SEACAR Nekton Analysis: Species Richness

Last compiled on 08 May, 2023

Contents

Important Notes

These scripts were created by J.E. Panzik for SEACAR.

All scripts and outputs can be found on the SEACAR GitHub repository:

https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses

This markdown file is designed to be compiled by SEACAR_CoastalWetlands_SpeciesRichness_ReportRender.R.

This script is based off of code originally written by Katie May Laumann

Libraries and Settings

Loads libraries used in the script. The inclusion of `scipen` option limits how frequently R defaults to scientific notation. Sets default settings for displaying warning and messages in created document, and sets figure dpi.

```
library(knitr)
library(data.table)
library(dplyr)
library(lubridate)
library(ggplot2)
library(scales)
library(tidyr)
library(gridExtra)
```

```
#library(tidyverse)
library(ggpubr)
library(scales)
options(scipen=999)
opts_chunk$set(warning=FALSE, message=FALSE, dpi=200)
```

File Import

Imports file that is determined in the SEACAR_CoastalWetlands_ReportRender.R script.

The command `fread` is used because of its improved speed while handling large data files. Only columns that are used by the script are imported from the file, and are designated in the `select` input.

The script then gets the name of the parameter as it appears in the data file and units of the parameter.

The file being used for the analysis is: **All Parameters but Hecatres-2021-Jul-26.csv**

```
#Import data from nekton file
data <- fread(file_in, sep=",", header=TRUE, stringsAsFactors=FALSE,
              na.strings="")

cat(paste("The data file used is:", file_in, sep="\n"))
```

```
## The data file used is:
## data/All Parameters but Hecatres-2021-Jul-26.csv
```

Data Filtering

The processing and filtering that is done to the data is as follows:

1. `[PercentCover-SpeciesComposition_%]` column is renamed `perccov`
2. Removes data that contains NA values in `GenusName`, `SpeciesName`, `Month`, `Year`, `SpeciesGroup1`, and removes invasive species data
3. Excludes data from program 5015 and 651
4. Removes duplicates (`MADup`==1) and where percent cover is 0
5. Combines genus and species names
6. Makes month and year numeric values
7. Makes a combined year+month column where all months have 2 digits.
8. Summarize data by managed area and remove managed areas with less than 5 years
9. Include only data with more than 5 years

```
# Create ParameterName Column
data$ParameterName <- "Species Richness"
parameter <- "Species Richness"

# Changes column name to perccov for ease moving forward
colnames(data)[colnames(data) == "[PercentCover-SpeciesComposition_%]"] <-
  "perccov"

#Changes "ManagedArea" column name to "ManagedAreaName" for consistency
colnames(data)[colnames(data) == "ManagedArea"] <- "ManagedAreaName"
```

```r
# Sets units for species richness
unit <- "# of species"
data$ParameterUnits <- unit

# Replace instances where NA values imported as blank character string or as "NA"
data <- replace(data, data=="", NA)
data <- replace(data, data=="NA", NA)

# Remove rows with missing ManagedAreaName
data <- data[!is.na(data$ManagedAreaName),]
data <- data[data$ManagedAreaName!="NA",]
# Remove rows with missing GenusName
data <- data[!is.na(data$GenusName),]
# Remove rows with missing SpeciesName
data <- data[!is.na(data$SpeciesName),]
# Remove rows with missing Months
data <- data[!is.na(data$Month),]
# Remove rows with missing Years
data <- data[!is.na(data$Year),]
# Remove rows with missing SpeciesGroup1
data <- data[!is.na(data$SpeciesGroup1),]
# Remove rows with invasive species
data <- data[data$SpeciesGroup1!="Invasive",]
# Set perccov to be a number value
data$perccov <- as.numeric(data$perccov)
# Remove rows where perccov is 0
data <- data[data$perccov!=0,]
# Remove duplicate rows
data <- data[data$MADup==1,]
# Create variable that combines the genus and species name
data$gensp <- paste(data$GenusName, data$SpeciesName, sep=" ")
# Corrects Managed Area names to be consistent with official names
data$ManagedAreaName[data$ManagedAreaName=="Apalachicola Bay"] <-
   "Apalachicola Bay Aquatic Preserve"
data$ManagedAreaName[data$ManagedAreaName=="Big Bend Seagrasses"] <-
   "Big Bend Seagrasses Aquatic Preserve"
data$ManagedAreaName[data$ManagedAreaName=="Cockroach Bay"] <-
   "Cockroach Bay Aquatic Preserve"
data$ManagedAreaName[data$ManagedAreaName=="Guana River Marsh"] <-
   "Guana River Marsh Aquatic Preserve"
data$ManagedAreaName[data$ManagedAreaName=="Guana Tolomato Matanzas NERR"] <-
   "Guana Tolomato Matanzas National Estuarine Research Reserve"

# Create Species Richness values for groups of unique combinations of
# ManagedAreaName, ProgramID, ProgramName, ProgramLocationID, and SampleDate.
data <- data %>%
   group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
            SampleDate) %>%
   summarise(ParameterName=parameter,
             Year=unique(Year), Month=unique(Month),
             SpeciesRichness=length(unique(gensp)))

# Adds AreaID for each managed area by combining the MA_All datatable to the
# data based on ManagedAreaName
data <- merge.data.frame(MA_All[,c("AreaID", "ManagedAreaName")],
                          data, by="ManagedAreaName", all=TRUE)

# Writes this data that is used by the rest of the script to a text file
fwrite(data, paste0(out_dir,"/CoastalWetlands_", param_file, "_UsedData.txt"),
       sep="|")

# Makes sure SampleDate is being stored as a Date object
data$SampleDate <- as.Date(data$SampleDate)

# Creates a variable with the names of all the managed areas that contain
# species observations
MA_Include <- unique(data$ManagedAreaName[!is.na(data$SpeciesRichness)])

# Puts the managed areas in alphabetical order
MA_Include <- MA_Include[order(MA_Include)]

# Determines the number of managed areas used
n <- length(MA_Include)
```

