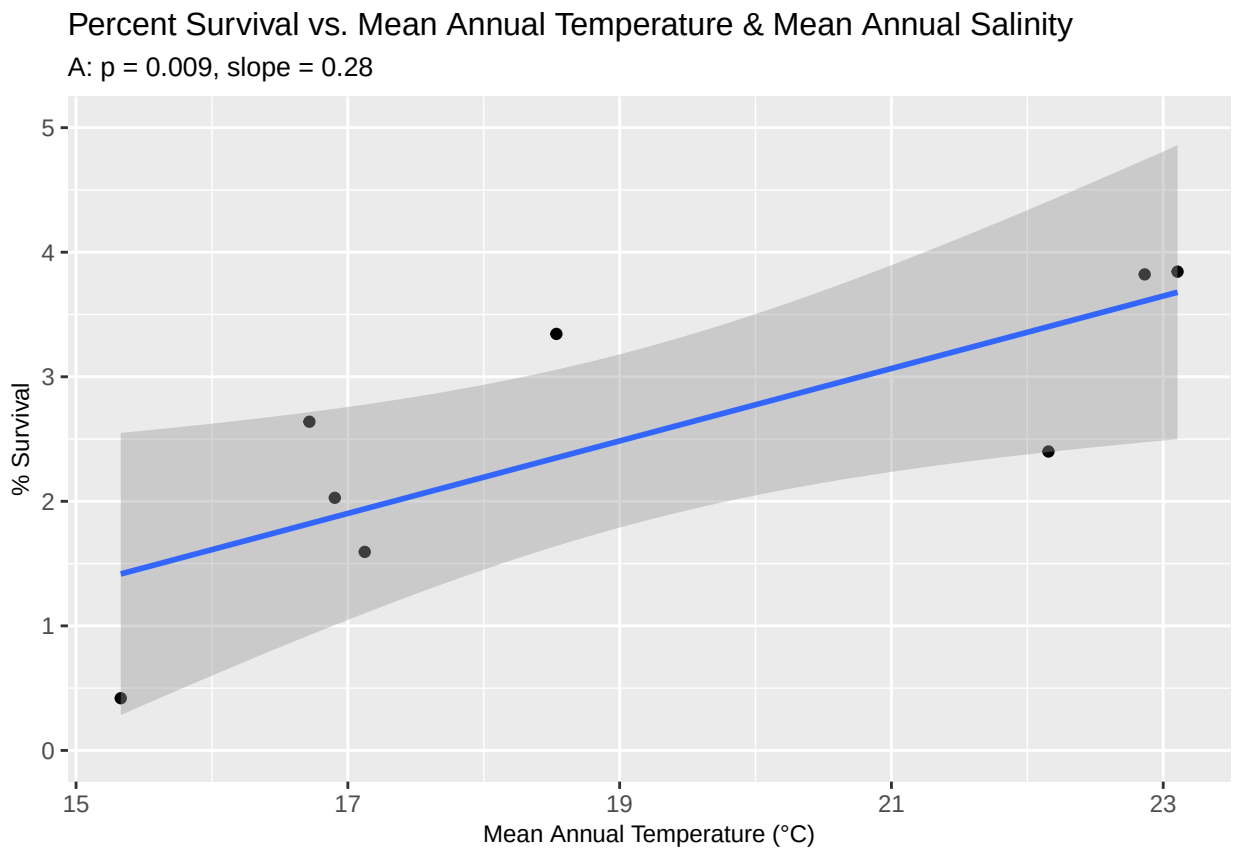
ADJUSTED P-VALUES - NICOLE YOU NEED TO UPDATE THESE - Mean annual temp is not a significant predictor of mean length at day 21 (p = 0.831) - Mean annual salinity is not a significant predictor of mean length at day 21 (p = 0.831). - Latitude is not a significant predictor of mean length at day 21 (p = 0.831).

- Mean annual temp is no longer a significant predictor of percent survival at day 21 (p = 0.210).
- Mean annual salinity is not a significant predictor of percent survival at day 21 (p = 0.516).
- Latitude is not a significant predictor of percent survival at day 21 (p = 0.210).
- Mean annual temp is not a significant predictor of mean length at day 78 (p = 0.831)
- Mean annual salinity is not a significant predictor of mean length at day 78 (p = 0.983).
