

SEACAR Continuous Water Quality Analysis: SW Region for Salinity

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Important Notes

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

https://github.com/FloridaSEACAR/SEACAR_Panzik

Note: The top 2% of data is excluded when computing mean and standard deviations in plotting sections solely for the purpose of getting y-axis scales. The exclusion of the top 2% is not used in any statistics that are exported.

Libraries and Settings

Loads libraries used in the script. The inclusion of `scipen` option limits how frequently R defaults to scientific notation.

```

library(knitr)
library(data.table)
library(dplyr)
library(lubridate)
library(ggplot2)
library(ggpubr)
library(scales)
library(EnvStats)
library(tidyr)
library(kableExtra)
windowsFonts(`Segoe UI` = windowsFont('Segoe UI'))
options(scipen=999)
opts_chunk$set(warning=FALSE, message=FALSE, dpi=200)

```

File Import

Imports file that is determined in the WC_Continuous_parameter_ReportCompile.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.

```

data <- fread(file_in, sep="|", header=TRUE, stringsAsFactors=FALSE,
              select=c("ManagedAreaName", "ProgramID", "ProgramName",
                      "ProgramLocationID", "SampleDate", "Year", "Month",
                      "RelativeDepth", "ActivityType", "ParameterName",
                      "ResultValue", "ParameterUnits", "ValueQualifier",
                      "SEACAR_QAQCFlagCode", "Include"),
              na.strings="")
parameter <- unique(data$ParameterName)
unit <- unique(data$ParameterUnits)

```

Data Filtering

Most data filtering is performed on export from the database, and is indicated by the `Include` variable. `Include` values of 1 indicate the data should be used for analysis, values of 0 indicate the data should not be used for analysis. Documentation on the database filtering is provided here: SEACAR Documentation-Analysis Filters and Calculations.docx

The filtering that is performed by the script at this point removes rows that are missing values for `ResultValue` and `RelativeDepth`, and removes any activity type that has “Blank” in the description. Data passes the filtering the process if it is has an `Include` value of 1.

The script then gets the units of the parameter, sets the `SampleDate` as a date object, and creates various scales of the date to be used by plotting functions.

Because the continuous data is extensive and most measurements are taken every 15 minutes, a daily average is determined and used based on grouping `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, and `SampleDate`. The new `ResultValue` is the mean of all values on that date from that specific monitoring location. Sets the `SampleDate` as a date object, and creates various scales of the date to be used by plotting functions.

Creates a variable for each MonitoringID which is defined as a unique combination of ManagedAreaName, ProgramID, ProgramAreaName, and ProgramLocationID.

After the initial filtering, a second filter variable is created to determine whether enough time is represented in the managed area, which is that each managed area has 5 year or more of unique year entries for observation that pass the initial filter. If data passes the first set of filtering criteria and the time criteria, they are used in the analysis.

```

data$Include <- as.logical(data$Include)
data <- data[data$Include==TRUE,]
data <- data[!is.na(data$ResultValue),]
data <- data[!is.na(data$RelativeDepth),]
data <- data[!grep("Blank", data$ActivityType),]

if(param_name=="Water_Temperature"){
  data <- data[data$ResultValue>=-5,]
} else{
  data <- data[data$ResultValue>=0,]
}

data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           SampleDate) %>%
  summarise(Year=unique(Year), Month=unique(Month),
            RelativeDepth=unique(RelativeDepth),
            ResultValue=mean(ResultValue), Include=unique(Include))

data <- merge.data.frame(MA_All[,c("AreaID", "ManagedAreaName")],
                         data, by="ManagedAreaName", all=TRUE)

data$SampleDate <- as.Date(data$SampleDate)
data$YearMonth <- format(data$SampleDate, format = "%m-%Y")
data$YearMonthDec <- data$Year + ((data$Month-0.5) / 12)
data$DecDate <- decimal_date(data$SampleDate)

data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID) %>%
  mutate(MonitoringID=cur_group_id())

Mon_Summ <- data %>%
  group_by(MonitoringID, AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            N_Data=length(ResultValue[Include==TRUE & !is.na(ResultValue)]),
            N_Years=length(unique(Year[Include==TRUE & !is.na(Year)])),
            EarliestYear=min(Year[Include==TRUE]),
            LatestYear=max(Year[Include==TRUE]),
            SufficientData=ifelse(N_Data>0 & N_Years>=10, TRUE, FALSE))

Mon_Summ <- as.data.table(Mon_Summ[order(Mon_Summ$MonitoringID), ])

```

```

data <- merge.data.frame(data, Mon_Summ[,c("MonitoringID", "SufficientData")],
                         by="MonitoringID")

data$Use_In_Analysis <- ifelse(data$Include==TRUE &
                                 data$SufficientData==TRUE, TRUE, FALSE)

Mon_IDs <- unique(data$MonitoringID[data$Use_In_Analysis==TRUE])
Mon_IDs <- Mon_IDs[order(Mon_IDs)]
n <- length(Mon_IDs)

```

Monitoring Location Statistics

Gets summary statistics for each monitoring location. Excluded monitoring locations are not included into whether the data should be used or not. Uses piping from dplyr package to feed into subsequent steps. The following steps are performed:

1. Take the data variable and only include rows that have a `Use_In_Analysis` value of TRUE
2. Group data that have the same `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, `Year`, and `Month`.
 - Second summary statistics consider the monitoring location grouping and `Year`.
 - Third summary statistics consider the monitoring location grouping and `Month`.
3. For each group, provide the following information: Earliest Sample Date (`EarliestSampleDate`), Latest Sample Date (`LastSampleDate`), Number of Entries (`N`), Lowest Value (`Min`), Largest Value (`Max`), Median, Mean, Standard Deviation, and a list of all Program IDs included in these measurements.
4. Sort the data in ascending (A to Z and 0 to 9) order based on `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, `Year`, and `Month` in that order.
5. Write summary stats to a pipe-delimited .txt file in the output directory

```

Mon_YM_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year, Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),
            StandardDeviation=sd(ResultValue))
Mon_YM_Stats <- as.data.table(Mon_YM_Stats[order(Mon_YM_Stats$ManagedAreaName,
                                                    Mon_YM_Stats$ProgramID,
                                                    Mon_YM_Stats$ProgramName,
                                                    Mon_YM_Stats$ProgramLocationID,
                                                    Mon_YM_Stats$Year,
                                                    Mon_YM_Stats$Month), ])
fwrite(Mon_YM_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_YearMonth_Stats.txt"), sep="|")

Mon_Y_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year) %>%

```

```

summarize(ParameterName=parameter,
          RelativeDepth=unique(RelativeDepth),
          EarliestSampleDate=min(SampleDate),
          LastSampleDate=max(SampleDate), N=length(ResultValue),
          Min=min(ResultValue), Max=max(ResultValue),
          Median=median(ResultValue), Mean=mean(ResultValue),
          StandardDeviation=sd(ResultValue))
Mon_Y_Stats <- as.data.table(Mon_Y_Stats[order(Mon_Y_Stats$ManagedAreaName,
                                                Mon_Y_Stats$ProgramID,
                                                Mon_Y_Stats$ProgramName,
                                                Mon_Y_Stats$ProgramLocationID,
                                                Mon_Y_Stats$Year), ])
fwrite(Mon_Y_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_Year_Stats.txt"), sep="|")

Mon_M_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),
            StandardDeviation=sd(ResultValue))
Mon_M_Stats <- as.data.table(Mon_M_Stats[order(Mon_M_Stats$ManagedAreaName,
                                                Mon_M_Stats$ProgramID,
                                                Mon_M_Stats$ProgramName,
                                                Mon_M_Stats$ProgramLocationID,
                                                Mon_M_Stats$Month), ])
fwrite(Mon_M_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_Month_Stats.txt"), sep="|")

```

Seasonal Kendall Tau Analysis

Gets seasonal Kendall Tau statistics using the `kendallSeasonalTrendTest` from the `EnvStats` package. The Trend parameter is determined from a user-defined function based on the median, Senn slope, and p values from the data. Analysis modified from that performed at The Water Atlas: <https://sarasota.wateratlas.usf.edu/water-quality-trends/#analysis-overview>

The following steps are performed:

1. Define the trend function.
2. Take the `data` variable and only include rows that have a `Use_In_Analysis` value of TRUE
3. Group data that have the same `ManagedAreaName`, `ProgramID`, `ProgramName`, and `ProgramLocationID`.
4. For each group, provides the following information: Earliest Sample Date (EarliestSampleDate), Latest Sample Date (LastSampleDate), Number of Entries (N), Lowest Value (Min), Largest Value (Max), Median, Mean, Standard Deviation,

5. For each group, a temporary variable is created to run the `kendallSeasonalTrendTest` function using the `Year` values for year, and `Month` as the seasonal qualifier, and `Trend`.
 - An `independent.obs` value of `TRUE` indicates that the data should be treated as not being serially auto-correlated. An `independent.obs` value of `FALSE` indicates that it is treated as being serially auto-correlated, but also requires one observation per season per year for the full time of observation.
 - `tau`, Senn Slope (`SennSlope`), Senn Intercept (`SennIntercept`), and `p` are extracted from the model results.
6. The two stats tables are merged based on similar groups, and then `Trend` is determined from the user-defined function.
7. Write summary stats to a pipe-delimited .txt file in the output directory
 - Click this text to open Git directory with output files
8. Add the Monitoring IDS to `KTStats` for easier use while plotting.

```
tauSeasonal <- function(data, independent, stats.median, stats.minYear,
                         stats.maxYear) {
  tau <- NULL
  tryCatch({ken <- kendallSeasonalTrendTest(
    y=data$resultValue,
    season=data$Month,
    year=data$Year,
    independent.obs=independent)

  tau <- ken$estimate[1]
  p <- ken$p.value[2]
  slope <- ken$estimate[2]
  intercept <- ken$estimate[3]
  trend <- trend_calculator(slope, stats.median, p)
  rm(ken)
  }, warning=function(w) {
  print(w)
  }, error=function(e) {
  print(e)
  }, finally={
  if (!exists("tau")) {
    tau <- NA
  }
  if (!exists("p")) {
    p <- NA
  }
  if (!exists("slope")) {
    slope <- NA
  }
  if (!exists("intercept")) {
    intercept <- NA
  }
  if (!exists("trend")) {
    trend <- NA
  }
})
}
```

```

KT <- c(unique(data$MonitoringID),
        stats.median,
        independent,
        tau,
        p,
        slope,
        intercept,
        trend)
return(KT)
}
runStats <- function(data) {
  data$Index <- as.Date(data$SampleDate) # , "%Y-%m-%d")
  data$ResultValue <- as.numeric(data$ResultValue)
  # Calculate basic stats
  stats.median <- median(data$ResultValue, na.rm=TRUE)
  stats.minYear <- min(data$Year, na.rm=TRUE)
  stats.maxYear <- max(data$Year, na.rm=TRUE)
  # Calculate Kendall Tau and Slope stats,
  # then update appropriate columns and table
  KT <- tauSeasonal(data, TRUE, stats.median,
                     stats.minYear, stats.maxYear)
  if (is.null(KT[8])) {
    KT <- tauSeasonal(data, FALSE, stats.median,
                      stats.minYear, stats.maxYear)
  }
  if (is.null(KT$Stats)==TRUE) {
    KT$Stats <- KT
  } else{
    KT$Stats <- rbind(KT$Stats, KT)
  }
  return(KT$Stats)
}
trend_calculator <- function(slope, median_value, p) {
  trend <-
    if (p < .05 & abs(slope) > abs(median_value) / 10.) {
      if (slope > 0) {
        2
      }
      else {
        -2
      }
    }
    else if (p < .05 & abs(slope) < abs(median_value) / 10.) {
      if (slope > 0) {
        1
      }
      else {
        -1
      }
    }
    else
      0
  return(trend)
}

```

```

}

KT.Stats <- NULL
# Loop that goes through each managed area.
# List of managed areas stored in MA_Years$ManagedAreaName
c_names <- c("MonitoringID", "Median", "Independent", "tau", "p",
           "SennSlope", "SennIntercept", "Trend")
if(n==0){
  KT.Stats <- data.frame(matrix(ncol=length(c_names),
                                 nrow=nrow(Mon_Summ)))
  colnames(KT.Stats) <- c_names
  KT.Stats[, c("MonitoringID")] <- Mon_Summ[, c("MonitoringID")]
} else{
  for (i in 1:n) {
    x <- nrow(data[data$Use_In_Analysis==TRUE &
                   data$MonitoringID==Mon_IDs[i], ])
    if (x>0) {
      KT.Stats <- runStats(data[data$Use_In_Analysis==TRUE &
                                  data$MonitoringID==Mon_IDs[i], ])
    }
  }
  KT.Stats <- as.data.frame(KT.Stats)

  if(dim(KT.Stats)[2]==1){
    KT.Stats <- as.data.frame(t(KT.Stats))
  }
  colnames(KT.Stats) <- c_names
  rownames(KT.Stats) <- seq(1:nrow(KT.Stats))
  KT.Stats$tau <- round(as.numeric(KT.Stats$tau), digits=4)
  KT.Stats$p <- round(as.numeric(KT.Stats$p), digits=4)
  KT.Stats$SennSlope <- as.numeric(KT.Stats$SennSlope)
  KT.Stats$SennIntercept <- as.numeric(KT.Stats$SennIntercept)
  KT.Stats$Trend <- as.integer(KT.Stats$Trend)
}

KT.Stats <- merge.data.frame(Mon_Summ, KT.Stats,
                             by=c("MonitoringID"), all=TRUE)

KT.Stats <- as.data.table(KT.Stats[order(KT.Stats$MonitoringID), ])

KT.Stats$MonitoringID <- NULL
fwrite(KT.Stats, paste0(out_dir, "/", param_name, "_", region,
                       "_KendallTau_Stats.txt"), sep="|")

KT.Stats$MonitoringID <- Mon_Summ$MonitoringID
data <- data[!is.na(data$ResultValue), ]

```

Appendix I: Dataset Summary Box Plots

Box plots are created by using the entire data set and excludes any data that has been previously filtered out. The scripts that create plots follow this format

1. Use the data set that only has `Use_In_Analysis` of TRUE

2. Set what values are to be used for the x-axis, y-axis, and the variable that should determine groups for the box plots
3. Set the plot type as a box plot with the size of the outlier points
4. Create the title, x-axis, y-axis, and color fill labels
5. Set the y and x limits
6. Make the axis labels bold
7. Plot the arrangement as a set of panels

This set of box plots are grouped by year.

```

plot_theme <- theme_bw() +
  theme(text=element_text(family="Segoe UI"),
        title=element_text(face="bold"),
        plot.title=element_text(hjust=0.5, size=14, color="#314963"),
        plot.subtitle=element_text(hjust=0.5, size=10, color="#314963"),
        axis.title.x = element_text(margin = margin(t = 5, r = 0,
                                                    b = 10, l = 0)),
        axis.title.y = element_text(margin = margin(t = 0, r = 10,
                                                    b = 0, l = 0)),
        axis.text=element_text(size=10),
        axis.text.x=element_text(face="bold", angle = 60, hjust = 1),
        axis.text.y=element_text(face="bold"))

min_RV <- min(data$ResultValue[data$Include==TRUE])
mn_RV <- mean(data$ResultValue[data$Include==TRUE &
                                data$ResultValue <
                                  quantile(data$ResultValue, 0.98)])
sd_RV <- sd(data$ResultValue[data$Include==TRUE &
                                data$ResultValue <
                                  quantile(data$ResultValue, 0.98)])
y_scale <- mn_RV + 4 * sd_RV

p1 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=SampleDate, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Year",
       y=paste0("Values (", unit, ")")) +
  plot_theme

p2 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=SampleDate, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation", x="Year",
       y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  plot_theme

p3 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=Year, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,

```

```

        outlier.size=3, outlier.color="#333333",
        outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(max(data$Year) - 10.5, max(data$Year)+0.5),
                     breaks=seq(max(data$Year) - 10, max(data$Year), 2)) +
  plot_theme

set <- ggarrange(p1, p2, p3, ncol=1)

p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",
                       subtitle="By Year") + plot_theme +
  theme(panel.border=element_blank(), panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

Yset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

```

This set of box plots are grouped by year and month with the color being related to the month.

```

p1 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Year",
       y=paste0("Values (", unit, ")"), color="Month") +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(color=guide_legend(nrow=1))

p2 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  plot_theme +
  theme(legend.position="none")

p3 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(max(data$Year) - 10.5, max(data$Year)+0.5),
                     breaks=seq(max(data$Year) - 10, max(data$Year), 2)) +
  plot_theme +
  theme(legend.position="none")

leg <- get_legend(p1)
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,

```

```

        heights=c(0.1, 1, 1, 1))

p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",
                      subtitle="By Year & Month") + plot_theme +
  theme(panel.border=element_blank(), panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

YMset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

```

The following box plots are grouped by month with fill color being related to the month. This is designed to view potential seasonal trends.

```

p1 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Month",
       y=paste0("Values (", unit, ")"), fill="Month") +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(fill=guide_legend(nrow=1))

p2 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation",
       x="Month", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")

p3 <- ggplot(data=data[data$Include==TRUE &
                           data$Year >= max(data$Year) - 10, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation, Last 10 Years",
       x="Month", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")

leg <- get_legend(p1)
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,
                 heights=c(0.1, 1, 1, 1))

p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",

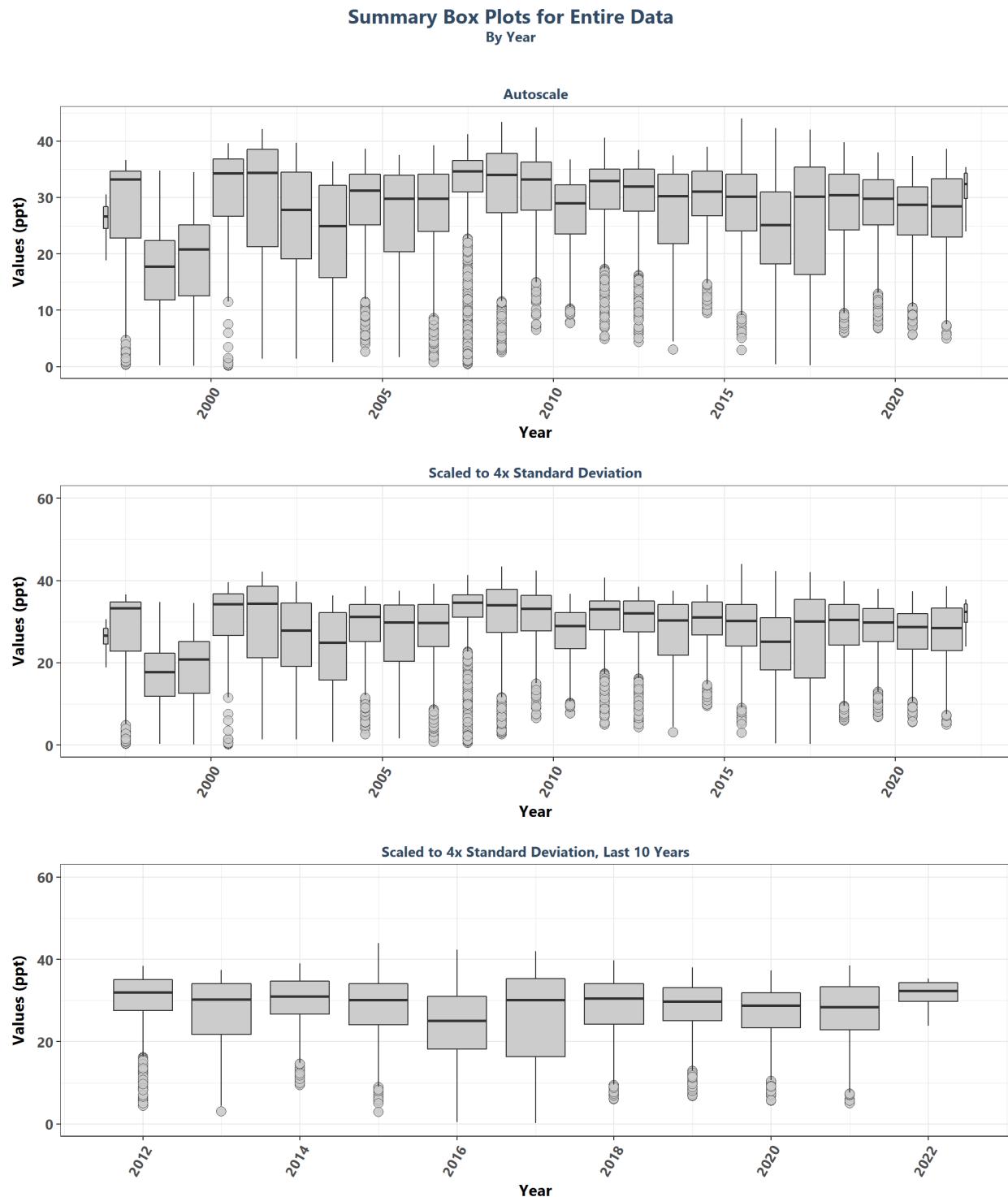
```

```

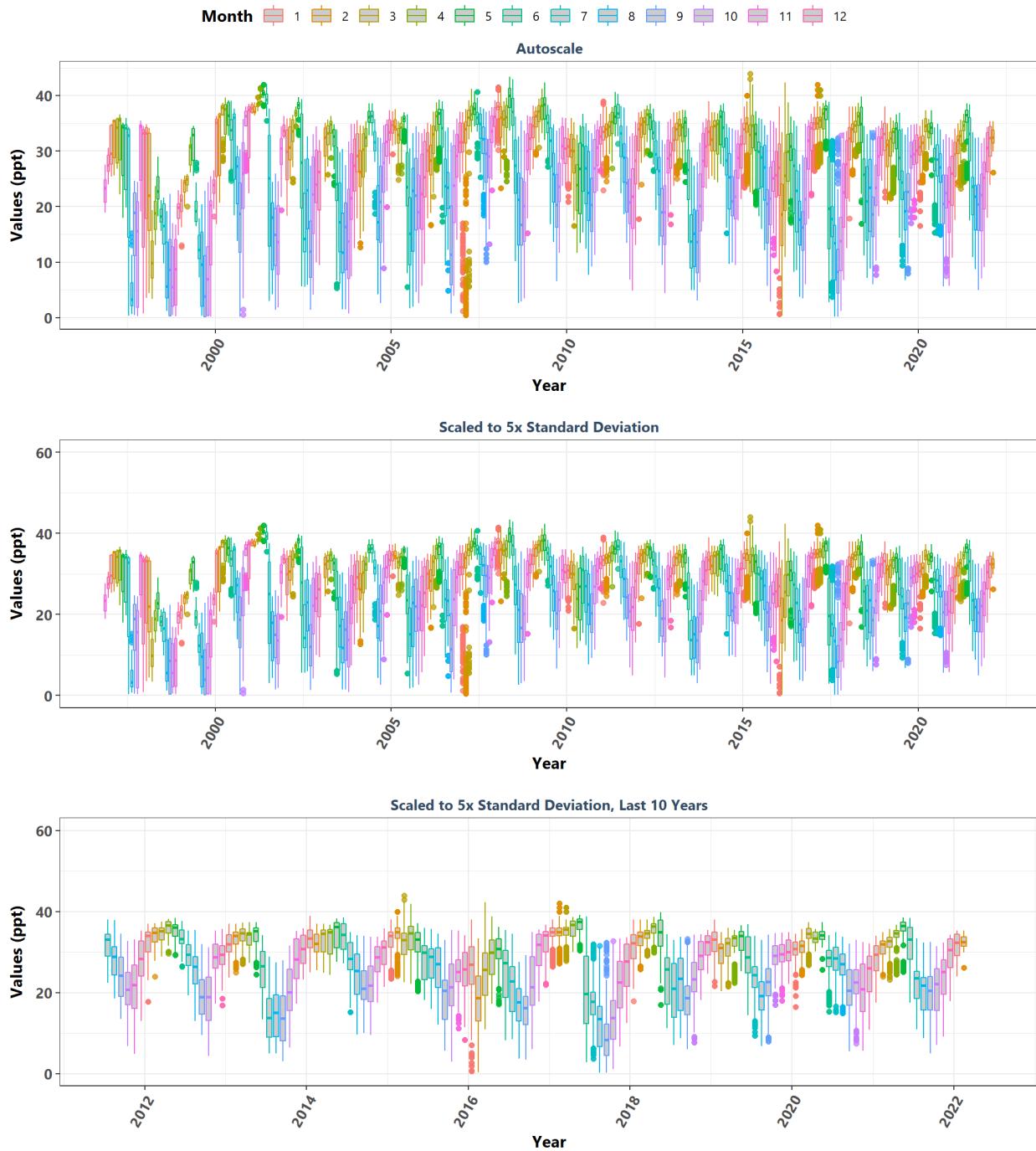
        subtitle="By Month") + plot_theme +
theme(panel.border=element_blank(), panel.grid.major=element_blank(),
      panel.grid.minor=element_blank(), axis.line=element_blank())

Mset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

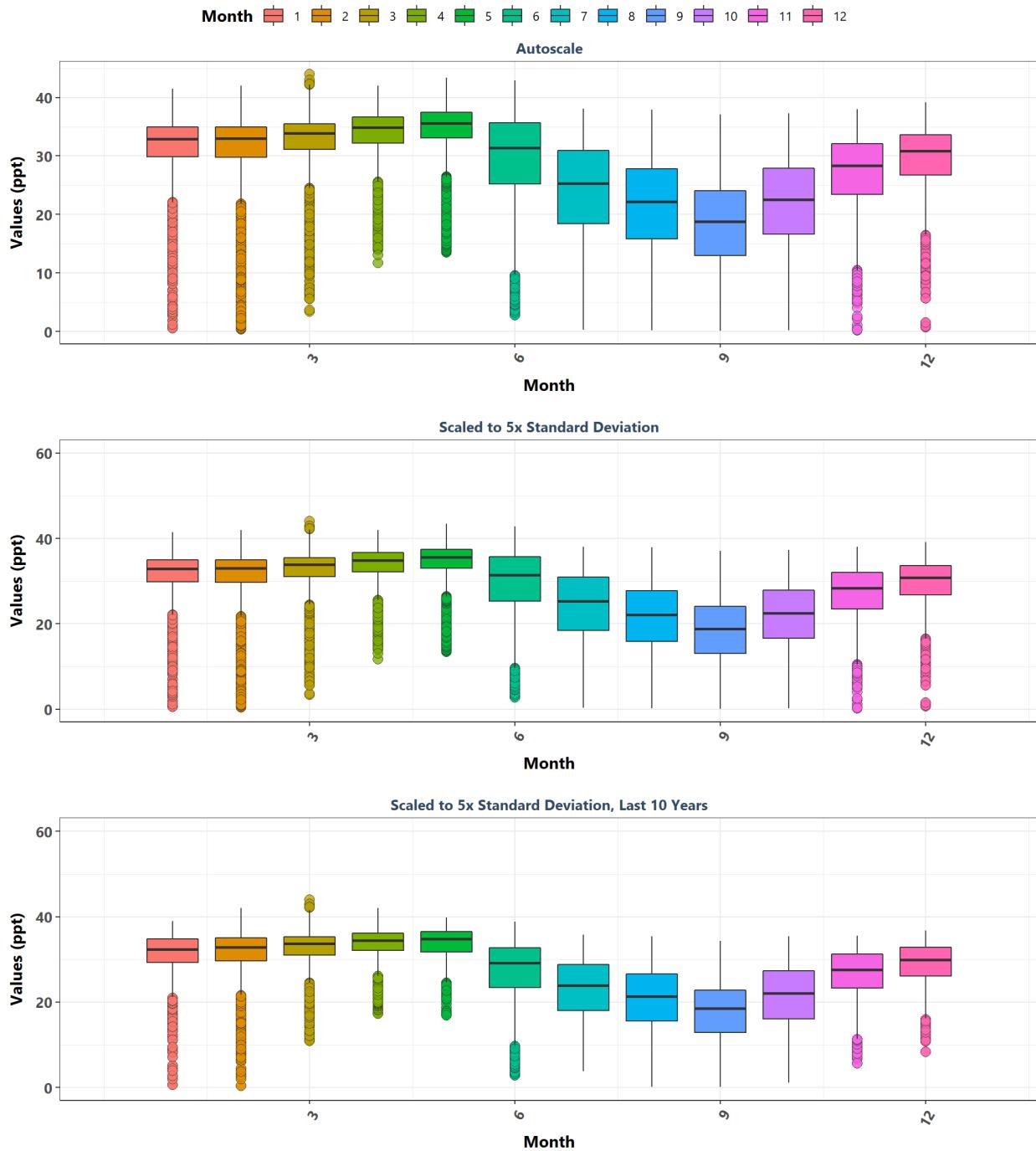
```