Managed Area Statistics

Gets summary statistics for each managed area. Uses piping from dplyr package to feed into subsequent steps. The following steps are performed:

1. Group data that have the same ManagedAreaName, Year, and Month.
   - Second summary statistics do not use the Month grouping and are only for ManagedAreaName and Year.
   - Third summary statistics do not use Year grouping and are only for ManagedAreaName and Month
2. For each group, provide the following information: Parameter Name (ParameterName), Number of Entries (N_Data), Lowest Value (Min), Largest Value (Max), Median, Mean, Standard Deviation, and a list of all Programs included in these measurements.
3. Sort the data in ascending (A to Z and 0 to 9) order based on ManagedAreaName then Year then Month
4. Write summary stats to a pipe-delimited .txt file in the output directory
   - Coastal Wetlands Output Files in SEACAR GitHub

```
# Create summary statistics for each managed area based on Year and Month
# intervals.
MA_YM_Stats <- data %>%
   group_by(AreaID, ManagedAreaName, Year, Month) %>%
   summarize(ParameterName=parameter,
             N_Data=length(na.omit(SpeciesRichness)),
             Min=min(SpeciesRichness),
             Max=max(SpeciesRichness),
             Median=median(SpeciesRichness),
             Mean=mean(SpeciesRichness),
             StandardDeviation=sd(SpeciesRichness),
             Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                              collapse=', '),
             ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '))
# Puts the data in order based on ManagedAreaName, Year, then Month
MA_YM_Stats <- as.data.table(MA_YM_Stats[order(MA_YM_Stats$ManagedAreaName,
                                               MA_YM_Stats$Year,
                                               MA_YM_Stats$Month), ])
# Writes summary statistics to file
fwrite(MA_YM_Stats, paste0(out_dir,"/CoastalWetlands_", param_file,
                           "_MA_MMYY_Stats.txt"), sep="|")
# Removes variable storing data to improve computer memory
rm(MA_YM_Stats)

# Create summary statistics for each managed area based on Year intervals
MA_Y_Stats <- data %>%
   group_by(AreaID, ManagedAreaName, Year) %>%
   summarize(ParameterName=parameter,
             N_Data=length(na.omit(SpeciesRichness)),
             Min=min(SpeciesRichness),
             Max=max(SpeciesRichness),
             Median=median(SpeciesRichness),
             Mean=mean(SpeciesRichness),
             StandardDeviation=sd(SpeciesRichness),
             Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                              collapse=', '),
             ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '))
# Puts the data in order based on ManagedAreaName then Year
MA_Y_Stats <- as.data.table(MA_Y_Stats[order(MA_Y_Stats$ManagedAreaName,
                                             MA_Y_Stats$Year), ])
# Writes summary statistics to file
fwrite(MA_Y_Stats, paste0(out_dir,"/CoastalWetlands_", param_file,
                          "_MA_Yr_Stats.txt"), sep="|")

# Create summary statistics for each managed area based on Month intervals.
MA_M_Stats <- data %>%
   group_by(AreaID, ManagedAreaName, Month) %>%
   summarize(ParameterName=parameter,
             N_Data=length(na.omit(SpeciesRichness)),
             Min=min(SpeciesRichness),
             Max=max(SpeciesRichness),
             Median=median(SpeciesRichness),
             Mean=mean(SpeciesRichness),
             StandardDeviation=sd(SpeciesRichness),
             Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                              collapse=', '),
             ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '))
# Puts the data in order based on ManagedAreaName then Month
MA_M_Stats <- as.data.table(MA_M_Stats[order(MA_M_Stats$ManagedAreaName,
                                             MA_M_Stats$Month), ])
# Writes summary statistics to file
fwrite(MA_M_Stats, paste0(out_dir,"/CoastalWetlands_", param_file,
                          "_MA_Mo_Stats.txt"), sep="|")
```

```
# Removes variable storing data to improve computer memory
rm(MA_M_Stats)

# Create summary overall statistics for each managed area.
MA_Ov_Stats <- data %>%
   group_by(AreaID, ManagedAreaName) %>%
   summarize(ParameterName=parameter,
             N_Years=length(unique(na.omit(Year))),
             EarliestYear=min(Year),
             LatestYear=max(Year),
             N_Data=length(na.omit(SpeciesRichness)),
             Min=min(SpeciesRichness),
             Max=max(SpeciesRichness),
             Median=median(SpeciesRichness),
             Mean=mean(SpeciesRichness),
             StandardDeviation=sd(SpeciesRichness),
             Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                              collapse=', '),
             ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '))
# Puts the data in order based on ManagedAreaName
MA_Ov_Stats <- as.data.table(MA_Ov_Stats[order(MA_Ov_Stats$ManagedAreaName), ])
# Creates Year_MinRichness and Year_MaxRichness columns
MA_Ov_Stats$Year_MinRichness <- NA
MA_Ov_Stats$Year_MaxRichness <- NA

# Loops through each ManagedAreaName.
# Determines what year the minimum and maximum species richness occurred
for(m in 1:nrow(MA_Ov_Stats)){
   # Stores ManagedAreaName for this row
   ma <- MA_Ov_Stats$ManagedAreaName[m]

   # Skips to next row if there are no data for this combination
   if(MA_Ov_Stats$N_Data[m]==0){
      next
   }
   # Gets subset of data from MA_Y_Stats (yearly summary stats) with this
   # ManagedAreaName
   ds <- MA_Y_Stats[MA_Y_Stats$ManagedAreaName==ma,]
   # Gets the minimum and maximum Mean (yearly averages)
   min <- min(ds$Mean)
   max <- max(ds$Mean)
   #Determines what years those minimum and maximum values occured
   year_min <- ds$Year[ds$Mean==min]
   year_max <- ds$Year[ds$Mean==max]
   # Stores the occurrence years of the minimum and maximum into the overall
   # stats for this row
   MA_Ov_Stats$Year_MinRichness[m] <- year_min
   MA_Ov_Stats$Year_MaxRichness[m] <- year_max
}
# Replaces blank ProgramIDs with NA (missing values)
MA_Ov_Stats$ProgramIDs <- replace(MA_Ov_Stats$ProgramIDs,
                                  MA_Ov_Stats$ProgramIDs=="", NA)
```

```
MA_Ov_Stats$Programs <- replace(MA_Ov_Stats$Programs,
                                  MA_Ov_Stats$Programs=="", NA)
# Write overall statistics to file
fwrite(MA_Ov_Stats, paste0(out_dir,"/CoastalWetlands_", param_file,
                           "_MA_Overall_Stats.txt"), sep="|")
# Removes entries from the overall statistics that do not have data.
# Based on presence or absence of EarliestYear
MA_Ov_Stats <- MA_Ov_Stats[!is.na(MA_Ov_Stats$EarliestYear), ]
```

