

SEACAR Nekton Analysis: Species Richness

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Important Notes

The purpose of this script is to determine species richness by gear type and size, create managed area statistics, generate plots, and create reports in pdf and Word document form for Nekton data.

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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 `Nekton_SpeciesRichness_ReportRender.R` (https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/Nekton/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](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/Nekton/SEACAR%20Nekton%20catch%20per%20unit%20effort.pdf) (https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/Nekton/SEACAR%20Nekton%20catch%20per%20unit%20effort.pdf).

Nekton Species Richness

Apalachicola Bay Aquatic Preserve

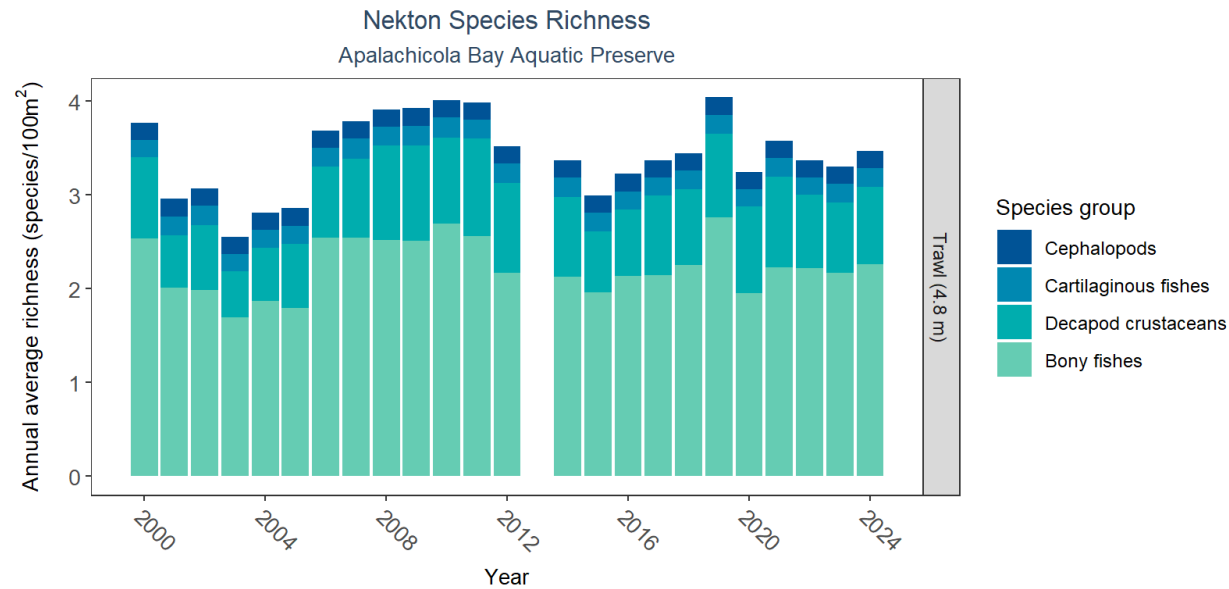
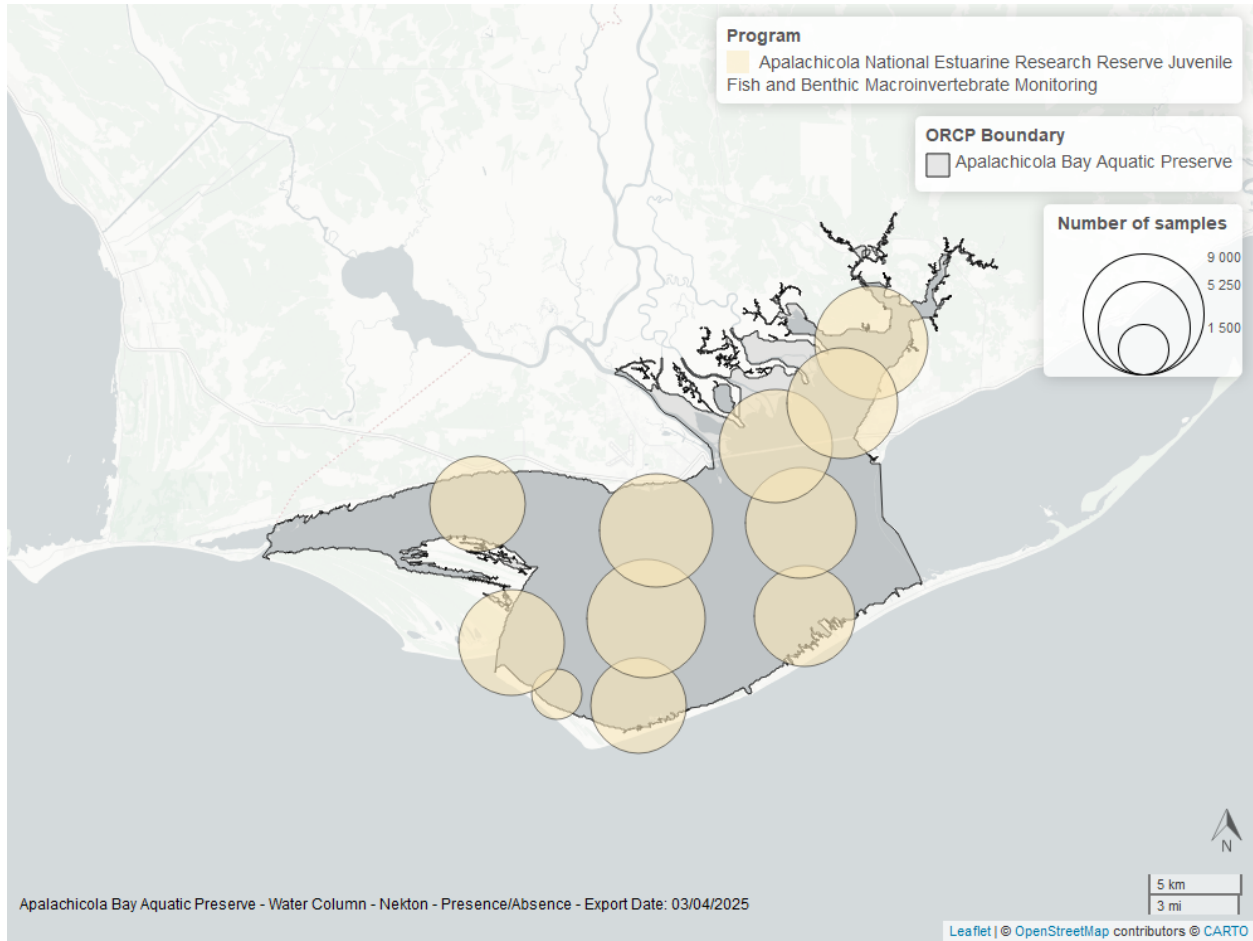


Figure 1: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 1: Nekton Species Richness - Apalachicola Bay Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	4.8	24	2000	2024	4967	0.19	5.56	0.74	1.13	1.05	2015	2010

The median annual number of taxa was 0.74 based on 4,967 observations collected by 4.8-meter trawl between 2000 and 2024.



Apalachicola National Estuarine Research Reserve

Table 2: Nekton Species Richness - Apalachicola National Estuarine Research Reserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	4.8	24	2000	2024	5685	0.19	5.93	0.74	1.13	1.06	2015	2010

The median annual number of taxa was 0.74 based on 5,685 observations collected by 4.8-meter trawl between 2000 and 2024.

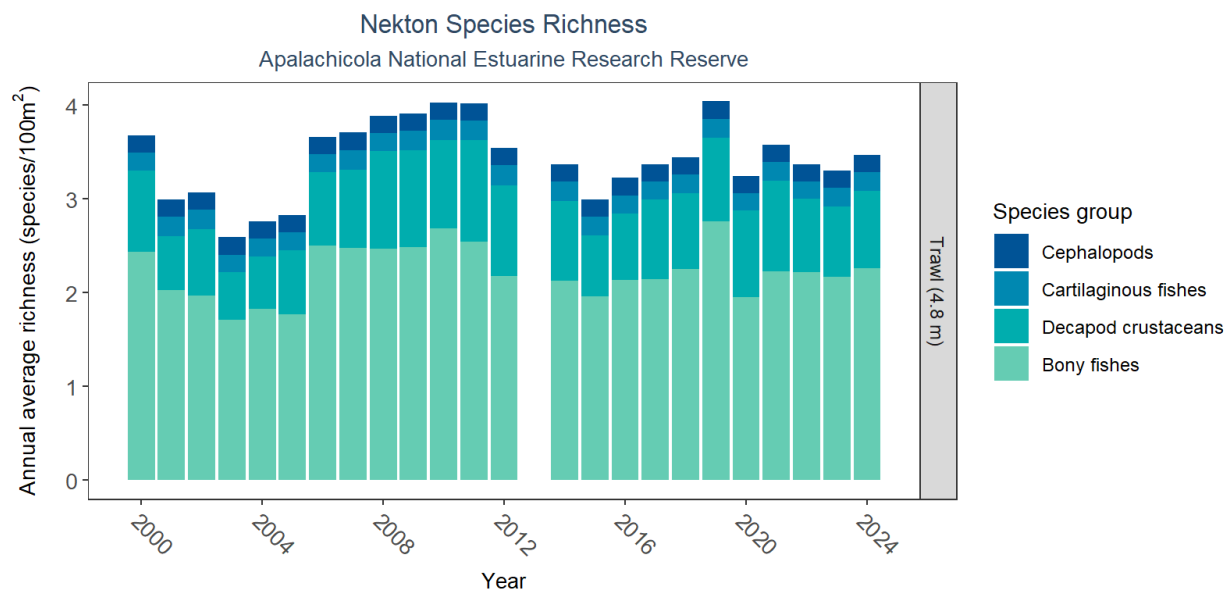
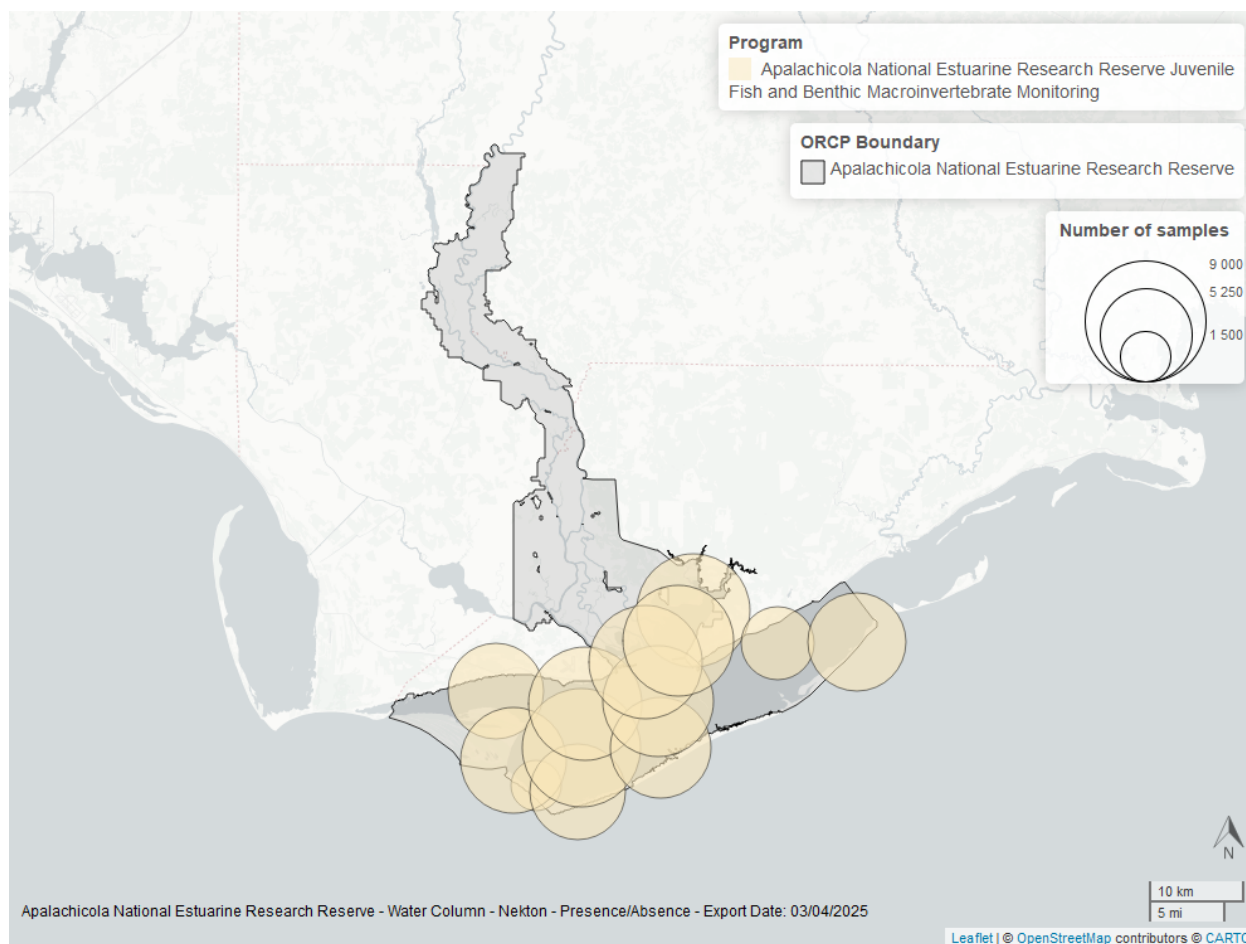


