

# SEACAR Nekton Analysis: Species Richness

Last compiled on 30 March, 2023

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## 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](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses)

This markdown file is designed to be compiled by [SEACAR\\_Nekton\\_SpeciesRichness\\_ReportRender.R](#).

Details on the determination of catch per unit effort can be found in the document [SEACAR Nekton catch per unit effort.pdf](#).

## 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\_Nekton\_SpeciesRichness\_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: **Presence-2022-Jun-29.txt**

```
#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/Presence-2022-Jun-29.txt
```

## Data Filtering

Documentation on database filtering is provided here: [SEACAR Documentation- Analysis Filters and Calculations.pdf](#).

Imported data is initially filtered to only contain the parameter of interest.

The other filtering performed by the script at this point removes rows that are missing values for `ResultValue` and `EffortCorrection_100m2`, and removes any `EffortCorrection_100m2` that is 0 because it will cause an infinite number when determining Species Richness.

A group of unique `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, `SampleDate`, and `GearSize_m` are being considered a “reference” for measurement. For each “reference”, the number of observed species is summed and then divided by the `EffortCorrection_100m2` to determine the Species Richness per 100 square meters.

The `ManagedAreaName` values from the data are actually shortened versions, and are merged with the full versions. The species richness data is then written to a file. And the list of Managed Areas with observations is stored.

```
# Filter data for the desired parameter
data <- data[data$ParameterName==param_name,]

if (param_name=="Presence"){
  parameter <- "Species Richness"
}
```

```

# Gets the units of the data
unit <- unique(data$ParameterUnits)

# Remove any data with missing EffortCorrection values
data <- data[!is.na(data$EffortCorrection_100m2),]

# Only keep data that has non-zero EffortCorrection values
data <- data[data$EffortCorrection_100m2!=0,]

# Remove any data with missing ResultValue entries
data <- data[!is.na(data$ResultValue),]

# Create Species Richness values for groups of unique combinations of
# ManagedAreaName, ProgramID, ProgramName, ProgramLocationID, SampleDate,
# GearType, and GearSize_m.
data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
    SampleDate, GearType, GearSize_m) %>%
  summarise(ParameterName=parameter,
    Year=unique(Year), Month=unique(Month),
    N_Species=sum(ResultValue),
    EffortCorrection_100m2=unique(EffortCorrection_100m2),
    SpeciesRichness=N_Species/unique(EffortCorrection_100m2))

# 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, "/Nekton_", 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$ManagedAreaName[!is.na(data$N_Species)])

# 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, Month, GearType, and GearSize\_m.

- 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 Program IDs 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
- [Nekton Output Files in SEACAR GitHub](#)

```
# Create summary statistics for each managed area based on Year and Month
# intervals, and each gear type and size.
MA_YM_Stats <- data %>%
  group_by(AreaID, ManagedAreaName, Year, Month, GearType, GearSize_m) %>%
  summarize(ParameterName=parameter,
            N_Data=length(na.omit(SpeciesRichness)),
            Min=min(SpeciesRichness),
            Max=max(SpeciesRichness),
            Median=median(SpeciesRichness),
            Mean=mean(SpeciesRichness),
            StandardDeviation=sd(SpeciesRichness),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                             collapse=', '))

# Puts the data in order based on ManagedAreaName, Year, Month, then GearSize
MA_YM_Stats <- as.data.table(MA_YM_Stats[order(MA_YM_Stats$ManagedAreaName,
                                              MA_YM_Stats$Year,
                                              MA_YM_Stats$Month,
                                              MA_YM_Stats$GearSize_m), ])

# Writes summary statistics to file
fwrite(MA_YM_Stats, paste0(out_dir, "/Nekton_", param_file,
                           "_MA_MMY_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,
# and each gear type and size.
MA_Y_Stats <- data %>%
  group_by(AreaID, ManagedAreaName, Year, GearType, GearSize_m) %>%
  summarize(ParameterName=parameter,
            N_Data=length(na.omit(SpeciesRichness)),
            Min=min(SpeciesRichness),
            Max=max(SpeciesRichness),
            Median=median(SpeciesRichness),
            Mean=mean(SpeciesRichness),
            StandardDeviation=sd(SpeciesRichness),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                             collapse=', '))

# Puts the data in order based on ManagedAreaName, Year, then GearSize
MA_Y_Stats <- as.data.table(MA_Y_Stats[order(MA_Y_Stats$ManagedAreaName,
                                              MA_Y_Stats$Year,
                                              MA_Y_Stats$GearSize_m), ])

# Writes summary statistics to file
fwrite(MA_Y_Stats, paste0(out_dir, "/Nekton_", param_file,
```

```

        "_MA_Yr_Stats.txt"), sep="|")

# Create summary statistics for each managed area based on Month intervals,
# and each gear type and size.
MA_M_Stats <- data %>%
  group_by(AreaID, ManagedAreaName, Month, GearType, GearSize_m) %>%
  summarize(ParameterName=parameter,
            N_Data=length(na.omit(SpeciesRichness)),
            Min=min(SpeciesRichness),
            Max=max(SpeciesRichness),
            Median=median(SpeciesRichness),
            Mean=mean(SpeciesRichness),
            StandardDeviation=sd(SpeciesRichness),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                             collapse=', '))

# Puts the data in order based on ManagedAreaName, Month, then GearSize
MA_M_Stats <- as.data.table(MA_M_Stats[order(MA_M_Stats$ManagedAreaName,
                                             MA_M_Stats$Month,
                                             MA_M_Stats$GearSize_m), ])

# Writes summary statistics to file
fwrite(MA_M_Stats, paste0(out_dir,"/Nekton_", 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 based each gear type
# and size.
MA_Ov_Stats <- data %>%
  group_by(AreaID, ManagedAreaName, GearType, GearSize_m) %>%
  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),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                             collapse=', '))

# Puts the data in order based on ManagedAreaName then GearSize
MA_Ov_Stats <- as.data.table(MA_Ov_Stats[order(MA_Ov_Stats$ManagedAreaName,
                                             MA_Ov_Stats$GearSize_m), ])