Appendix I: Managed Area Species Richness

The plots shown here are the species richness for each managed area with a yearly average.

1. Set common plot theme.
2. Determine the earliest and latest year of the data to create x-axis scale and intervals
3. Determine the upper and lower limit of the plot for better y-axis labels
4. Determines what gear types are present and adjusts legend entries
5. Add the plot line
6. Set the plot type as a point plot with the size of the points
7. Create the title, x-axis, y-axis, and color fill labels
8. Set the y and x limits
9. Apply common plot theme
10. Add table with summary statistics below each figure

- Numerical non-integer values are rounded to 2 decimal places
- StandardDeviation is renamed StDev for space reasons

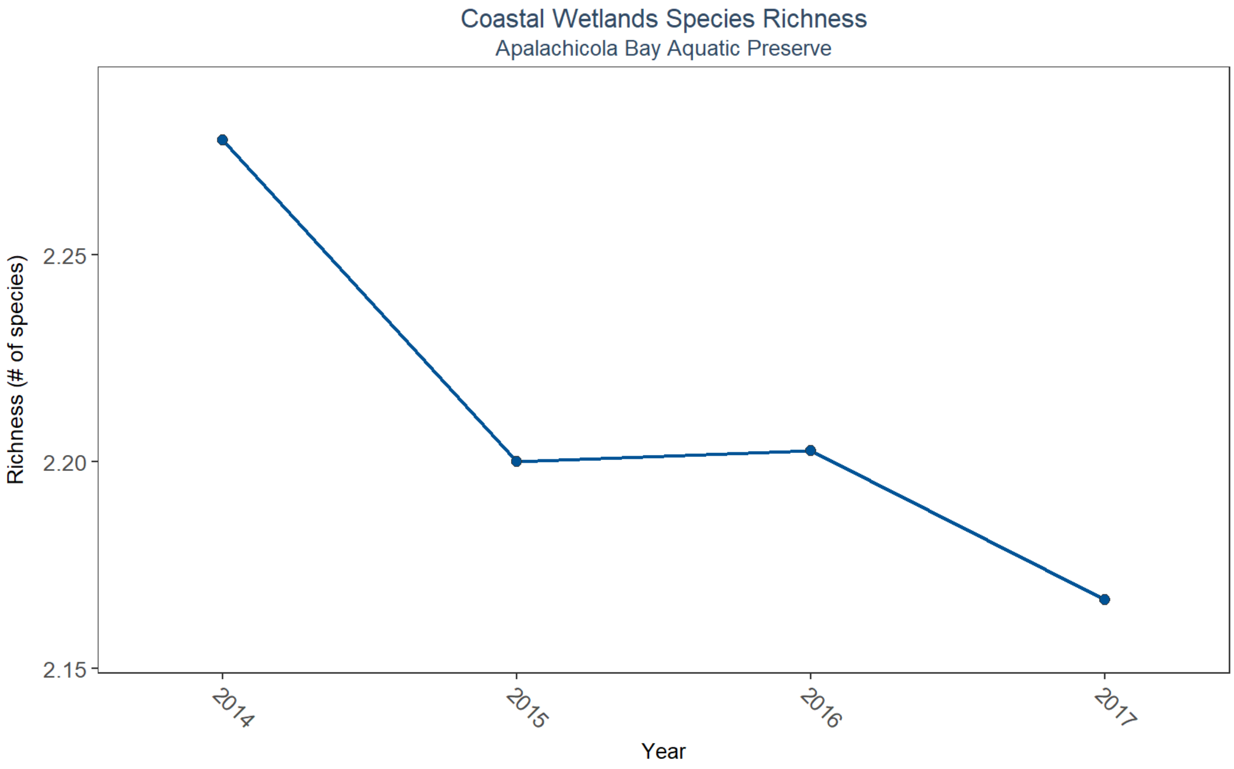
11. Create file name to save figure
12. Save figure as png file