Summary Box Plots for Entire Data
By Year & Month



Summary Box Plots for Entire Data By Month



Appendix II: Excluded Monitoring Locations

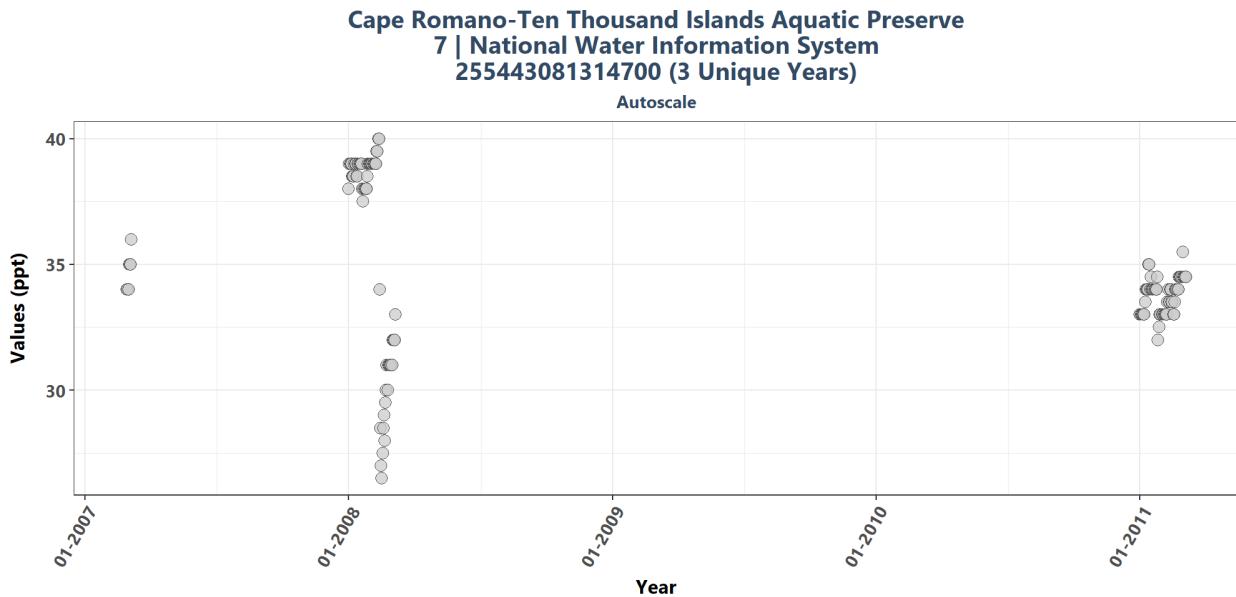
Scatter plots of data values are created for monitoring locations that have fewer than 5 separate years of data entries.

```

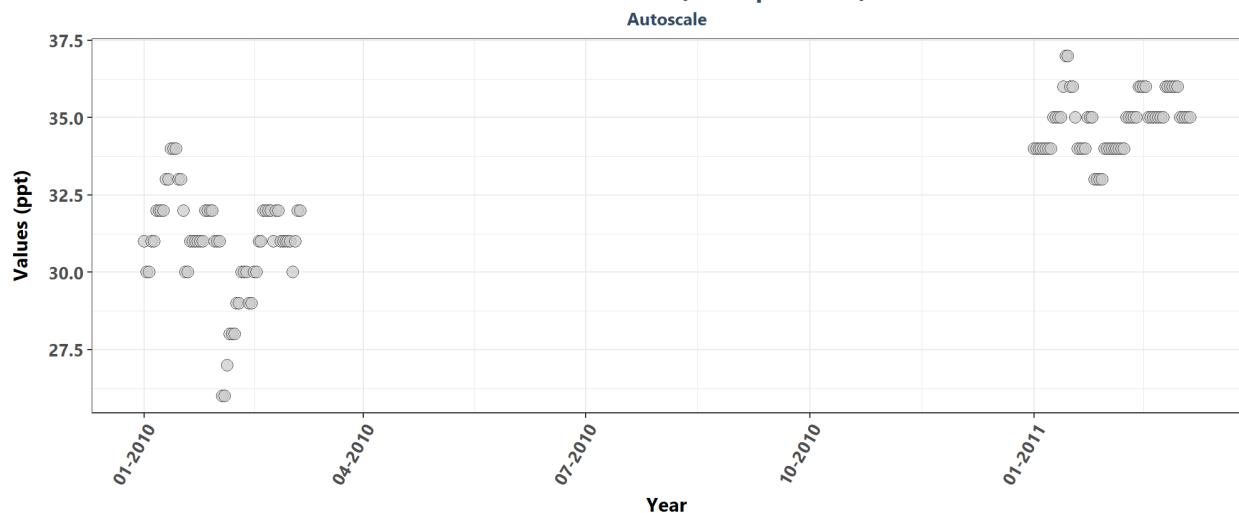
Mon_Exclude <- Mon_Summ[Mon_Summ$N_Years<5 & Mon_Summ$N_Years>0,]
Mon_Exclude <- Mon_Exclude[order(Mon_Exclude$MonitoringID),]
z=nrow(Mon_Exclude)

if(z==0){
  print("There are no monitoring locations that qualify.")
} else {
  for(i in 1:z){
    MA_name <- unique(data$ManagedAreaName[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]])
    Mon_name <- paste0(unique(data$ProgramID[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]]), " | ",
      unique(data$ProgramName[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]]), "\n",
      unique(data$ProgramLocationID[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]])))
  }
}

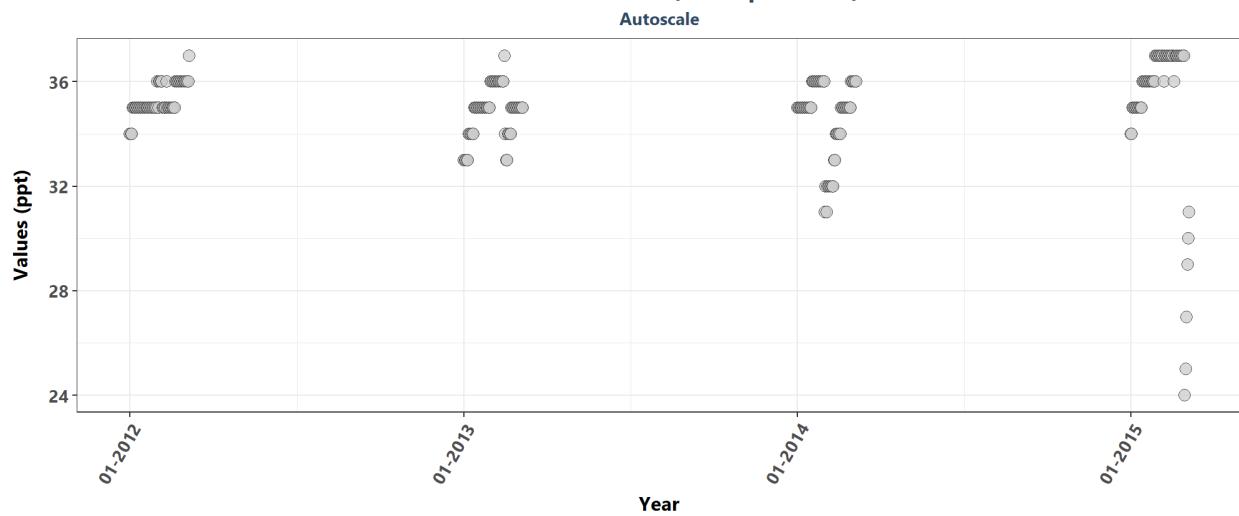
```



Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255532081314300 (2 Unique Years)

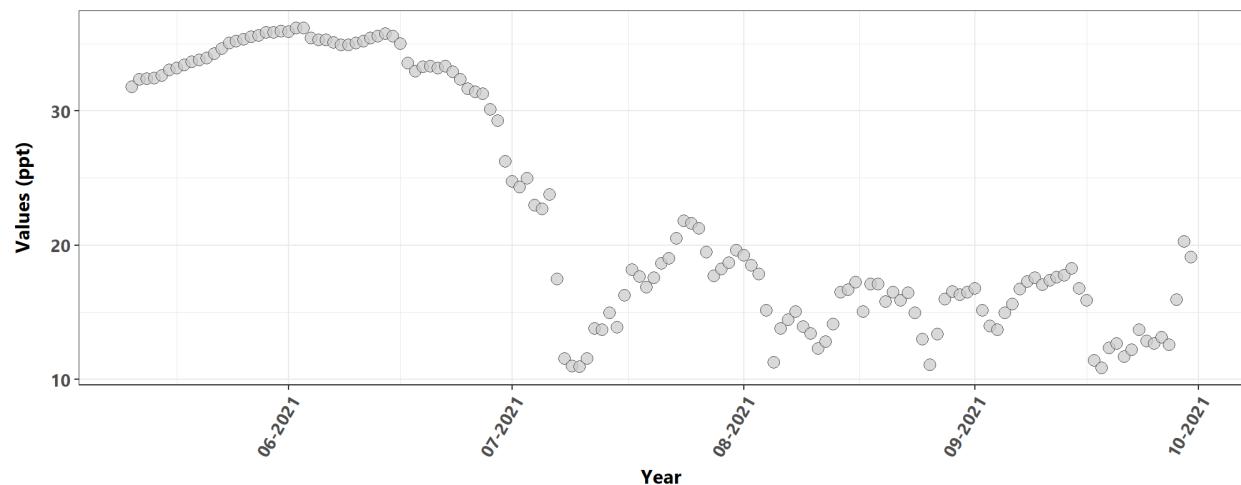


Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255732081363700 (4 Unique Years)



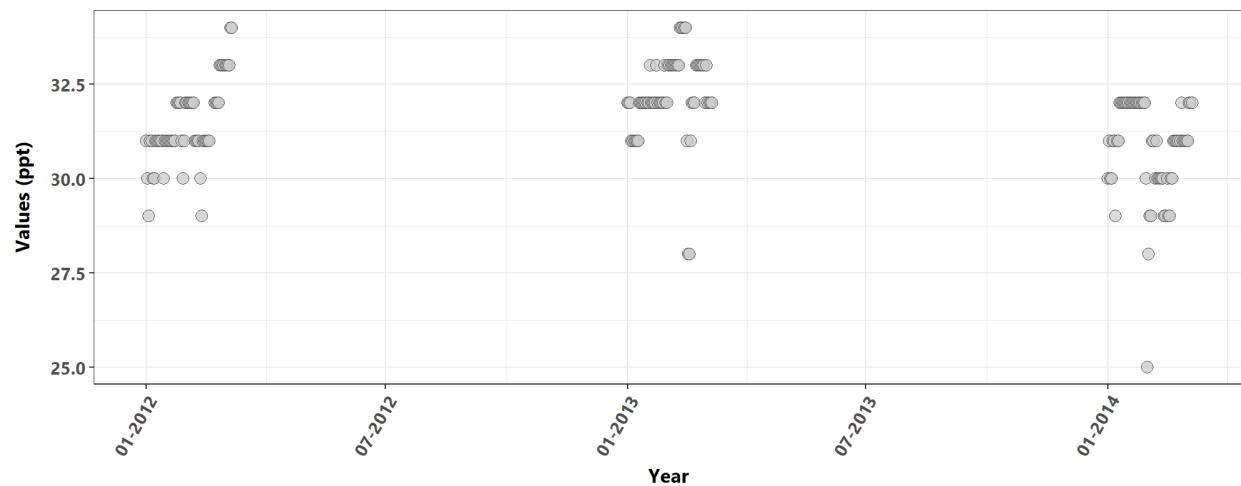
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB04 (1 Unique Years)

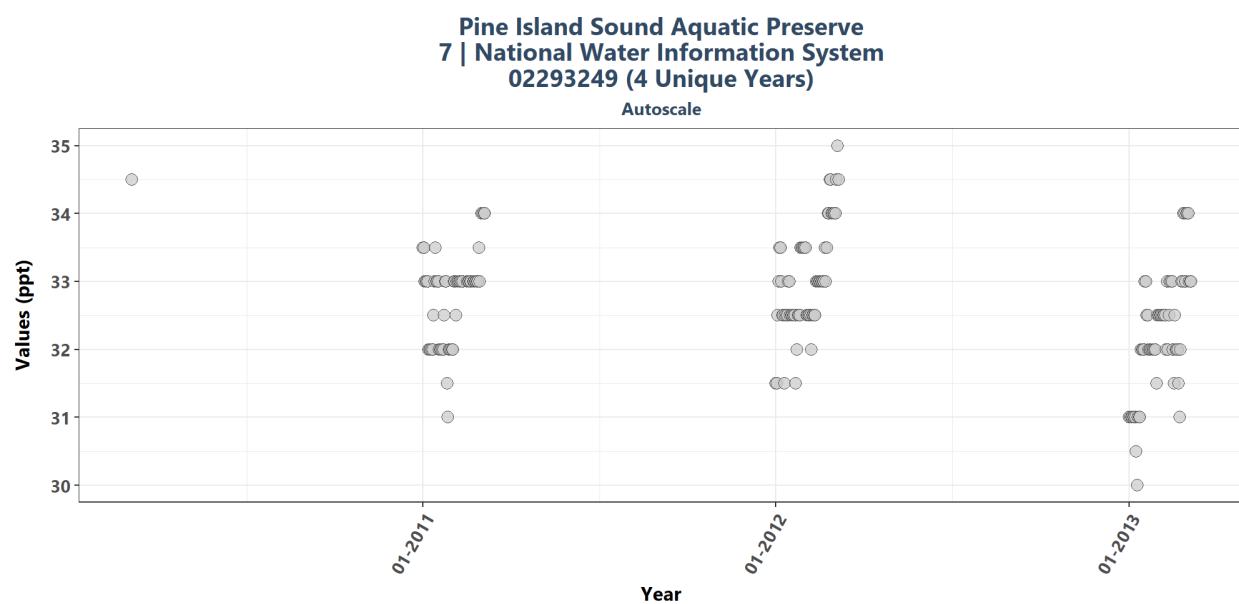
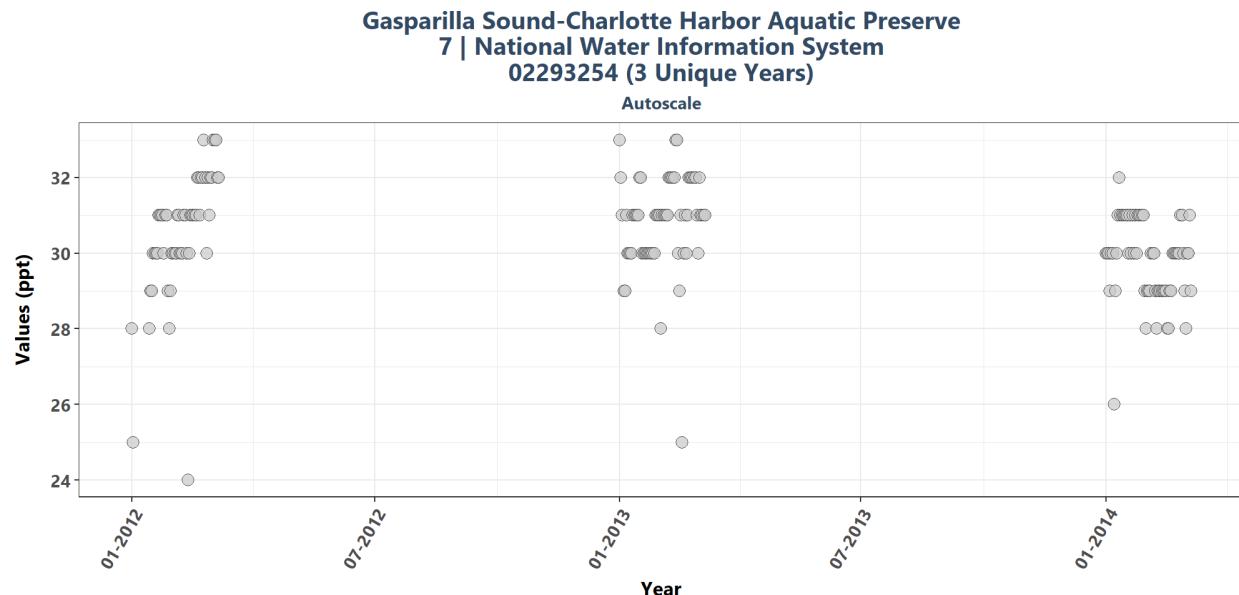
Autoscale



Gasparilla Sound-Charlotte Harbor Aquatic Preserve
7 | National Water Information System
02293252 (3 Unique Years)

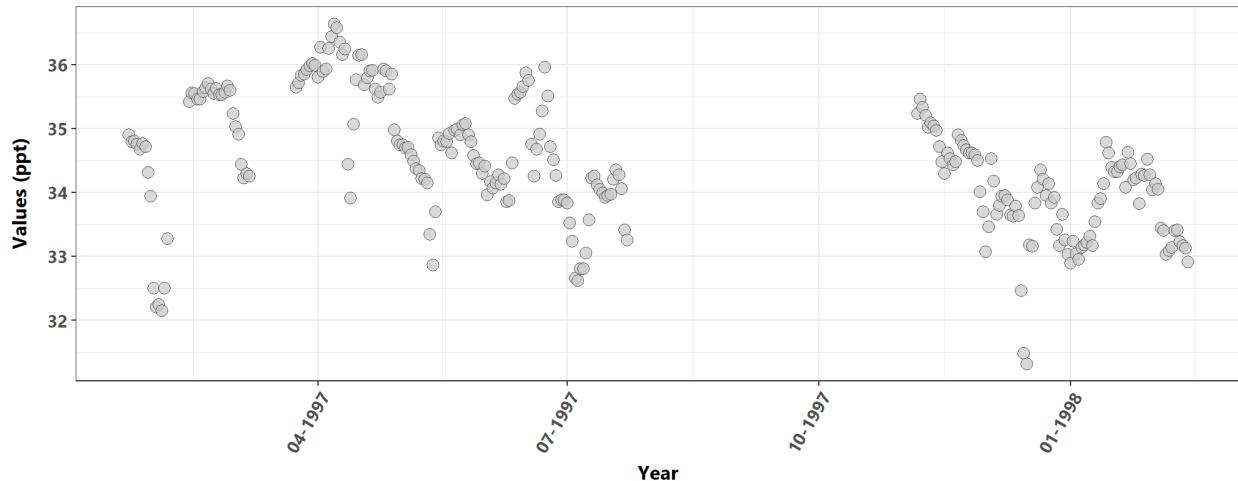
Autoscale





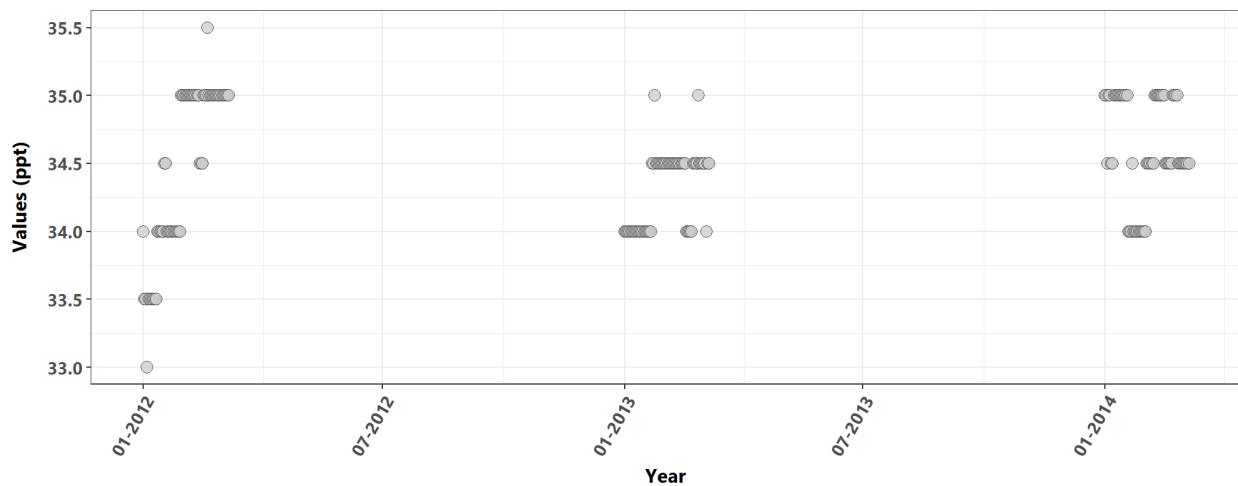
Rookery Bay Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbbmwq (2 Unique Years)

Autoscale



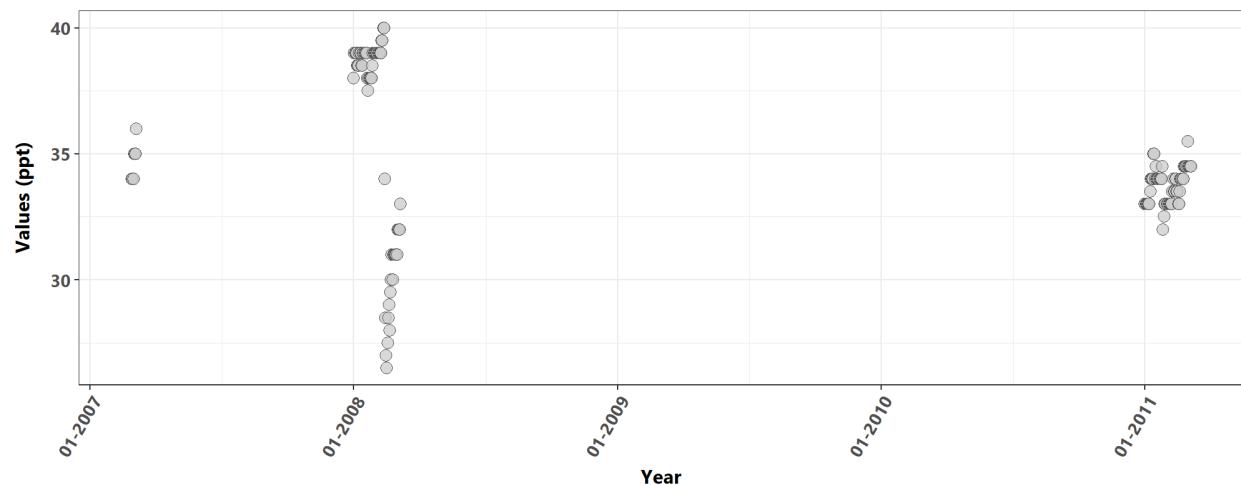
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
02291330 (3 Unique Years)