Figure 2: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



Boca Ciega Bay Aquatic Preserve

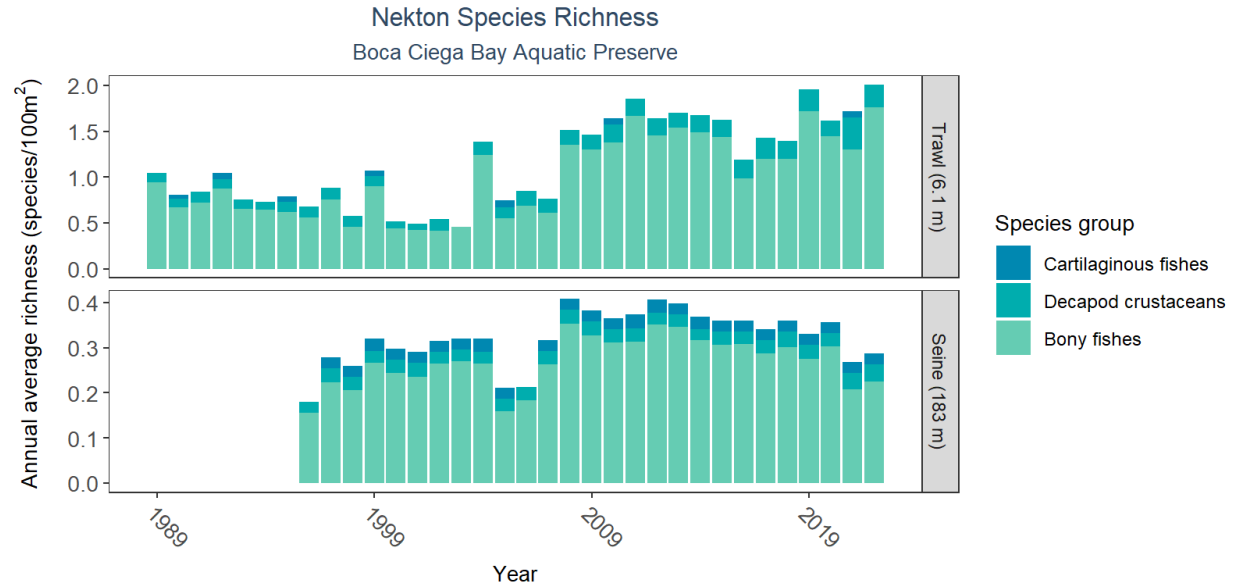
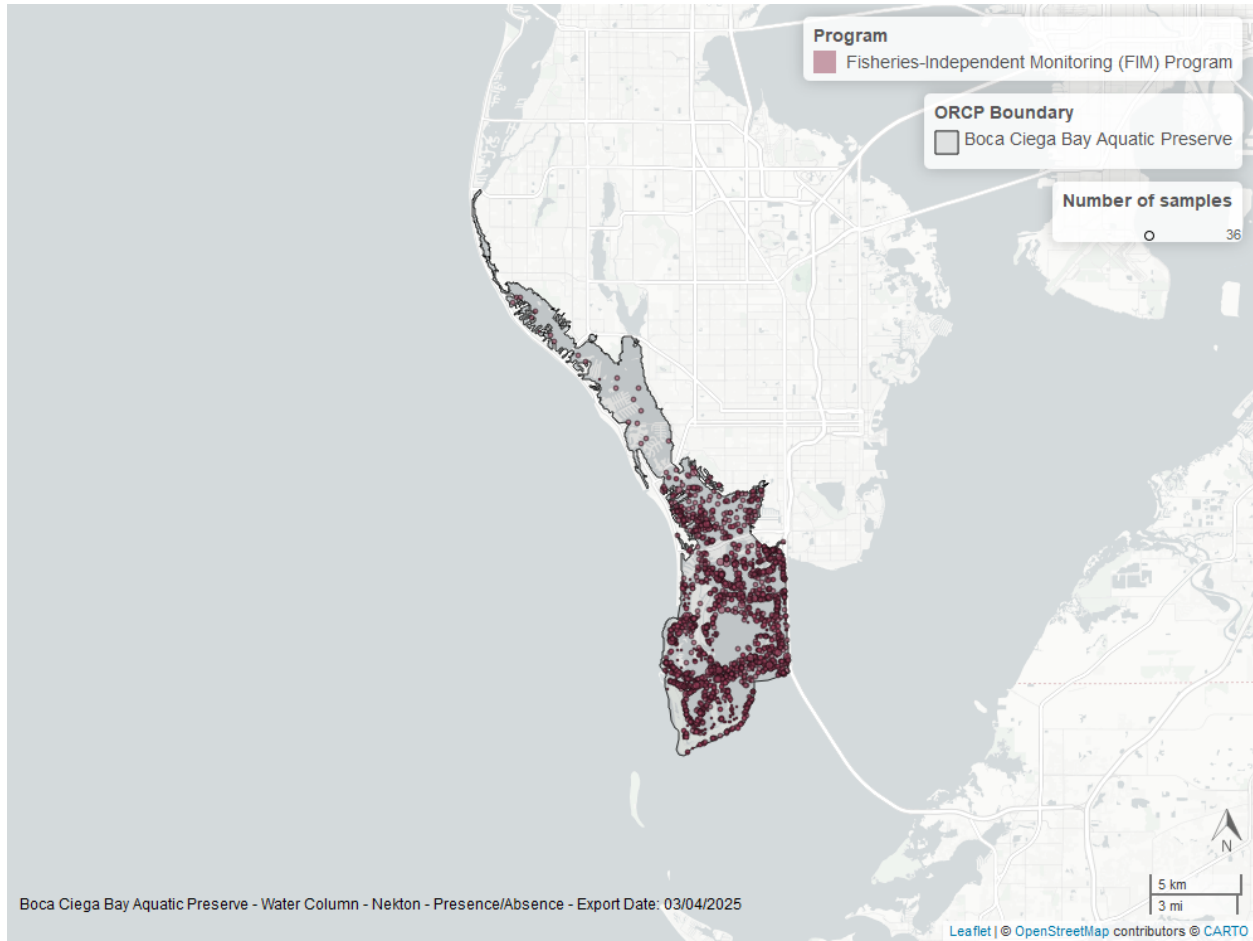


Figure 3: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 3: Nekton Species Richness - Boca Ciega Bay Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	34	1989	2022	1680	0.04	3.78	0.43	0.74	0.79	2000	2022
Seine	183.0	27	1996	2022	1642	0.02	0.85	0.16	0.19	0.17	2005	2008

The median annual number of taxa was 0.16 based on 1,642 observations collected by 183-meter seine between 1996 and 2022, and the median annual number of taxa was 0.43 based on 1,680 observations collected by 6.1-meter trawl between 1989 and 2022.



Cape Romano-Ten Thousand Islands Aquatic Preserve

Table 4: Nekton Species Richness - Cape Romano-Ten Thousand Islands Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	20	1999	2020	5002	0.13	3.24	0.4	0.67	0.57	2015	2010

The median annual number of taxa was 0.40 based on 5,002 observations collected by 6.1-meter trawl between 1999 and 2020.