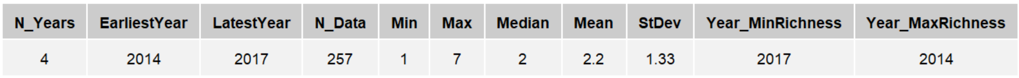
- Coastal Wetlands Figures in SEACAR GitHub

```
# Defines standard plot theme: black and white, no major or minor grid lines,
# Arial font. Title is centered, size 12, and blue (hex coded). Subtitle is
# centered, size 10, and blue (hex coded). Legend title is size 10 and the
# legend is left-justified. X-axis title is size 10 and the margins are padded
# at the top and bottom to give more space for angled axis labels. Y-axis title
# is size 10 and margins are padded on the right side to give more space for
# axis labels. Axis labels are size 10 and the x-axis labels are rotated -45
# degrees with a horizontal justification that aligns them with the tick mark
plot_theme <- theme_bw() +
   theme(panel.grid.major = element_blank(),
         panel.grid.minor = element_blank(),
         text=element_text(family="Arial"),
         plot.title=element_text(hjust=0.5, size=12, color="#314963"),
         plot.subtitle=element_text(hjust=0.5, size=10, color="#314963"),
         legend.title=element_text(size=10),
         legend.text.align = 0,
         axis.title.x = element_text(size=10, margin = margin(t = 5, r = 0,
                                                              b = 10, l = 0)),
         axis.title.y = element_text(size=10, margin = margin(t = 0, r = 10,
                                                              b = 0, l = 0)),
         axis.text=element_text(size=10),
         axis.text.x=element_text(angle = -45, hjust = 0))

# Color palette for SEACAR
color_palette <- c("#005396", "#0088B1", "#00ADAE", "#65CCB3", "#AEE4C1",
                   "#FDEBA8", "#F8CD6D", "#F5A800", "#F17B00")



# Loop that cycles through each managed area with data
if(n==0){
   # Prints a statement if there are no managed areas with appropriate data
   print("There are no monitoring locations that qualify.")
} else {
   for (i in 1:n) {
      # Gets data for target managed area
      plot_data <- MA_Y_Stats[MA_Y_Stats$ManagedAreaName==MA_Include[i]]
      # Determines most recent year with available data for managed area
      t_max <- max(MA_Ov_Stats$LatestYear[MA_Ov_Stats$ManagedAreaName==
                                             MA_Include[i]])
      # Determines earliest recent year with available data for managed area
      t_min <- min(MA_Ov_Stats$EarliestYear[MA_Ov_Stats$ManagedAreaName==
                                               MA_Include[i]])
      # Determines how many years of data are present
      t <- t_max-t_min

      # Creates break intervals for plots based on number of years of data
      if(t>=30){
         # Set breaks to every 10 years if more than 30 years of data
         brk <- -10
      }else if(t<30 & t>=10){
         # Set breaks to every 5 years if between 30 and 10 years of data
         brk <- -5
      }else if(t<10 & t>=4){
         # Set breaks to every 2 years if between 10 and 4 years of data
         brk <- -2
      }else if(t<4){
         # Set breaks to every year if less than 4 years of data
         brk <- -1
      }
      # Determine range of data values for the managed area
      y_range <- max(plot_data$Mean) - min(plot_data$Mean)

      # Determines lower bound of y-axis based on data range. Set based on
      # relation of data range to minimum value. Designed to set lower boundary
      # to be 10% of the data range below the minimum value
      y_min <- if(min(plot_data$Mean)-(0.1*y_range)<0){
         # If 10% of the data range below the minimum value is less than 0,
         # set as 0
         y_min <- 0
      } else {
```