# Creates Year_MinRichness and Year_MaxRichness columns
MA_Ov_Stats$Year_MinRichness <- NA
MA_Ov_Stats$Year_MaxRichness <- NA

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

```

```

gear <- MA_Ov_Stats$GearType[m]
size <- MA_Ov_Stats$GearSize_m[m]
# Skips to next row if there are no data for this combination
if(MA_Ov_Stats$N_Data[m]==0){
  next
}
# Gets subset of data from MA_Y_Stats (yearly summary stats) with this
# combination of ManagedAreaName, GearType, and GearSize_m
ds <- MA_Y_Stats[MA_Y_Stats$ManagedAreaName==ma &
  MA_Y_Stats$GearType==gear &
  MA_Y_Stats$GearSize_m==size,]
# Gets the minimum and maximum Mean (yearly averages)
min <- min(ds$Mean)
max <- max(ds$Mean)
#Determines what years those minimum and maximum values occurred
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$ProgramIDs <- gsub("", NA, MA_Ov_Stats$ProgramIDs)
# Write overall statistics to file
fwrite(MA_Ov_Stats, paste0(out_dir, "/Nekton-", 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, separated by gear size.

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

- [Nekton 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))

# Defines and sets variable with standardized gear colors for plots
gear_colors <- c("Trawl (4.8 m)"="#00374f",
                "Trawl (6.1 m)"="#007c99",
                "Seine (183 m)"="#00c9db")

# Defines and sets variable with standardized gear shapes for plots
gear_shapes <- c("Trawl (4.8 m)"=21,
                "Trawl (6.1 m)"=22,
                "Seine (183 m)"=24)

# 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$ManagedAreaName==MA_Include[i]]
    # Gets the gear type(s) present for the managed area.
    # Combine type and size into one label for plots
    plot_data$GearType_Plot <- paste0(plot_data$GearType, " (",
                                      plot_data$GearSize_m, " m)")
    # 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)

# Determines what combination of gear are present for managed area
# and subsets color and shape scheme to be used by plots.
# Used so only gear combinations present for managed area appear in legend.
gear_colors_plot <- gear_colors[unique(plot_data$GearType_Plot)]
gear_shapes_plot <- gear_shapes[unique(plot_data$GearType_Plot)]

# Creates plot object using plot_data and grouping by the plot gear types.
# Data is plotted as symbols with connected lines.
p1 <- ggplot(data=plot_data, group=as.factor(GearType_Plot)) +
  geom_line(aes(x=Year, y=Mean, color=as.factor(GearType_Plot)),
    size=0.75, alpha=1) +
  geom_point(aes(x=Year, y=Mean, fill=as.factor(GearType_Plot),
    shape=as.factor(GearType_Plot)), size=2,
    color="#333333", alpha=1) +
  labs(title="Nekton Species Richness",
    subtitle=MA_Include[i],

```



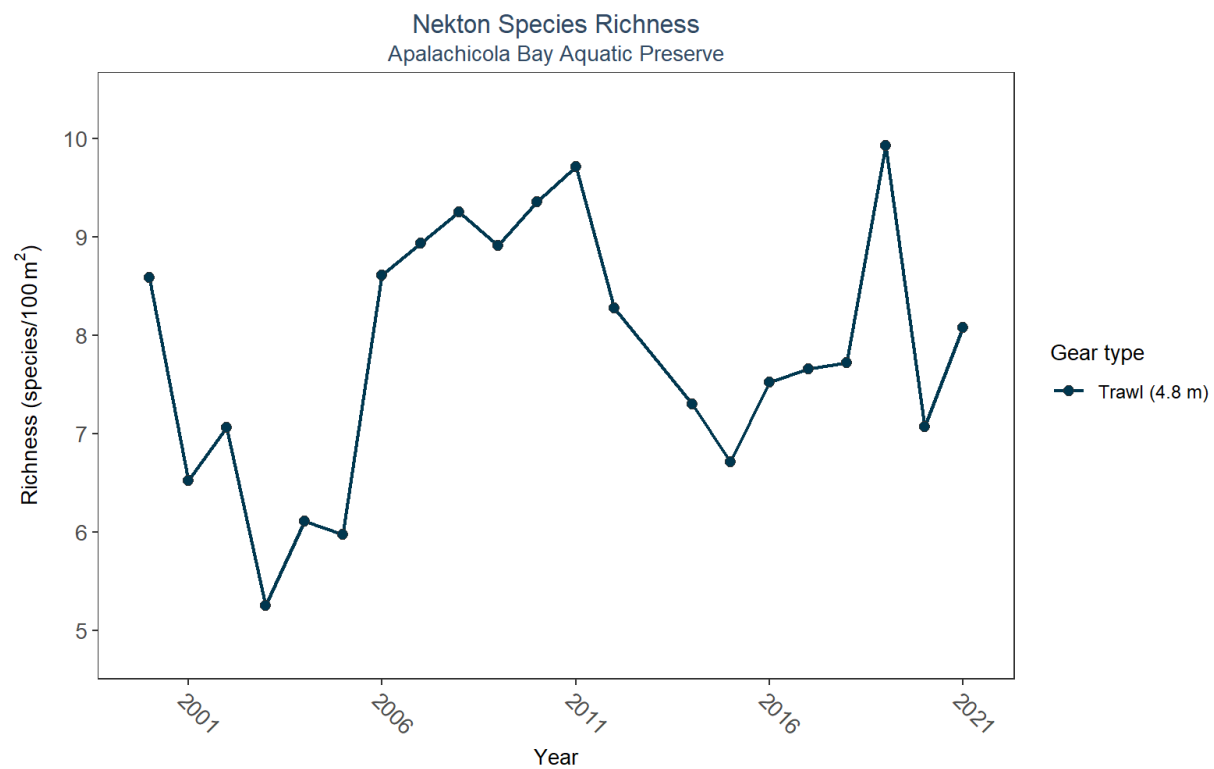
```

      x="Year", y=bquote('Richness (species/100*~m^{2}*~m^{2}*)'),
      fill="Gear type", color="Gear type", shape="Gear type") +
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)) +
scale_fill_manual(values=gear_colors_plot) +
scale_color_manual(values=gear_colors_plot) +
scale_shape_manual(values=gear_shapes_plot) +
plot_theme
# Sets file name of plot created
outname <- paste0("Nekton_", 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()