Autoscale



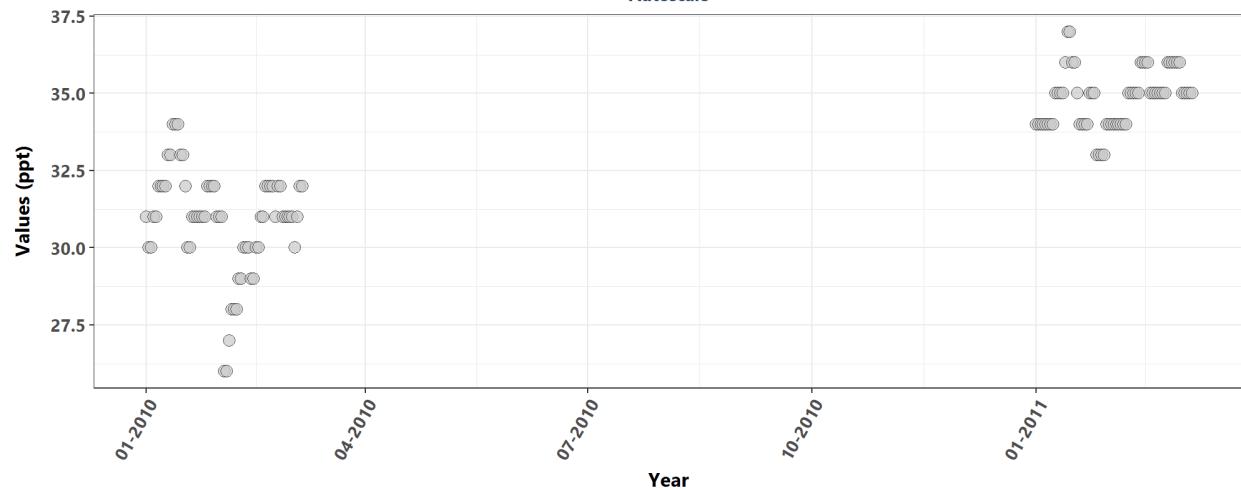
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255443081314700 (3 Unique Years)

Autoscale



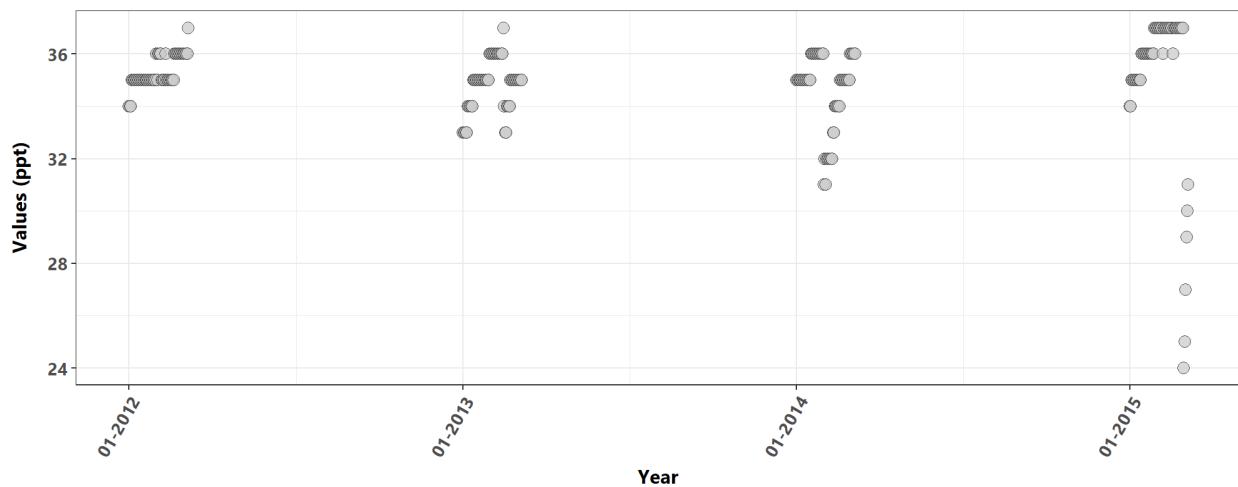
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255532081314300 (2 Unique Years)

Autoscale



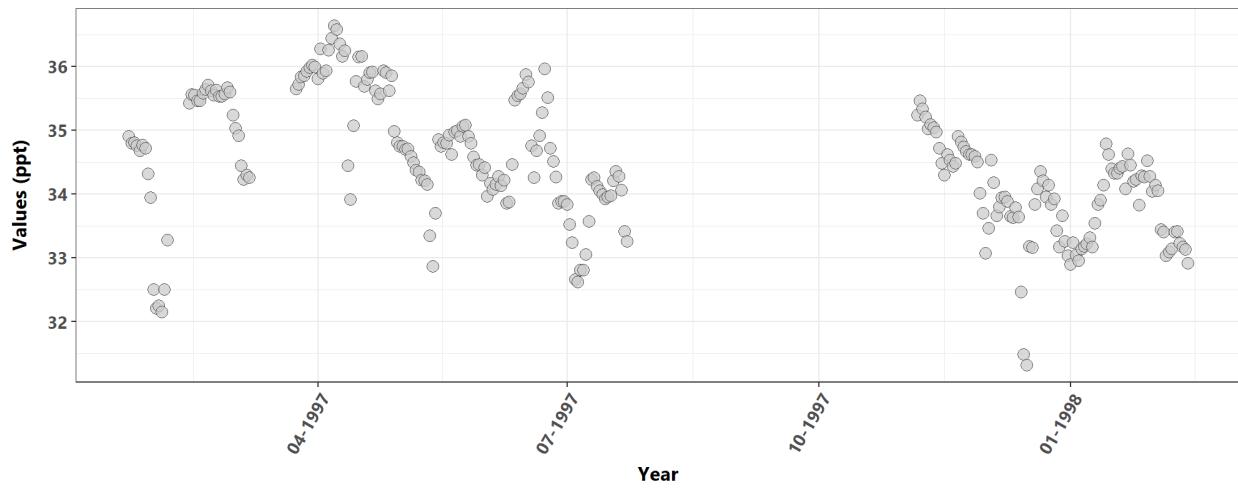
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255732081363700 (4 Unique Years)

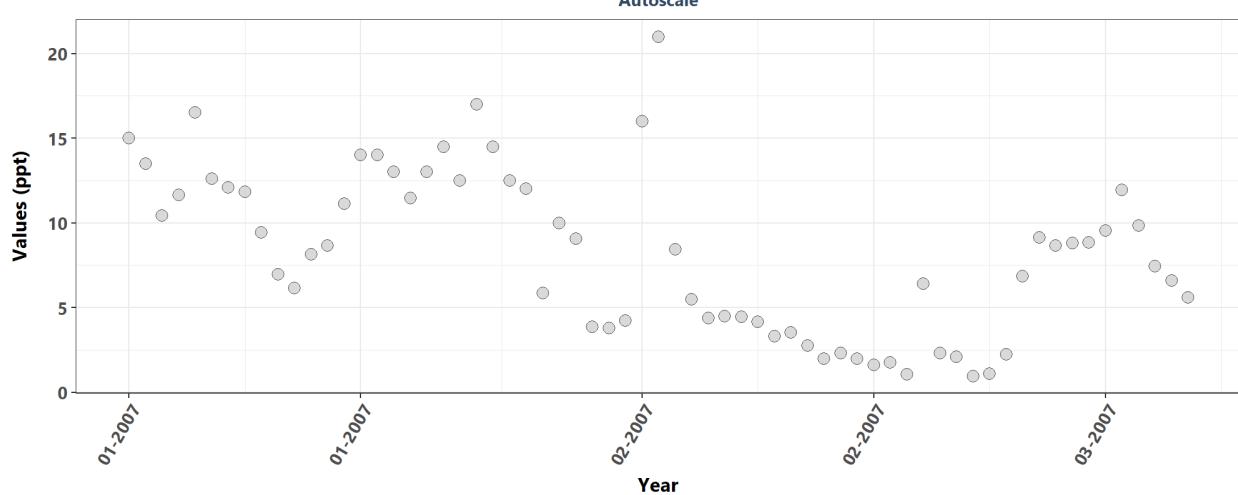
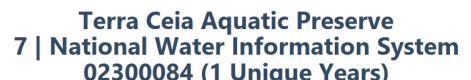
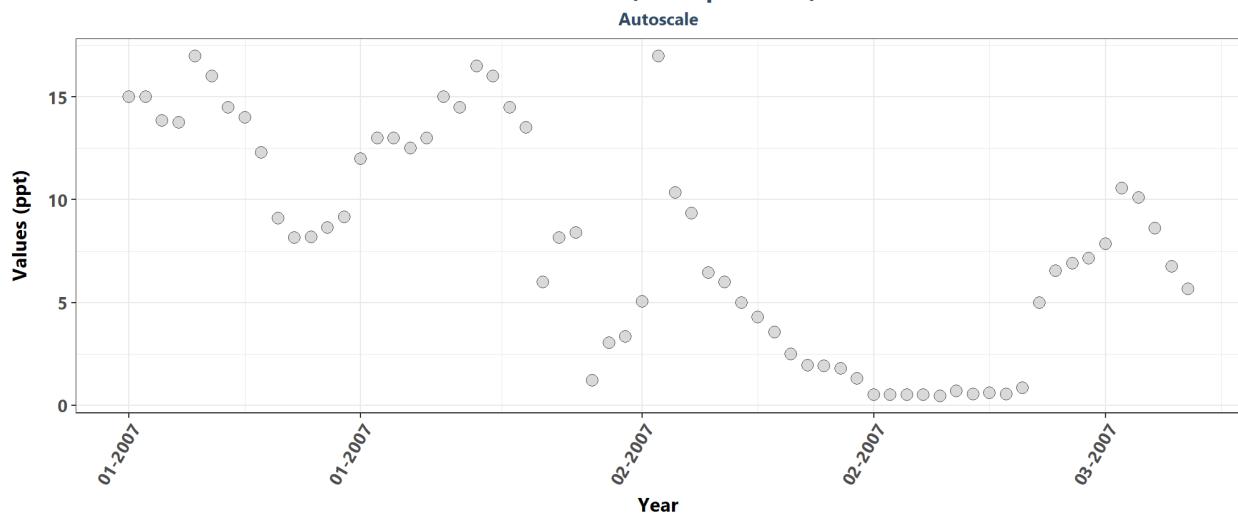
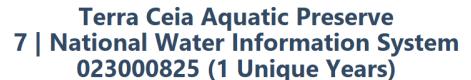
Autoscale



Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbbmwq (2 Unique Years)

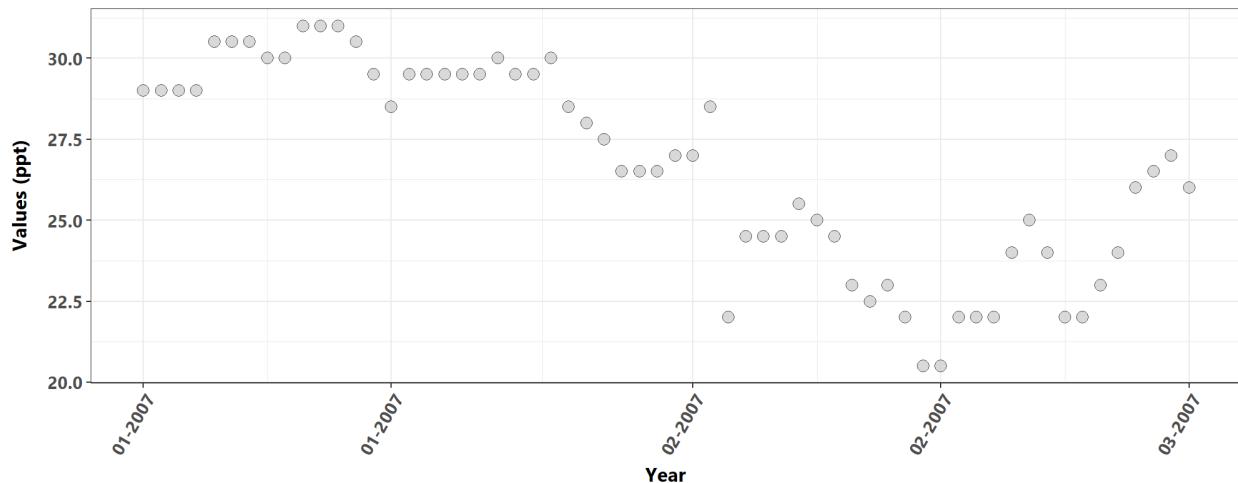
Autoscale





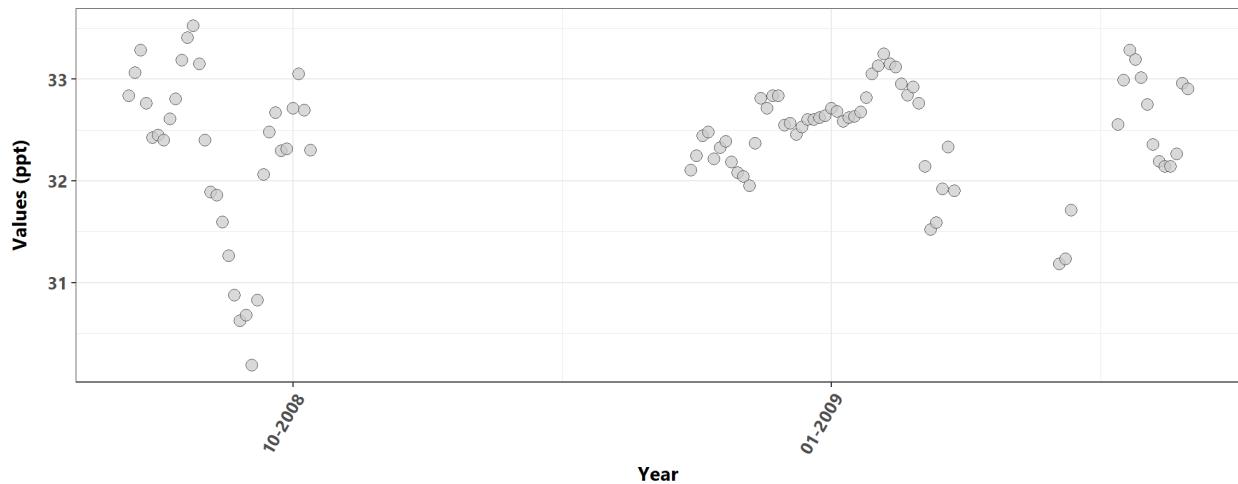
Terra Ceia Aquatic Preserve
7 | National Water Information System
023000842 (1 Unique Years)

Autoscale



Terra Ceia Aquatic Preserve
473 | Terra Ceia Aquatic Preserve Continuous Water Quality Monitoring
TCBH (2 Unique Years)

Autoscale



Appendix III: Monitoring Location Trendlines

The plots created in this section are designed to show the general trend of the data. Data is taken and grouped by `MonitoringID`. The trendlines on the plots are created using the Senn slope and intercept from the seasonal Kendall Tau analysis. The scripts that create plots follow this format

1. Use the data set that only has `Use_In_Analysis` of TRUE for the desired monitoring location
2. Determine the earliest and latest year of the data to create x-axis scale and intervals
3. Determine the minimum, mean, and standard deviation for the data to be used for y-axis scales
 - Excludes the top 2% of values to reduce the impact of extreme outliers on the y-axis scale
4. Set what values are to be used for the x-axis, y-axis, and the variable that should determine groups for the plots

5. Set the plot type as a point plot with the size of the points
6. Add the linear trend
7. Create the title, x-axis, y-axis, and color fill labels
8. Set the y and x limits
9. Make the axis labels bold
10. Plot the arrangement as a set of panels

```

if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  for (i in 1:n) {
    plot_data <- data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i],]
    year_lower <- min(plot_data$Year)
    year_upper <- max(plot_data$Year)
    min_RV <- min(plot_data$ResultValue)
    mn_RV <- mean(plot_data$ResultValue[plot_data$ResultValue <
                                              quantile(plot_data$ResultValue, 0.98)])
    sd_RV <- sd(plot_data$ResultValue[plot_data$ResultValue <
                                              quantile(plot_data$ResultValue, 0.98)])
    x_scale <- ifelse(year_upper - year_lower > 30, 10, 5)
    y_scale <- mn_RV + 4 * sd_RV

    tau <- KT.Stats$tau[KT.Stats$MonitoringID==Mon_IDs[i]]
    s_slope <- KT.Stats$SennSlope[KT.Stats$MonitoringID==Mon_IDs[i]]
    s_int <- KT.Stats$SennIntercept[KT.Stats$MonitoringID==Mon_IDs[i]]
    trend <- KT.Stats$Trend[KT.Stats$MonitoringID==Mon_IDs[i]]
    p <- KT.Stats$p[KT.Stats$MonitoringID==Mon_IDs[i]]

    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
                       " | ", KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
                       KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])

    p1 <- ggplot(data=plot_data,
                  aes(x=DecDate, y=ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
                 alpha=0.75) +
      geom_abline(aes(slope=s_slope, intercept=s_int),
                  color="#000099", size=1.2, alpha=0.7) +
      labs(subtitle="Autoscale",
            x="Year", y=paste0("Values (", unit, ")")) +
      plot_theme

    p2 <- ggplot(data=plot_data,
                  aes(x=DecDate, y=ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
                 alpha=0.75) +
      geom_abline(aes(slope=s_slope, intercept=s_int),
                  color="#000099", size=1.2, alpha=0.7) +
      ylim(min_RV-0.1*y_scale, y_scale) +
      labs(subtitle="Scaled to 4x Standard Deviation",
            x="Year", y=paste0("Values (", unit, ")")) +
}

```

```

plot_theme

KTset <- ggarrange(p1, p2, ncol=1, heights=c(1, 1))

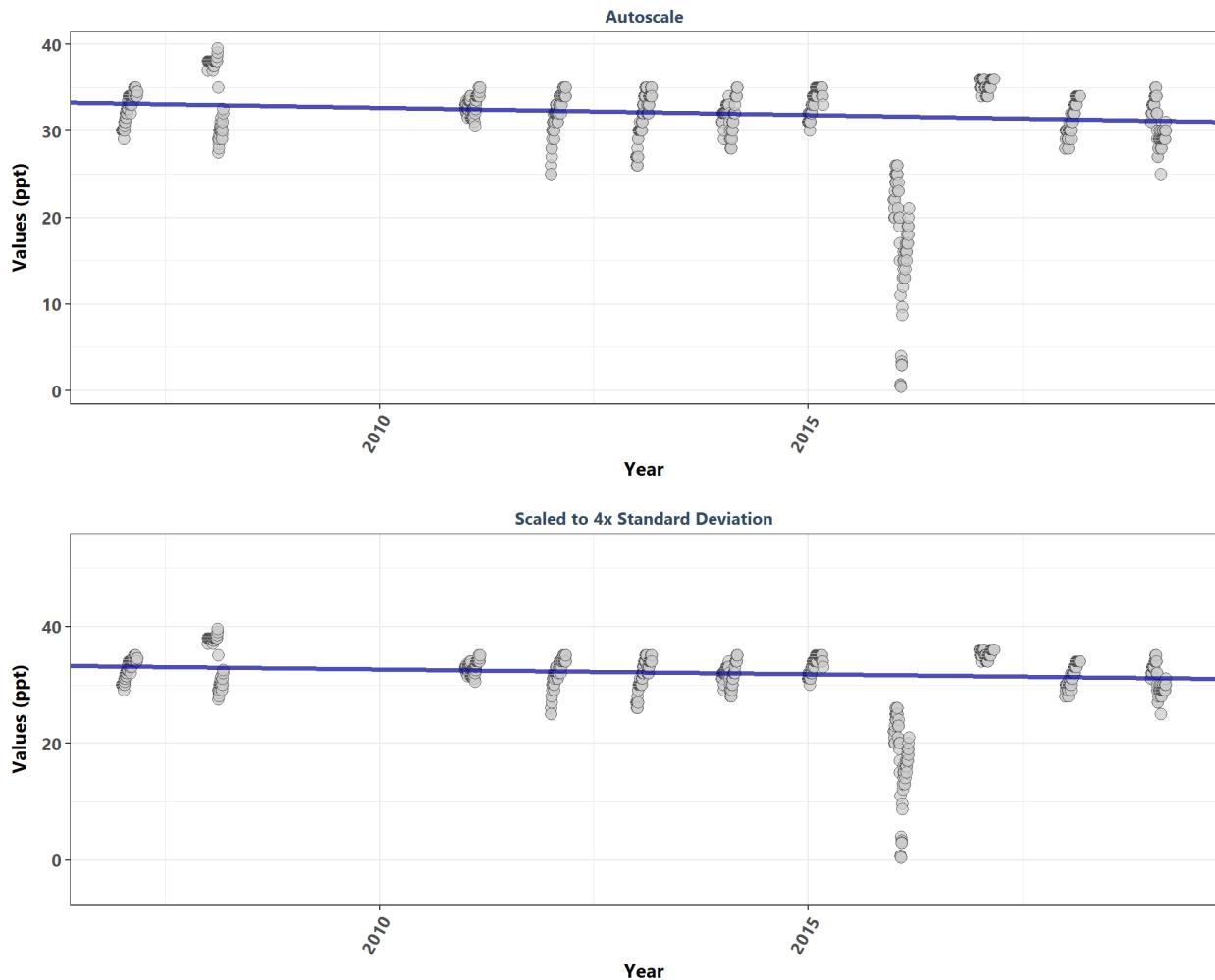
p0 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name)) +
  plot_theme + theme(panel.border=element_blank(),
                     panel.grid.major=element_blank(),
                     panel.grid.minor=element_blank(),
                     axis.line=element_blank())

print(ggarrange(p0, KTset, ncol=1, heights=c(0.1, 1)))
cat('\n')
print(KT$Stats[KT$Stats$MonitoringID==Mon_IDs[i], ] %>%
  select(N_Data, Median, tau, SennSlope, SennIntercept, p, Trend) %>%
  kable(format="latex") %>%
  row_spec(0, bold=TRUE) %>%
  kable_styling(latex_options = "HOLD_position") %>%
  add_footnote(
    "p < 0.00005 appear as 0 due to rounding"))
cat('\n')
rm(plot_data)
rm(KTset, leg)
}

}

```

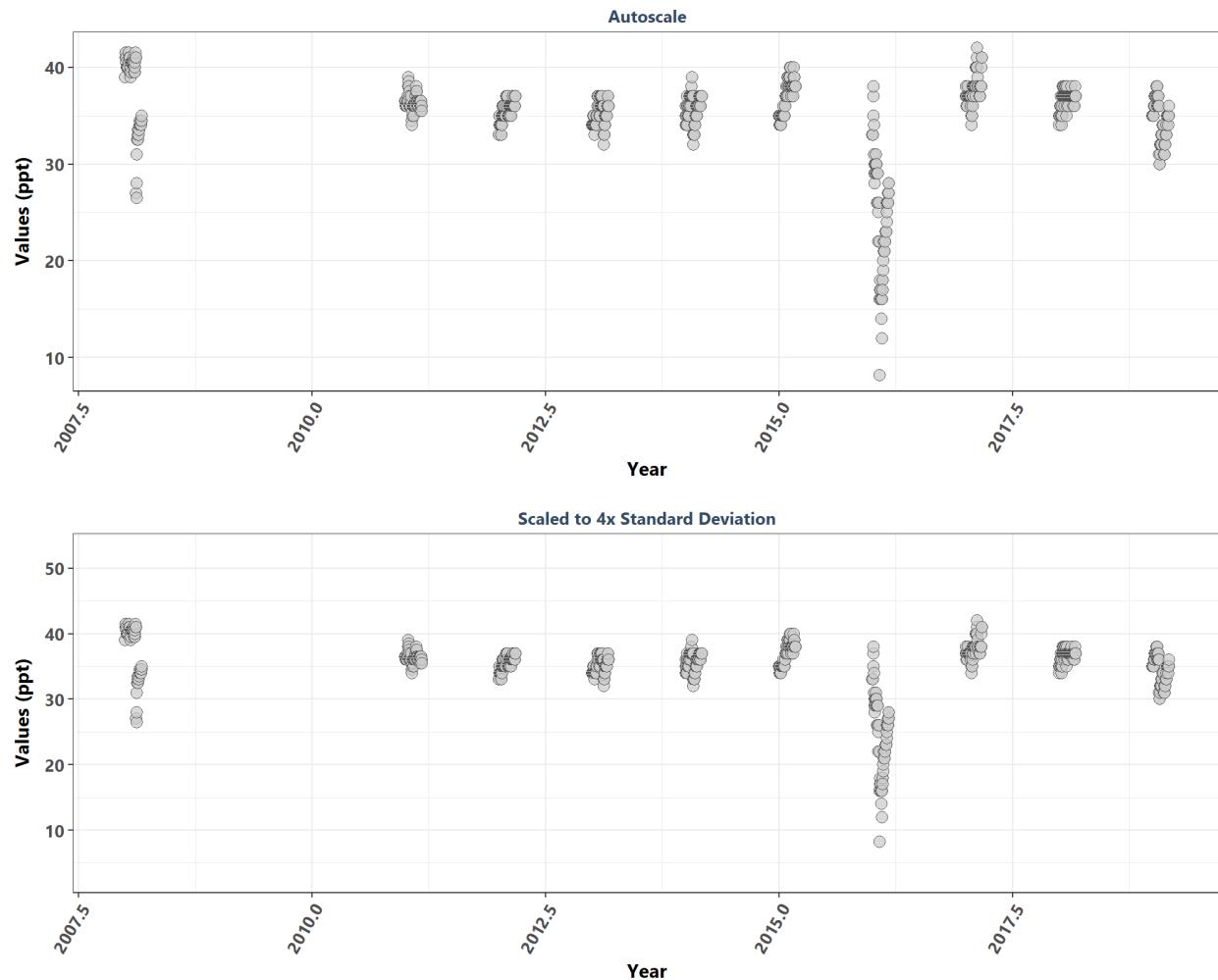
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255432081303900



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
718	33	-0.1307	-0.1666667	367.6667	0	-1