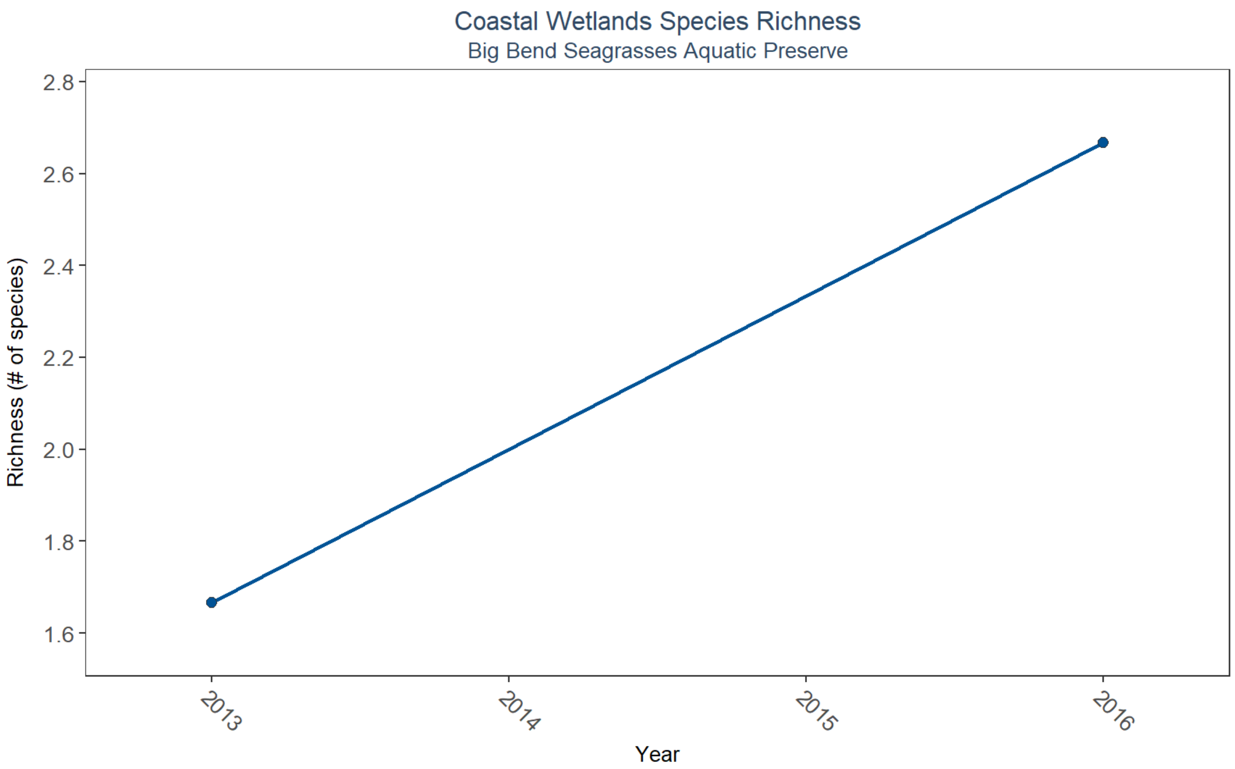
```
   # Otherwise set minimum bound as 10% data range below minimum value
   y_min <- min(plot_data$Mean)-(0.1*y_range)
}

# Sets upper bound of y-axis to be 10% of the data range above the
# maximum value.
y_max <- max(plot_data$Mean)+(0.1*y_range)


# Creates plot object using plot_data.
# Data is plotted as symbols with connected lines.
p1 <- ggplot(data=plot_data) +
   geom_line(aes(x=Year, y=Mean), color=color_palette[1],
             size=0.75, alpha=1) +
   geom_point(aes(x=Year, y=Mean), fill=color_palette[1],
                  shape=21, size=2, color="#333333", alpha=1) +
   labs(title="Coastal Wetlands Species Richness",
        subtitle=MA_Include[i],
        x="Year", y="Richness (# of species)") +
   scale_x_continuous(limits=c(t_min-0.25, t_max+0.25),
                      breaks=seq(t_max, t_min, brk)) +
   scale_y_continuous(limits=c(y_min, y_max),
                      breaks=pretty_breaks(n=5)) +
   plot_theme
# Sets file name of plot created
outname <- paste0("CoastalWetlands_", gsub(" ", "", MA_Include[i]), "_",
                  param_file, ".png")
# Saves plot as a png image
png(paste0(out_dir, "/Figures/", outname),
    width = 8,
    height = 4,
    units = "in",
    res = 200)
print(p1)
dev.off()

# Creates a data table object to be shown underneath plots in report
ResultTable <-
   MA_Ov_Stats[MA_Ov_Stats$ManagedAreaName==MA_Include[i],]
# Removes location, and parameter information because it is in plot
# labels
ResultTable <- ResultTable[,-c("AreaID", "ManagedAreaName",
                               "ProgramIDs", "Programs", "ParameterName")]
# Renames StandardDeviation to StDev to save horizontal space
ResultTable <- ResultTable %>%
   rename("StDev"="StandardDeviation")
# Converts all non-integer values to 2 decimal places for space
ResultTable$Min <- round(ResultTable$Min, digits=2)
ResultTable$Max <- round(ResultTable$Max, digits=2)
ResultTable$Median <- round(ResultTable$Median, digits=2)
ResultTable$Mean <- round(ResultTable$Mean, digits=2)
ResultTable$StDev <- round(ResultTable$StDev, digits=2)
# Stores as plot table object
```

```
      t1 <- ggtexttable(ResultTable, rows = NULL,
                        theme=ttheme(base_size=7))
      # Combines plot and table into one figure
      print(ggarrange(p1, t1, ncol=1, heights=c(0.85, 0.15)))

      # Add extra space at the end to prevent the next figure from being too
      # close
      cat("\n \n \n \n")
   }
}
```