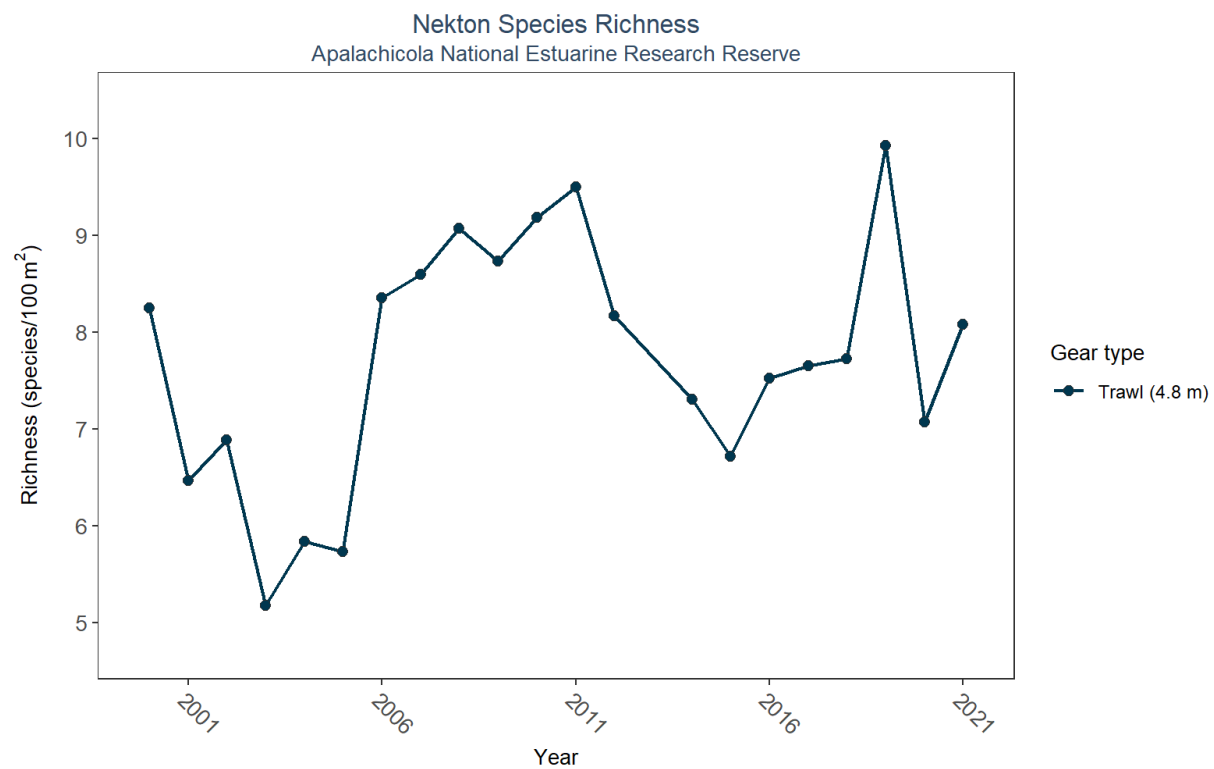
# Creates a data table object to be shown underneath plots in report
ResultTable <-
  MA_Ov_Stats[MA_Ov_Stats$ManagedAreaName==MA_Include[i],]
# Removes location, gear, and parameter information because it is in plot
# labels
ResultTable <- ResultTable[,-c("AreaID", "ManagedAreaName",
              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