^a p < 0.00005 appear as 0 due to rounding

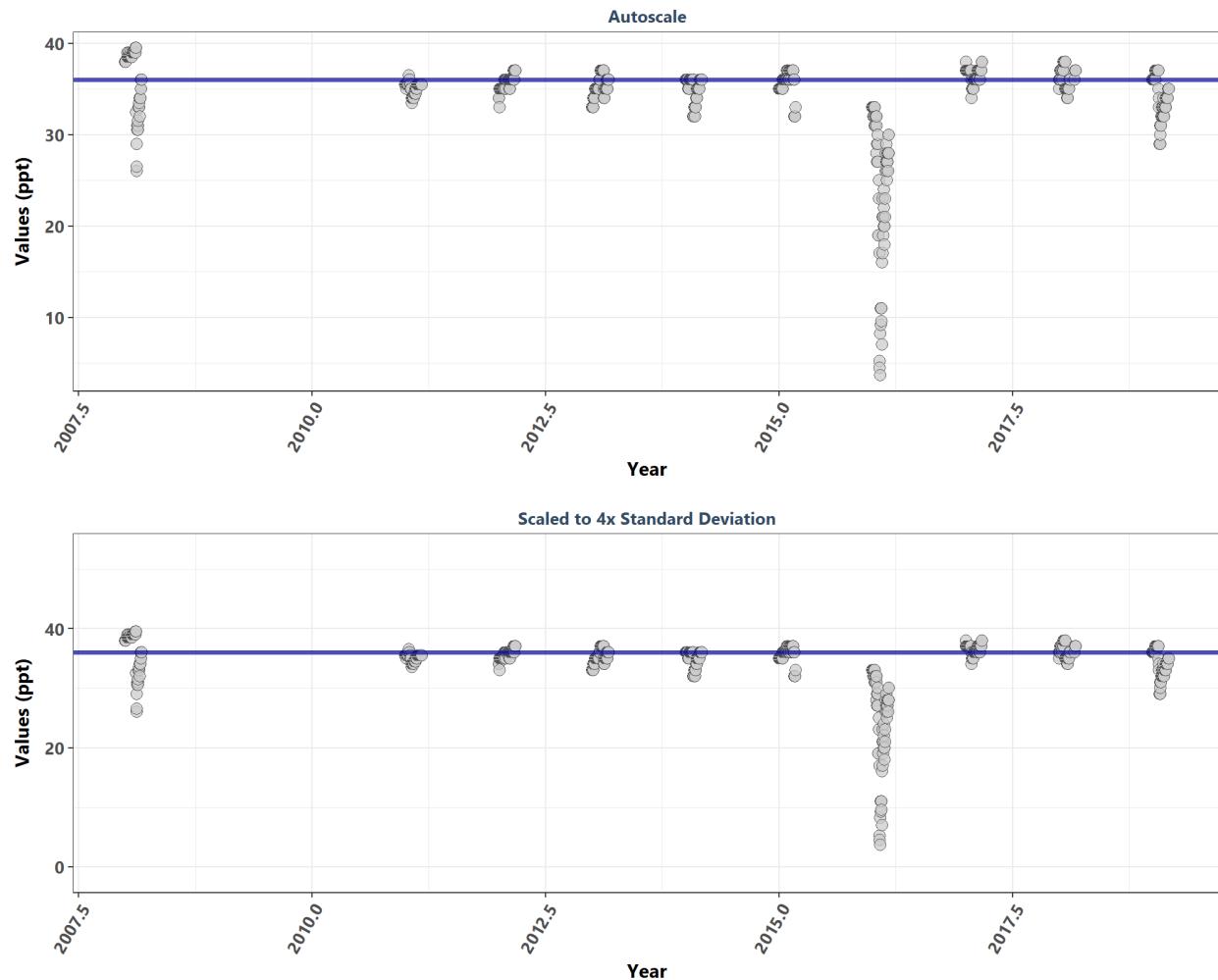
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255534081324000



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
645	36	-0.0636	-0.0454545	36	0.0013	-1

^a p < 0.00005 appear as 0 due to rounding

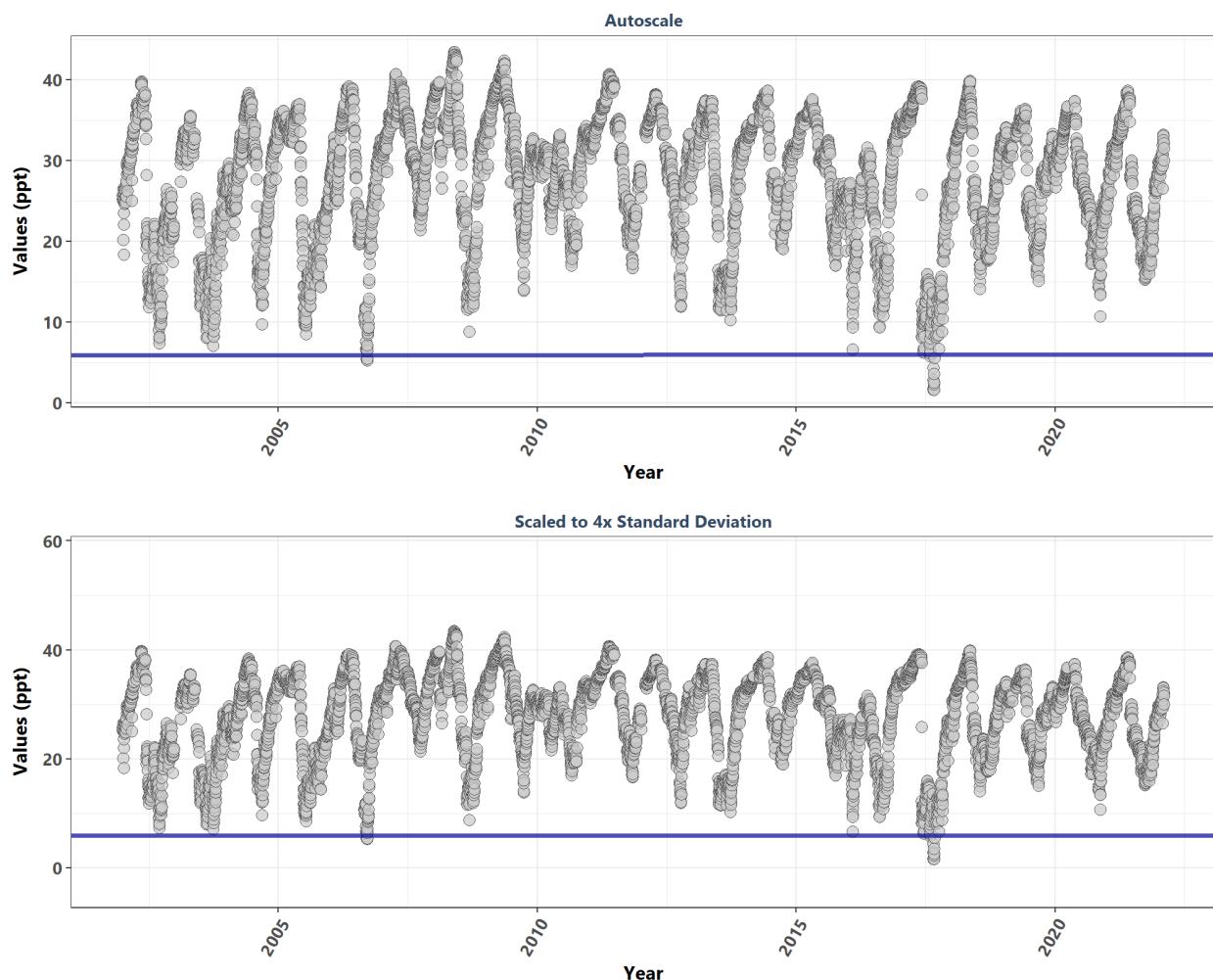
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255654081350200



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
626	35.5	-0.0501	0	36	0.0718	0

^a p < 0.00005 appear as 0 due to rounding

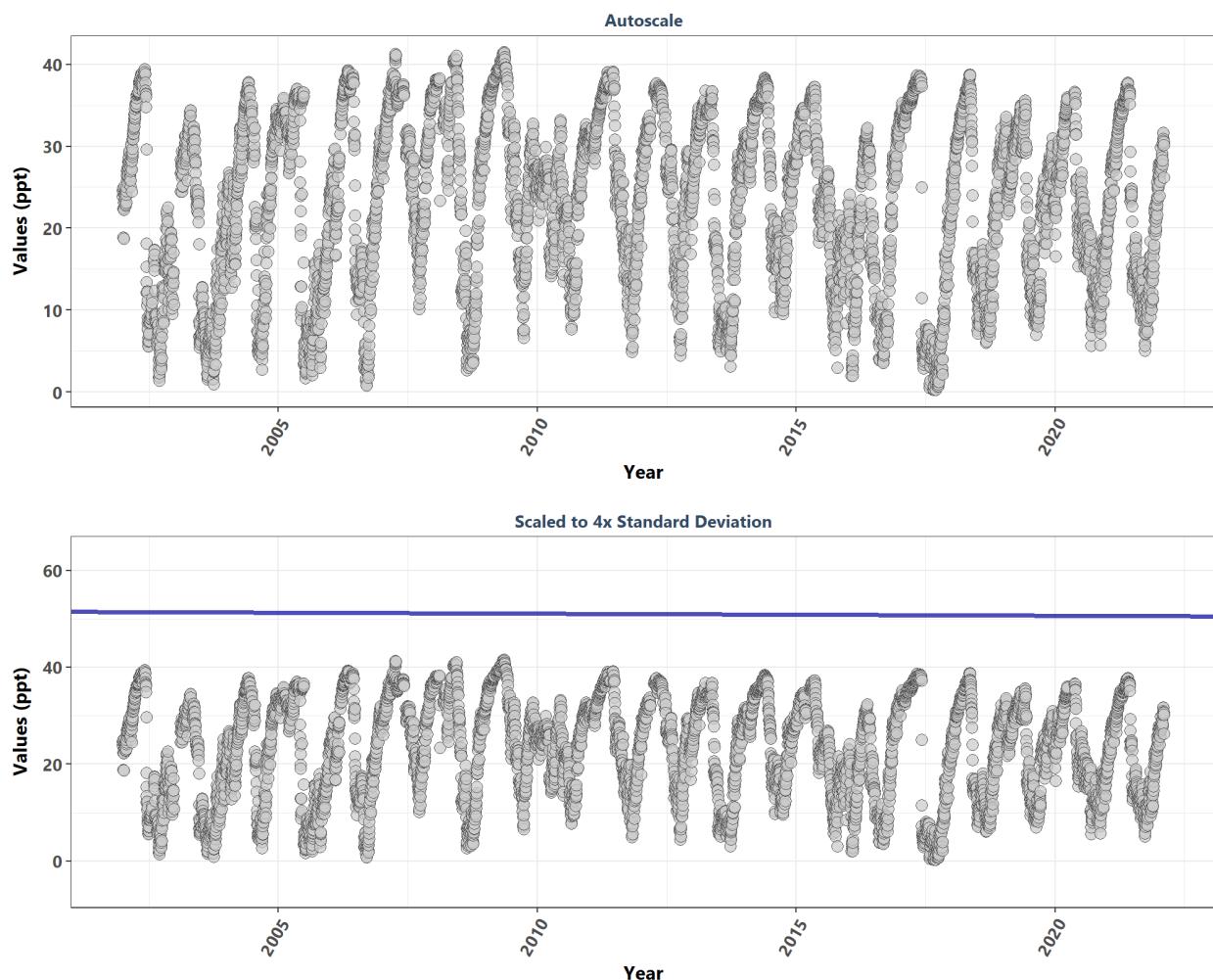
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfbwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6826	29.49583	0.0051	0.0044189	-2.962937	0.6492	0

^a p < 0.00005 appear as 0 due to rounding

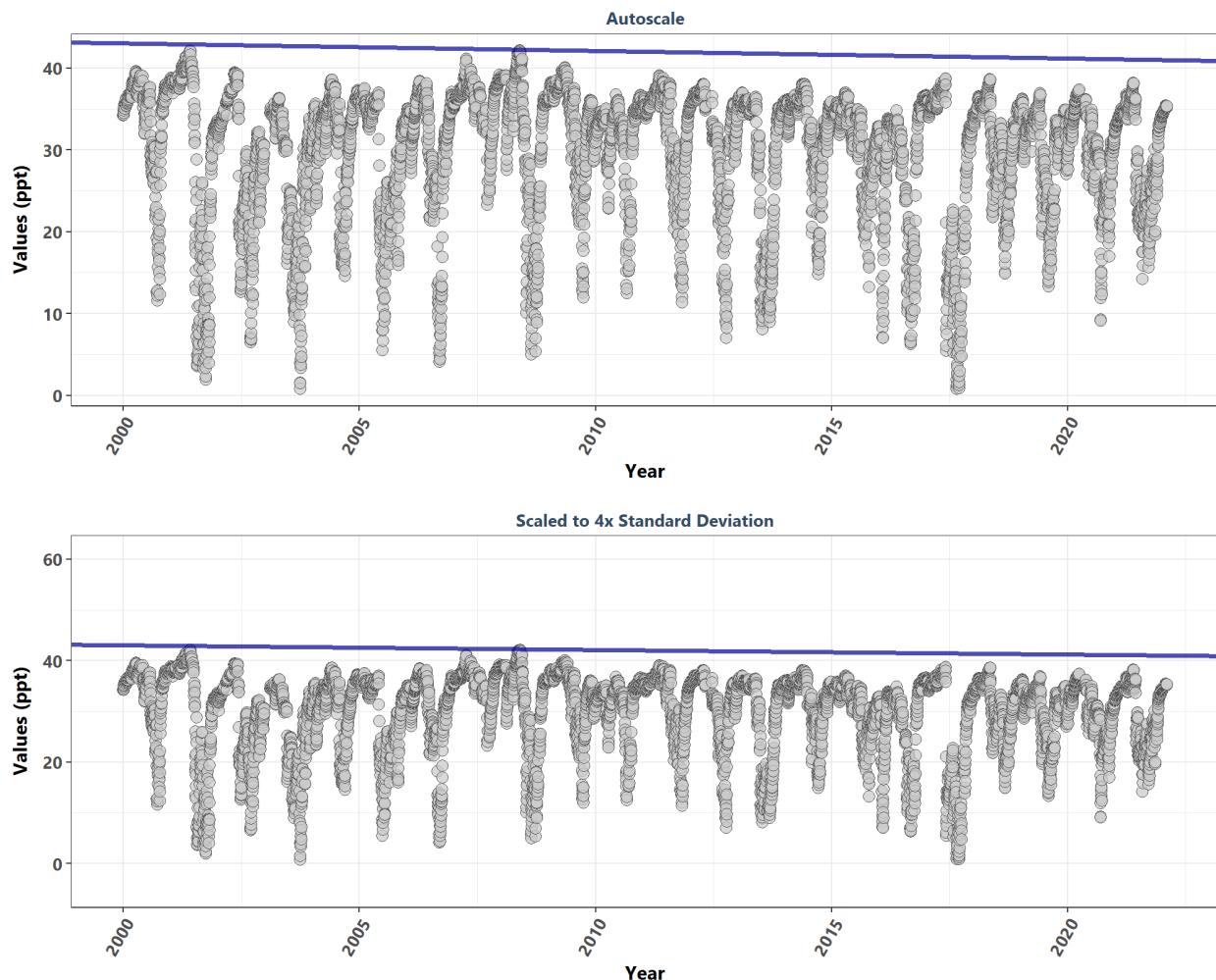
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbftuwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6984	24.78698	-0.0295	-0.0420139	135.4607	0.0003	-1

^a p < 0.00005 appear as 0 due to rounding

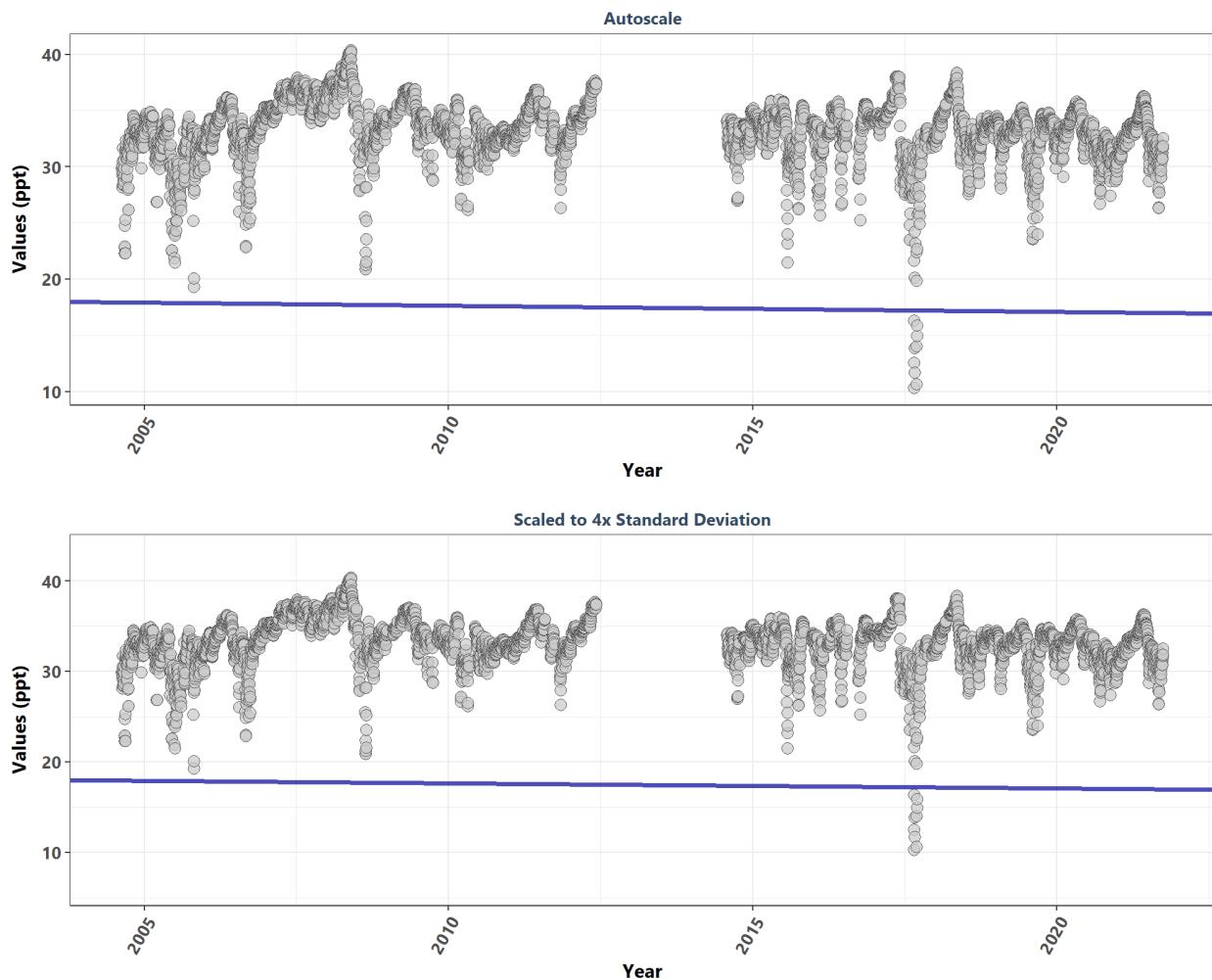
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbmbwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
7514	33.23646	-0.1148	-0.0915972	226.21	0	-1

^a p < 0.00005 appear as 0 due to rounding

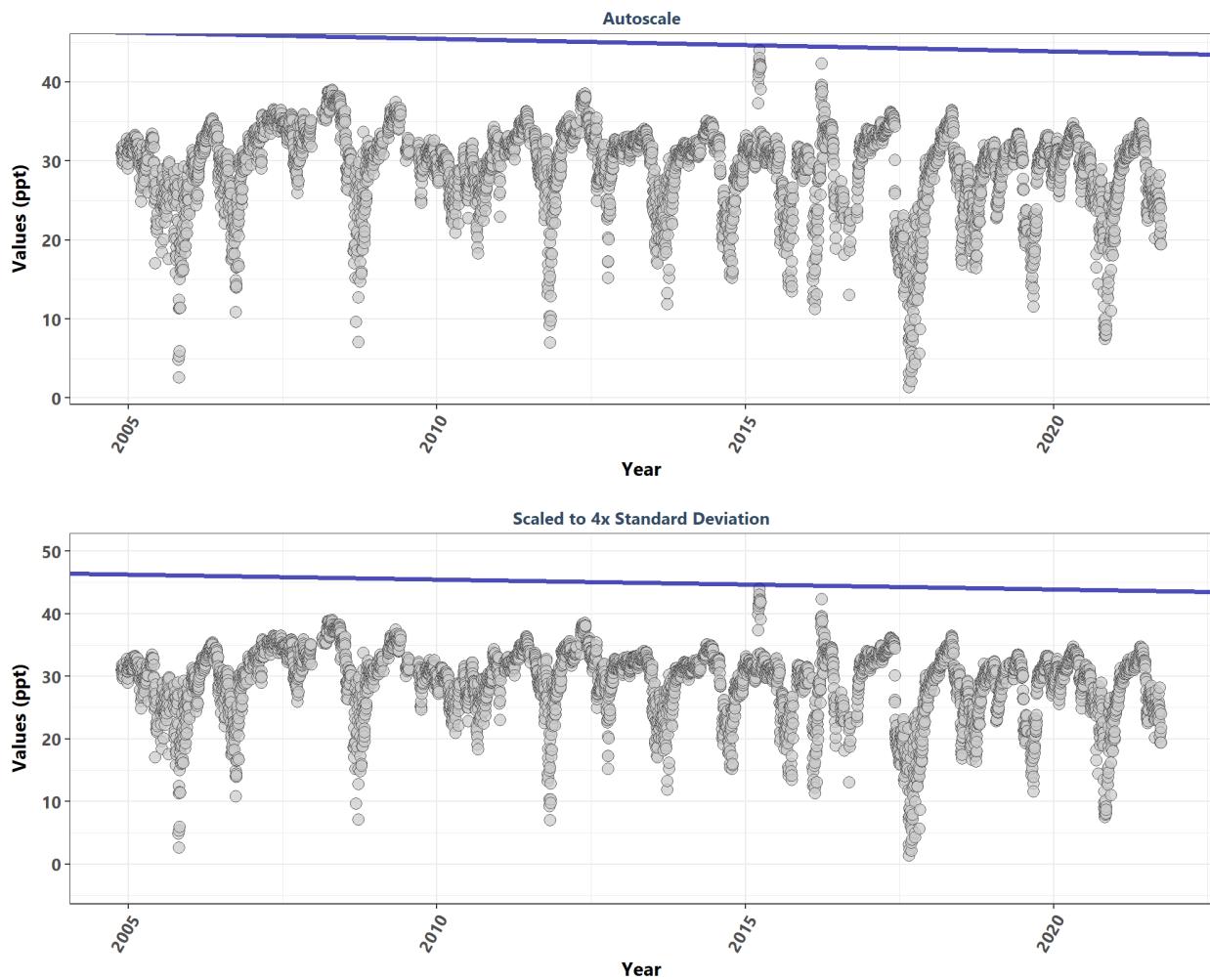
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB02



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4922	33.4375	-0.1043	-0.055599	129.3885	0	-1

^a p < 0.00005 appear as 0 due to rounding

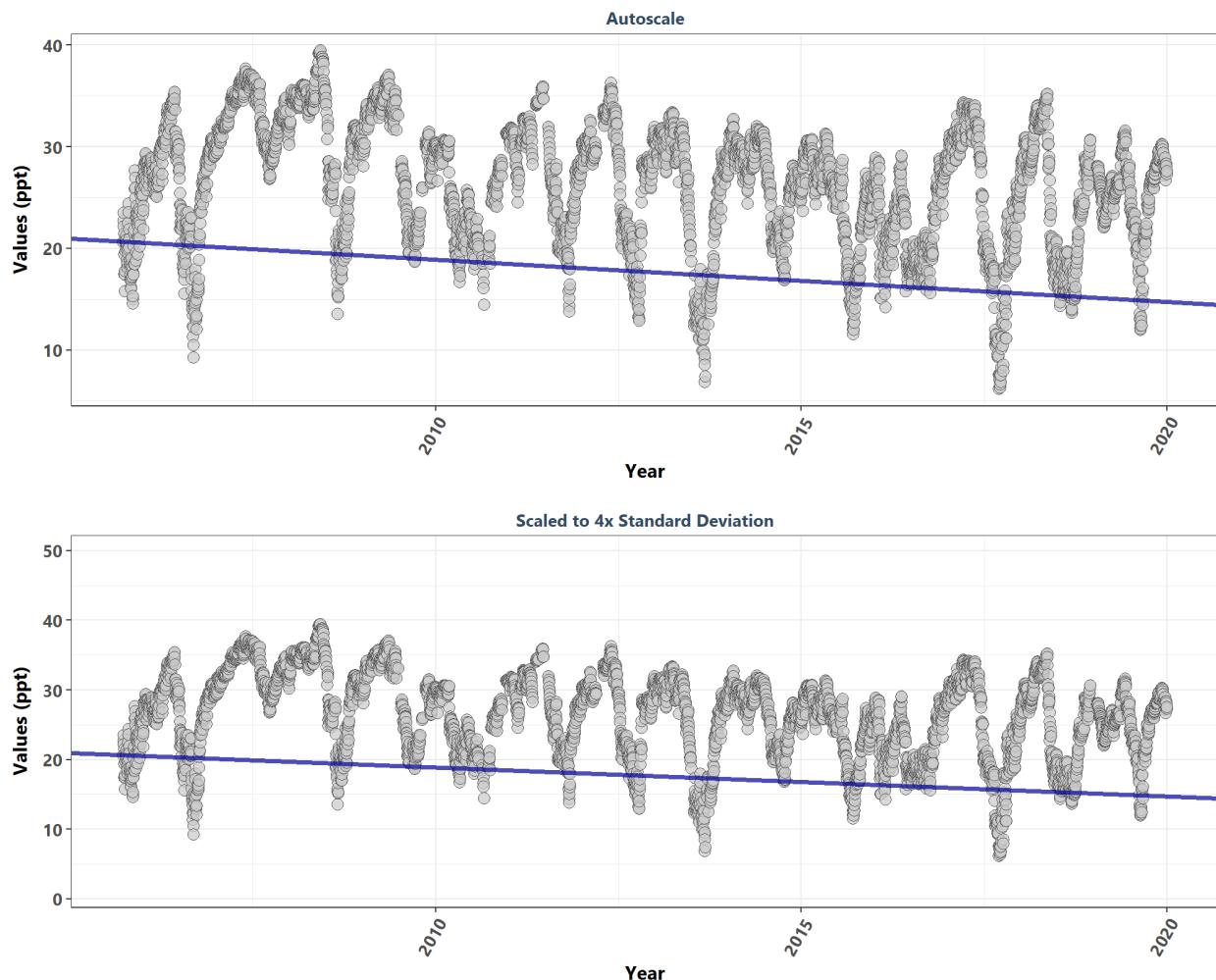
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB03