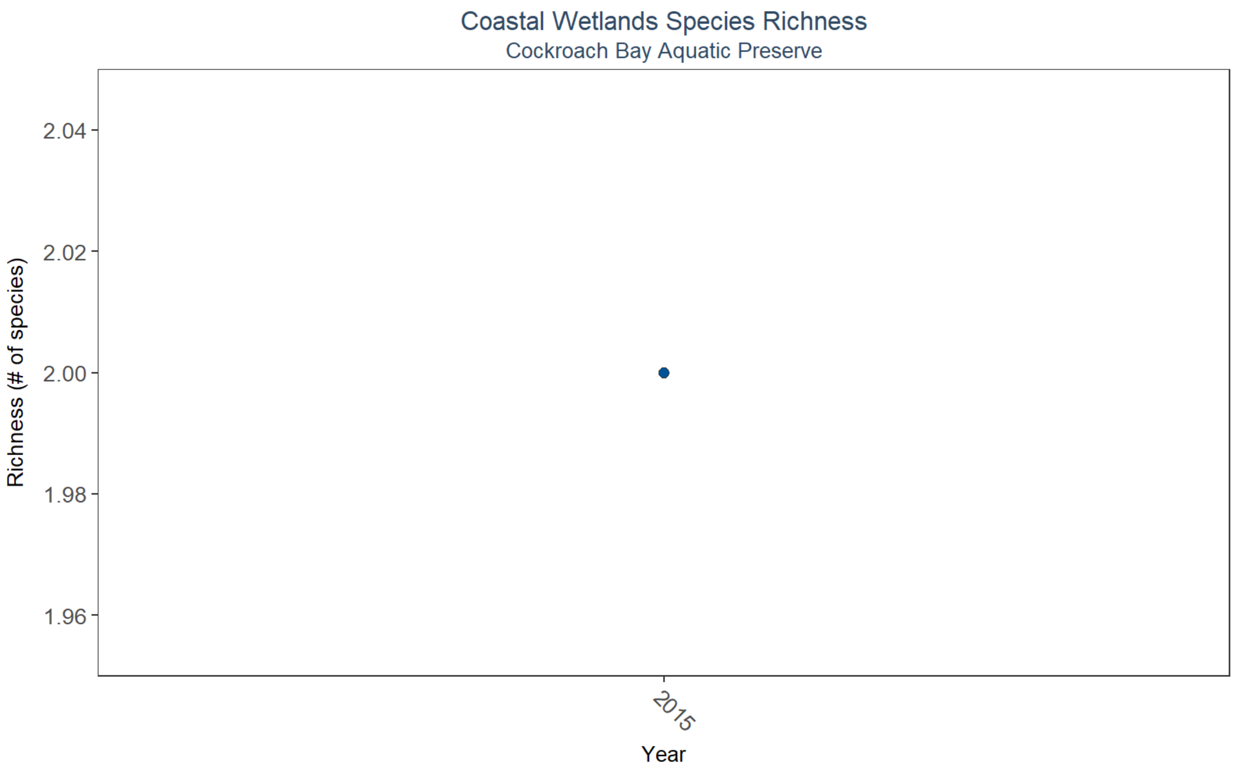




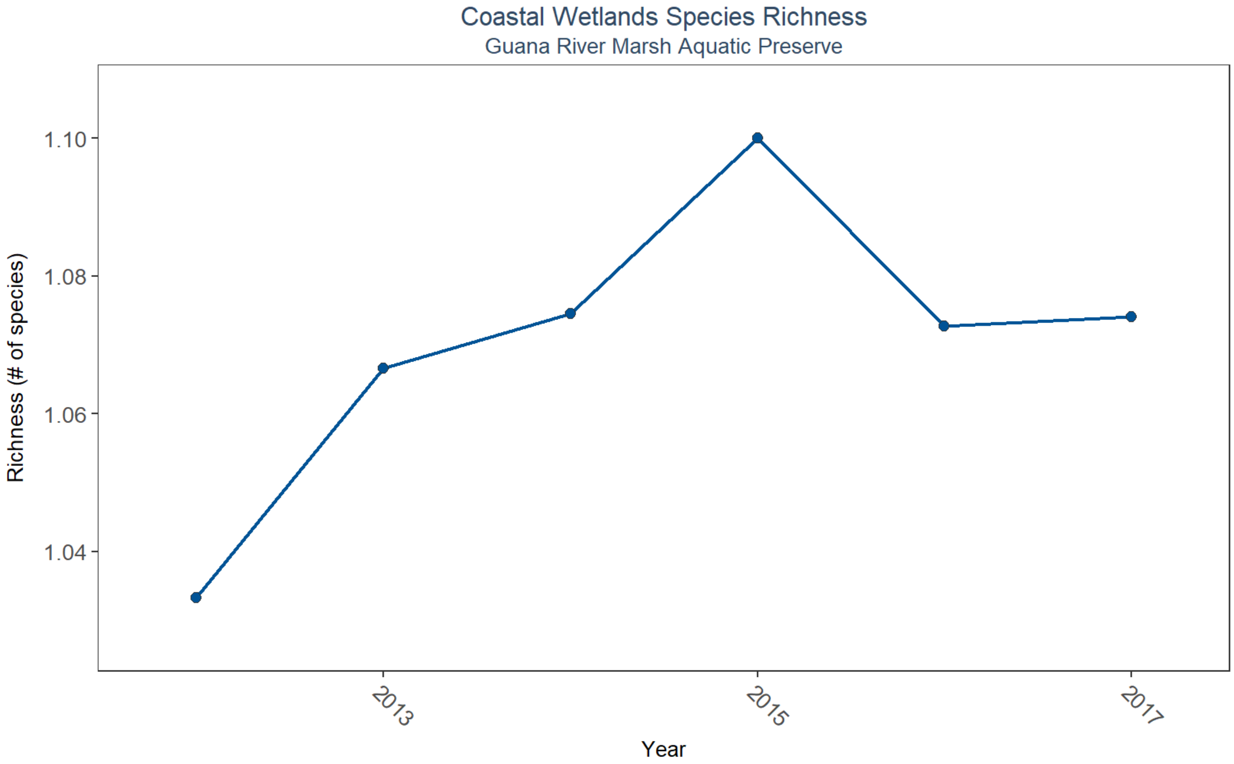
N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
4	2014	2017	257	1	7	2	2.2	1.33	2017	2014