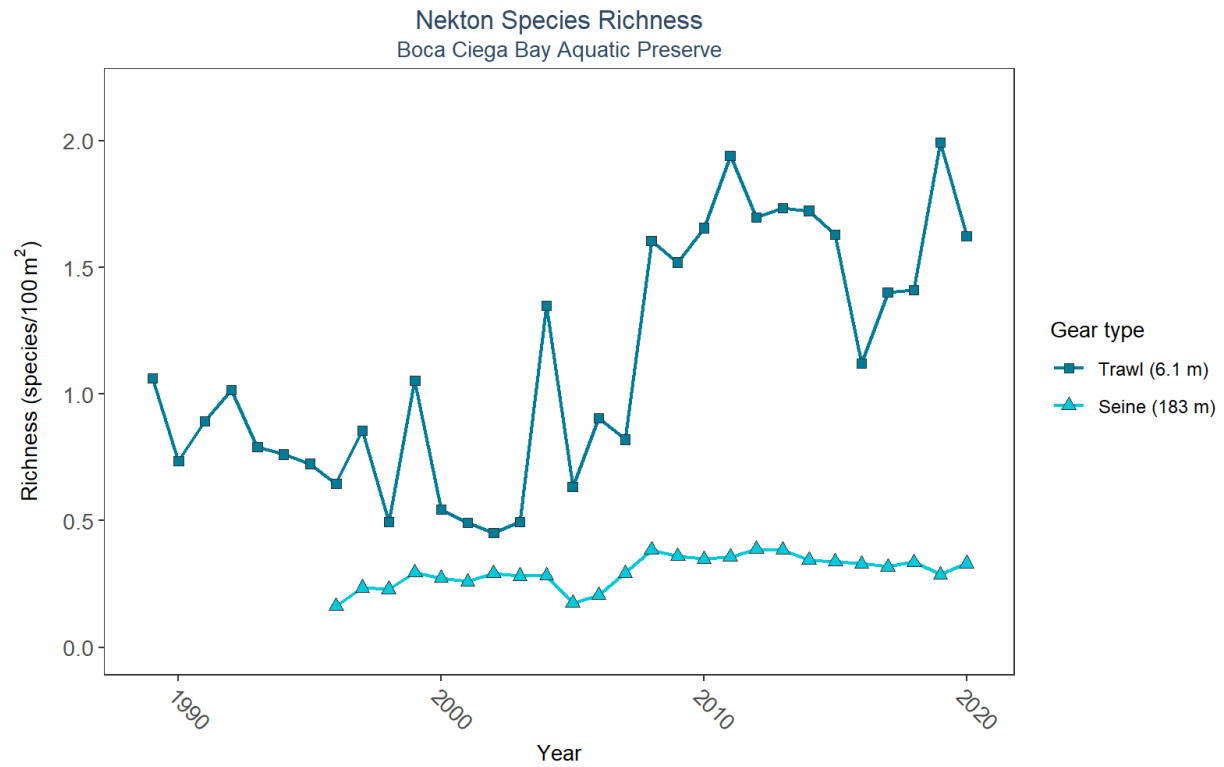
```



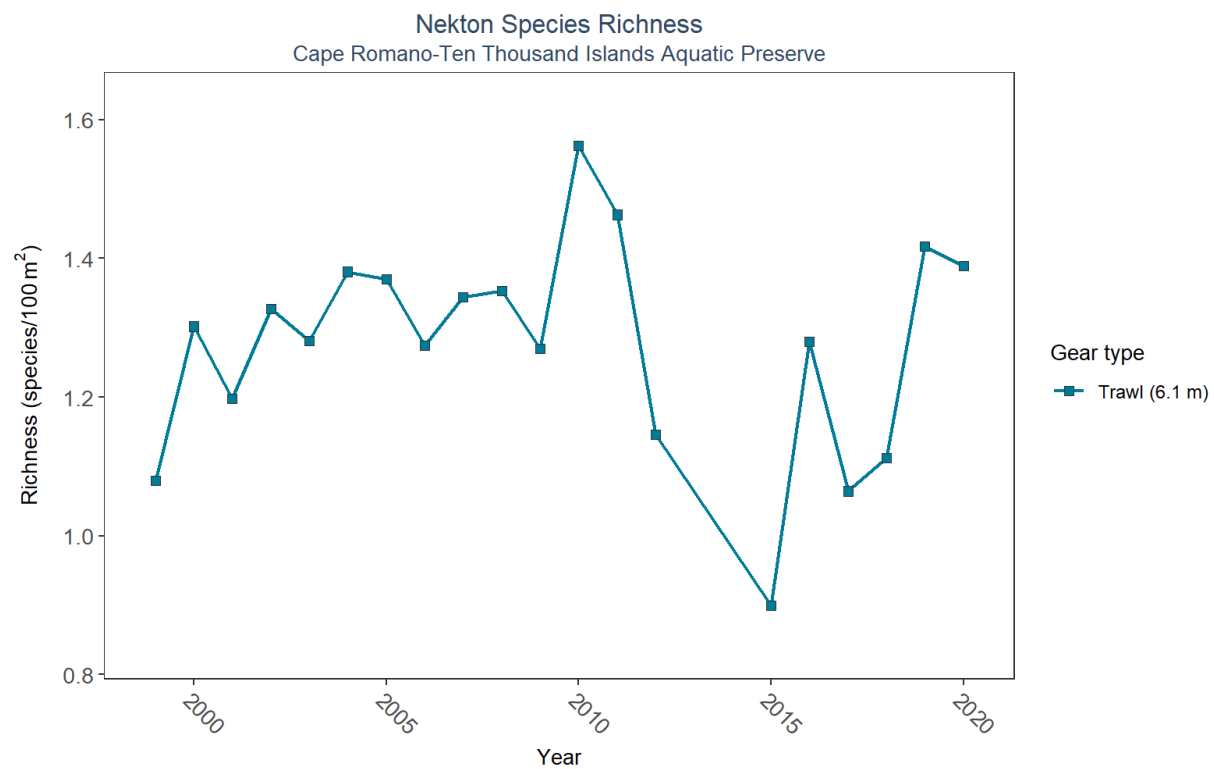
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	4.8	21	2000	2021	1664	0.19	24.81	7.78	7.79	3.62	2003	2019



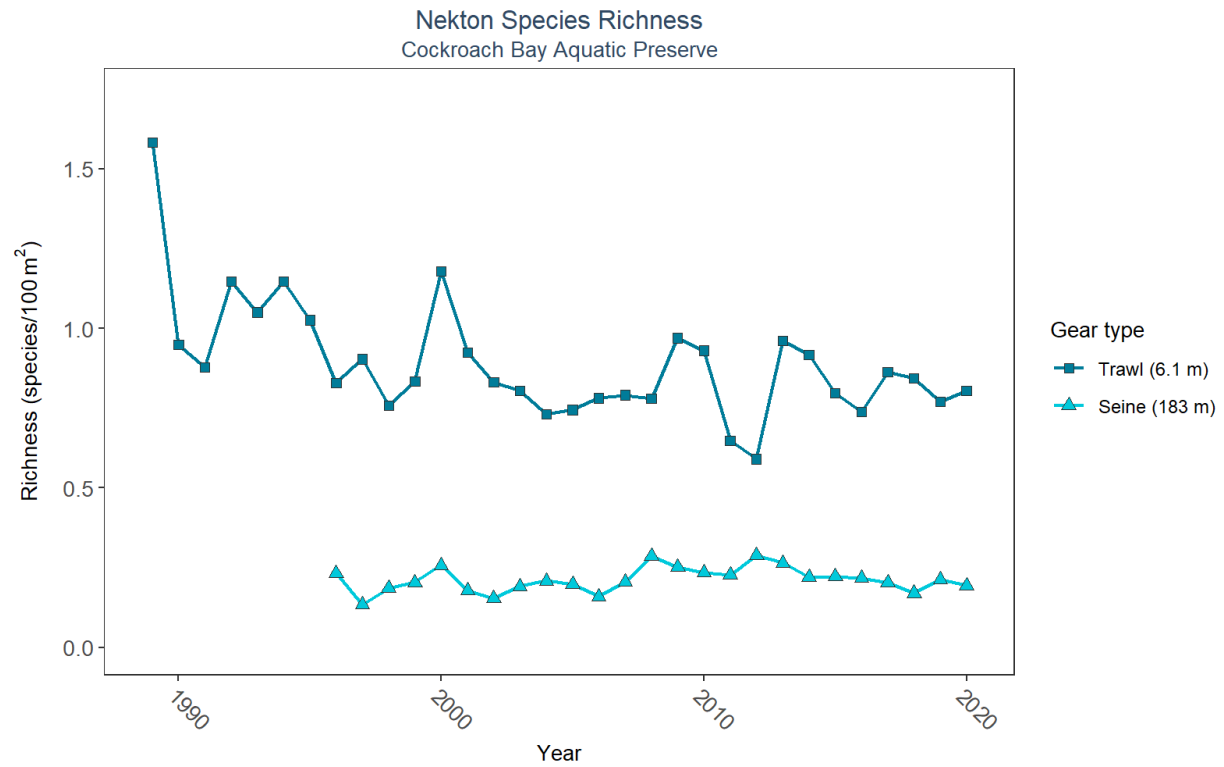
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	4.8	21	2000	2021	1931	0.19	24.81	7.41	7.62	3.72	2003	2019



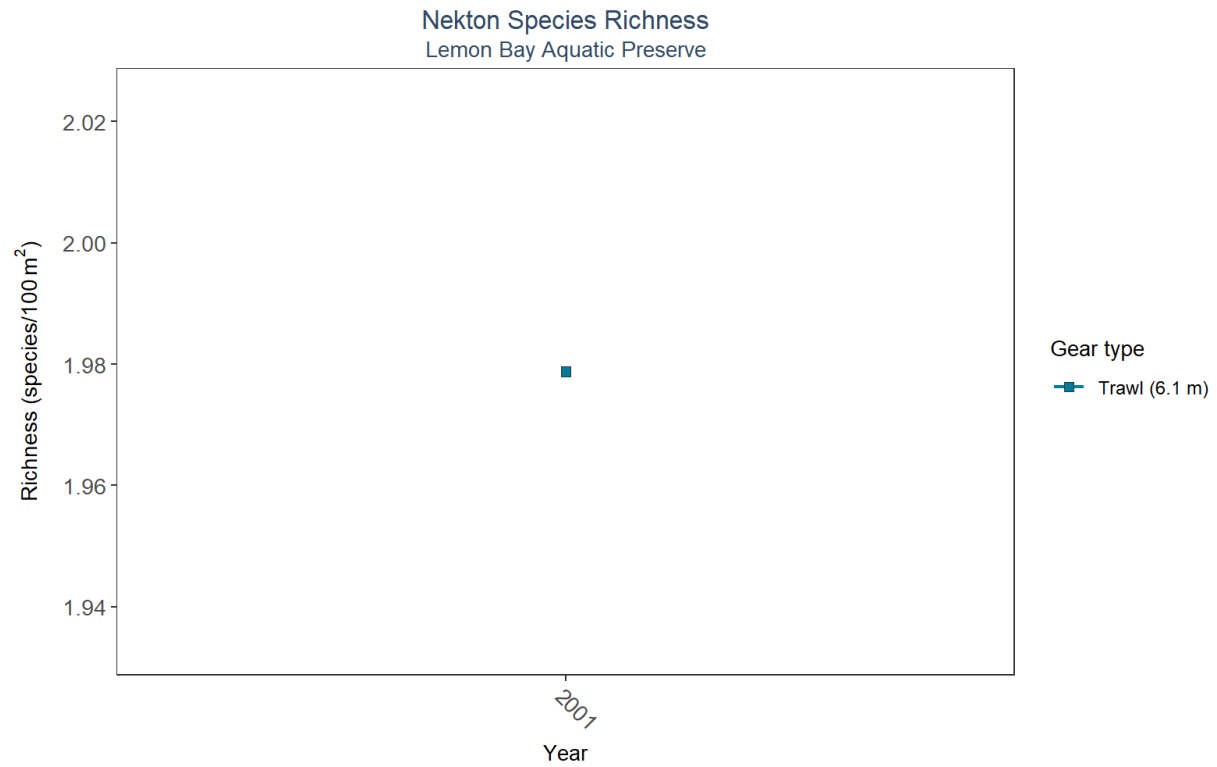