- Latitude is not a significant predictor of mean length at day 78 (p = 0.983).

```
#make function to wrap title text
wrapper <- function(x, ...)
{
  paste(strwrap(x, ...), collapse = "\n")
}

surv_temp_plot <- surv_length_envr %>%
  ggplot(aes(x = Mean_Annual_Temperature_C, y = percent_survival))+
```

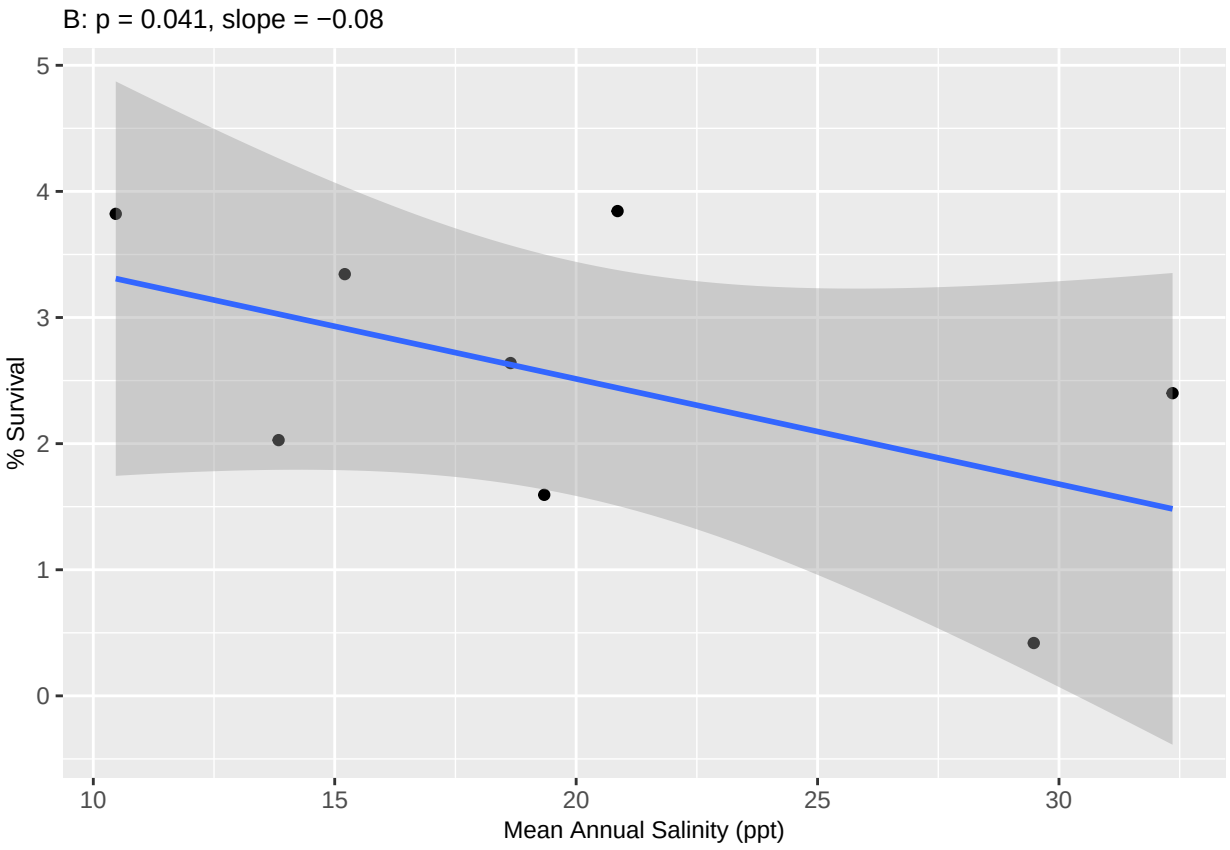
```
  geom_point()+
  labs(subtitle = "A: p = 0.009, slope = 0.28")+
  ggtitle("Percent Survival vs. Mean Annual Temperature & Mean Annual Salinity")+
  ylab("% Survival")+
  xlab("Mean Annual Temperature (°C)")+
  ylim(c(0,5))+
  theme(axis.title.y = element_text(size = 9), axis.title.x = element_text(size = 9), axis.text.x = ele
  geom_smooth(method = "lm", se = TRUE, fullrange = TRUE)

surv_temp_plot
```

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




```
surv_sal_plot <- surv_length_envr %>%
  ggplot(aes(x = Mean_Annual_Salinity_ppt, y = percent_survival))+
  geom_point()+
  labs(subtitle = "B: p = 0.041, slope = -0.08")+
  ylab("% Survival")+
  xlab("Mean Annual Salinity (ppt)")+