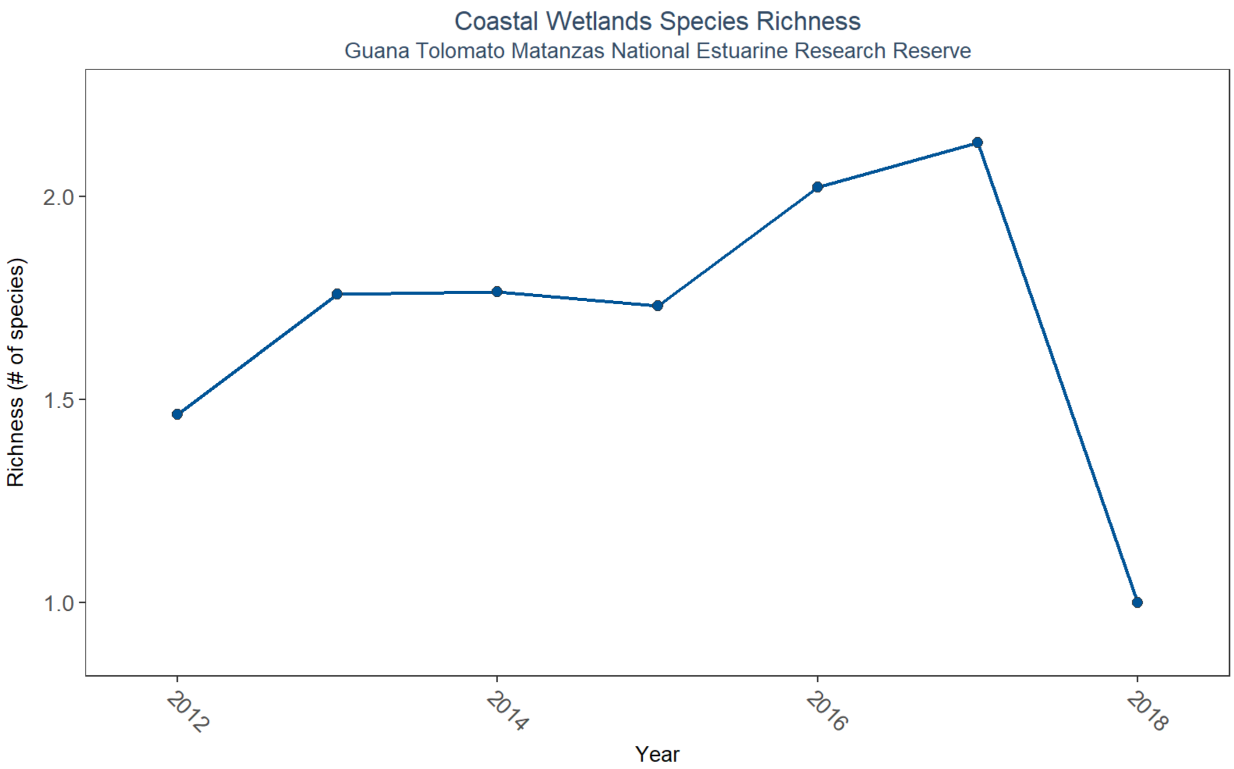
N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
2	2013	2016	6	1	3	2	2.17	0.75	2013	2016