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5423	30.57021	-0.1706	-0.1590278	365.0984	0	-1

^a p < 0.00005 appear as 0 due to rounding

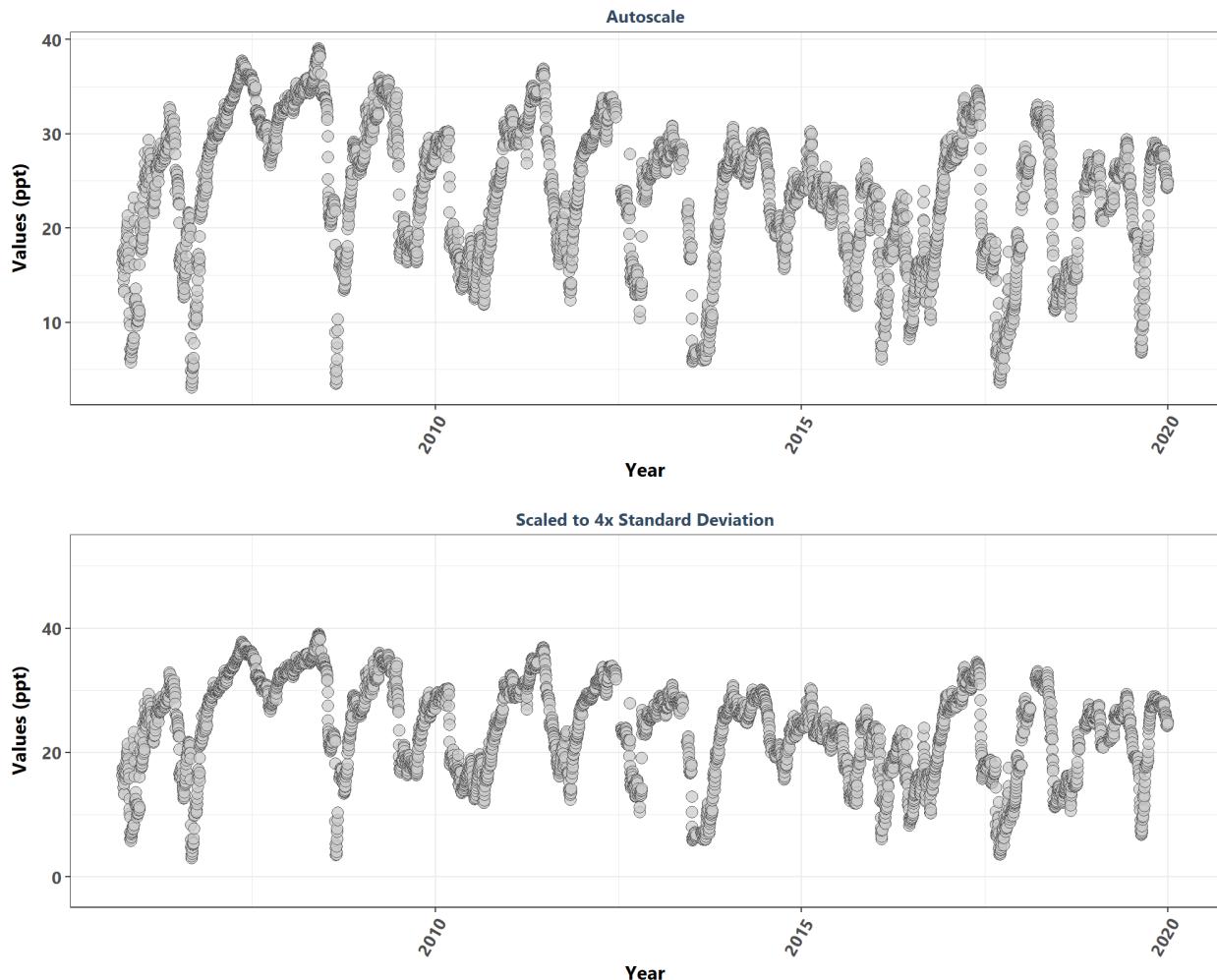
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP1A



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4872	27.36302	-0.2793	-0.4148437	852.7164	0	-1

^a p < 0.00005 appear as 0 due to rounding

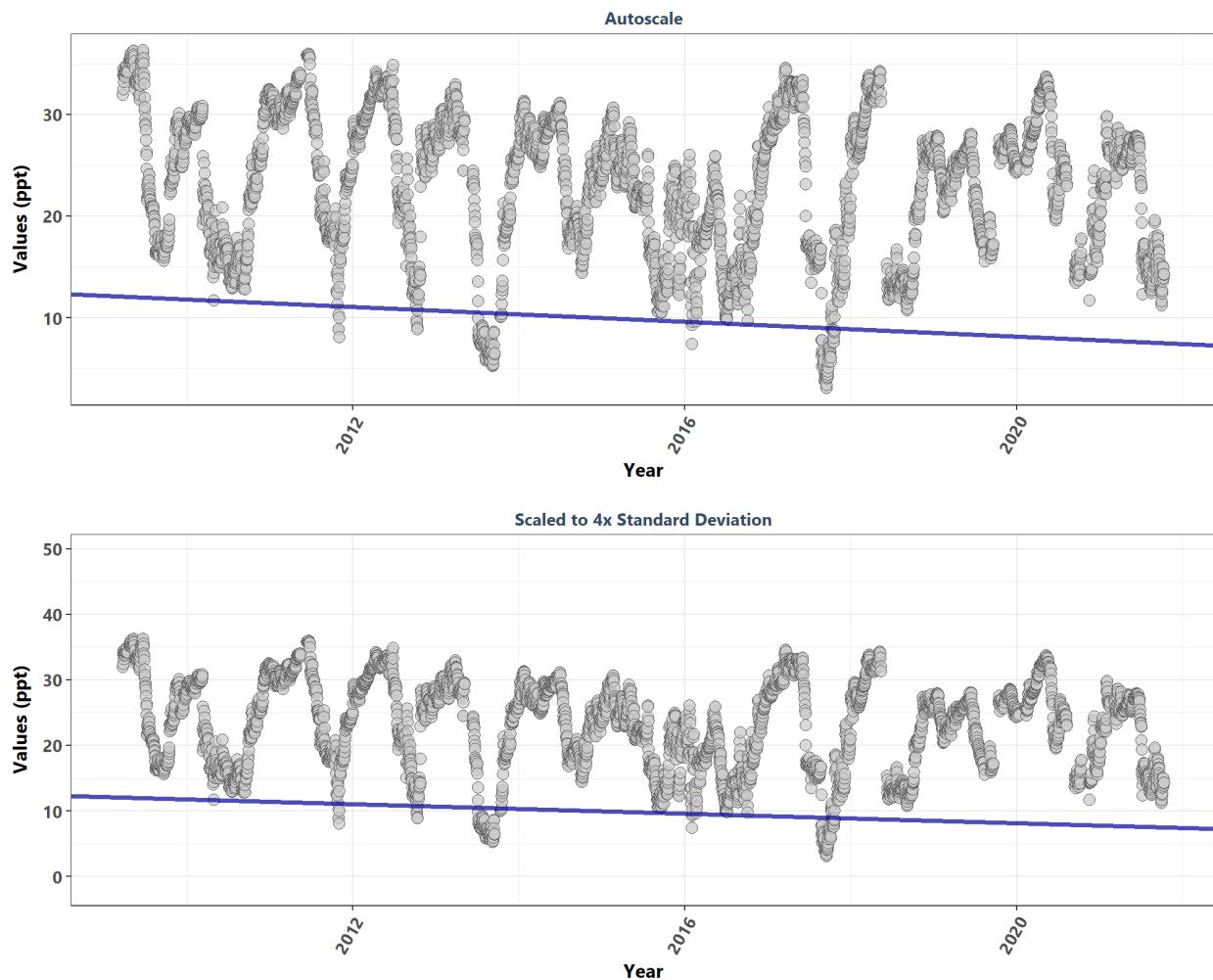
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP2B



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4965	24.95312	-0.2792	-0.4848958	1086.97	0	-1

^a p < 0.00005 appear as 0 due to rounding

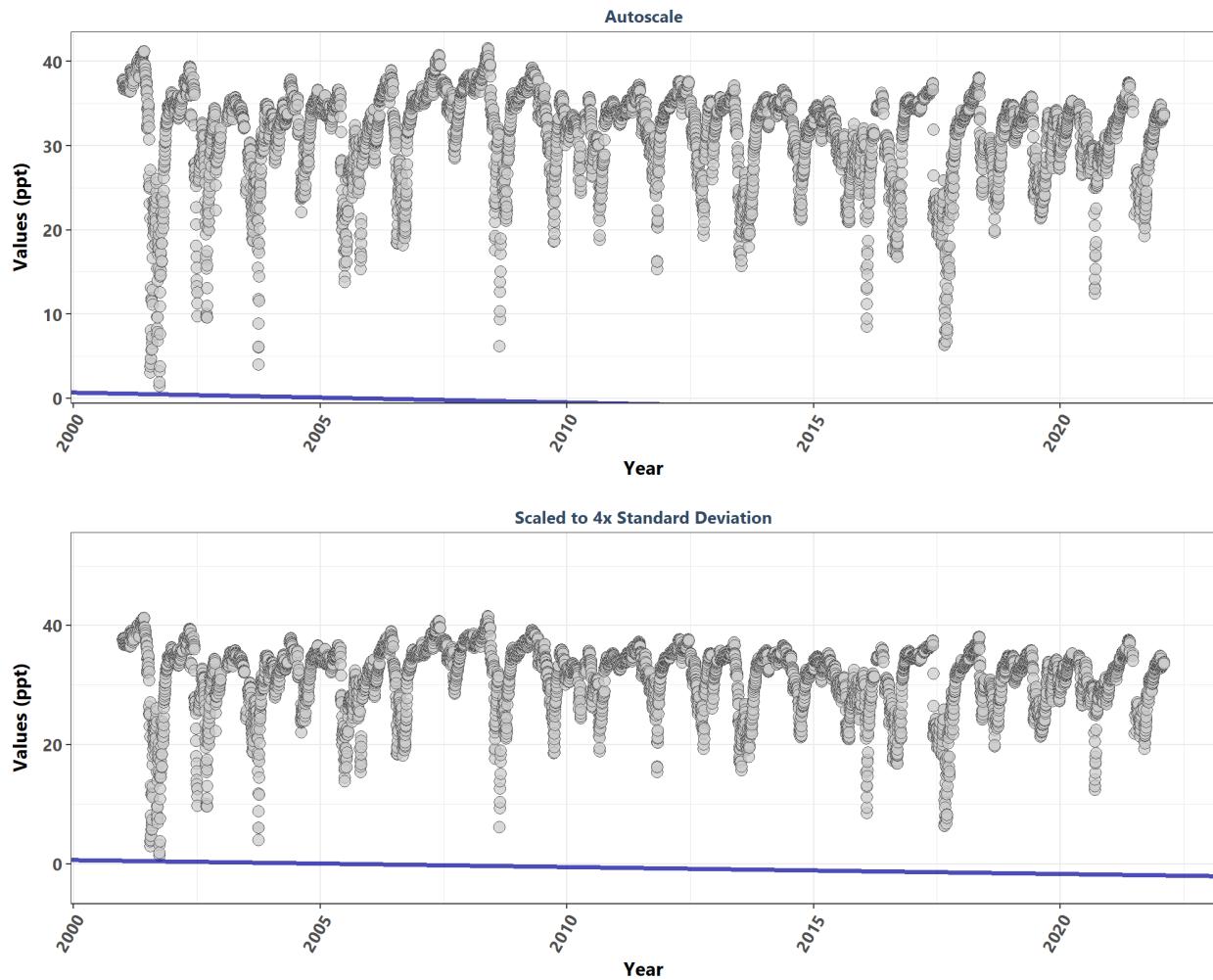
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP3C



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4310	24.03125	-0.2067	-0.3639323	743.2913	0	-1

^a p < 0.00005 appear as 0 due to rounding

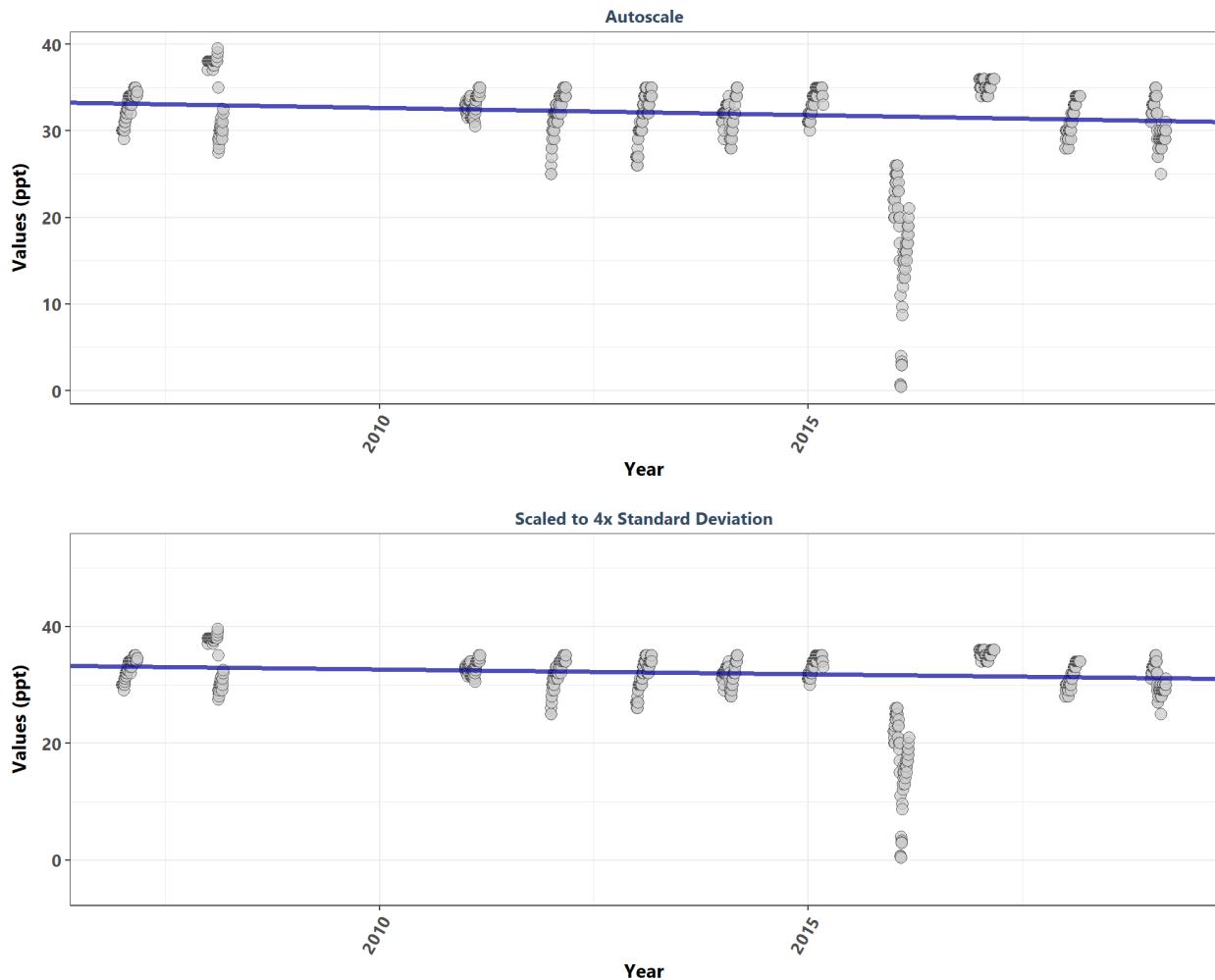
Rookery Bay Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbhwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
7024	33.05156	-0.1667	-0.1169271	234.5463	0	-1

^a p < 0.00005 appear as 0 due to rounding

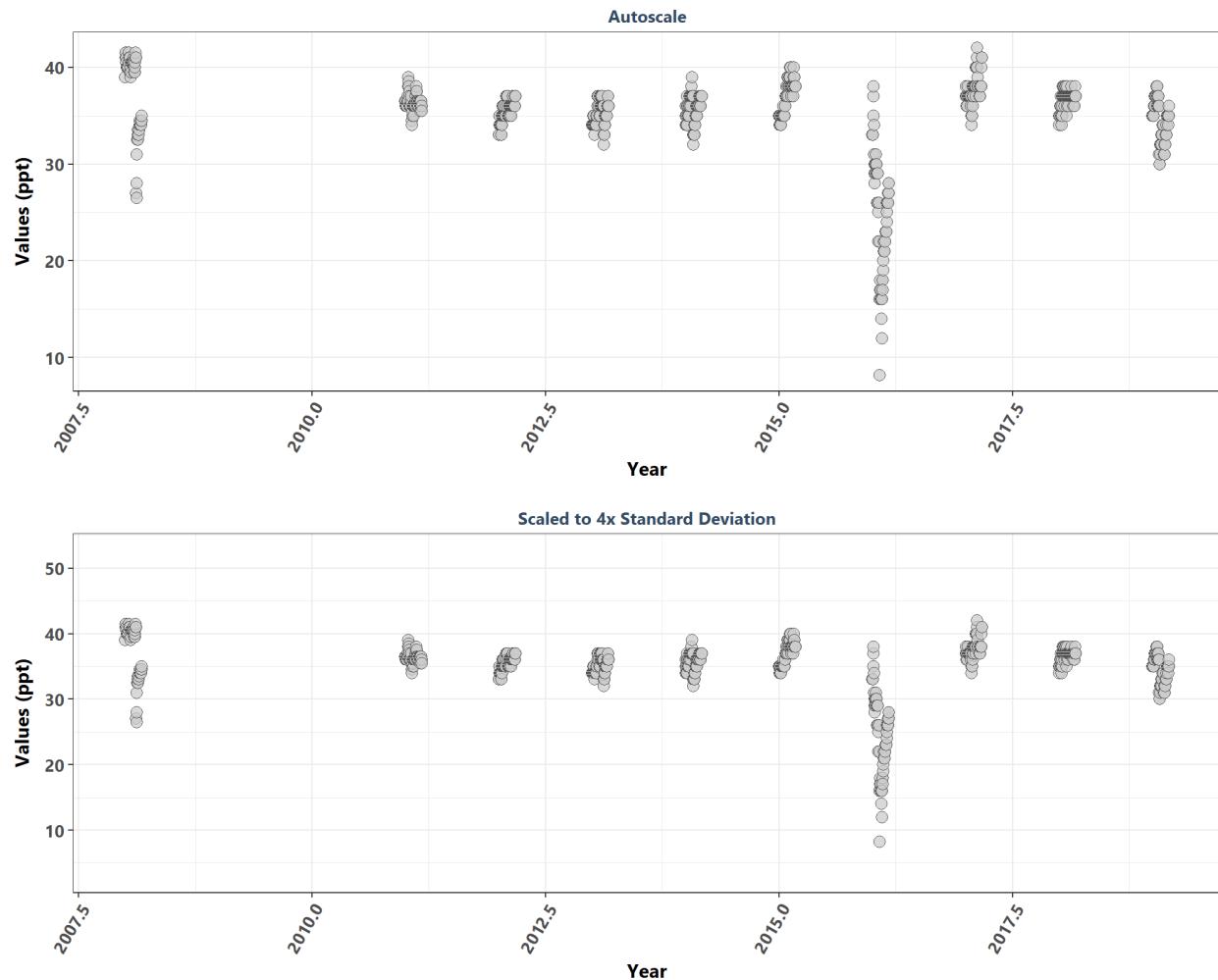
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255432081303900



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
718	33	-0.1307	-0.1666667	367.6667	0	-1

^a p < 0.00005 appear as 0 due to rounding

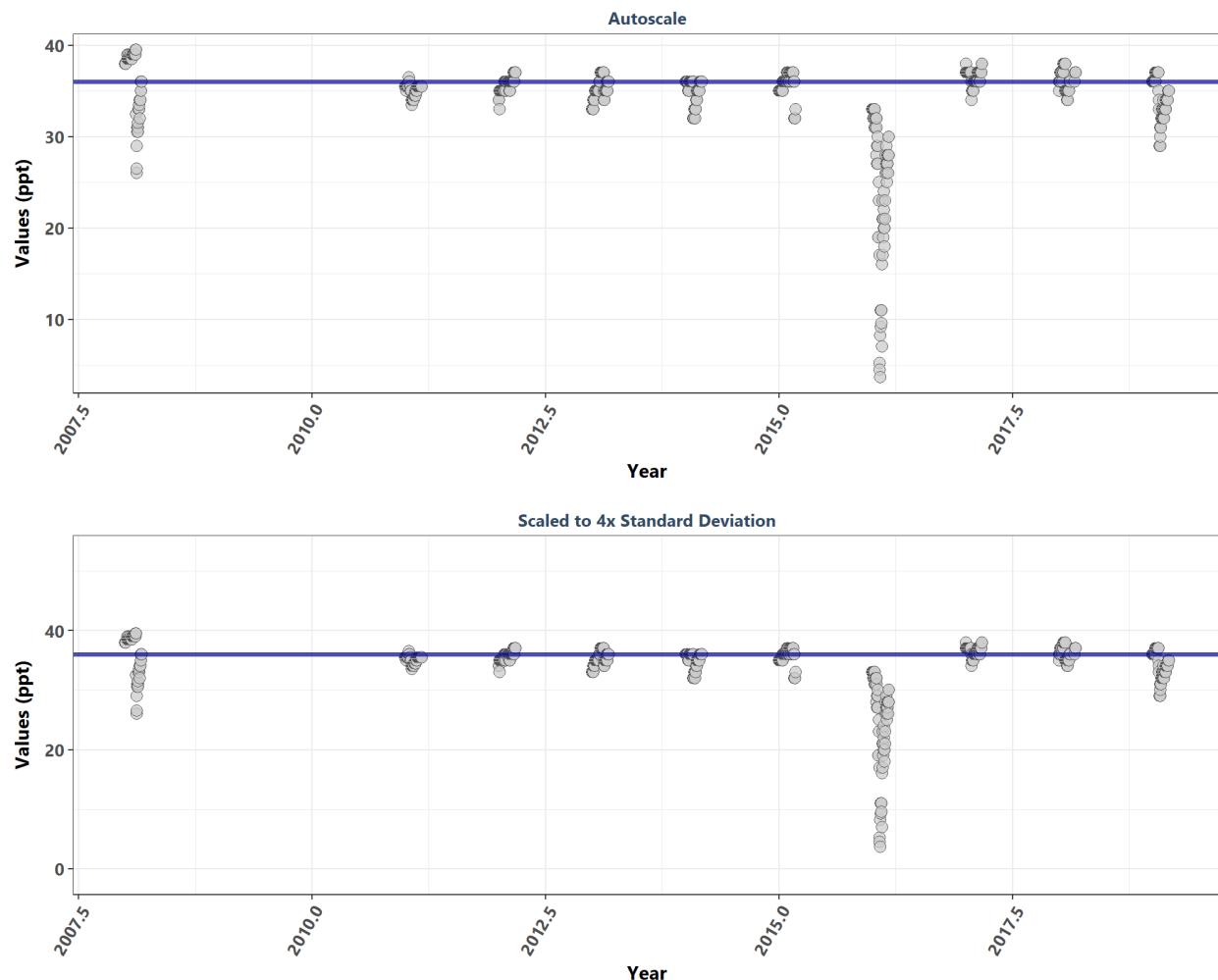
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255534081324000



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
645	36	-0.0636	-0.0454545	36	0.0013	-1

^a p < 0.00005 appear as 0 due to rounding

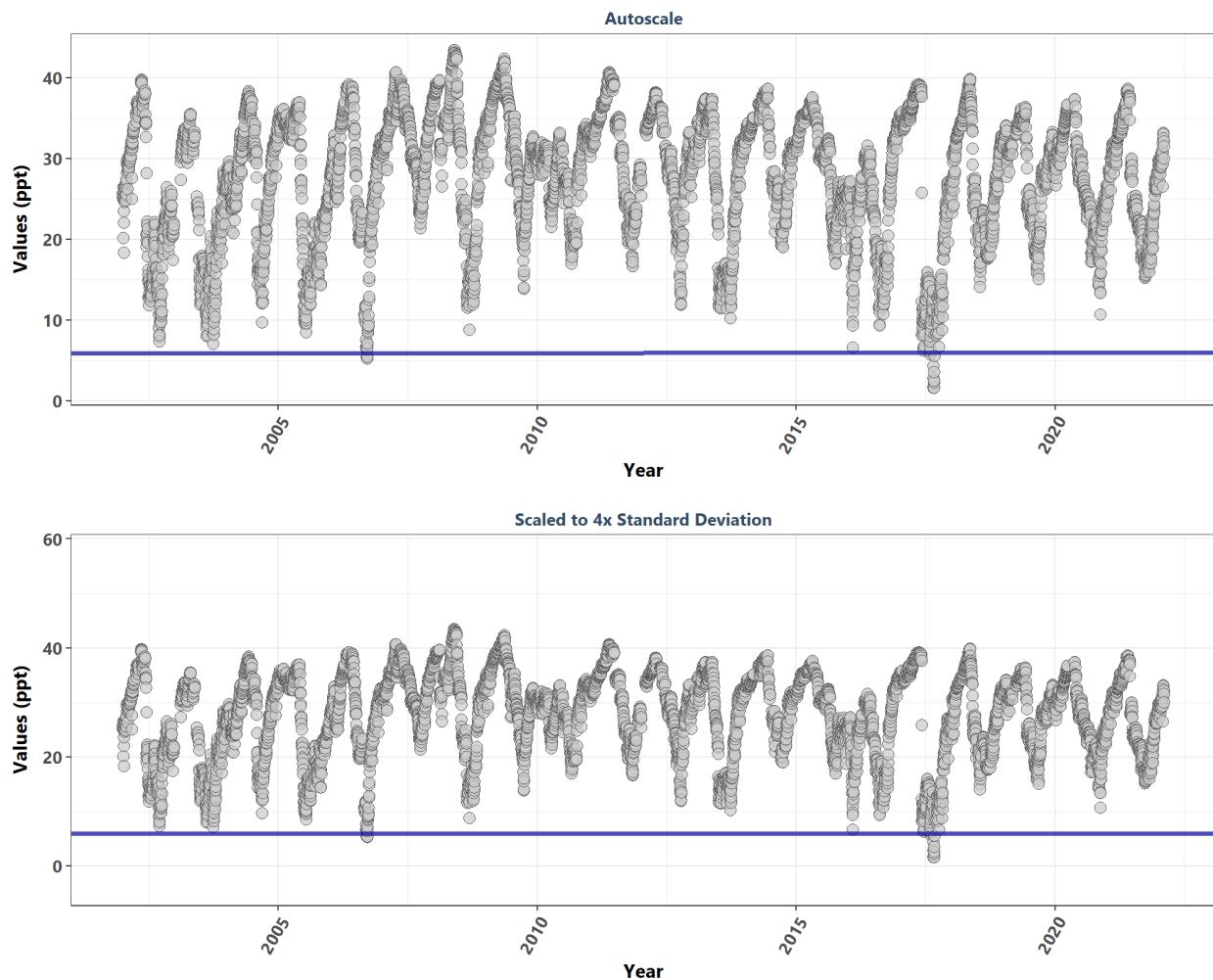
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255654081350200