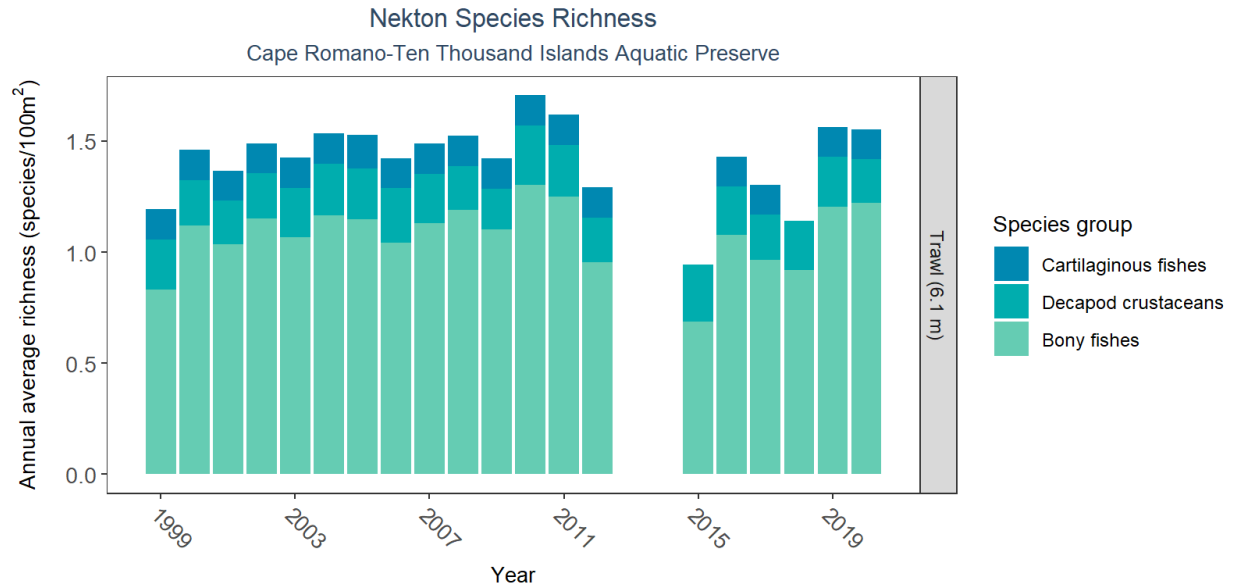
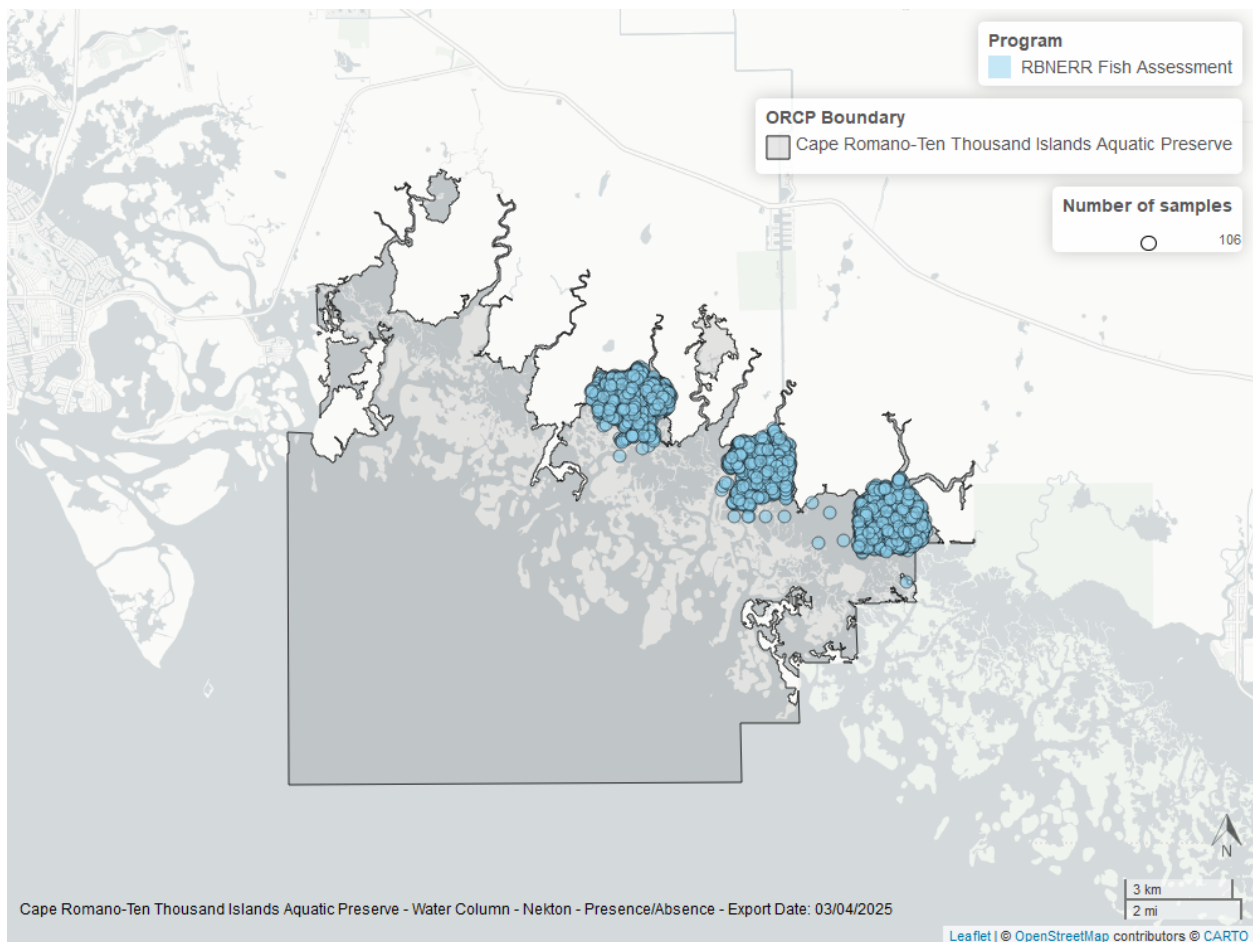


Figure 4: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



Cockroach Bay Aquatic Preserve

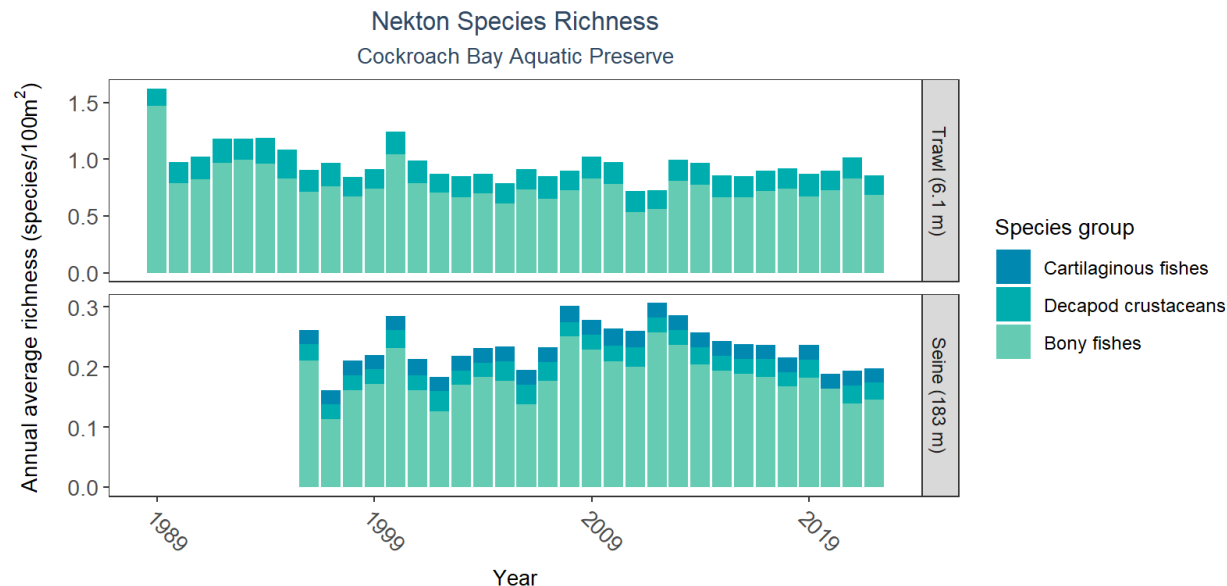
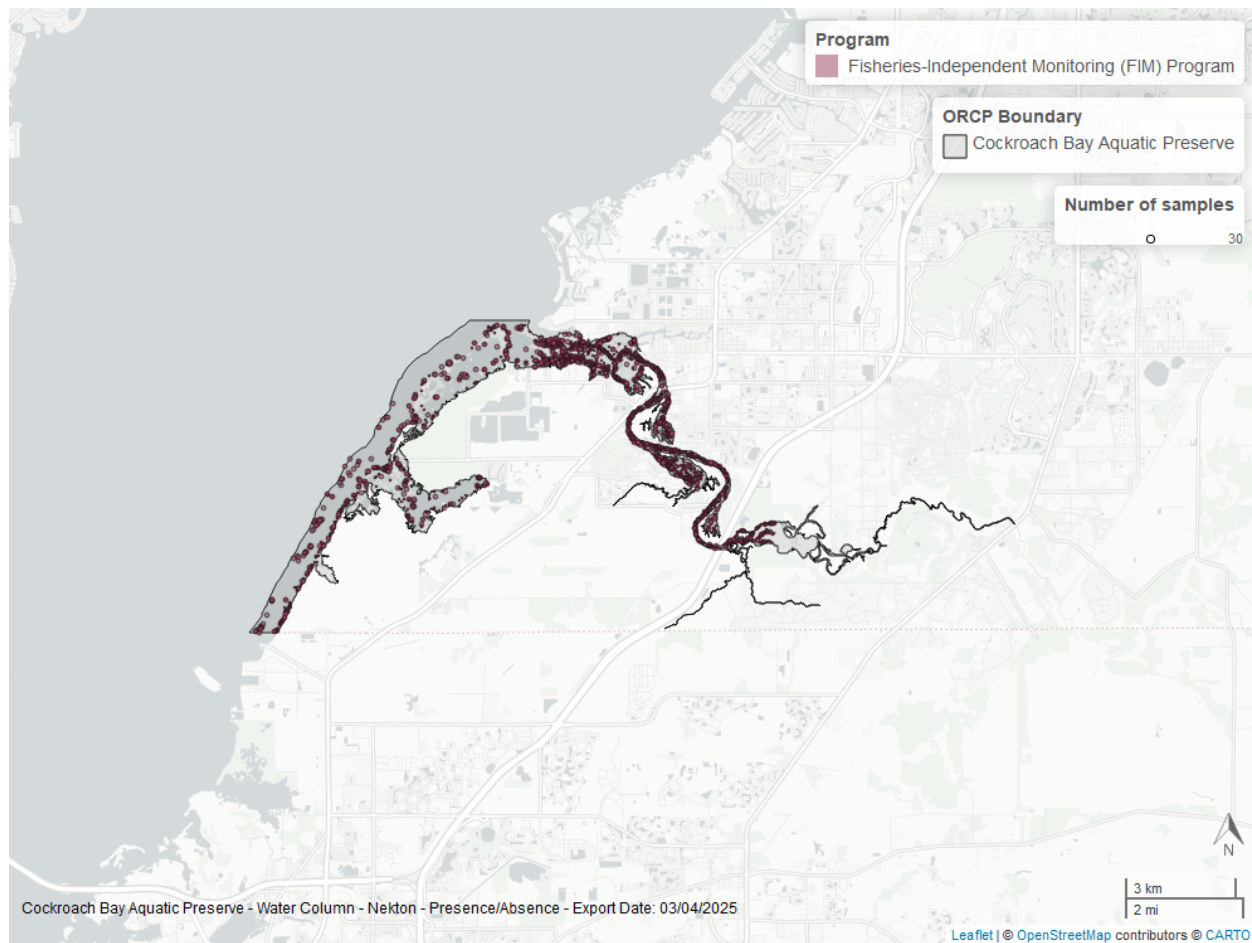


Figure 5: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 5: Nekton Species Richness - Cockroach Bay Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	34	1989	2022	2832	0.07	3.30	0.3	0.50	0.45	2011	1989
Seine	183.0	27	1996	2022	789	0.02	0.63	0.1	0.13	0.11	1997	2012

The median annual number of taxa was 0.10 based on 789 observations collected by 183-meter seine between 1996 and 2022, and the median annual number of taxa was 0.30 based on 2,832 observations collected by 6.1-meter trawl between 1989 and 2022.