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	32	1989	2020	868	0	4.59	1.01	1.33	0.92	2002	2019
Seine	183.0	25	1996	2020	997	0	0.92	0.29	0.31	0.17	1996	2012



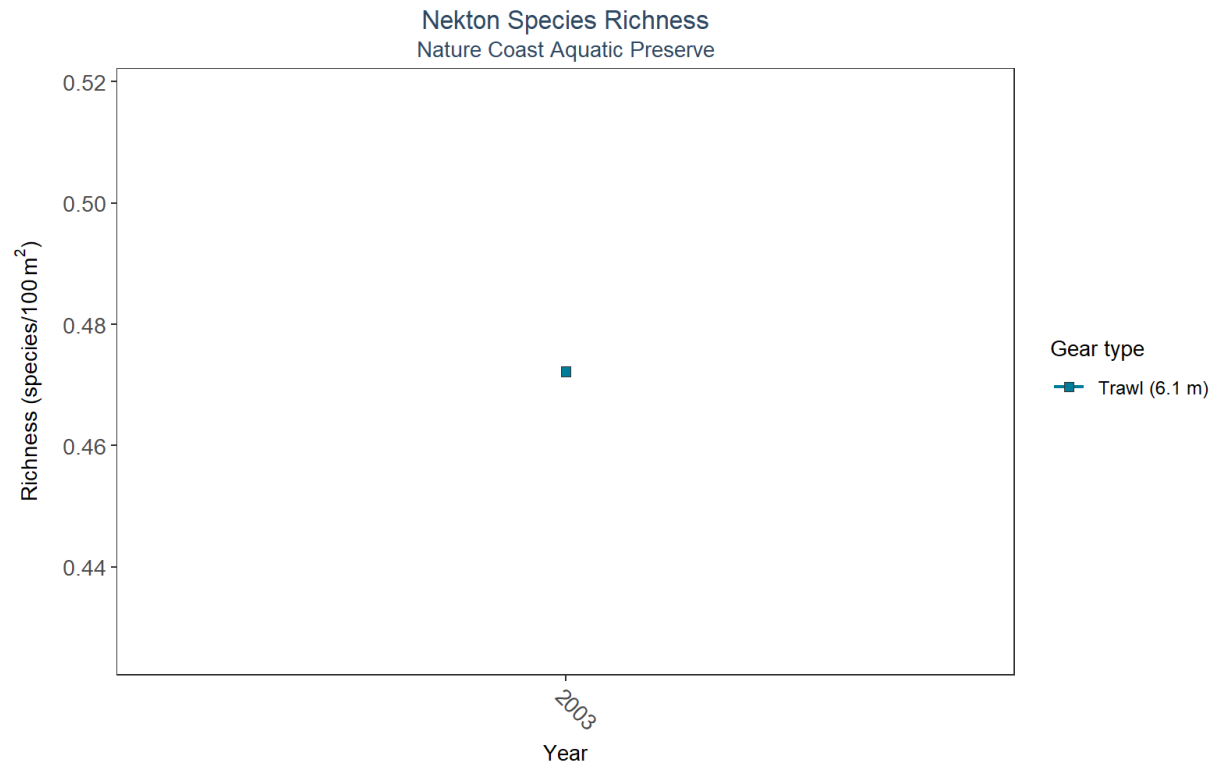
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	20	1999	2020	2555	0	3.37	1.35	1.31	0.53	2015	2010



GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	32	1989	2020	1666	0	3.75	0.75	0.84	0.54	2012	1989