  theme(axis.title.x = element_text(size = 9), plot.title = element_blank(), plot.subtitle = element_te
  geom_smooth(method = "lm", se = TRUE, fullrange = TRUE)

surv_sal_plot
```

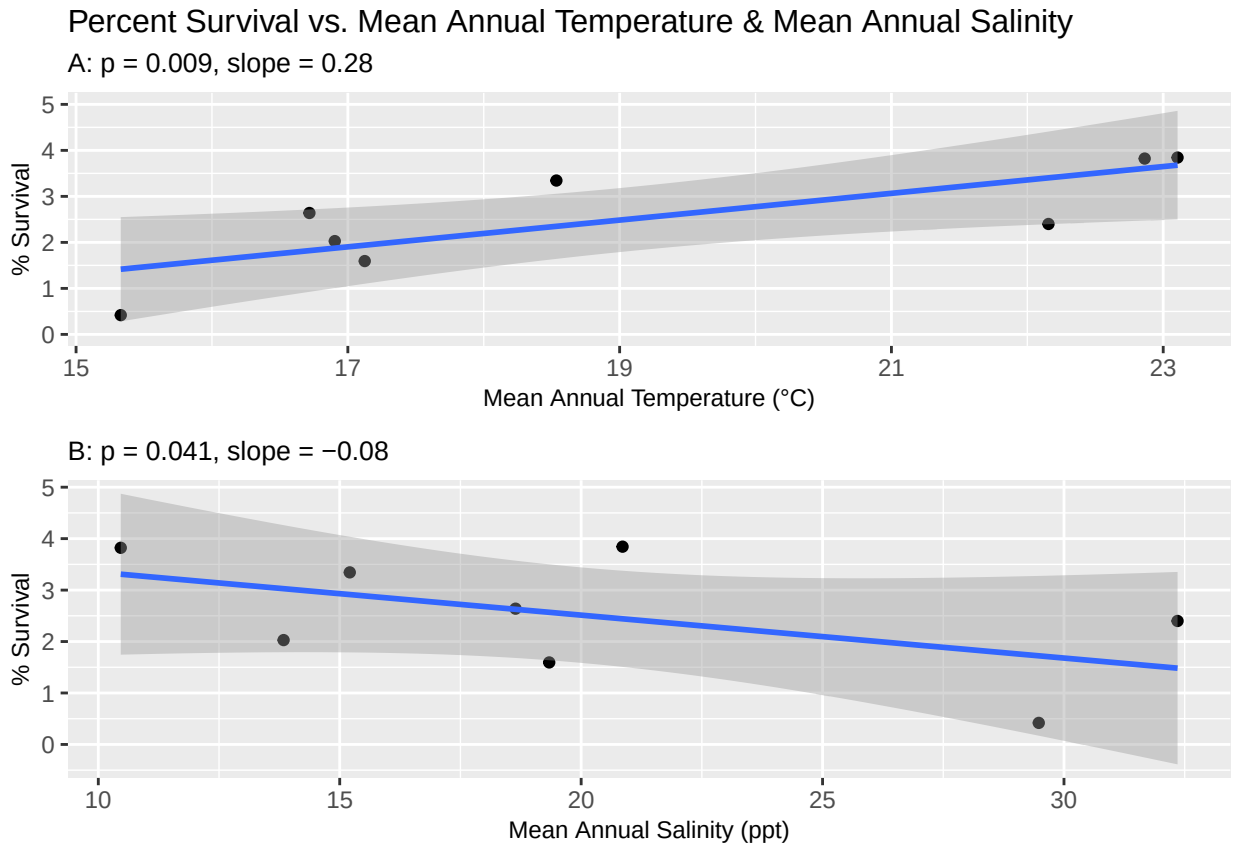
```
## `geom_smooth()` using formula = 'y ~ x'
```




```
surv_plots <- plot_grid(surv_temp_plot, surv_sal_plot, ncol = 1, align = "v")
```

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

```
surv_plots
```




```
ggsave("surv_plots.png",
       plot = surv_plots,
       device = png,
       path = "/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/results/NM_results/Resu
```

```
## Saving 6.5 x 4.5 in image
```

Make distance matrices for difference in mean length across groups at days 21 and 78 and difference in survival across groups at day 21

```
#save vector of row and column names
rownames <- c("DEBY", "LOLA", "JR", "TX", "LA", "FL", "NH", "ME")
colnames <- c("DEBY", "LOLA", "JR", "TX", "LA", "FL", "NH", "ME")

means_mm_21 <- subset(means_mm_21, select = -c(site_name))