Lemon Bay Aquatic Preserve

Table 6: Nekton Species Richness - Lemon Bay Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	1	2001	2001	6	0.13	2.02	0.74	0.93	0.87	2001	2001

The median annual number of taxa was 0.74 based on 6 observations collected by 6.1-meter trawl between 2001 and 2001.

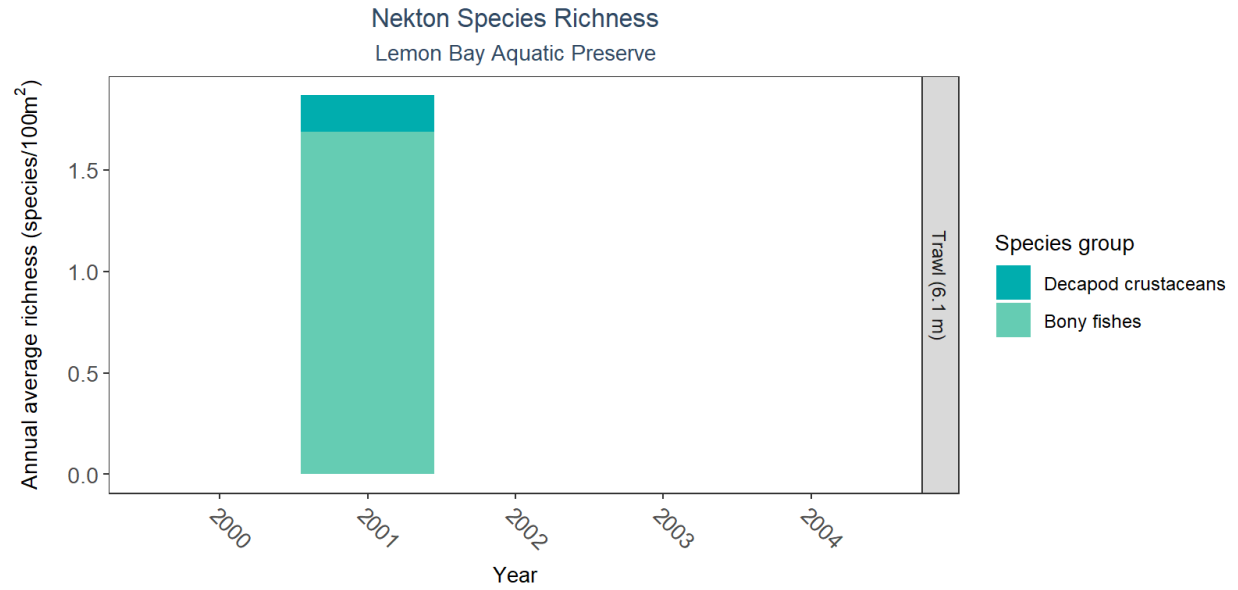
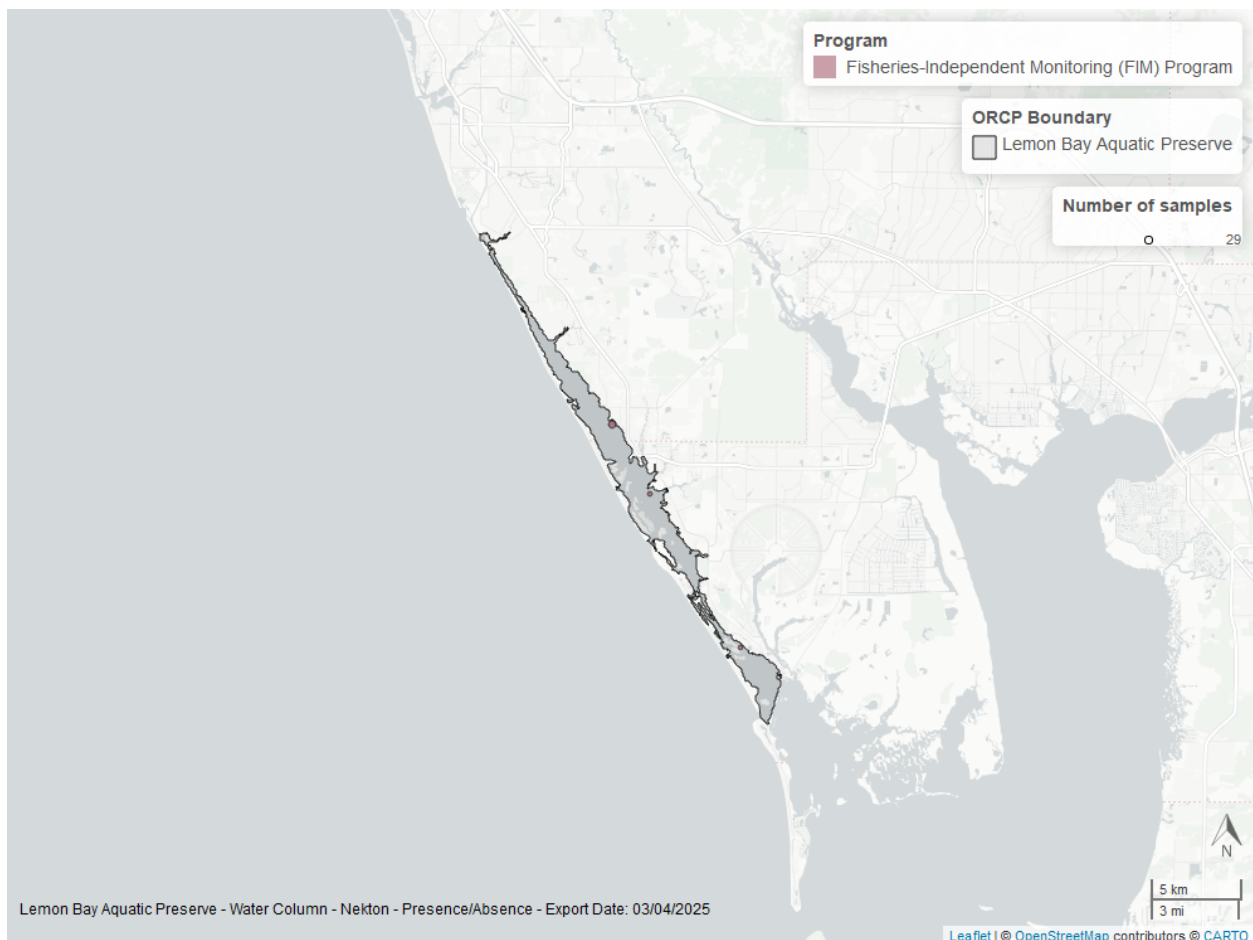