Seine	183.0	25	1996	2020	476	0	0.78	0.19	0.21	0.12	1997	2012

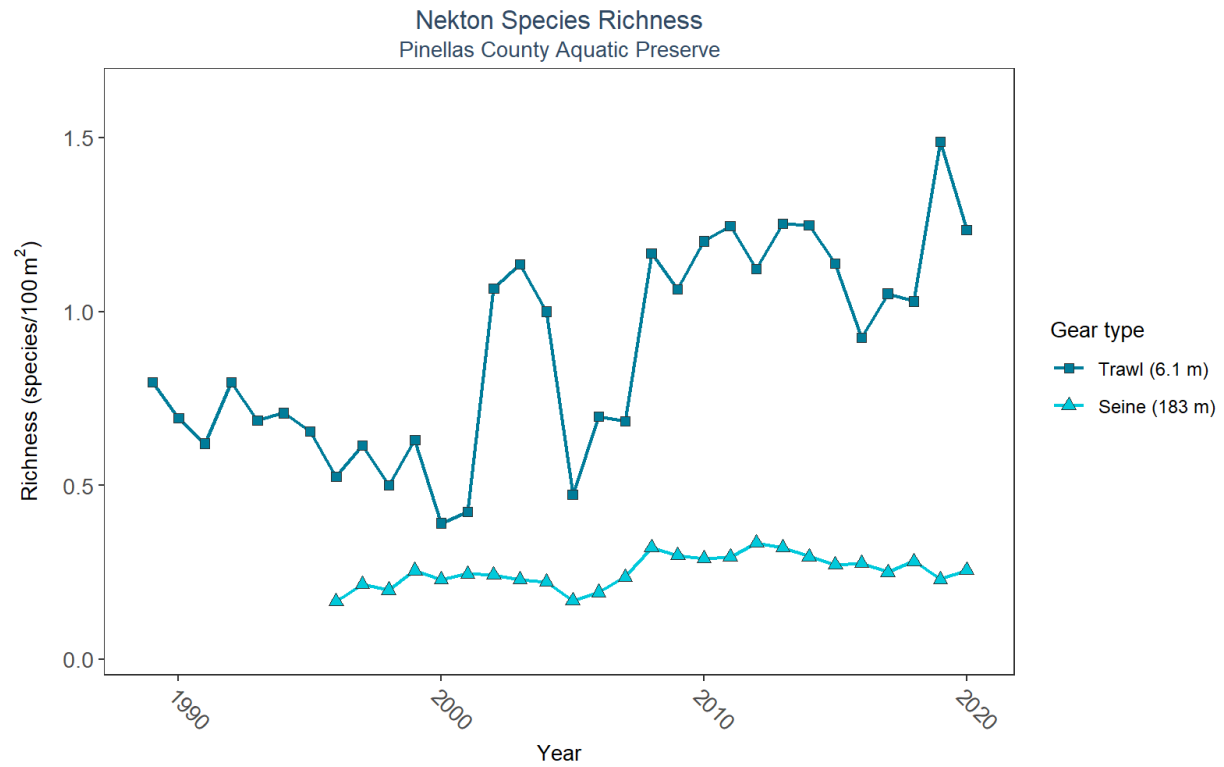


GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	1	2001	2001	3	1.48	2.43	2.02	1.98	0.47	2001	2001

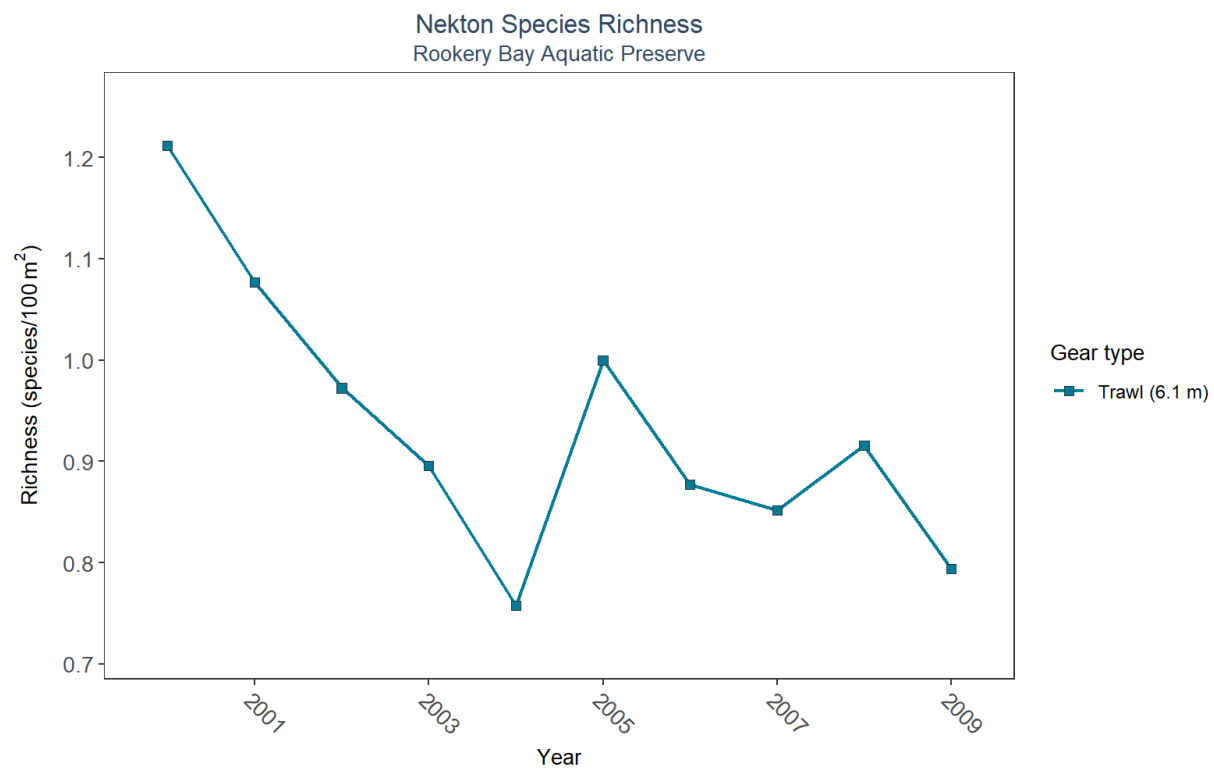


GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	1	2003	2003	2	0	0.94	0.47	0.47	0.67	2003	2003

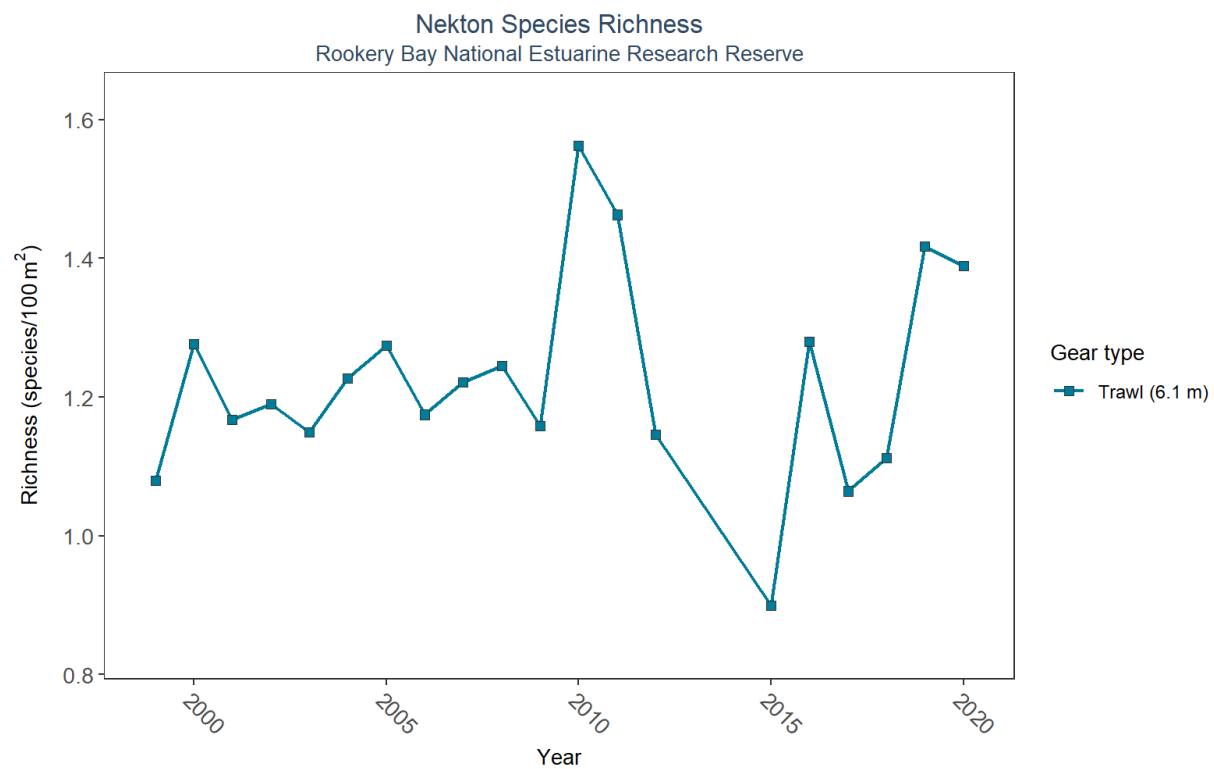