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
626	35.5	-0.0501	0	36	0.0718	0

^a p < 0.00005 appear as 0 due to rounding

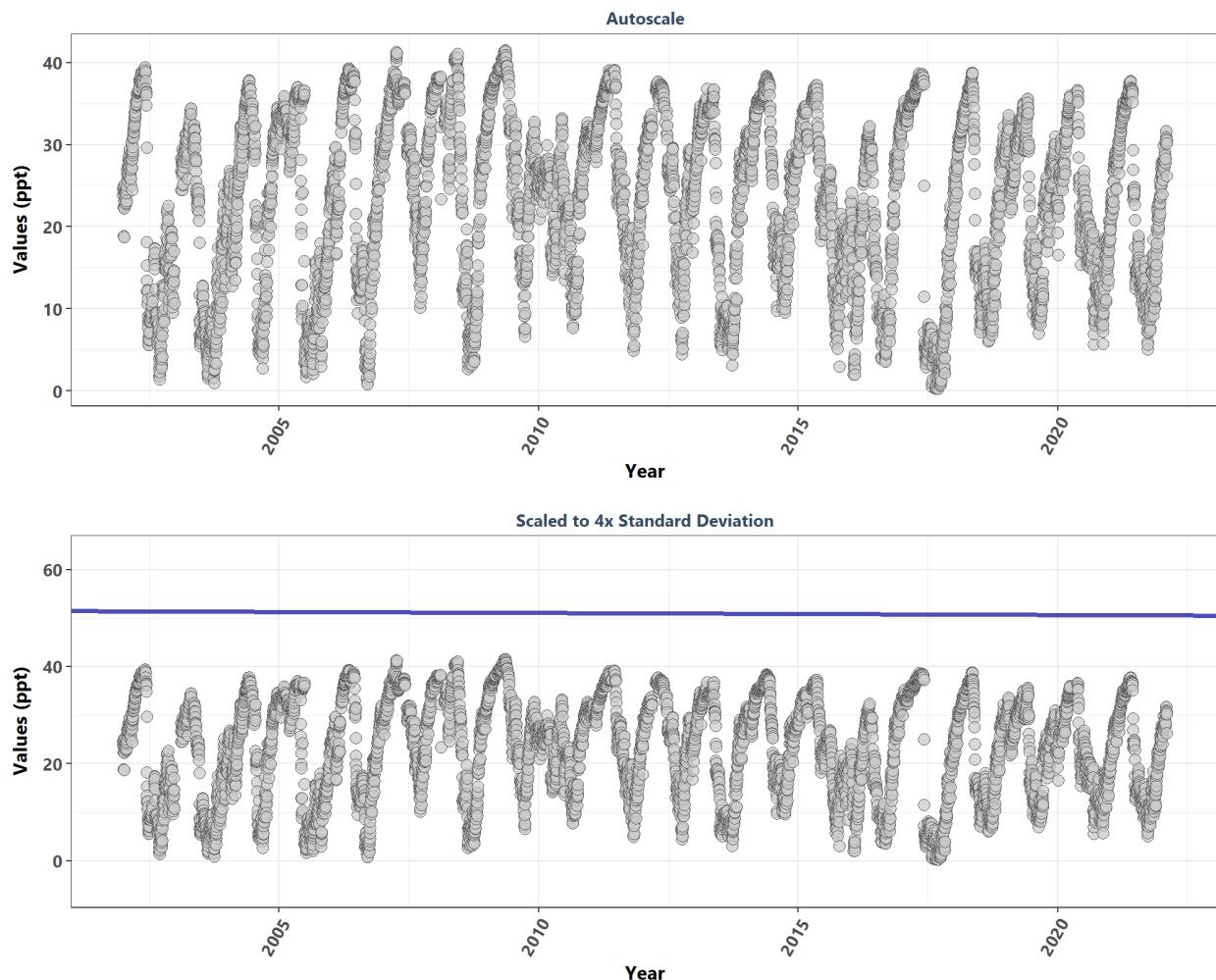
Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfbwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6826	29.49583	0.0051	0.0044189	-2.962937	0.6492	0

^a p < 0.00005 appear as 0 due to rounding

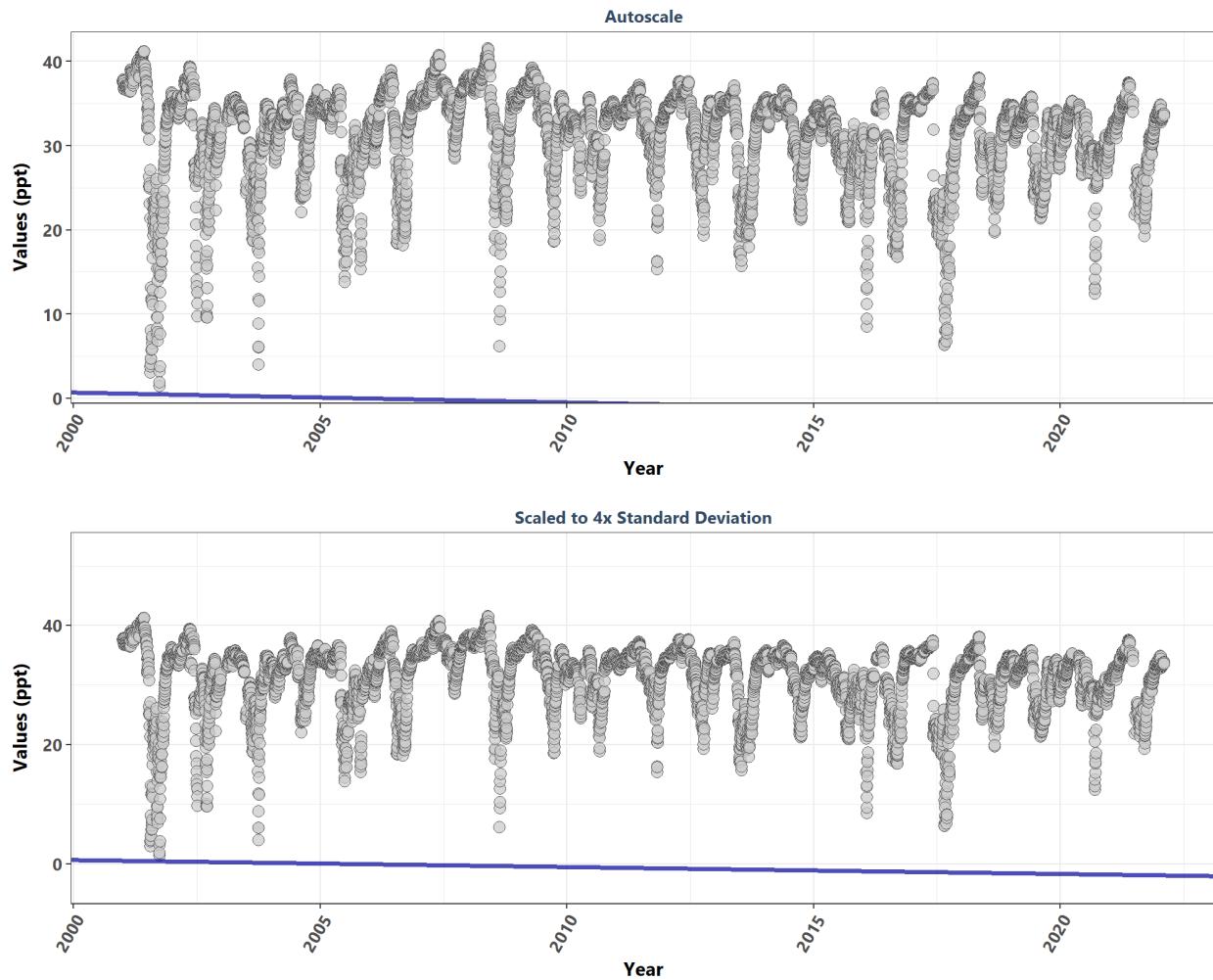
Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbftuwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6984	24.78698	-0.0295	-0.0420139	135.4607	0.0003	-1

^a p < 0.00005 appear as 0 due to rounding

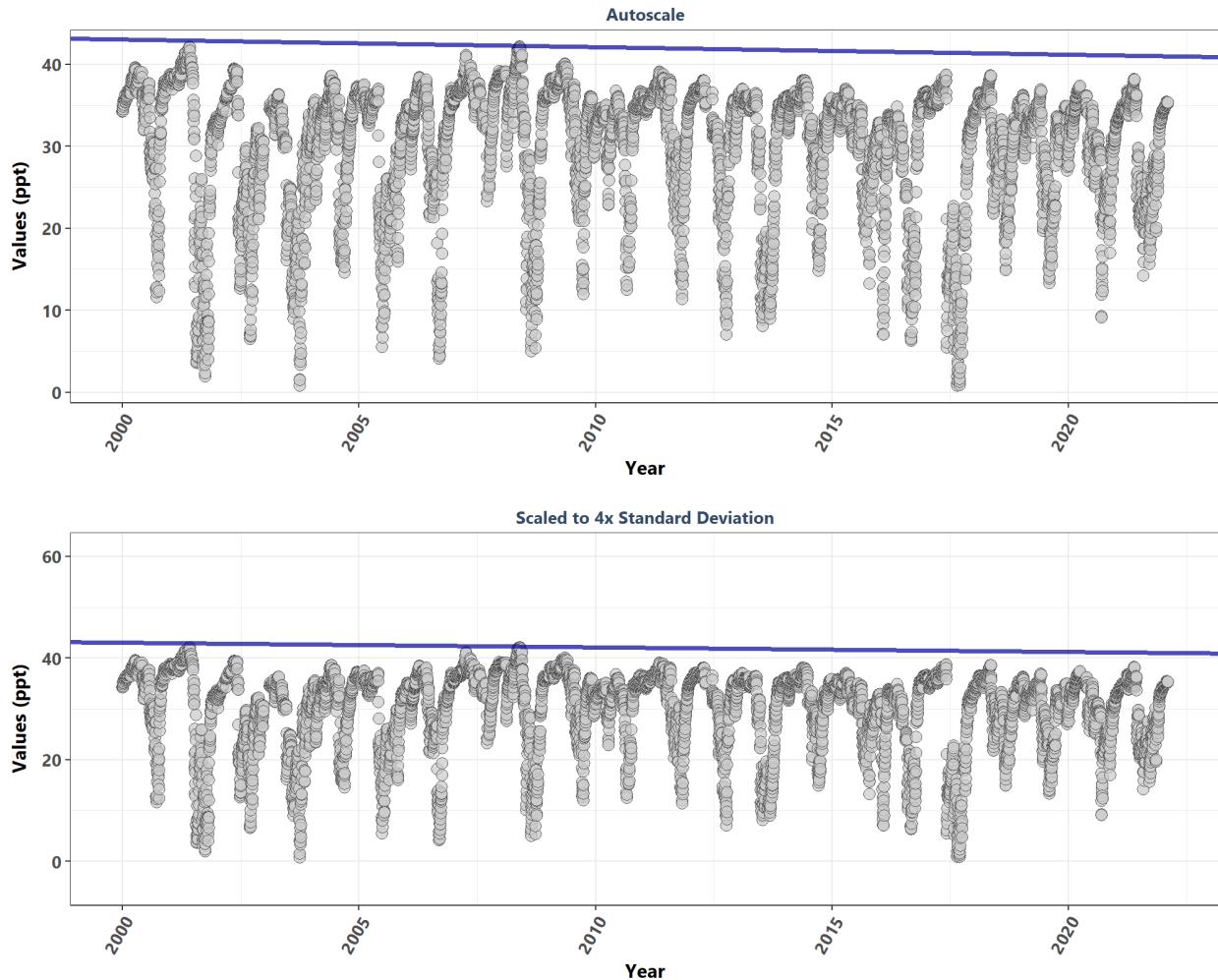
Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbhwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
7024	33.05156	-0.1667	-0.1169271	234.5463	0	-1

^a p < 0.00005 appear as 0 due to rounding

Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbmbwq



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
7514	33.23646	-0.1148	-0.0915972	226.21	0	-1

^a p < 0.00005 appear as 0 due to rounding

Appendix IV: Monitoring Location Summary Box Plots

Data is taken and grouped by MonitoringID. The scripts that create plots follow this format

1. Use the data set that only has `Use_In_Analysis` of TRUE for the desired monitoring location
2. Determine the earliest and latest year of the data to create x-axis scale and intervals
3. Determine the minimum, mean, and standard deviation for the data to be used for y-axis scales
 - Excludes the top 2% of values to reduce the impact of extreme outliers on the y-axis scale
4. Set what values are to be used for the x-axis, y-axis, and the variable that should determine groups for the box plots
5. Set the plot type as a box plot with the size of the outlier points

6. Create the title, x-axis, y-axis, and color fill labels
7. Set the y and x limits
8. Make the axis labels bold
9. Plot the arrangement as a set of panels

The following plots are arranged by `MonitoringID` with data grouped by `Year`, then `Year` and `Month`, then finally `Month` only. Each program area will have 3 sets of plots, each with 3 panels in them. Each panel goes as follows:

1. Y-axis autoscaled
2. Y-axis set to be mean + 4 times the standard deviation
3. Y-axis set to be mean + 4 times the standard deviation for most recent 10 years of data

```

if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  for (i in 1:n) {
    year_lower <- min(data$Year[data$Use_In_Analysis==TRUE &
                                data$MonitoringID==Mon_IDs[i]])
    year_upper <- max(data$Year[data$Use_In_Analysis==TRUE &
                                data$MonitoringID==Mon_IDs[i]])
    min_RV <- min(data$ResultValue[data$Use_In_Analysis==TRUE &
                                data$MonitoringID==Mon_IDs[i]])
    mn_RV <- mean(data$ResultValue[data$Use_In_Analysis==TRUE &
                                data$MonitoringID==Mon_IDs[i] &
                                data$ResultValue <
                                quantile(data$ResultValue, 0.98)])
    sd_RV <- sd(data$ResultValue[data$Use_In_Analysis==TRUE &
                                data$MonitoringID==Mon_IDs[i] &
                                data$ResultValue <
                                quantile(data$ResultValue, 0.98)])
    x_scale <- ifelse(year_upper - year_lower > 30, 10, 5)
    y_scale <- mn_RV + 4 * sd_RV
    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
                       " | ", KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
                       KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])

    ##Year plots
    p1 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                            data$MonitoringID==Mon_IDs[i], ],
                  aes(x=Year, y=ResultValue, group=Year)) +
      geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
                   outlier.size=3, outlier.color="#333333",
                   outlier.fill="#cccccc", outlier.alpha=0.75) +
      labs(subtitle="Autoscale",
            x="Year", y=paste0("Values (", unit, ")")) +
      scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                         breaks=rev(seq(year_upper,
                                        year_lower, -x_scale))) +
      plot_theme

    p2 <- ggplot(data=data[data$Use_In_Analysis==TRUE &

```

```

            data$MonitoringID==Mon_IDs[i], ],
aes(x=Year, y=ResultValue, group=Year)) +
geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
            outlier.size=3, outlier.color="#333333",
            outlier.fill="#cccccc", outlier.alpha=0.75) +
labs(subtitle="Scaled to 4x Standard Deviation",
      x="Year", y=paste0("Values (", unit, ")")) +
ylim(min_RV, y_scale) +
scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                   breaks=rev(seq(year_upper,
                                  year_lower, -x_scale))) +
plot_theme

p3 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i] &
                           data$Year>=year_upper-10, ],
aes(x=Year, y=ResultValue, group=Year)) +
geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
            outlier.size=3, outlier.color="#333333",
            outlier.fill="#cccccc", outlier.alpha=0.75) +
labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
      x="Year", y=paste0("Values (", unit, ")")) +
ylim(min_RV, y_scale) +
scale_x_continuous(limits=c(year_upper - 10.5, year_upper + 1),
                   breaks=rev(seq(year_upper, year_upper - 10,-2))) +
plot_theme

Yset <- ggarrange(p1, p2, p3, ncol=1)

p0 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                      subtitle="By Year") +
plot_theme + theme(panel.border=element_blank(),
                    panel.grid.major=element_blank(),
                    panel.grid.minor=element_blank(),
                    axis.line=element_blank())

## Year & Month Plots
p4 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i], ],
aes(x=YearMonthDec, y=ResultValue,
    group=YearMonth, color=as.factor(Month))) +
geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
labs(subtitle="Autoscale",
      x="Year", y=paste0("Values (", unit, ")"), color="Month") +
scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                   breaks=rev(seq(year_upper,
                                  year_lower, -x_scale))) +
plot_theme +
theme(legend.position="none")

p5 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i], ],

```

```

aes(x=YearMonthDec, y=ResultValue,
    group=YearMonth, color=as.factor(Month))) +
geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
labs(subtitle="Scaled to 4x Standard Deviation",
    x="Year", y=paste0("Values (", unit, ")"), color="Month") +
ylim(min_RV, y_scale) +
scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
    breaks=rev(seq(year_upper,
                    year_lower, -x_scale))) +
plot_theme +
theme(legend.position="top", legend.box="horizontal") +
guides(color=guide_legend(nrow=1))

p6 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i], ],
               aes(x=YearMonthDec, y=ResultValue,
                   group=YearMonth, color=as.factor(Month))) +
geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
    x="Year", y=paste0("Values (", unit, ")"), color="Month") +
ylim(min_RV, y_scale) +
scale_x_continuous(limits=c(year_upper - 10.5, year_upper + 1),
    breaks=rev(seq(year_upper, year_upper - 10,-2))) +
plot_theme +
theme(legend.position="none")

leg1 <- get_legend(p5)
YMset <- ggarrange(leg1, p4, p5 + theme(legend.position="none"), p6,
                    ncol=1, heights=c(0.1, 1, 1, 1))

p00 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                        subtitle="By Year & Month") + plot_theme +
theme(panel.border=element_blank(),
      panel.grid.major=element_blank(),
      panel.grid.minor=element_blank(), axis.line=element_blank())

## Month Plots
p7 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i], ],
               aes(x=Month, y=ResultValue,
                   group=Month, fill=as.factor(Month))) +
geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
             outlier.color="#333333", outlier.alpha=0.75) +
labs(subtitle="Autoscale",
    x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
plot_theme +
theme(legend.position="none")

p8 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i], ],
               aes(x=Month, y=ResultValue,
                   group=Month, fill=as.factor(Month))) +

```

```

geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
             outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation",
       x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(fill=guide_legend(nrow=1))

p9 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                           data$MonitoringID==Mon_IDs[i] &
                           data$Year >= year_upper - 10, ],
               aes(x=Month, y=ResultValue,
                   group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")

leg2 <- get_legend(p8)
Mset <- ggarrange(leg2, p7, p8 + theme(legend.position="none"), p9,
                  ncol=1, heights=c(0.1, 1, 1, 1))

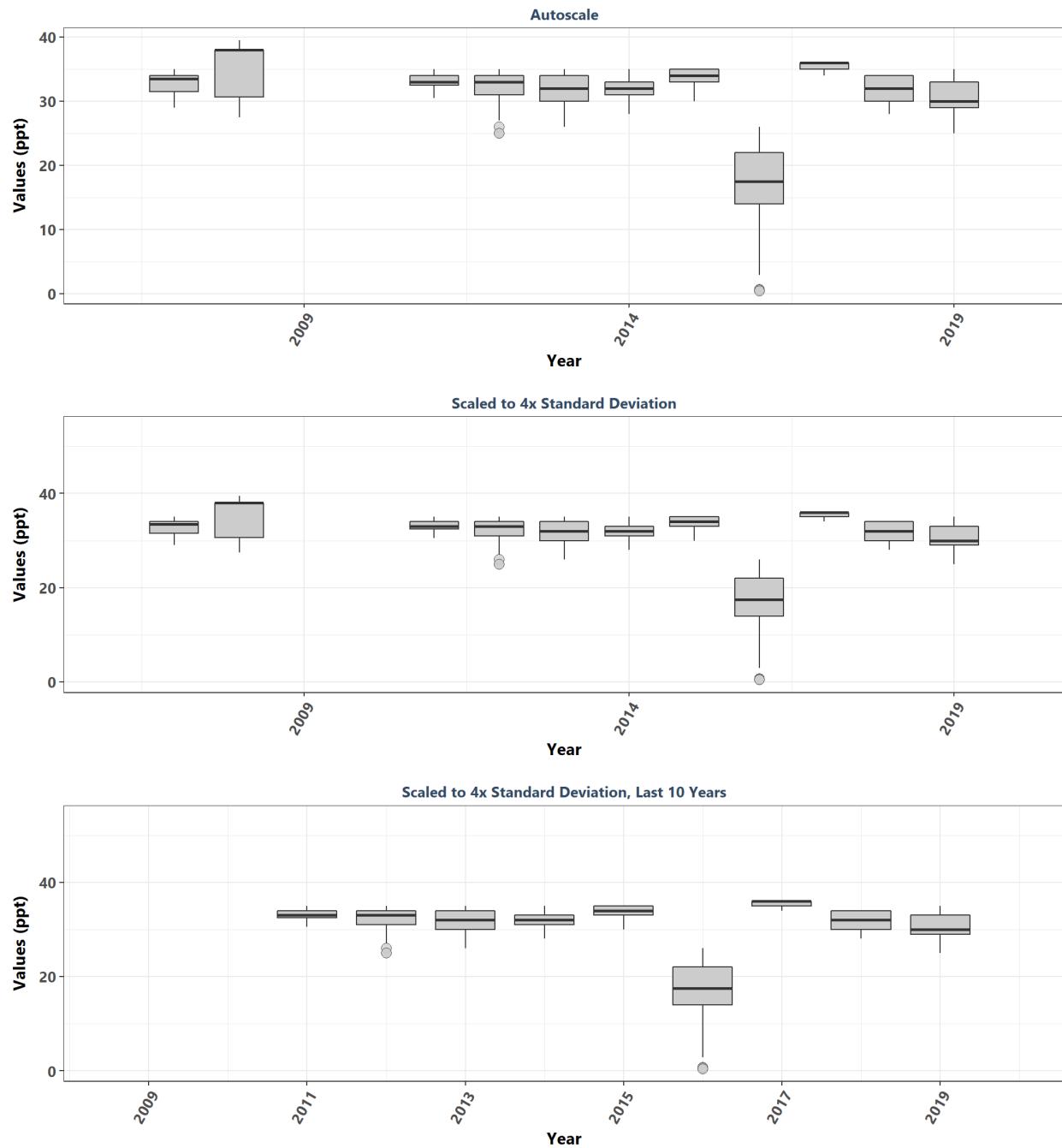
p000 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                         subtitle="By Month") + plot_theme +
  theme(panel.border=element_blank(),
        panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

print(ggarrange(p0, Yset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p00, YMset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p000, Mset, ncol=1, heights=c(0.1, 1)))

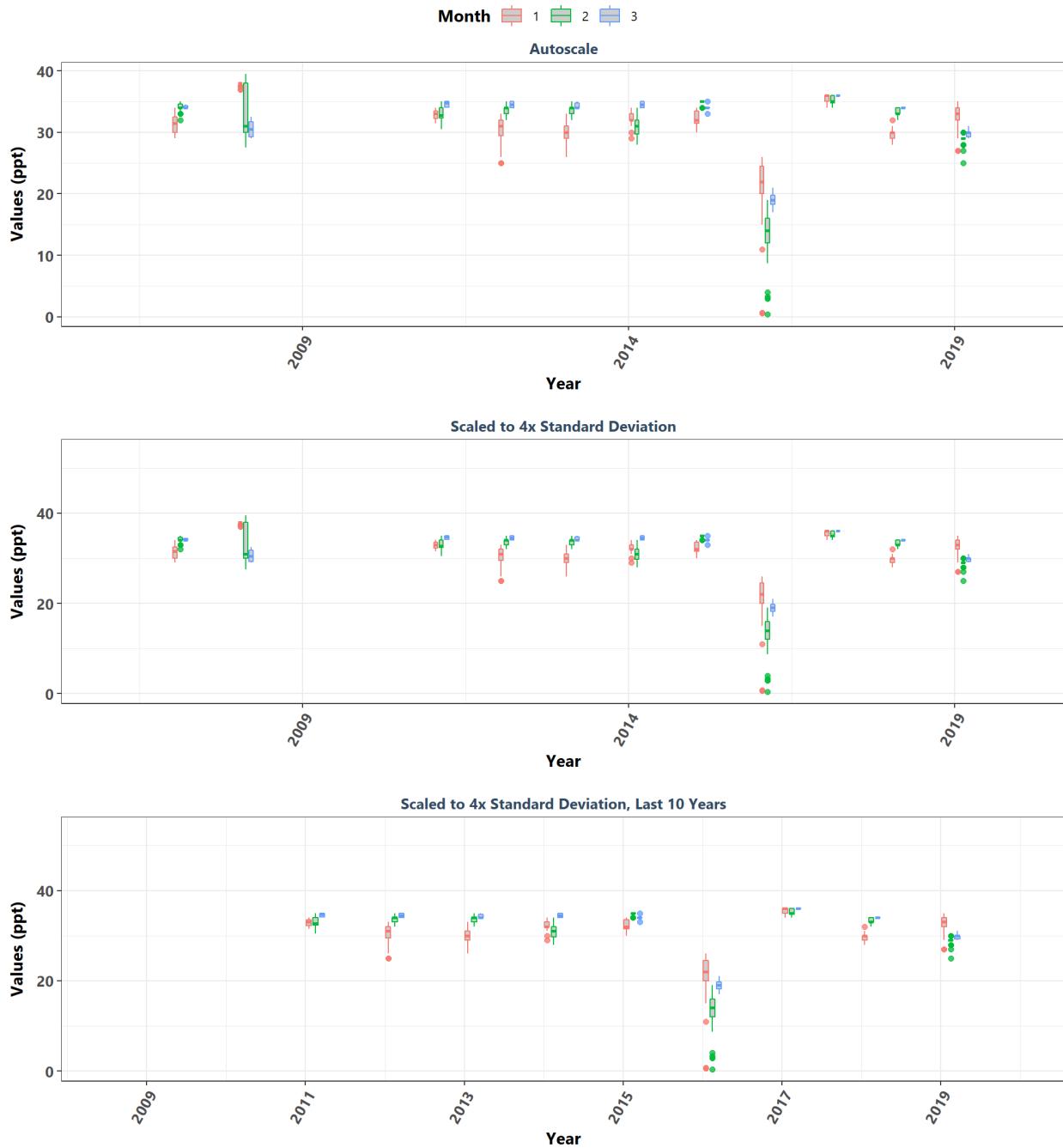
rm(plot_data)
rm(p1, p2, p3, p4, p5, p6, p7, p8, p9, p0, p00, p000, leg1, leg2,
    Yset, YMset, Mset)
}
}