Figure 6: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



Nature Coast Aquatic Preserve

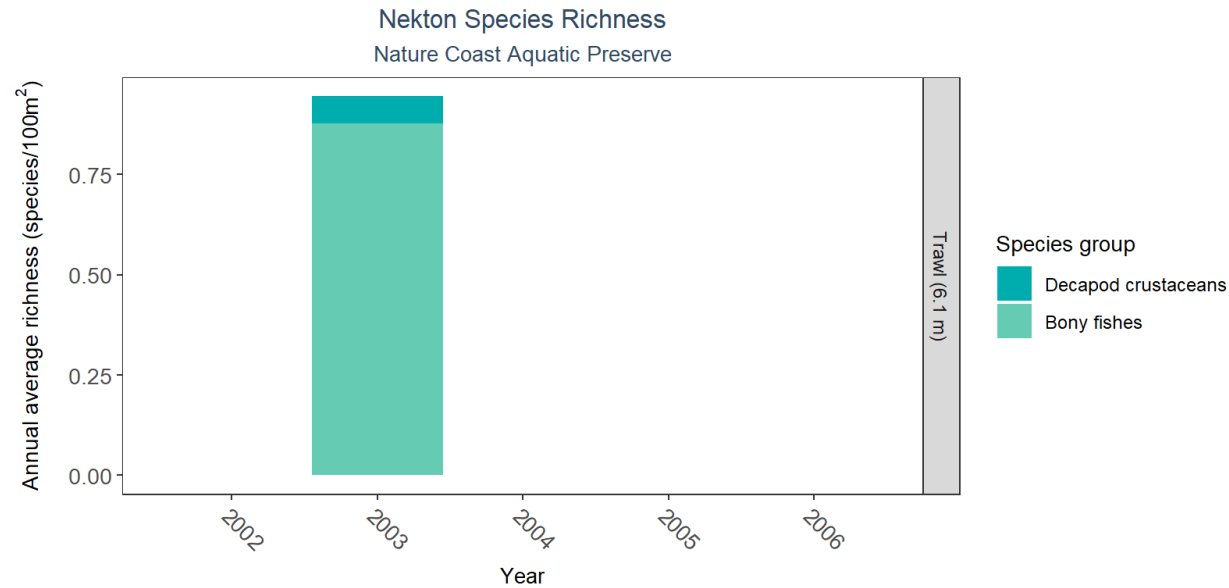
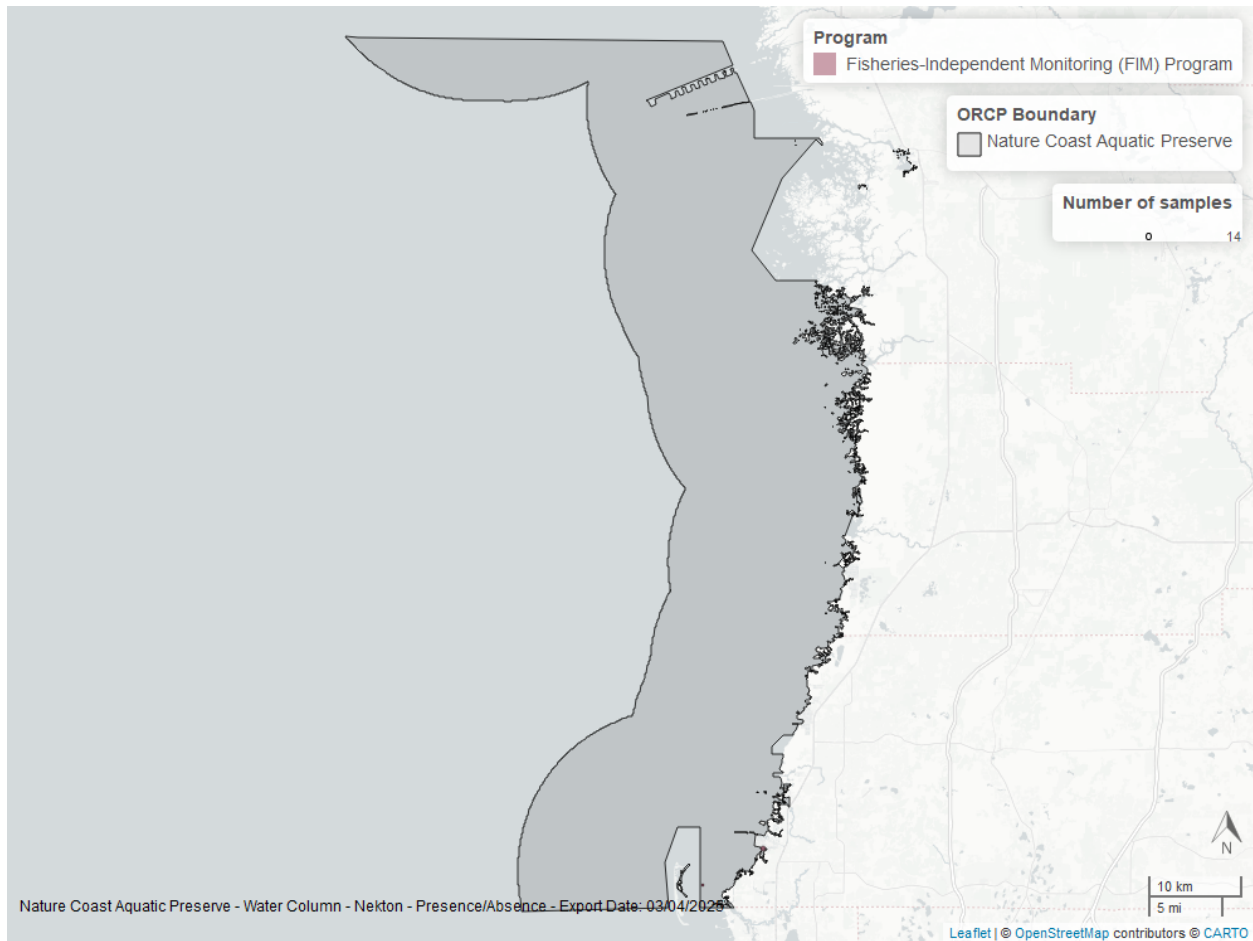


Figure 7: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 7: Nekton Species Richness - Nature Coast Aquatic Preserve

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	0.07	0.88	0.47	0.47	0.57	2003	2003

The median annual number of taxa was 0.47 based on 2 observations collected by 6.1-meter trawl between 2003 and 2003.



Pinellas County Aquatic Preserve

Table 8: Nekton Species Richness - Pinellas County Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	34	1989	2022	5254	0.03	4.86	0.3	0.54	0.63	2001	2022
Seine	183.0	27	1996	2022	4407	0.02	0.85	0.1	0.15	0.15	2005	2013

The median annual number of taxa was 0.10 based on 4,407 observations collected by 183-meter seine between 1996 and 2022, and the median annual number of taxa was 0.30 based on 5,254 observations collected by 6.1-meter trawl between 1989 and 2022.

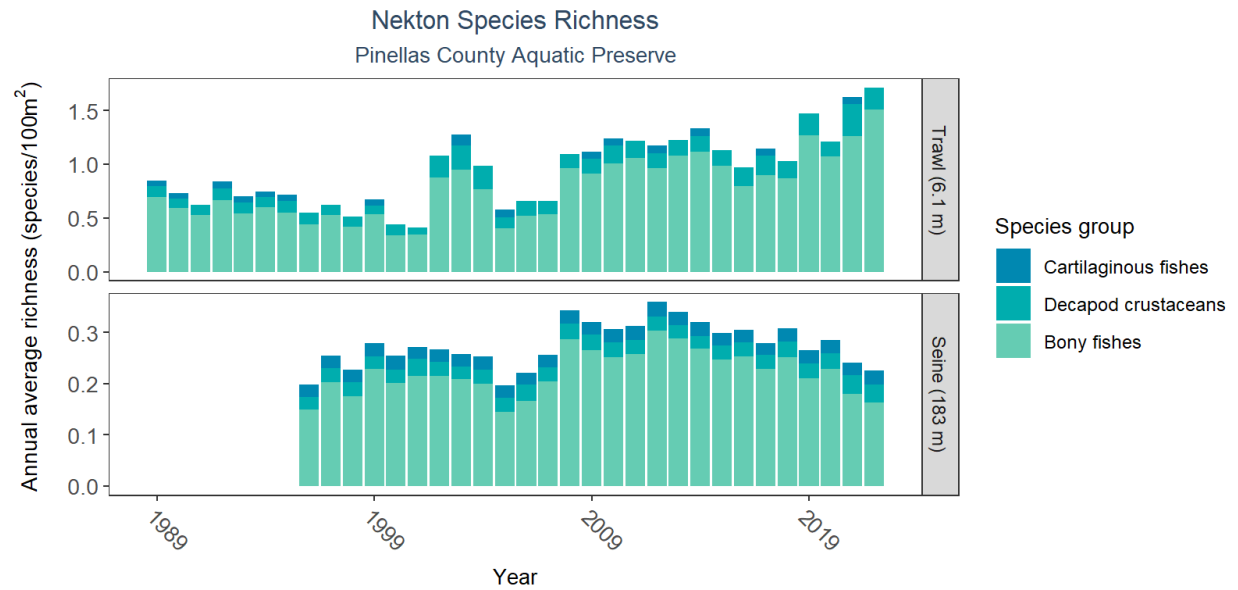
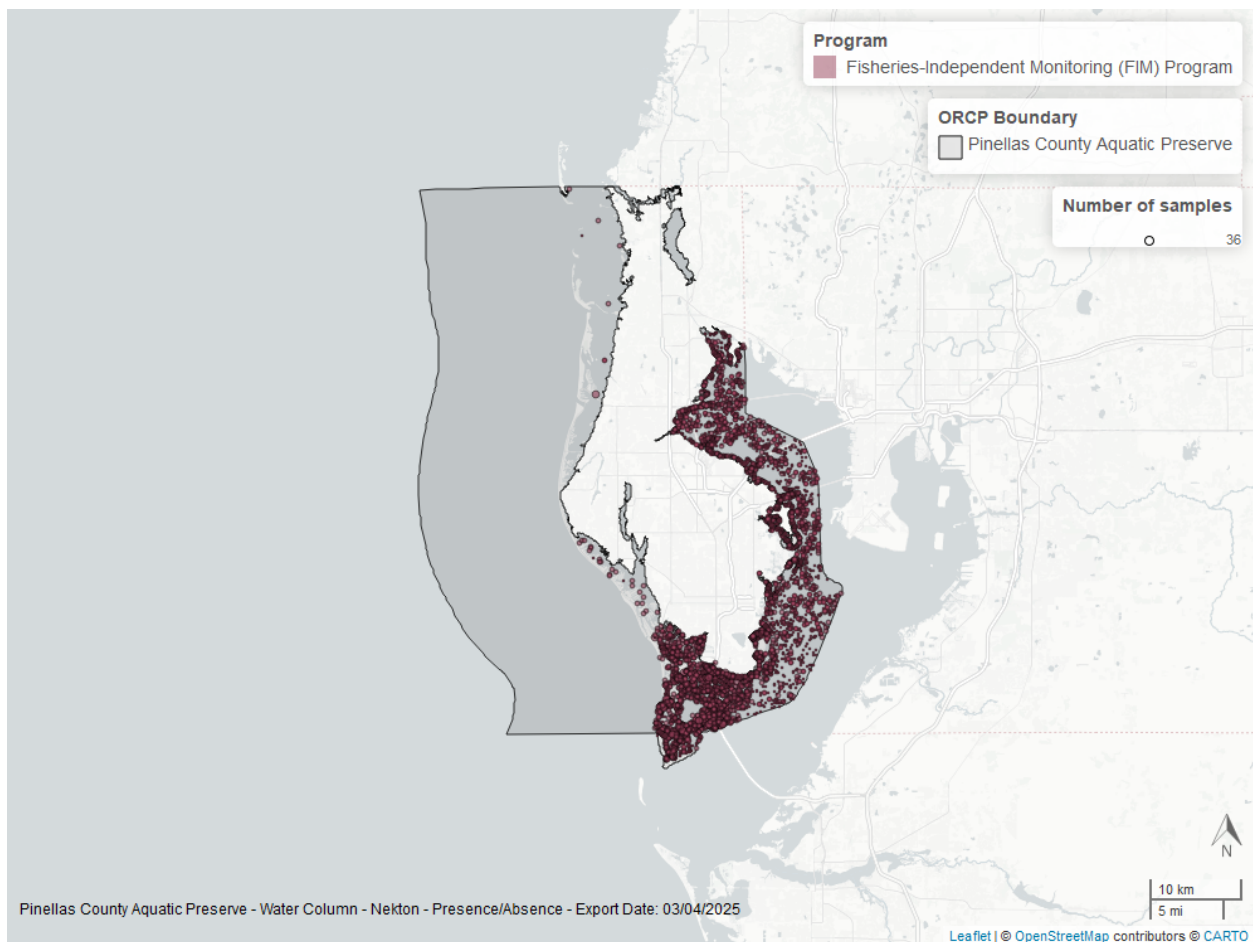