day21_len_dist <- as.matrix(dist(means_mm_21$mean_length_mm_21))
rownames(day21_len_dist) <- rownames
colnames(day21_len_dist) <- colnames

day78_len_dist <- as.matrix(dist(means_mm_78$mean_length_mm_78))
rownames(day78_len_dist) <- rownames
colnames(day78_len_dist) <- colnames

day21_surv_dist <- as.matrix(dist(survival_filter$percent_survival))
```

```
rownames(day21_surv_dist) <- rownames
colnames(day21_surv_dist) <- colnames

#remove site_name column from envr_dist, and make it a matrix
envr_dist <- subset(envr_dist, select = -c(X))
envr_dist_mat <- as.matrix(envr_dist)
```

I will run Mantel tests comparing days 21 and 78 length distance and day 21 survival distance to environmental distance. The goal is to see if more environmentally distant pairs of groups also have greater differences in length and survival.

H0: There is no correlation between the environmental distance matrix values and the length or survival matrix values. Environmental distance and length/survival do not vary with each other in any predictable way

#Mantel test

```
length21_envr = mantel(day21_len_dist, envr_dist_mat, method = "spearman", permutations = 10000, na.rm =
length21_envr
```

```
##
## Mantel statistic based on Spearman's rank correlation rho
##
## Call:
## mantel(xdis = day21_len_dist, ydis = envr_dist_mat, method = "spearman",      permutations = 10000, r
##
## Mantel statistic r: 0.3054
##       Significance: 0.081292
##
## Upper quantiles of permutations (null model):
##   90%   95% 97.5%   99%
## 0.274 0.384 0.500 0.589
## Permutation: free
## Number of permutations: 10000
```

```
#mantel r = 0.3054, p = 0.078492. As environmental distance between a pair of sights increases, so does

length78_envr = mantel(day78_len_dist, envr_dist_mat, method = "spearman", permutations = 10000, na.rm =
length78_envr
```

```
##
## Mantel statistic based on Spearman's rank correlation rho
##
## Call:
## mantel(xdis = day78_len_dist, ydis = envr_dist_mat, method = "spearman",      permutations = 10000, r
##
## Mantel statistic r: -0.1653
##       Significance: 0.72883
##
## Upper quantiles of permutations (null model):
##   90%   95% 97.5%   99%
## 0.352 0.443 0.504 0.560
## Permutation: free
## Number of permutations: 10000
```