```

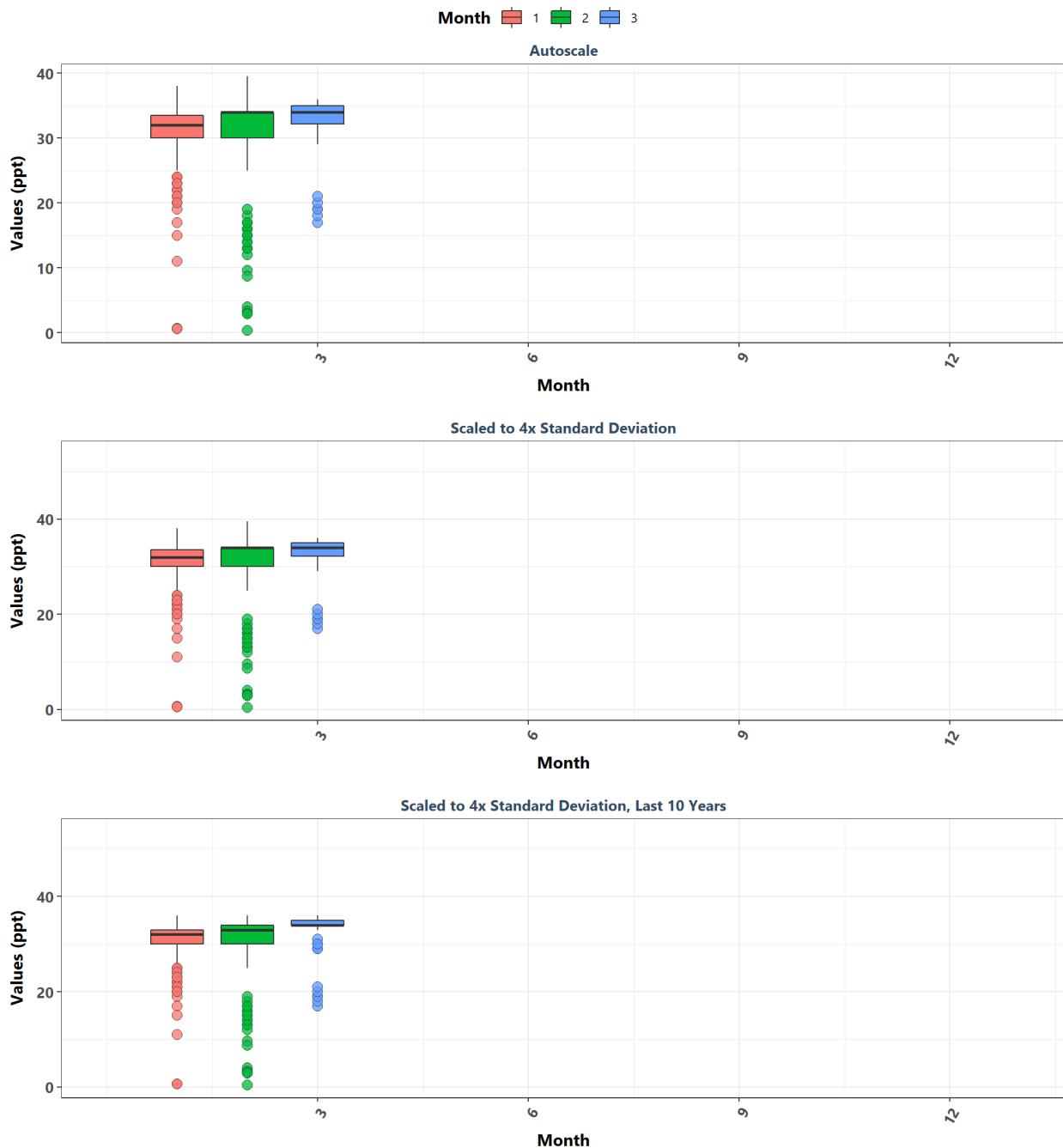
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255432081303900
By Year



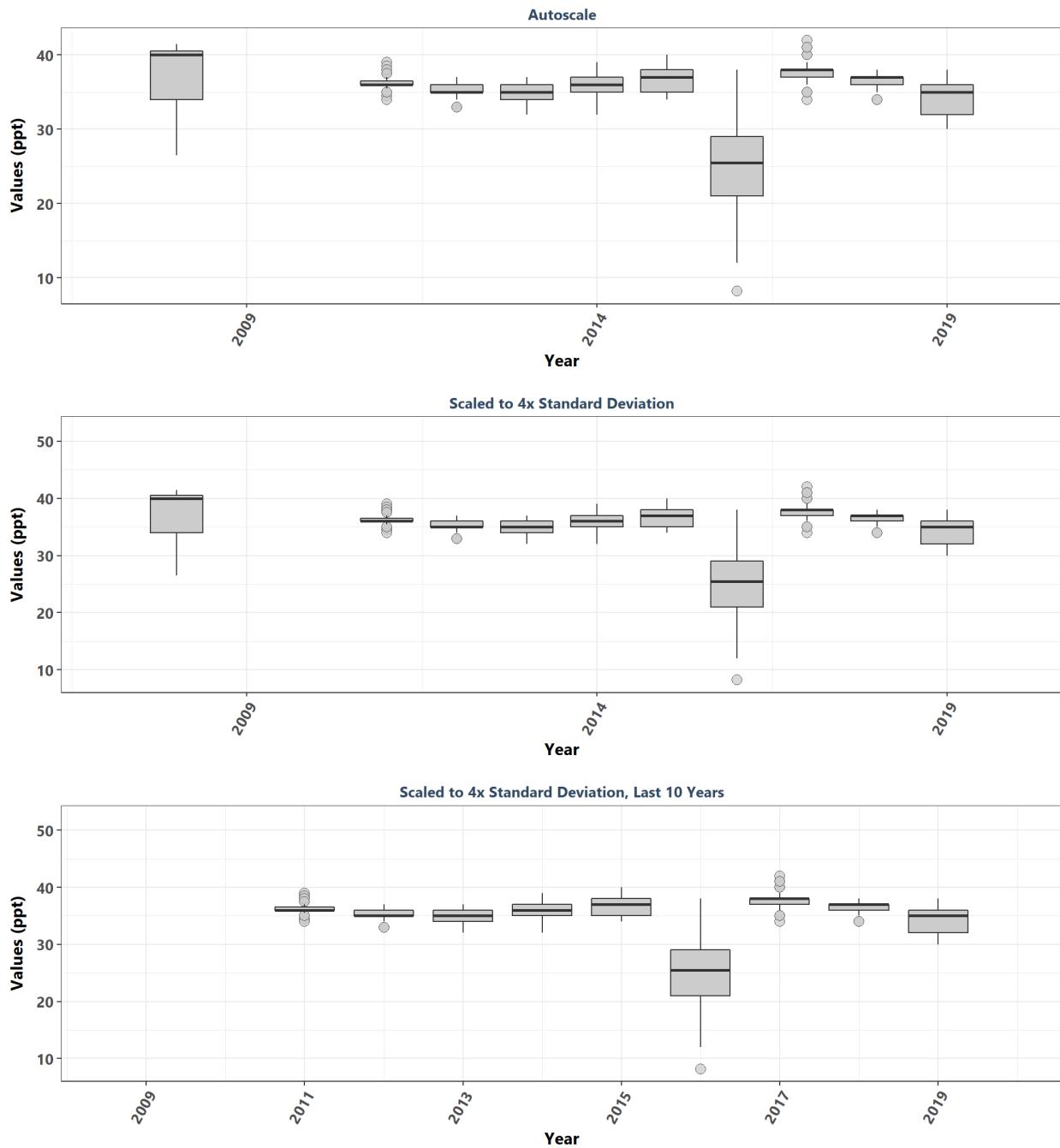
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255432081303900
By Year & Month



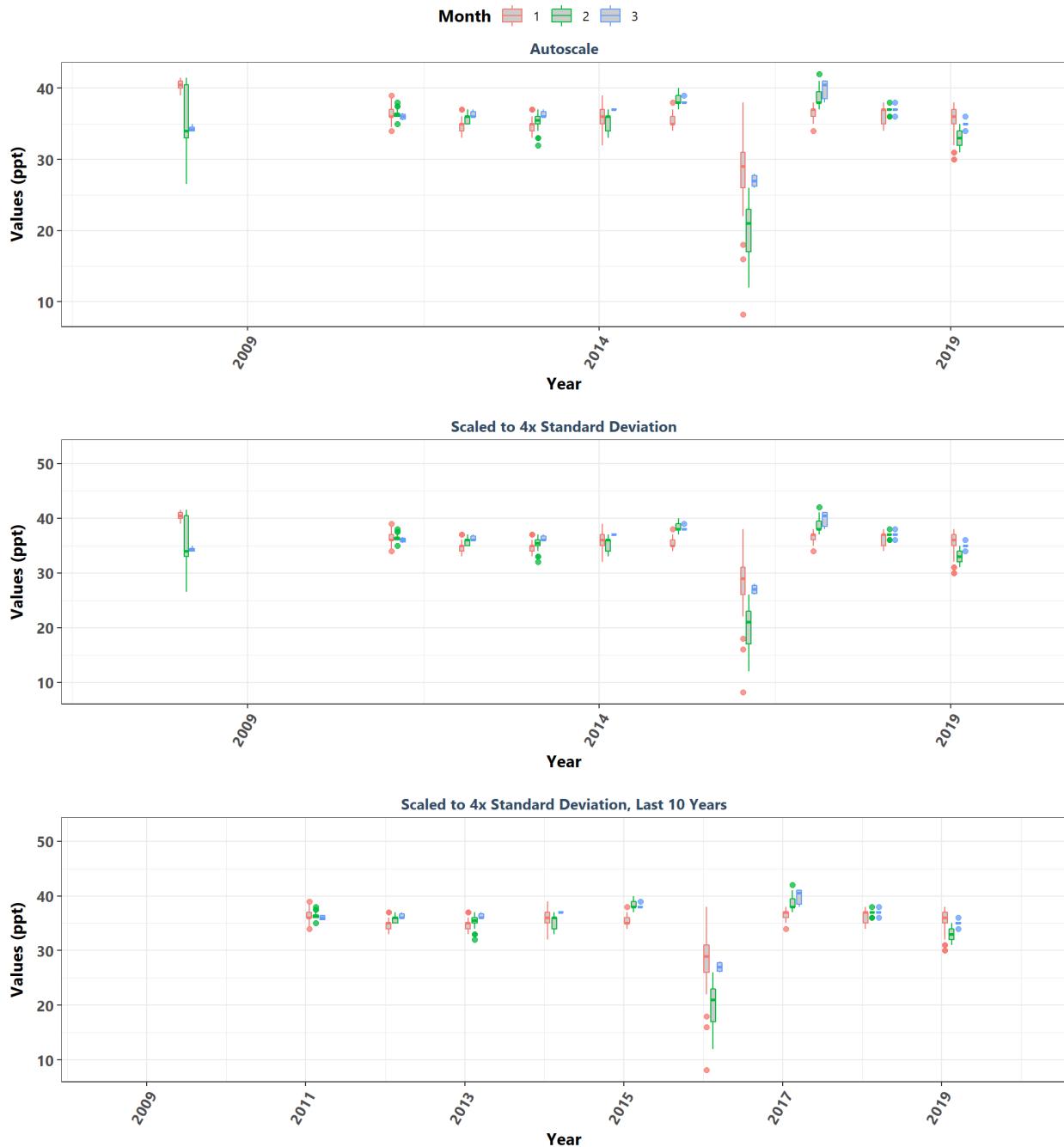
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255432081303900
By Month



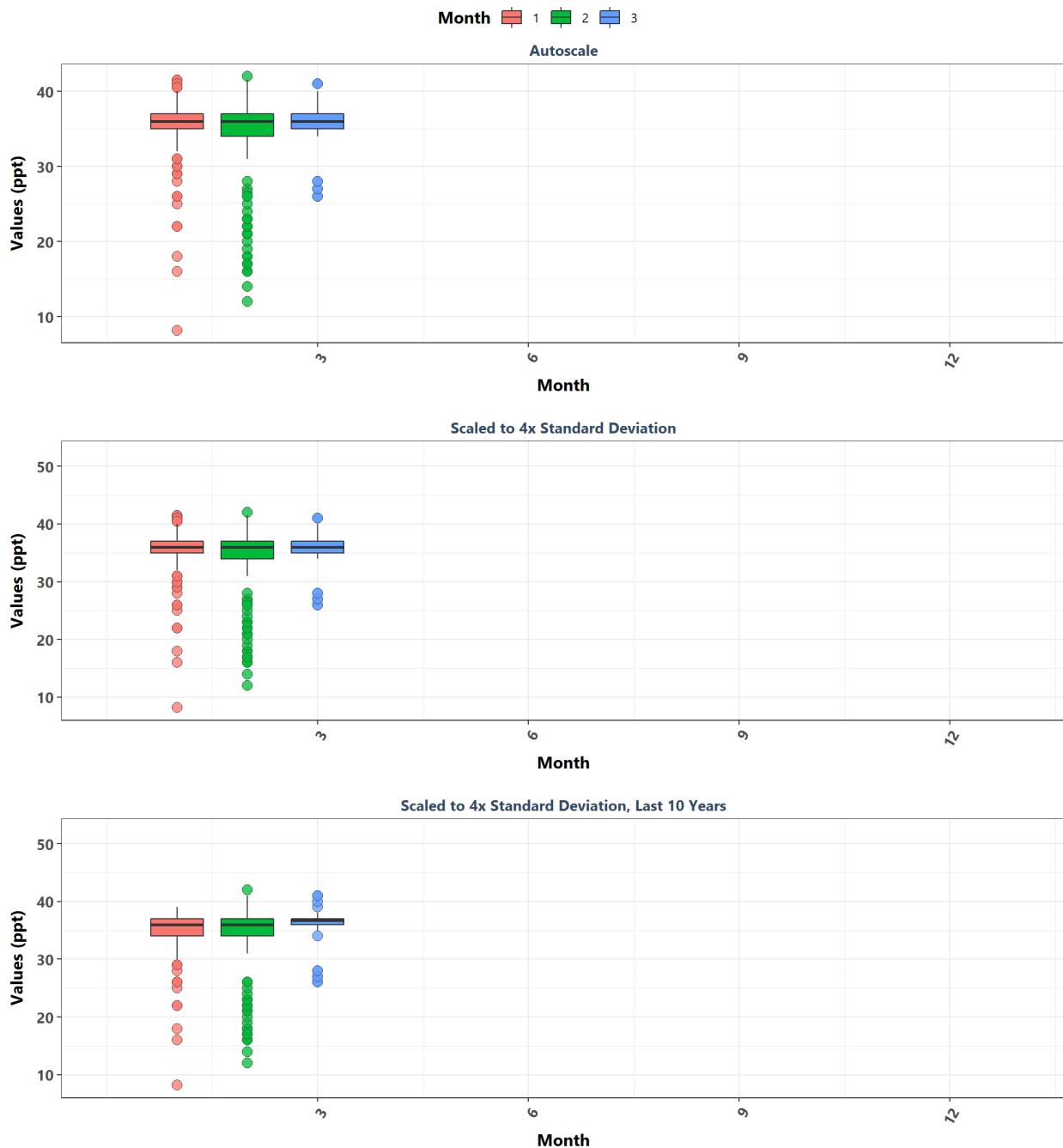
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255534081324000
 By Year



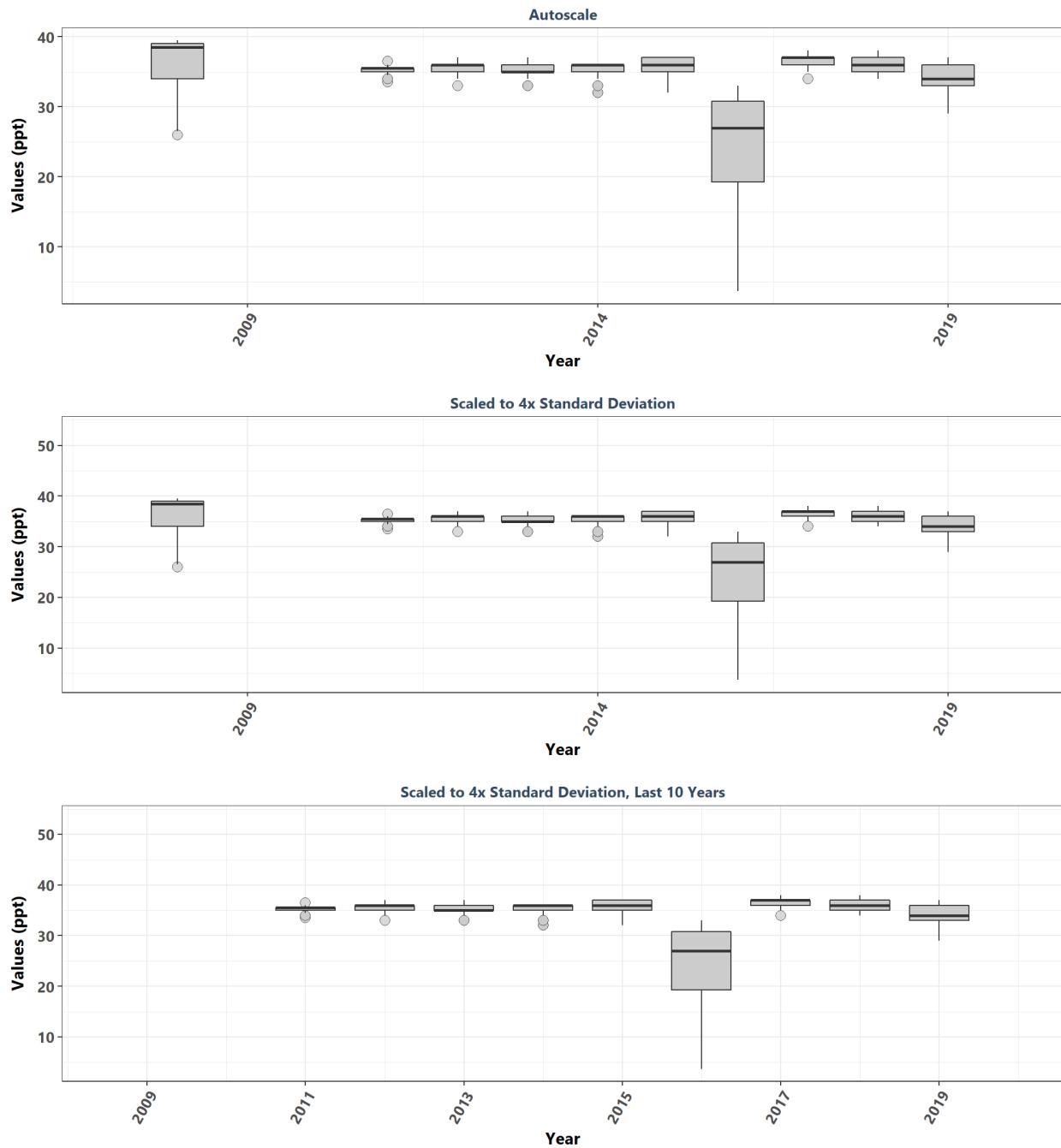
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255534081324000
By Year & Month



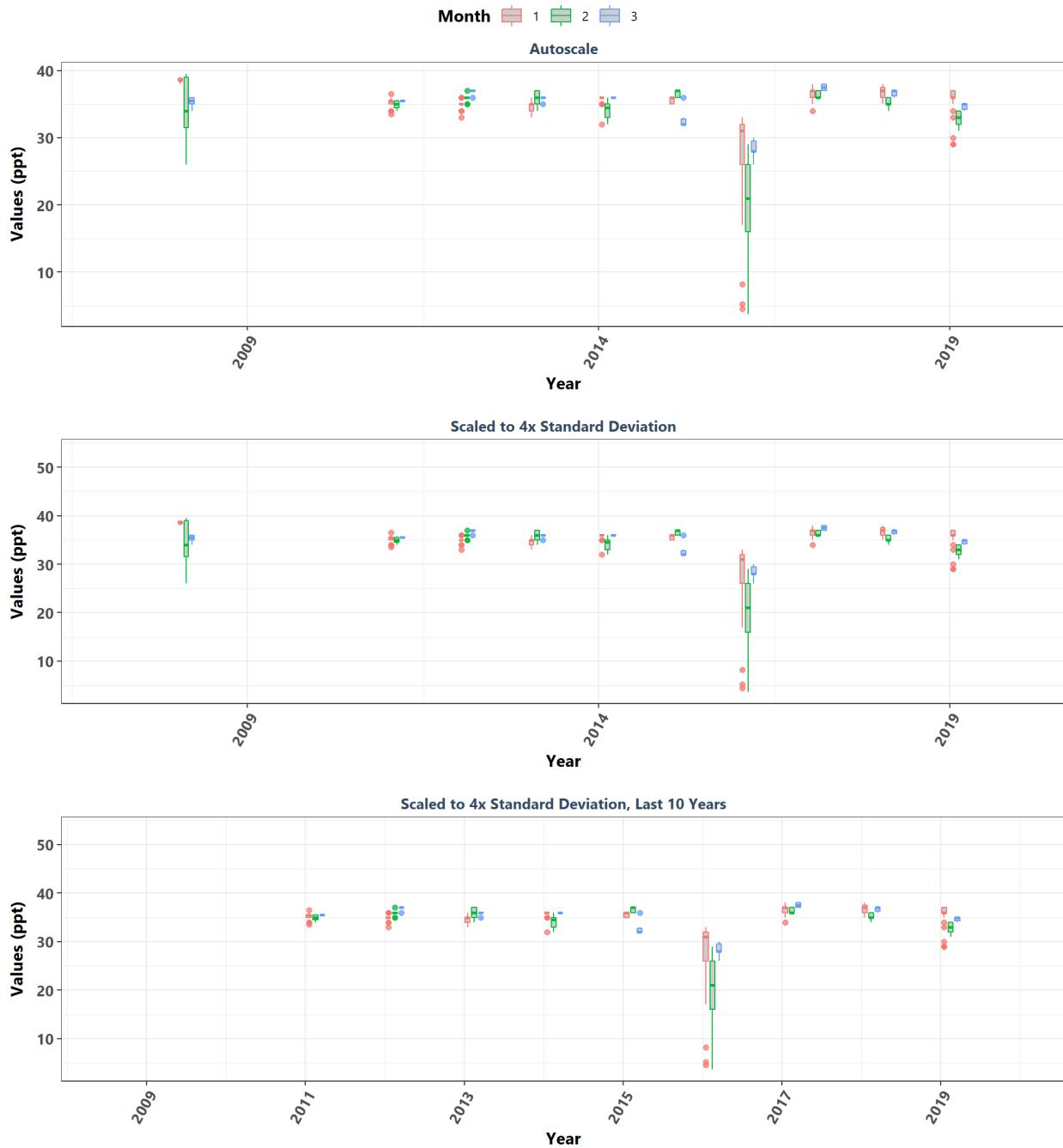
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255534081324000
By Month