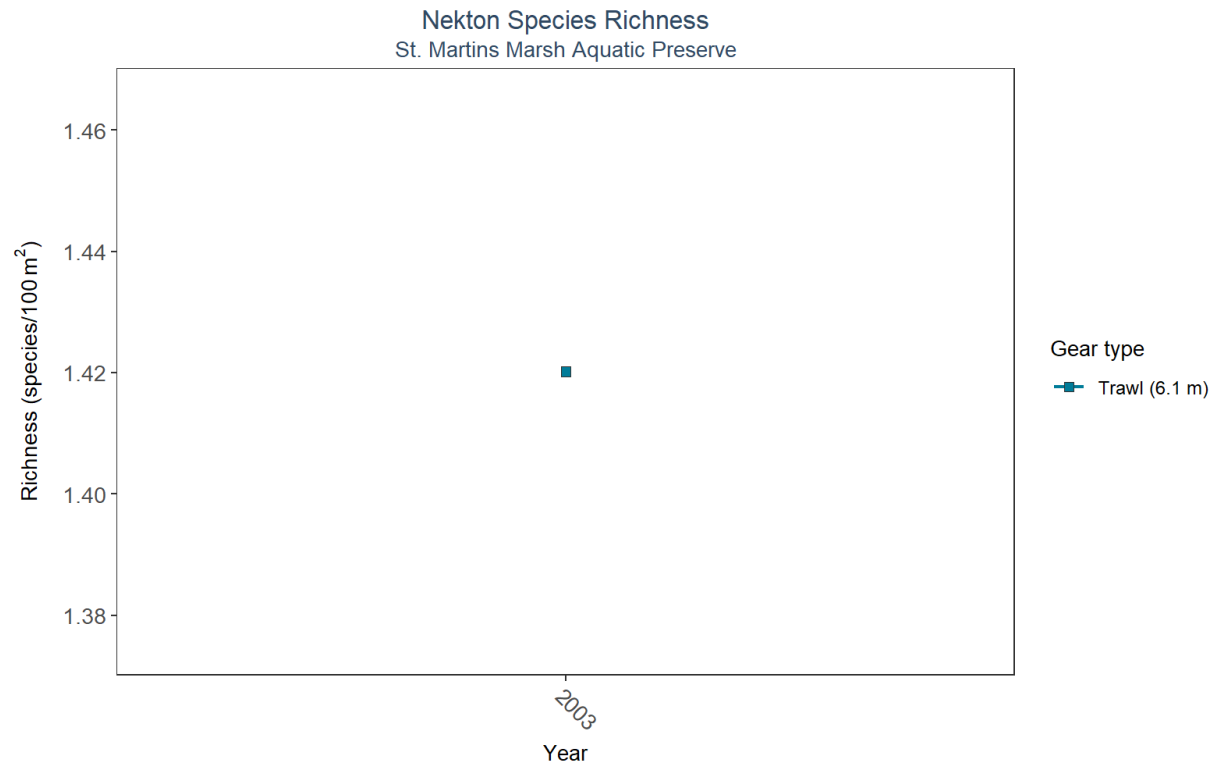
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	32	1989	2020	2903	0	6.21	0.71	0.95	0.78	2000	2019
Seine	183.0	25	1996	2020	2621	0	0.92	0.22	0.26	0.15	1996	2012



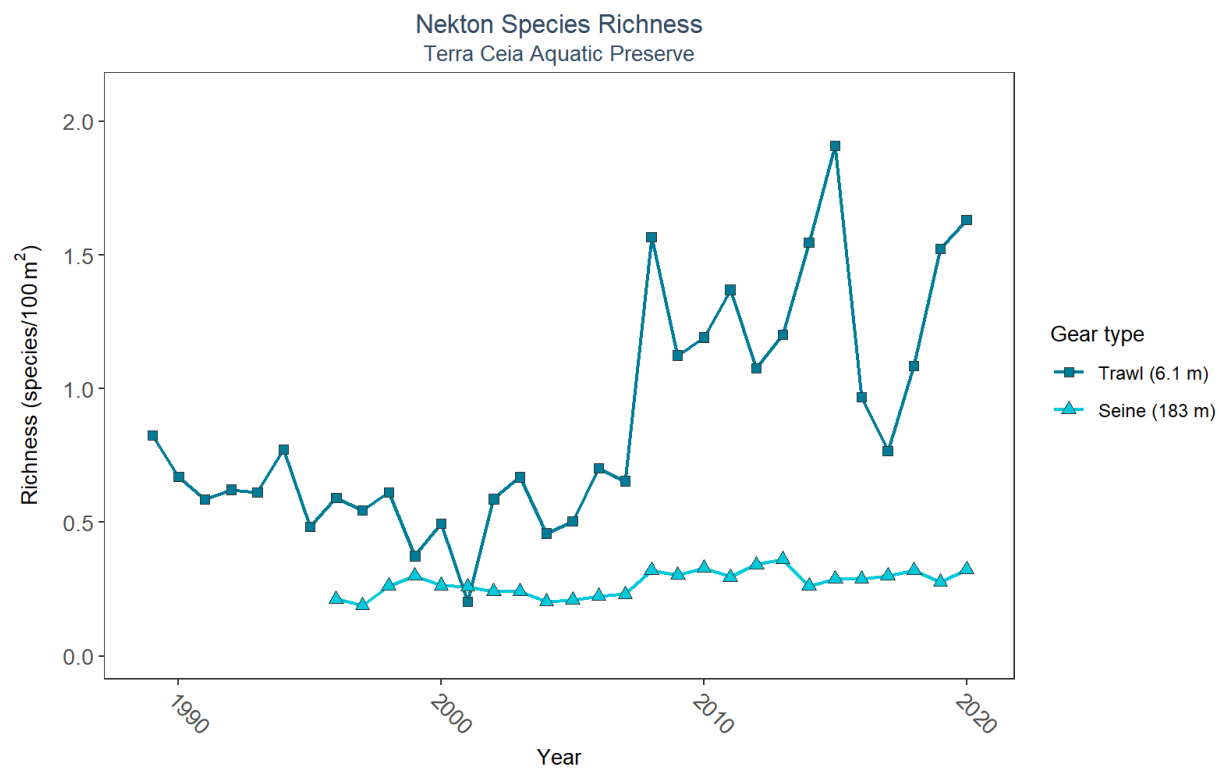
GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	10	2000	2009	535	0	2.56	0.94	0.94	0.42	2004	2000



GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	20	1999	2020	3098	0	3.37	1.21	1.24	0.53	2015	2010



GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	1	2003	2003	1	1.42	1.42	1.42	1.42	NA	2003	2003



GearType	GearSize_m	N_Years	EarliestYear	LatestYear	N_Data	Min	Max	Median	Mean	StDev	Year_MinRichness	Year_MaxRichness
Trawl	6.1	32	1989	2020	709	0	4.22	0.74	1.03	0.84	2001	2015
Seine	183.0	25	1996	2020	921	0	0.75	0.27	0.28	0.13	1997	2013