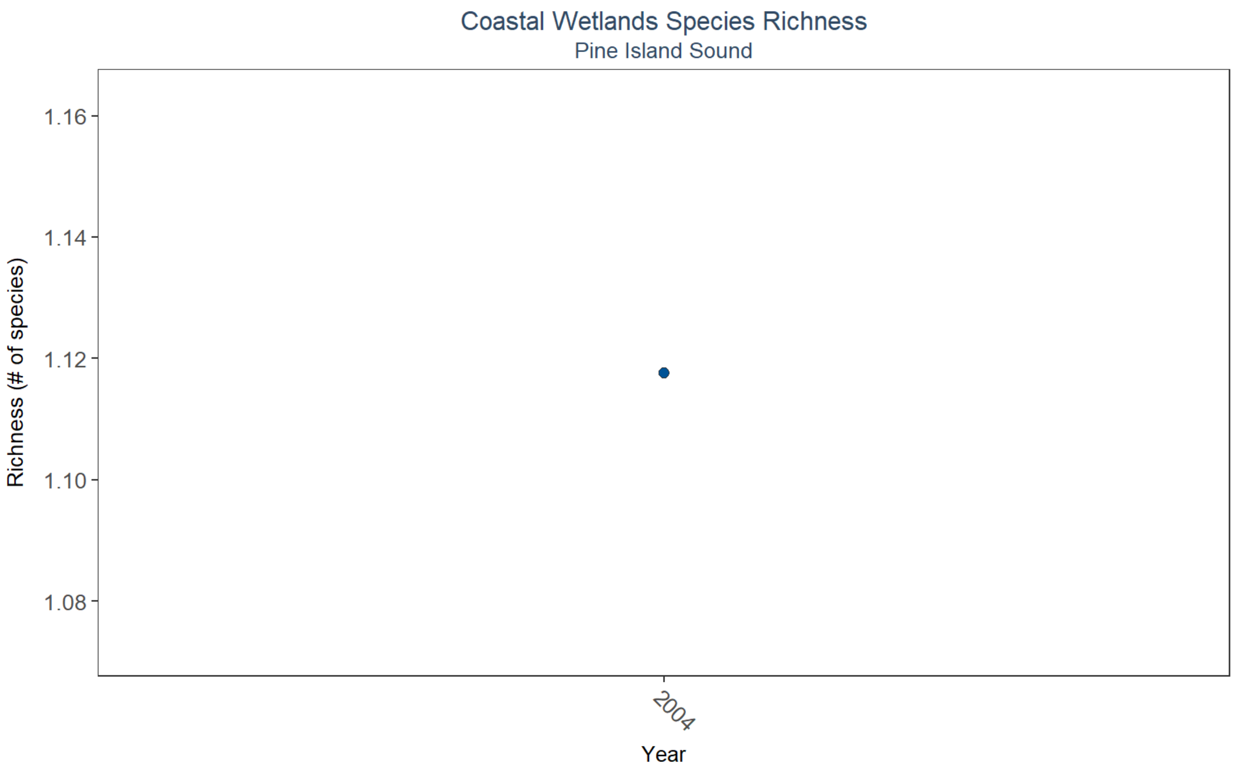
N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
1	2015	2015	1	2	2	2	2	NA	2015	2015



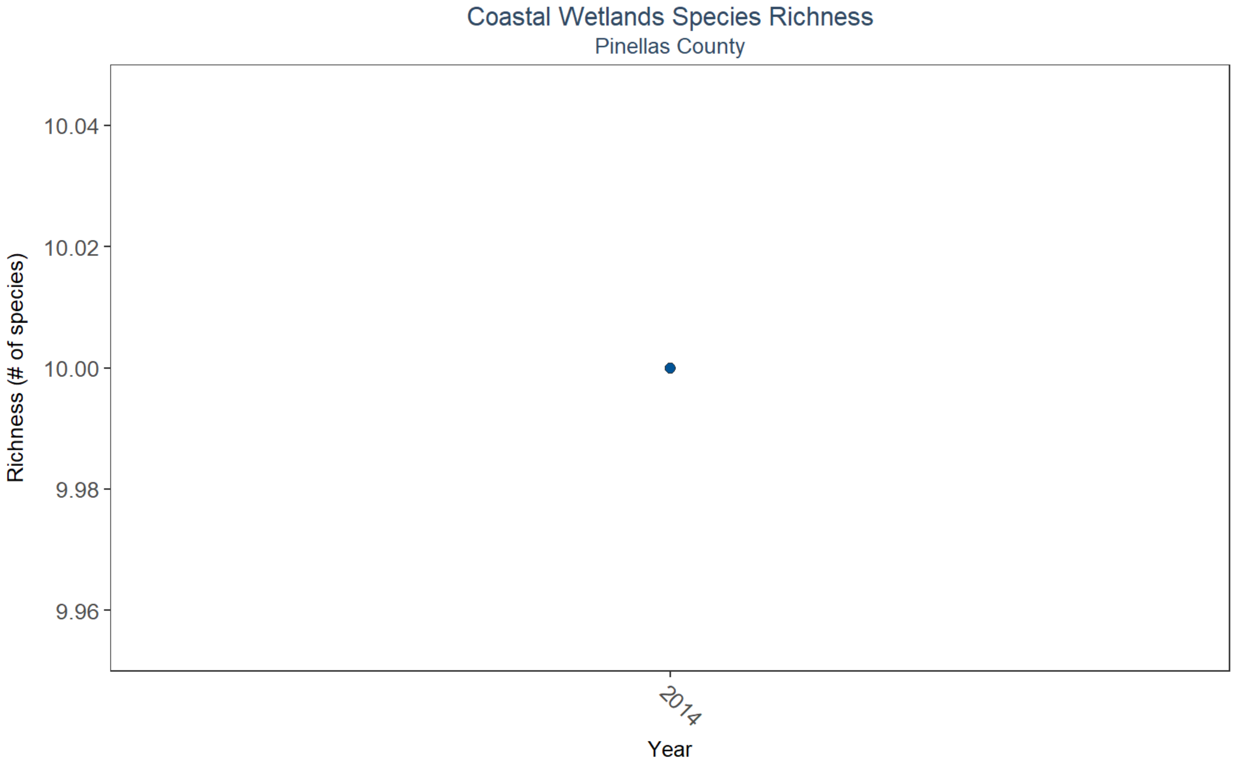
N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
6	2012	2017	497	1	3	1	1.07	0.27	2012	2015



N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
7	2012	2018	1188	1	7	2	1.78	0.96	2018	2017



N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
1	2004	2004	17	1	2	1	1.12	0.33	2004	2004



N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
1	2014	2014	1	10	10	10	10	NA	2014	2014