```
#mantel r = -0.1653. p = 0.73843. As environmental distance between a pair of sights increases, the dis

surv21_envr = mantel(day21_surv_dist, envr_dist_mat, method = "spearman", permutations = 10000, na.rm =
surv21_envr
```

```
##
## Mantel statistic based on Spearman's rank correlation rho
##
## Call:
## mantel(xdis = day21_surv_dist, ydis = envr_dist_mat, method = "spearman",      permutations = 10000,
##
## Mantel statistic r: -0.02299
##       Significance: 0.51015
##
## Upper quantiles of permutations (null model):
##   90%   95% 97.5%   99%
## 0.292 0.379 0.448 0.522
## Permutation: free
## Number of permutations: 10000
```

```
#mantel r = -0.2299, p = 0.50545
```

#Correct Mantel p-values

```
mantel_p <- c(0.078492, 0.73843, 0.50545)

mantel_p_adj <- p.adjust(mantel_p, method = "BH")

mantel_p_adj
```

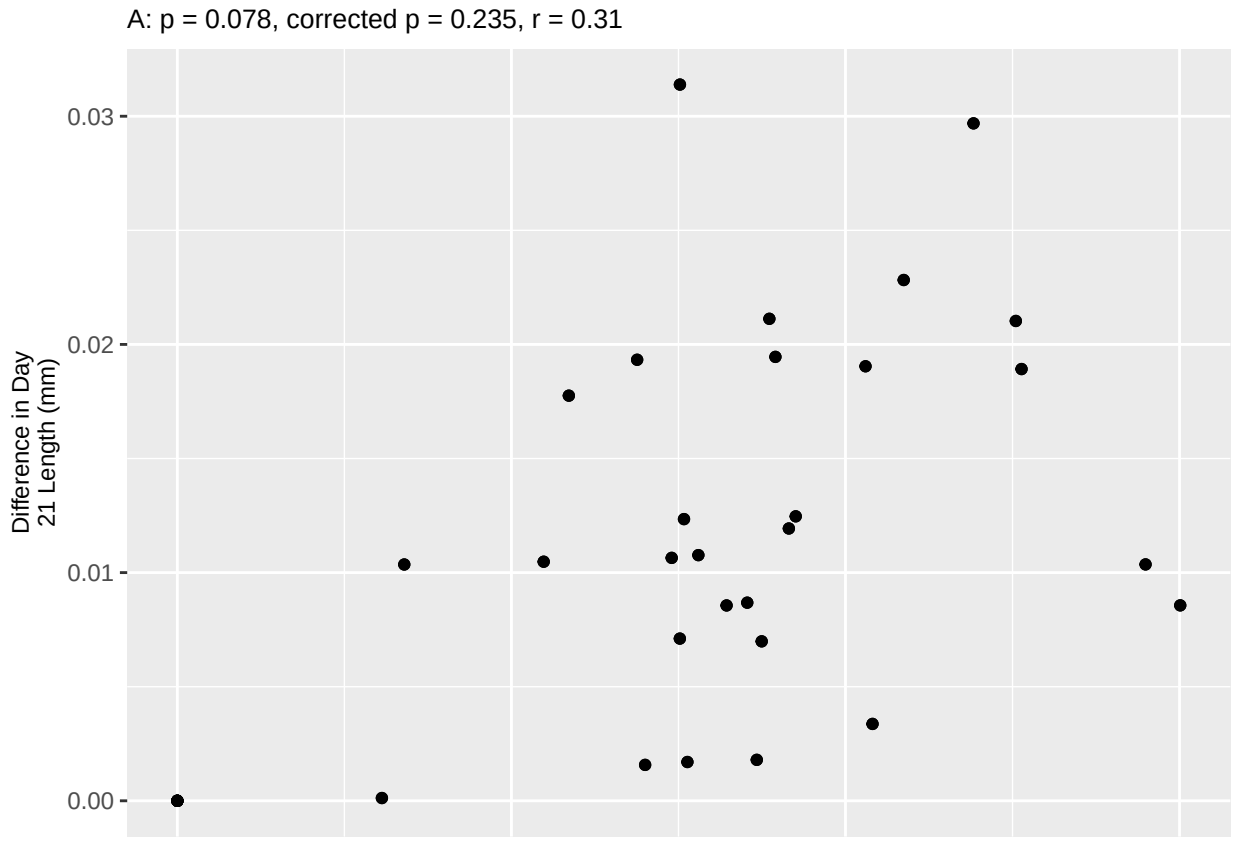
```
## [1] 0.235476 0.738430 0.738430
```

```