Figure 8: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



Rookery Bay Aquatic Preserve

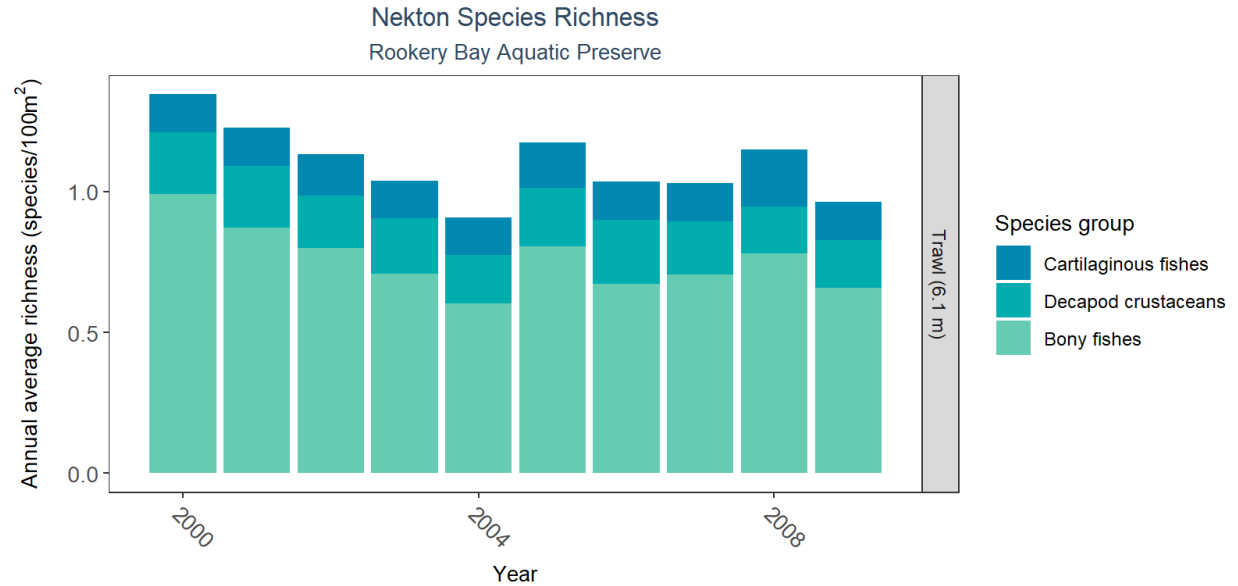
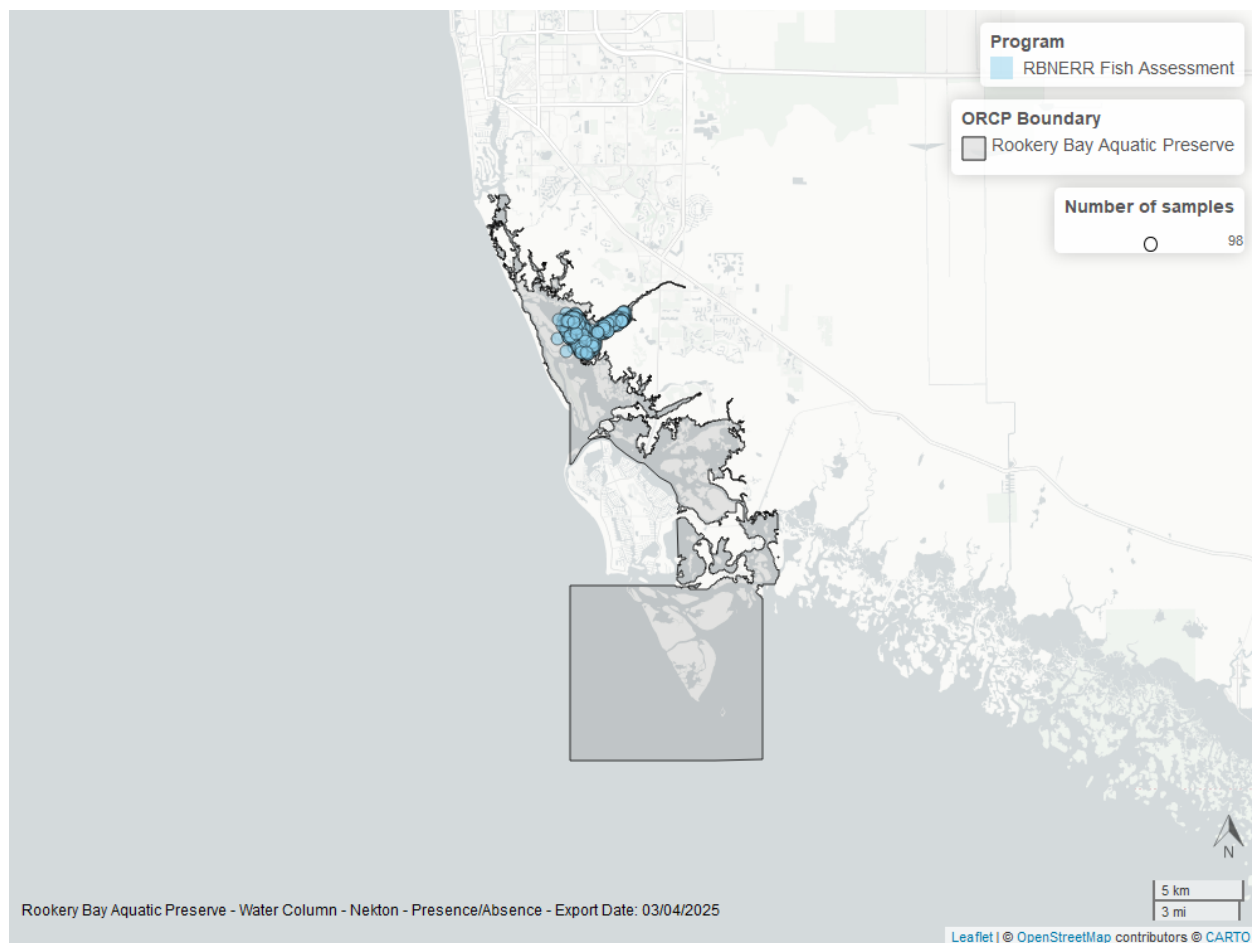


Figure 9: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 9: Nekton Species Richness - Rookery Bay Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	10	2000	2009	1052	0.13	2.16	0.27	0.48	0.39	2004	2000

The median annual number of taxa was 0.27 based on 1,052 observations collected by 6.1-meter trawl between 2000 and 2009.



Rookery Bay National Estuarine Research Reserve

Table 10: Nekton Species Richness - Rookery Bay National Estuarine Research Reserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	20	1999	2020	6071	0.13	3.24	0.27	0.63	0.55	2015	2010

The median annual number of taxa was 0.27 based on 6,071 observations collected by 6.1-meter trawl between 1999 and 2020.

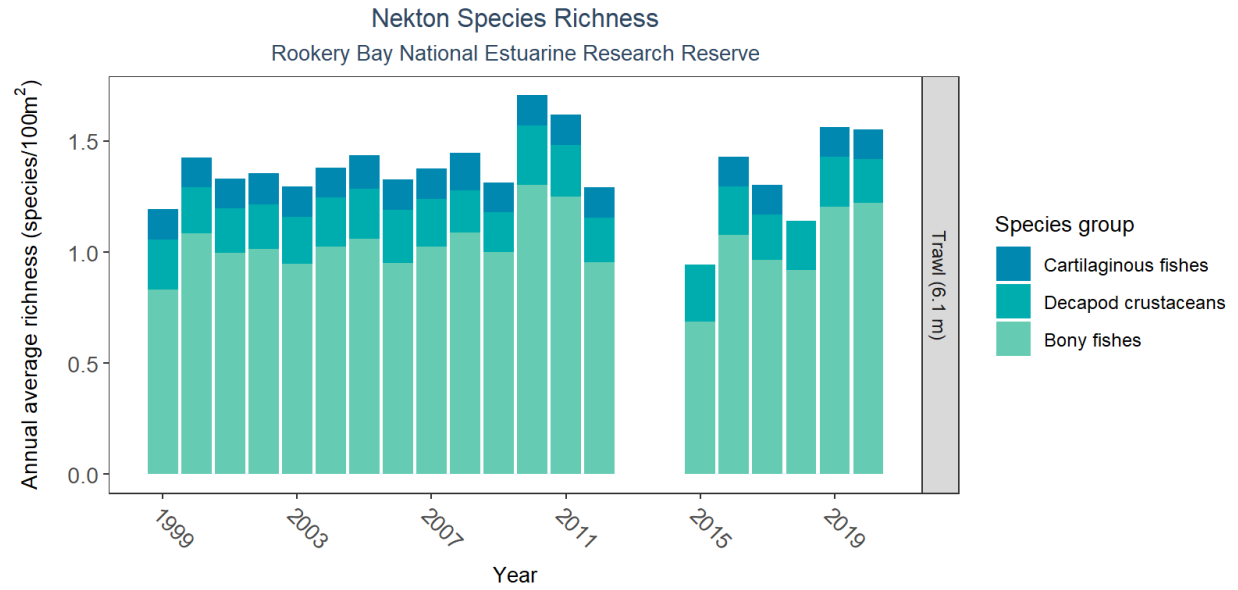
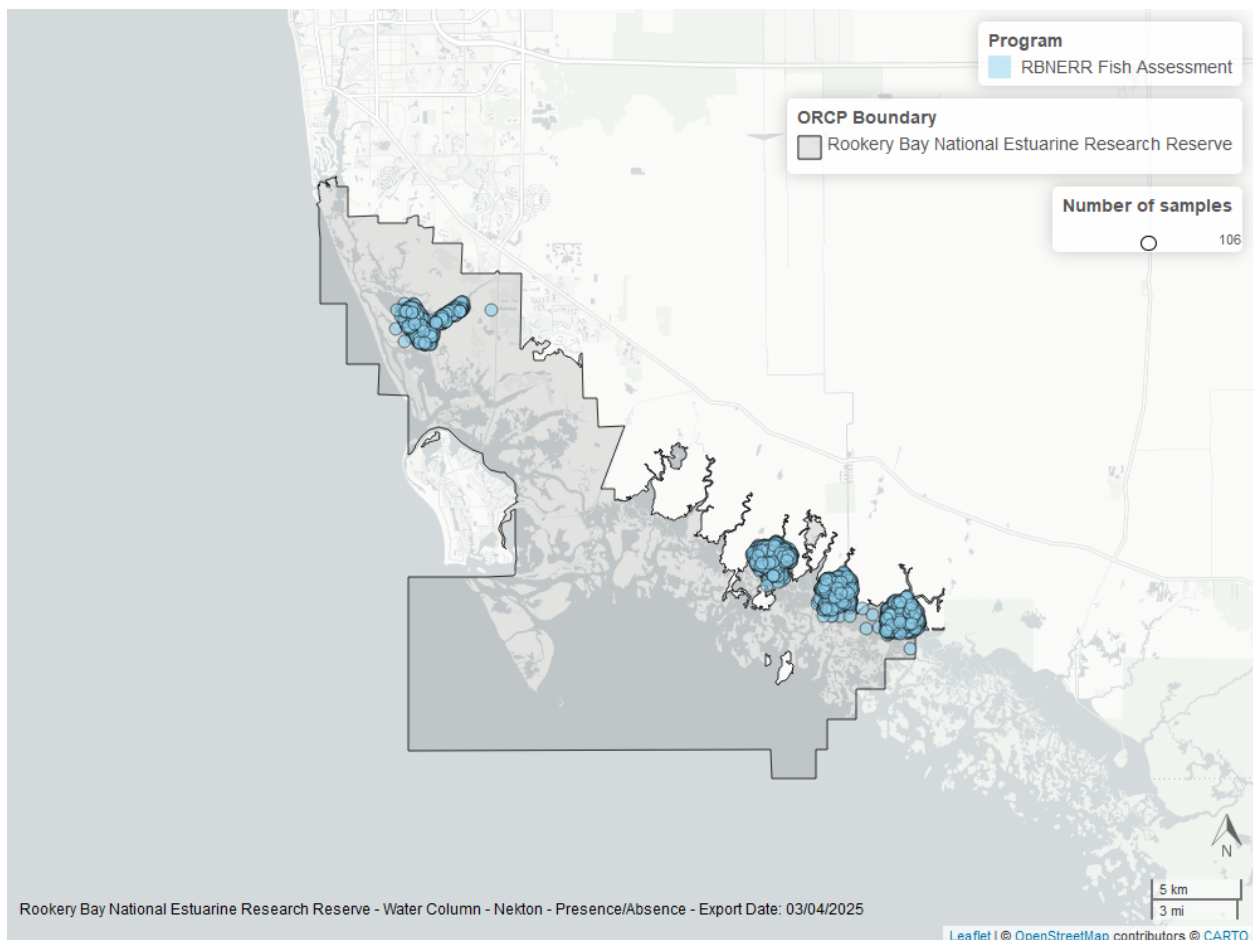


Figure 10: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



St. Martins Marsh Aquatic Preserve

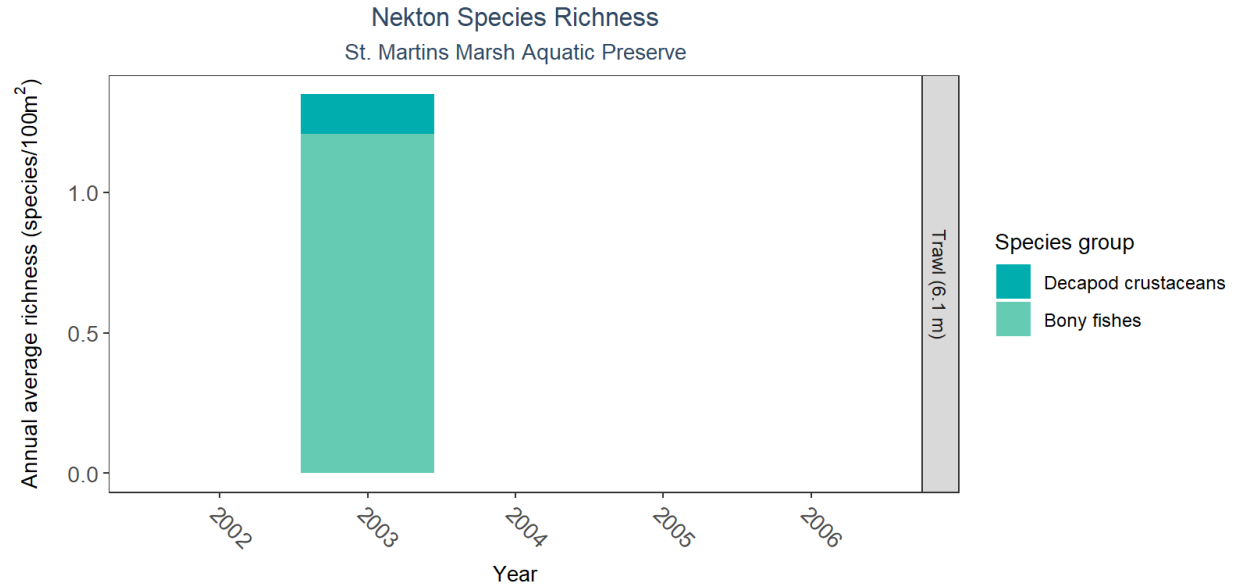
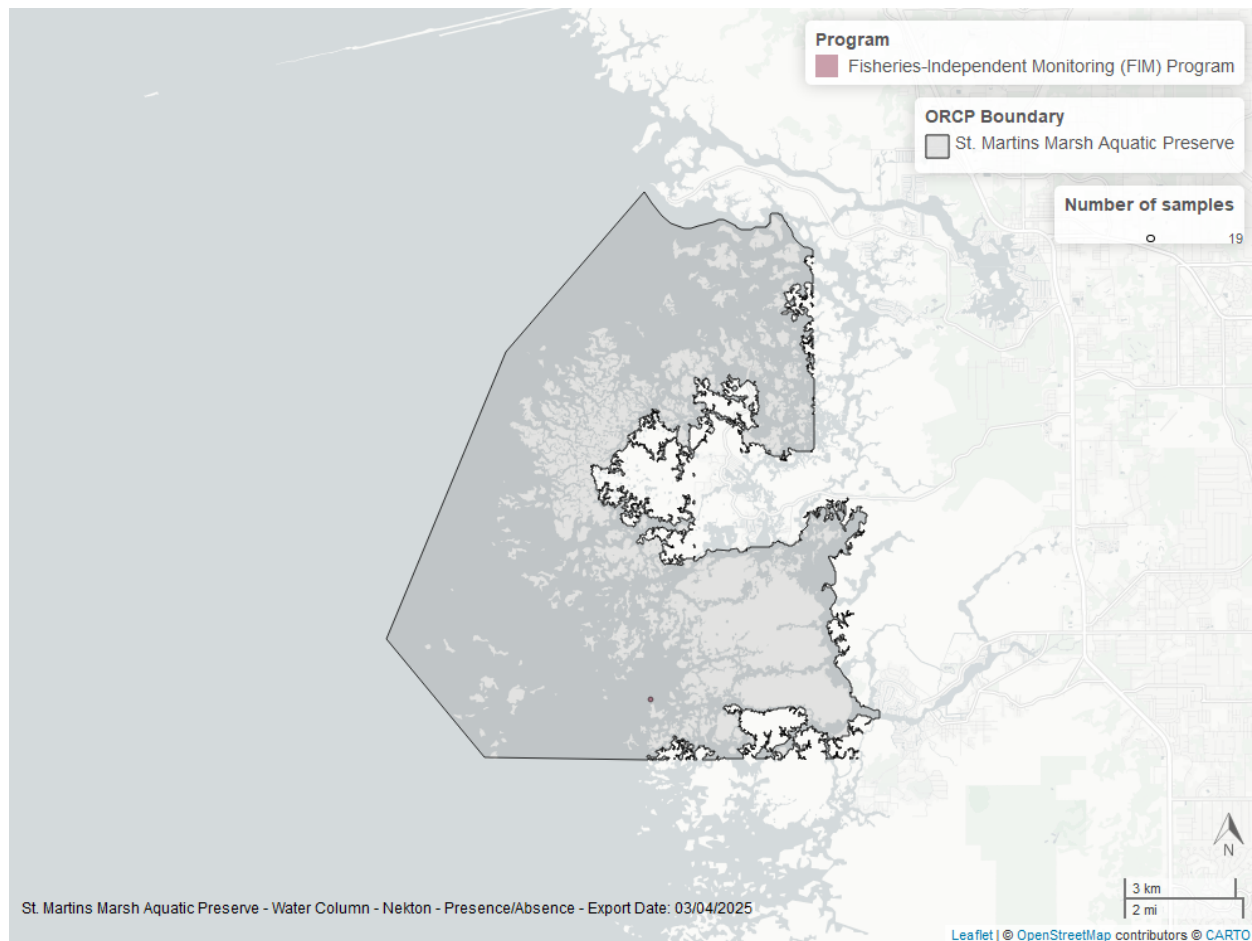


Figure 11: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 11: Nekton Species Richness - St. Martins Marsh Aquatic Preserve

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	0.14	1.21	0.67	0.67	0.75	2003	2003

The median annual number of taxa was 0.67 based on 2 observations collected by 6.1-meter trawl between 2003 and 2003.



Terra Ceia Aquatic Preserve

Table 12: Nekton Species Richness - Terra Ceia Aquatic Preserve

GearType	GearSize-m	N-Years	EarliestYear	LatestYear	N-Data	Min	Max	Median	Mean	StDev	Year-MinRichness	Year-MaxRichness
Trawl	6.1	34	1989	2022	1280	0.04	3.88	0.30	0.62	0.73	2001	2022
Seine	183.0	27	1996	2022	1449	0.02	0.66	0.17	0.17	0.14	2004	2012

The median annual number of taxa was 0.17 based on 1,449 observations collected by 183-meter seine between 1996 and 2022, and the median annual number of taxa was 0.30 based on 1,280 observations collected by 6.1-meter trawl between 1989 and 2022.