#length21_envr corrected p = 0.235476, length78_envr corrected p = 0.738430, surv21_envr corrected p =
```

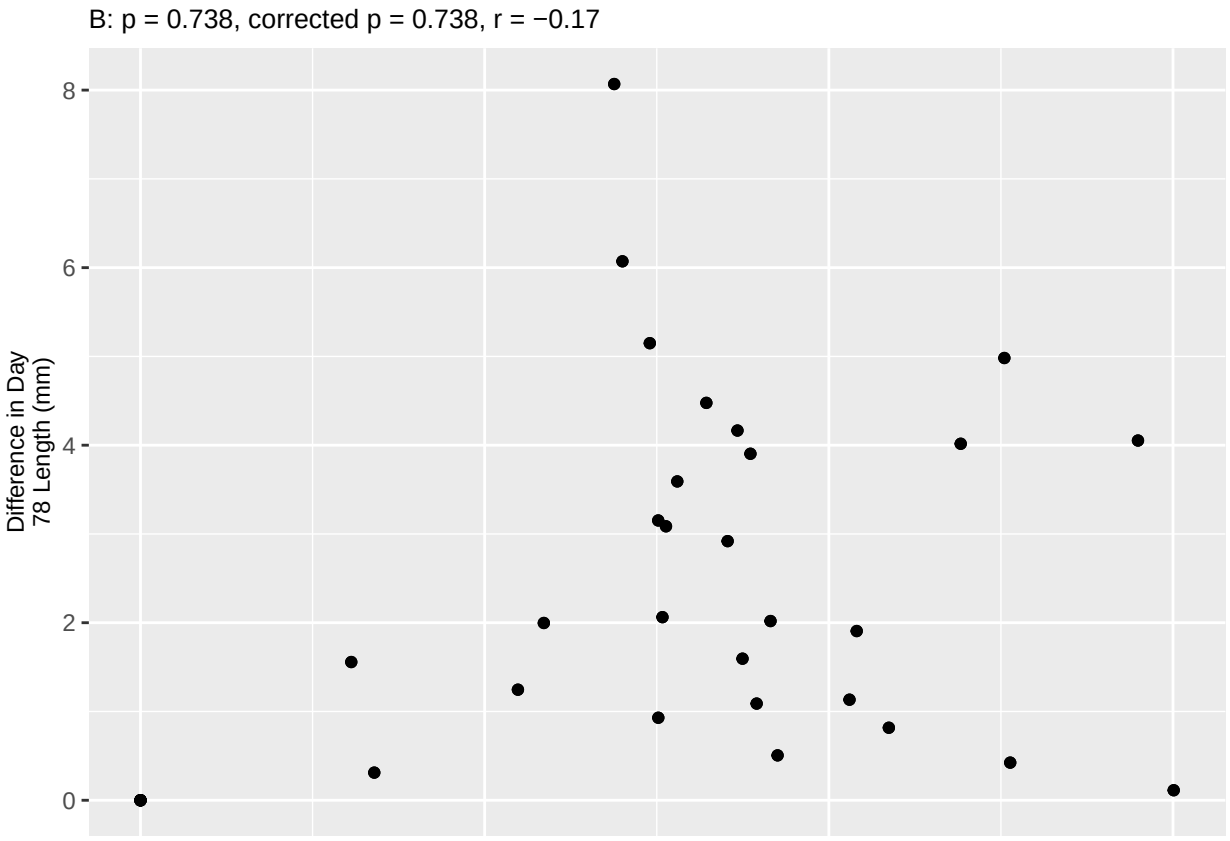
#Plot Mantel test results

```
envr_pairwise_dist <- as.vector(envr_dist_mat)

day21_pairwise_len_dist <- as.vector(day21_len_dist)

day78_pairwise_len_dist <- as.vector(day78_len_dist)

day21_pairwise_surv_dist <- as.vector(day21_surv_dist)

pairwise_dist <- as.data.frame(cbind(envr_pairwise_dist, day21_pairwise_len_dist, day78_pairwise_len_dis

length21_envr_dist <- pairwise_dist %>%
  ggplot(aes(x = envr_pairwise_dist, y = day21_pairwise_len_dist))+
  geom_point()+
  labs(subtitle = "A: p = 0.078, corrected p = 0.235, r = 0.31")+
  ylab(wrapper("Difference in Day 21 Length (mm)", width = 20))+
```

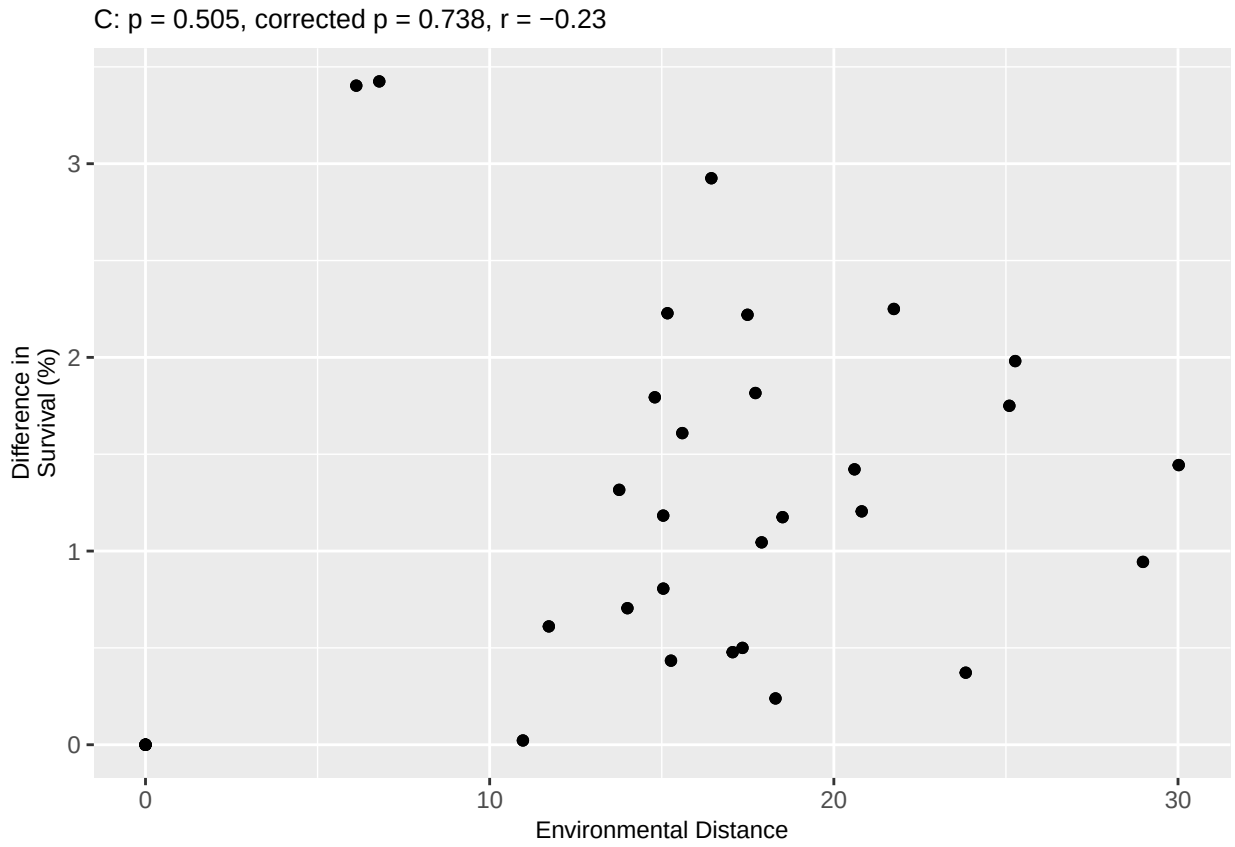
```
  theme(axis.title.y = element_text(size = 9), axis.title.x = element_blank(), axis.text.x = element_bla

length21_envr_dist
```



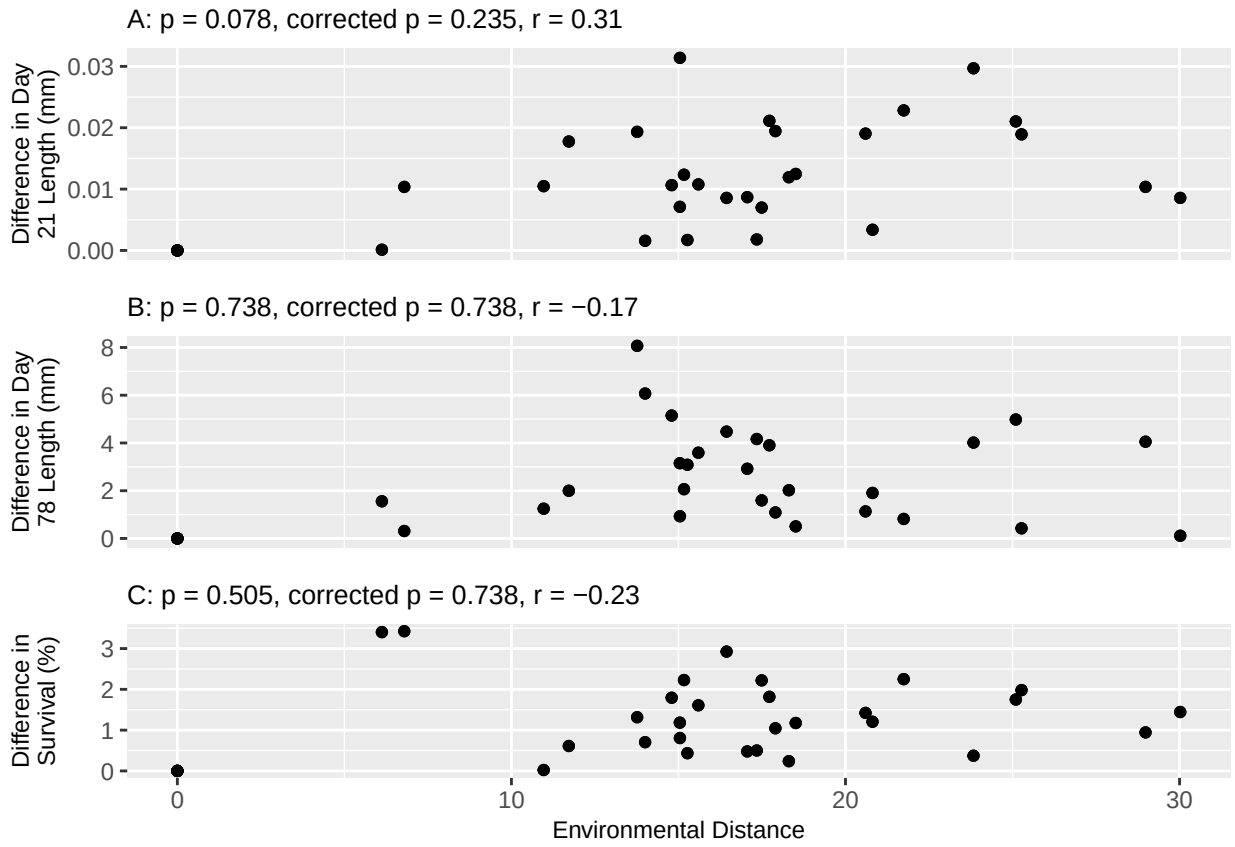

```
length78_envr_dist <- pairwise_dist %>%
  ggplot(aes(x = envr_pairwise_dist, y = day78_pairwise_len_dist))+
  geom_point()+
  labs(subtitle = "B: p = 0.738, corrected p = 0.738, r = -0.17")+
  ylab(wrapper("Difference in Day 78 Length (mm)", width = 20))+
  theme(axis.title.y = element_text(size = 9), axis.title.x = element_blank(), axis.text.x = element_bla

length78_envr_dist
```




```
surv_envr_dist <- pairwise_dist %>%
  ggplot(aes(x = envr_pairwise_dist, y = day21_pairwise_surv_dist))+
  geom_point()+
  labs(subtitle = "C: p = 0.505, corrected p = 0.738, r = -0.23")+
  ylab(wrapper("Difference in Survival (%)", width = 20))+
  xlab("Environmental Distance")+
  theme(axis.title.y = element_text(size = 9), axis.title.x = element_text(size = 9), plot.subtitle = el

surv_envr_dist
```




```
mantel_plots <- plot_grid(length21_envr_dist, length78_envr_dist, surv_envr_dist, ncol = 1, align = "v"

mantel_plots
```




```
ggsave("mantel_plots.png",
       plot = mantel_plots,
       device = png,
       path = "/Users/nicolemongillo/Desktop/GitHub/MVP_Chesapeake_VIMS_hatchery/results/NM_results/Resu
```

```
## Saving 6.5 x 4.5 in image
```