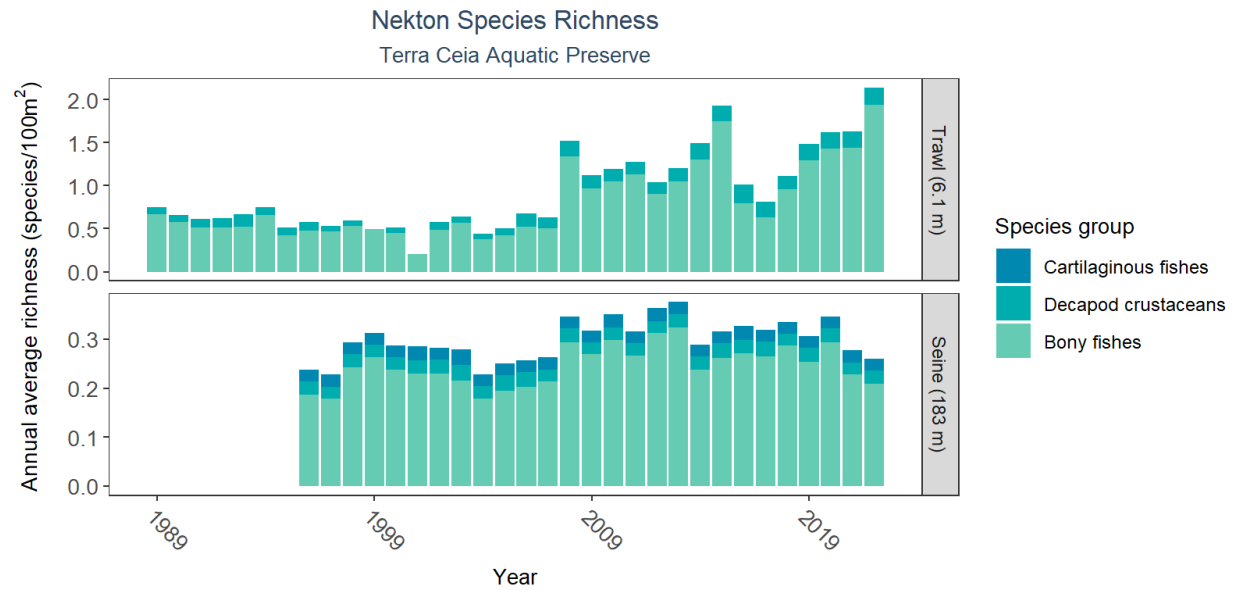
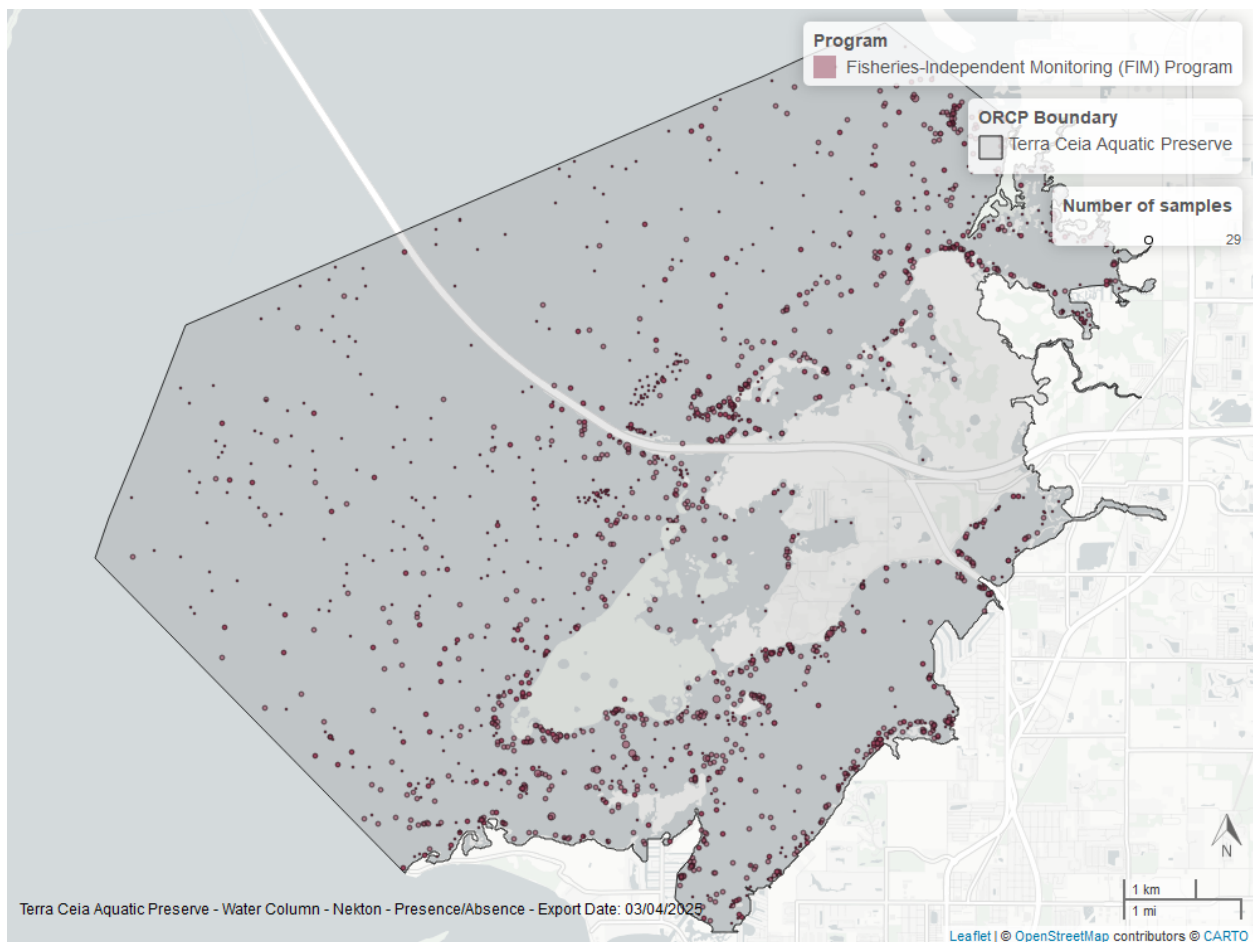


Figure 12: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.



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)
library(glue)
options(scipen=999)
knitr::opts_chunk$set(
  warning=FALSE,
  message=FALSE,
  dpi=200,
  fig.pos = 'H'
)
```

File Import

Imports file that is determined in the `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 latest version of Nekton data is available at: <https://usf.box.com/s/35sn0n0lrrxi9dtkik030nozbnj9dyj>

The file being used for the analysis is: **All_NEKTON_Parameters-2025-Jun-06.txt**

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

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

Data Filtering

Documentation on database filtering is provided here: [SEACAR Documentation- Analysis Filters and Calculations.pdf](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/SEACAR%20Documentation%20-%20Analysis%20Filters%20and%20Calculations.pdf) (https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/SEACAR%20Documentation%20-%20Analysis%20Filters%20and%20Calculations.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 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[ParameterName==param_name, ]

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

# Makes sure EffortCorrection is numeric value
data$EffortCorrection_100m2 <- as.numeric(data$EffortCorrection_100m2)

# 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(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
    SampleDate, GearType, GearSize_m) %>%
  summarise(ParameterName=parameter,
    Year=unique(Year), Month=unique(Month),
    N_Species=sum(ResultValue),
    EffortCorrection_100m2=as.numeric(unique(EffortCorrection_100m2)),
    SpeciesRichness=N_Species/unique(EffortCorrection_100m2),
    .groups = "keep")

# 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
nekton_MA_Include <- unique(data$ManagedAreaName[!is.na(data$N_Species)])

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

# Determines the number of managed areas used
n <- length(nekton_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, Year, GearType, and GearSize_m.
 - Third summary statistics do not use Year grouping and are only for ManagedAreaName, Month, GearType, and GearSize_m
 - Fourth summary statistics are only grouped based on ManagedAreaName, GearType, and GearSize_m
 - Determines the years that the minimum and maximum species richness occurred
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](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/tree/main/Nekton/output) (https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/tree/main/Nekton/output)

```
# 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),
            Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                           collapse=', '),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '),
            .groups = "keep")
# 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),
    Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                    collapse=', '),
    ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                     collapse=', '),
    .groups = "keep")
# 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),
            Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                            collapse=', '),
            ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                              collapse=', '),
            .groups = "keep")
# 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),
        Programs=paste(sort(unique(ProgramName), decreasing=FALSE),
                        collapse=', '),
        ProgramIDs=paste(sort(unique(ProgramID), decreasing=FALSE),
                          collapse=', '),
        .groups = "keep")
# 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 <- 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,"/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(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** (https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/tree/main/Nekton/output/Figures)

```
# 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 = element_text(hjust=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")
```

```
# Determine geartype palette and shapes dynamically
```

```
# Combine type and size into one label for plots
```

```

MA_Y_Stats$GearType_Plot <- paste0(MA_Y_Stats$GearType, " (",
                                   MA_Y_Stats$GearSize_m, " m)")
# Determine unique gear types to create palettes
# gear_types <- unique(MA_Y_Stats$GearType_Plot)
gear_types <- c("Trawl (4.8 m)", "Trawl (6.1 m)", "Seine (183 m)")
# Trawl = triangle, seine = square
gear_shapes <- c(24, 24, 22)
# Trawl = #005396, Seine = #00ADAE
gear_colors <- c("#005396", "#005396", "#00ADAE")
names(gear_colors) <- gear_types
names(gear_shapes) <- gear_types

# 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) {
    ma_i <- nekton_MA_Include[i]
    ma_abrev <- MA_All[ManagedAreaName==ma_i, Abbreviation]
    # Gets data for target managed area
    plot_data <- MA_Y_Stats[ManagedAreaName==ma_i, ]
    # Find values <5% occurrence
    remove_groups <- plot_data %>%
      group_by(SpeciesGroup2) %>%
      reframe(pct = (sum(N_Data) / sum(plot_data$N_Data))*100) %>%
      filter(pct<5) %>% pull(unique(SpeciesGroup2))
    # Filter values <5% occurrence
    plot_data <- plot_data %>% filter(!SpeciesGroup2 %in% remove_groups)

    # Determines most recent year with available data for managed area
    t_max <- max(MA_Ov_Stats[ManagedAreaName==ma_i, LatestYear])
    # Determines earliest recent year with available data for managed area
    t_min <- min(MA_Ov_Stats[ManagedAreaName==ma_i, EarliestYear])
    # 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 & t>=2){
      # Set breaks to every year if between 4 and 2 years of data
      brk <- -1
    }else if(t<2){
      # Set breaks to every year if less than 2 years of data
      brk <- -1
    }
  }
}

```

```

# Sets t_max to be 1 year greater and t_min to be 1 year lower
# Forces graph to have at least 3 tick marks
t_max <- t_max+1
t_min <- t_min-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)

## Legend labels - grab list of unique SG2 for this MA
sp_list <- unique(plot_data$SpeciesGroup2)
sp_list <- sp_list[order(match(sp_list, names(sg2_palette)))]
# Create common name labels for legend display
sp_labels <- sapply(sp_list, function(x){sg_common[[x]]})

# 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,
             aes(fill = SpeciesGroup2, y=Mean, x=Year)) +
  geom_bar(position="stack", stat="identity") +
  facet_wrap(~GearType_Plot,
            nrow=2, ncol=1,
            strip.position = "right",
            scales = "free_y") +
  labs(title="Nekton Species Richness",
       subtitle=ma_i,
       x="Year", y=bquote('Richness (species/100'*~m^{2}*')')) +
  scale_fill_manual(name = "Species group",
                   values = subset(sg2_palette, names(sg2_palette) %in%
                                   unique(plot_data$SpeciesGroup2)),
                   labels = sp_labels) +
  scale_x_continuous(limits = c(t_min-1, t_max+1),
                    breaks = seq(t_max, t_min, brk)) +
  plot_theme
# Sets file name of plot created
outname <- paste0("Nekton_", param_file, "_", ma_abrev, ".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[ManagedAreaName==ma_i, ]
# Removes location, gear, and parameter information because it is in plot
# labels
ResultTable <- ResultTable[,-c("AreaID", "ManagedAreaName",
                                "ProgramIDs", "Programs", "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. Does not add space after last plot
if(i!=n){
  cat("\n \n \n \n")
}
}
}

```