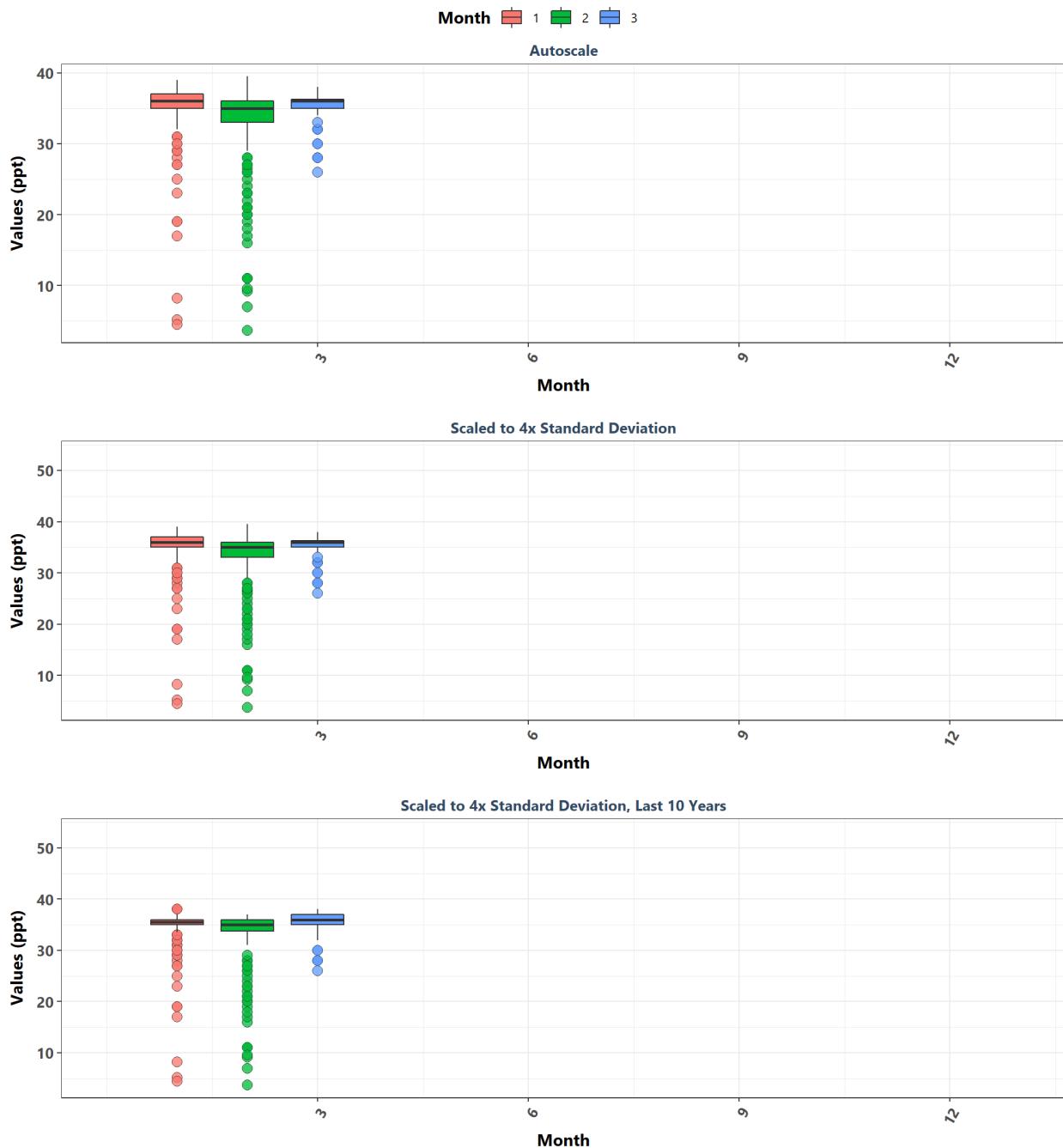
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255654081350200
By Year



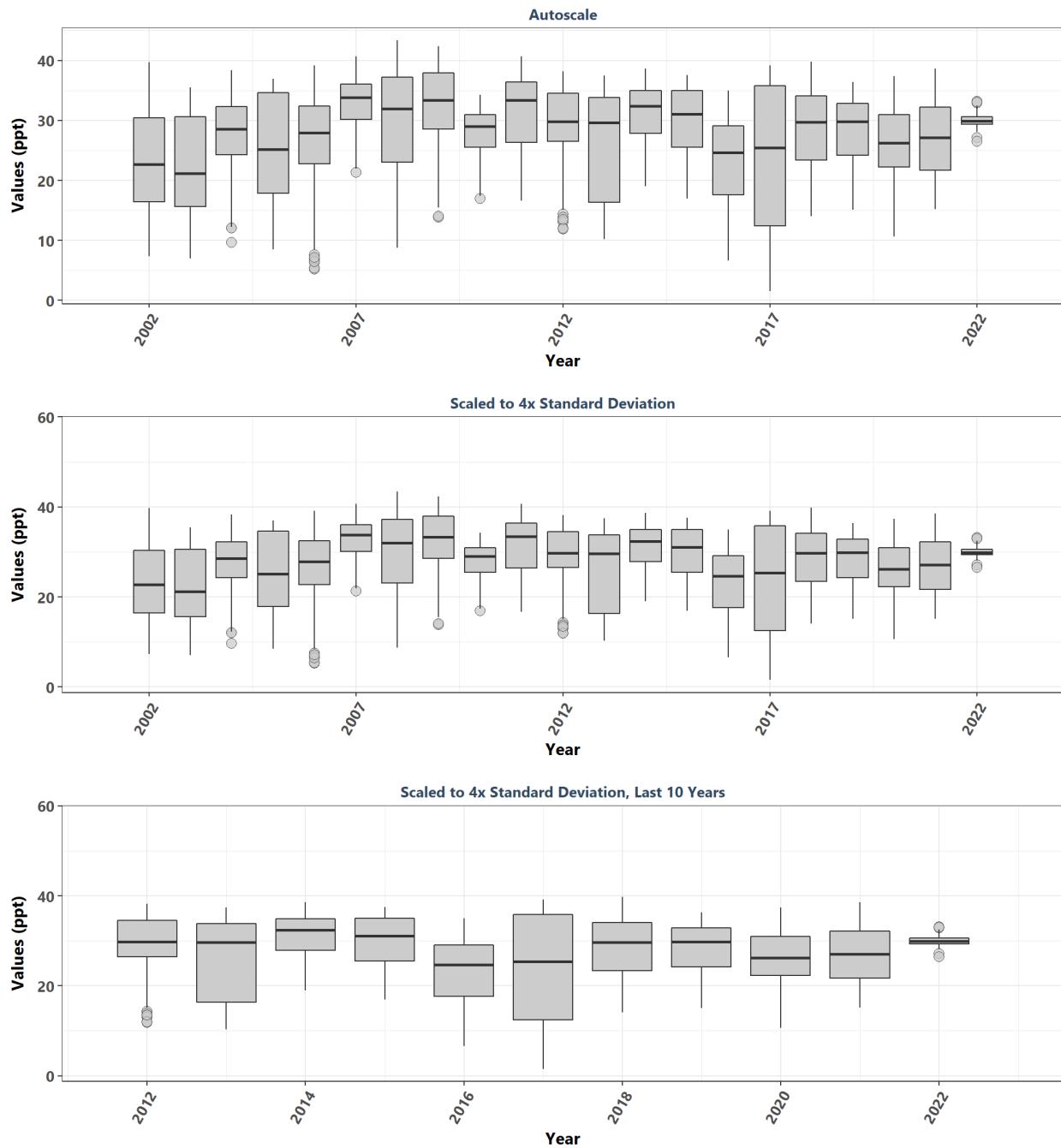
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255654081350200
By Year & Month



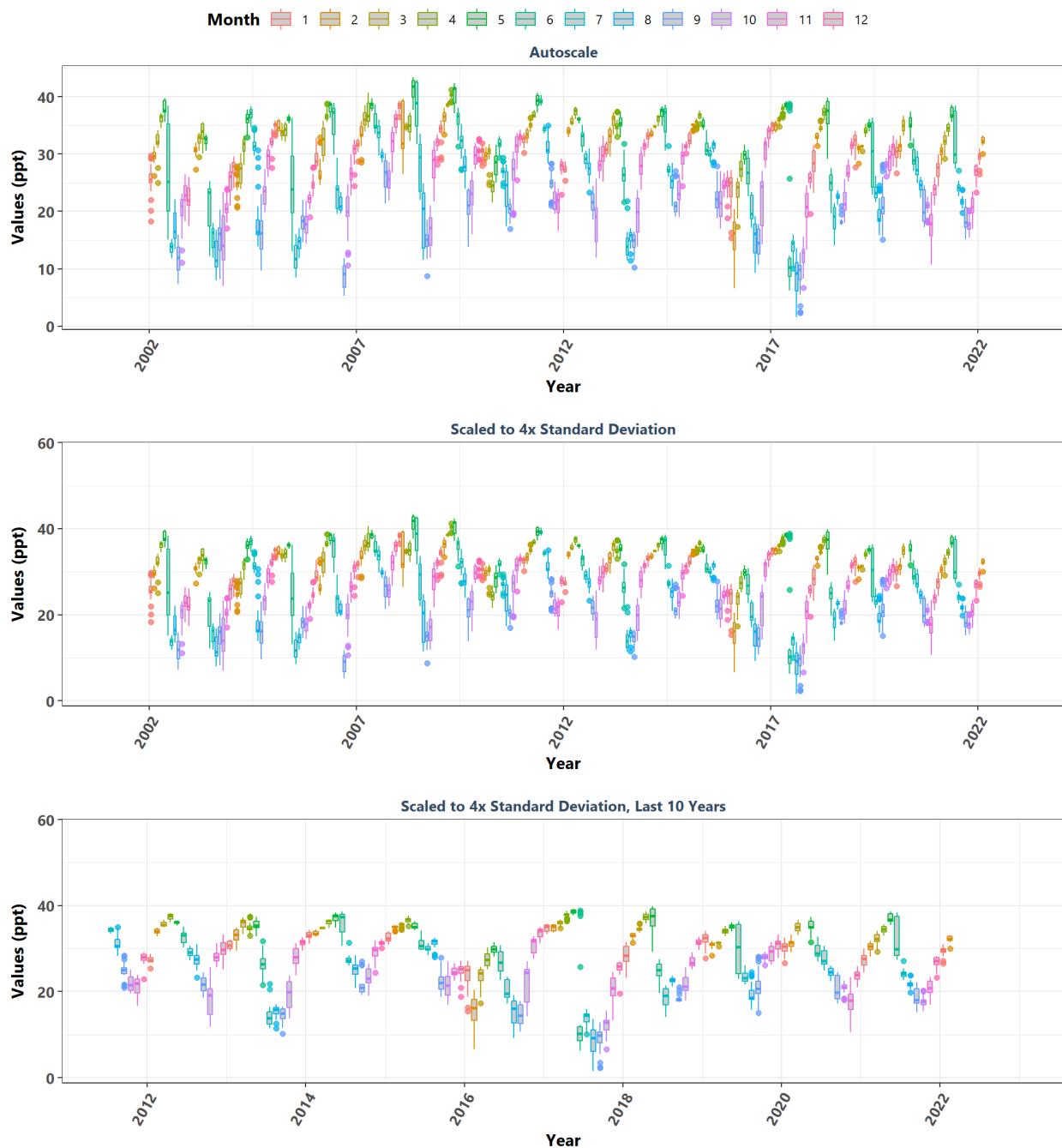
Cape Romano-Ten Thousand Islands Aquatic Preserve
7 | National Water Information System
255654081350200
By Month



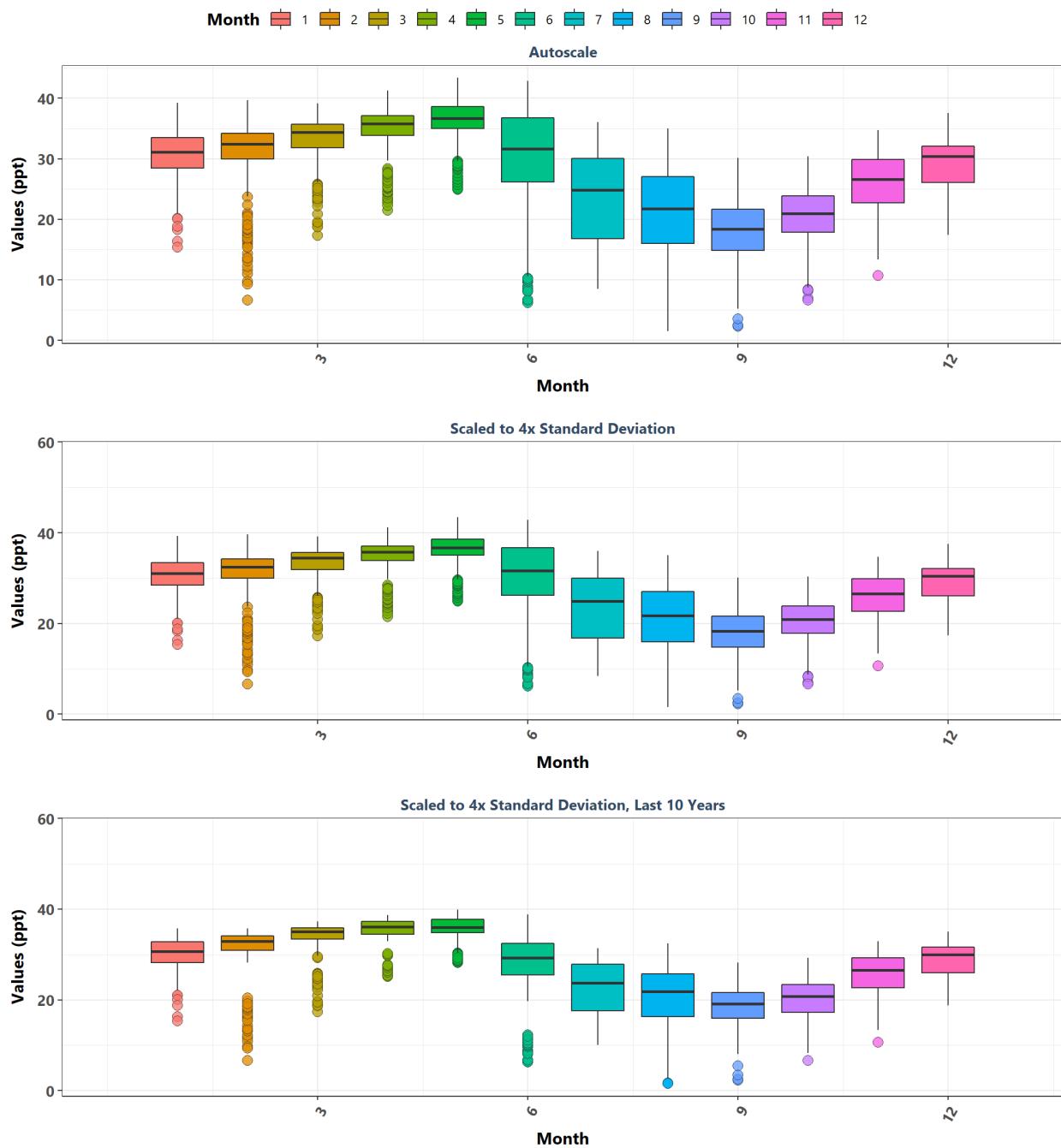
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfbwq
By Year



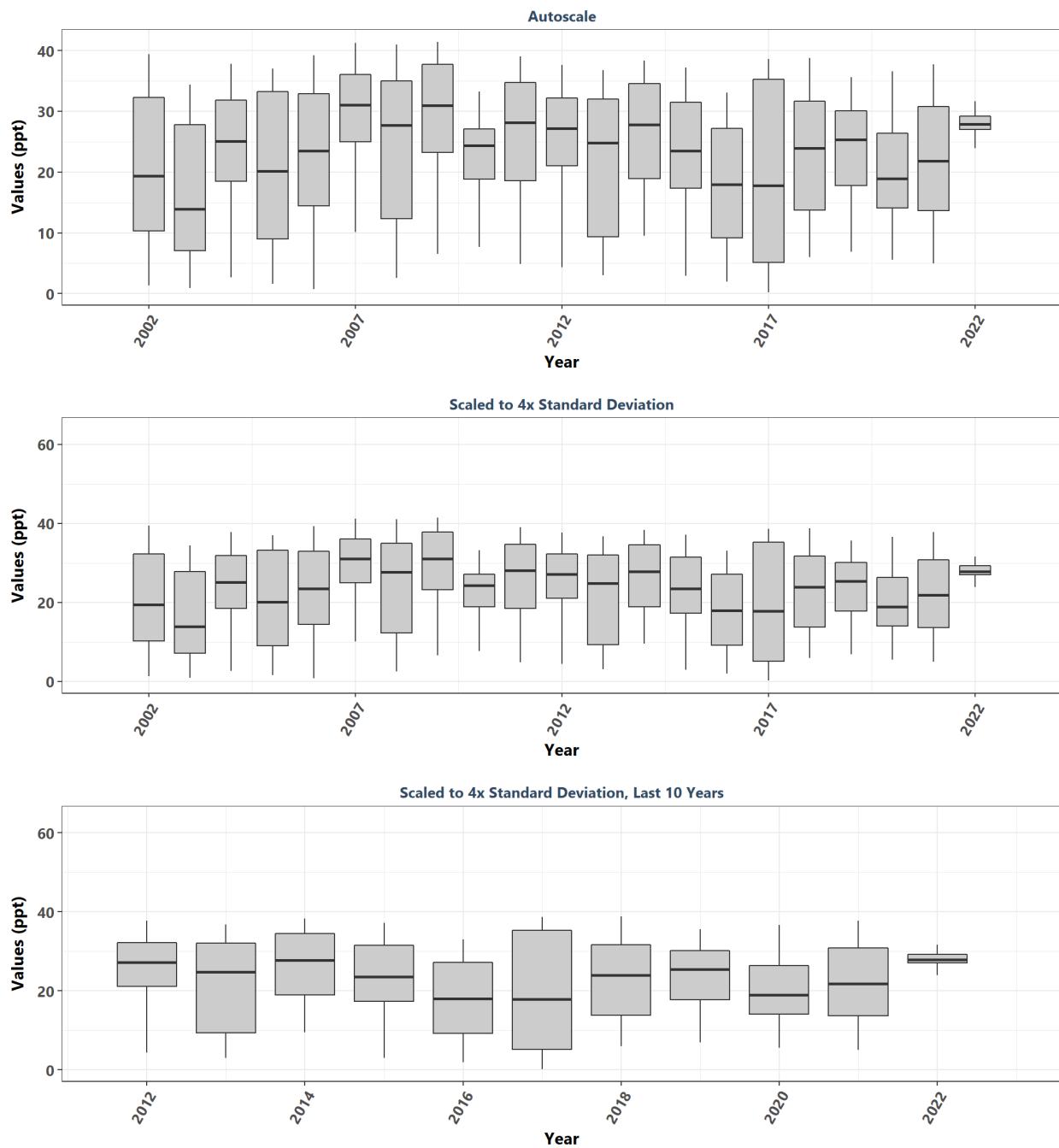
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfbwq
By Year & Month



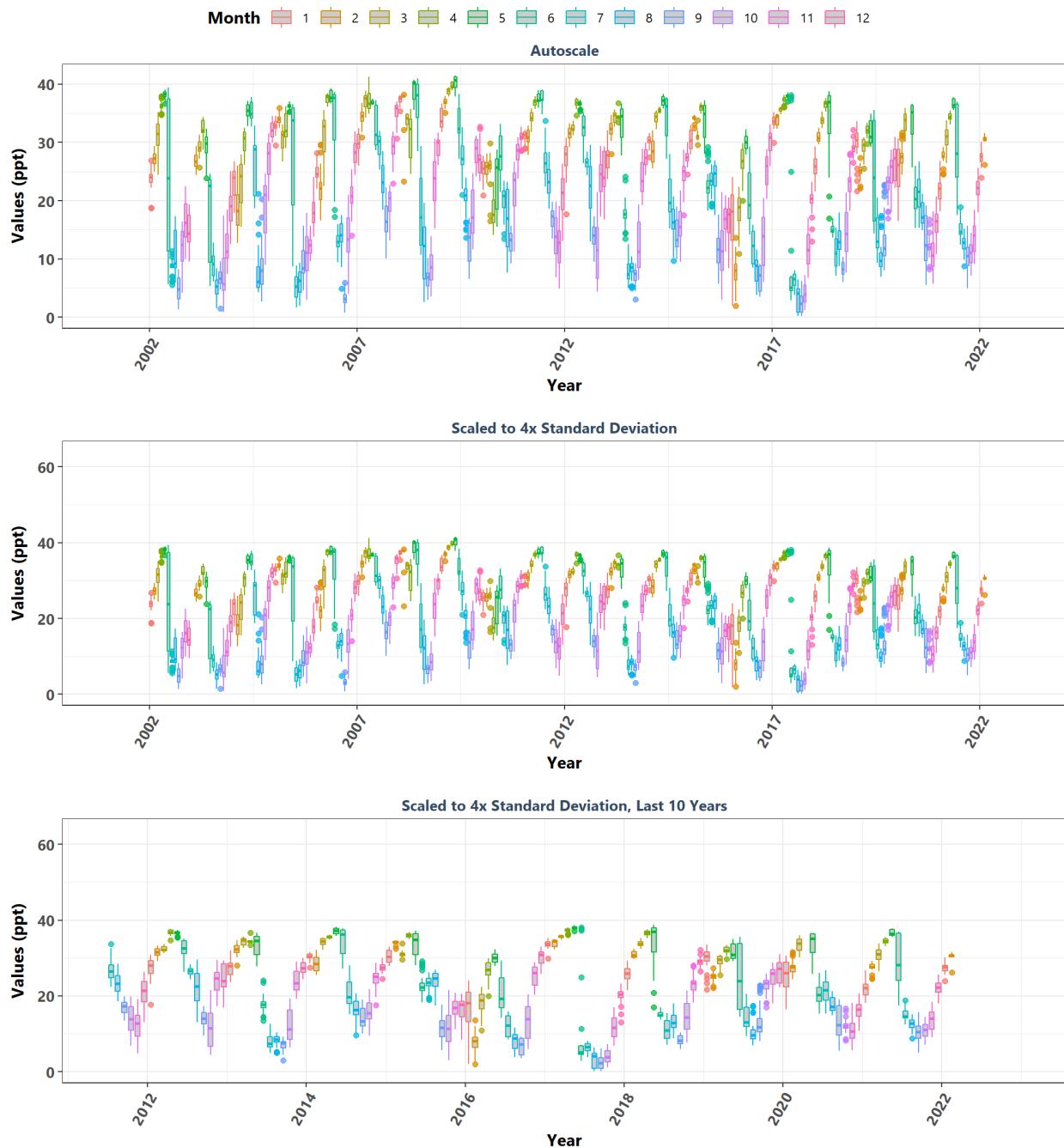
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfbwq
By Month



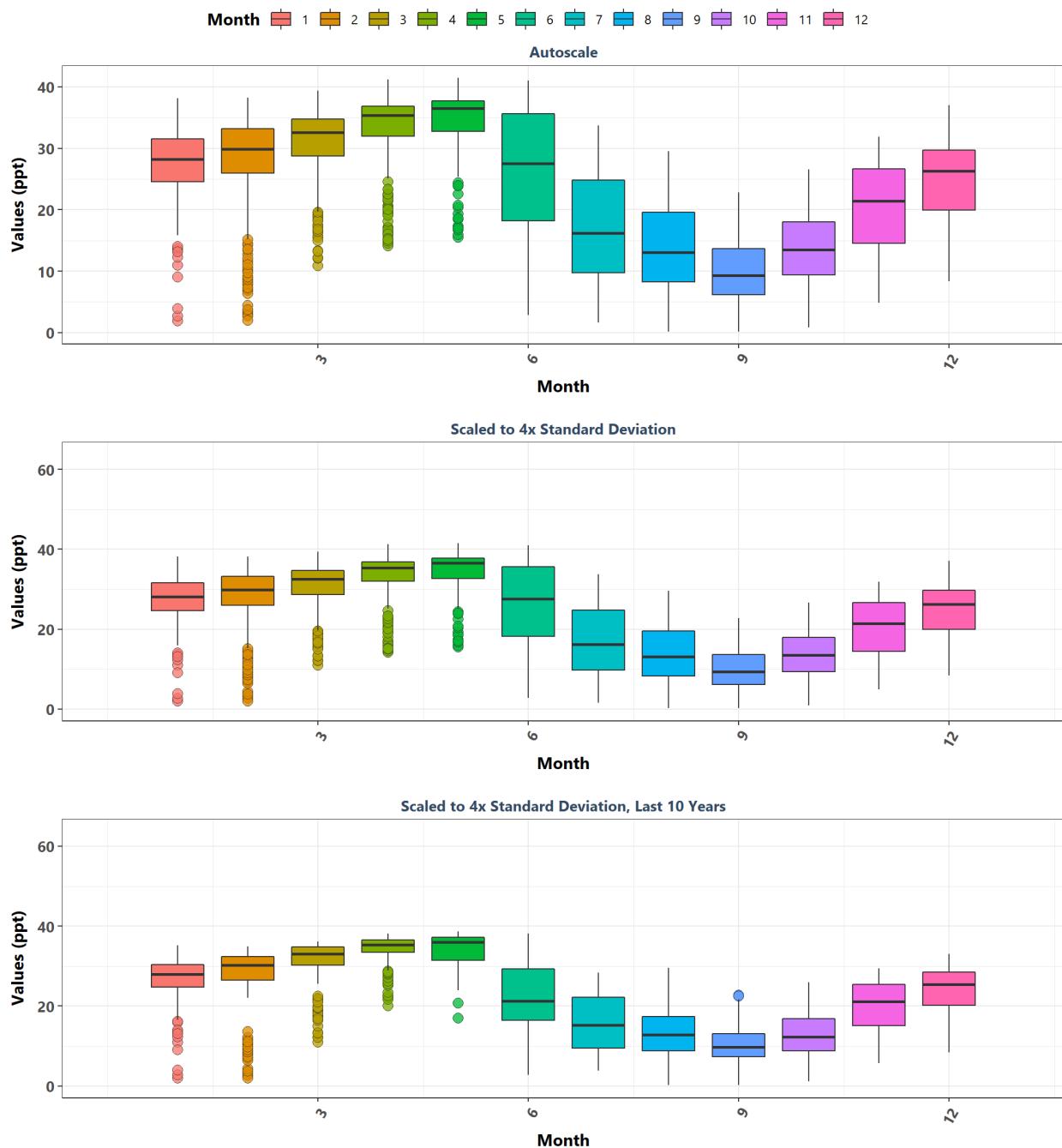
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbfuwq
By Year



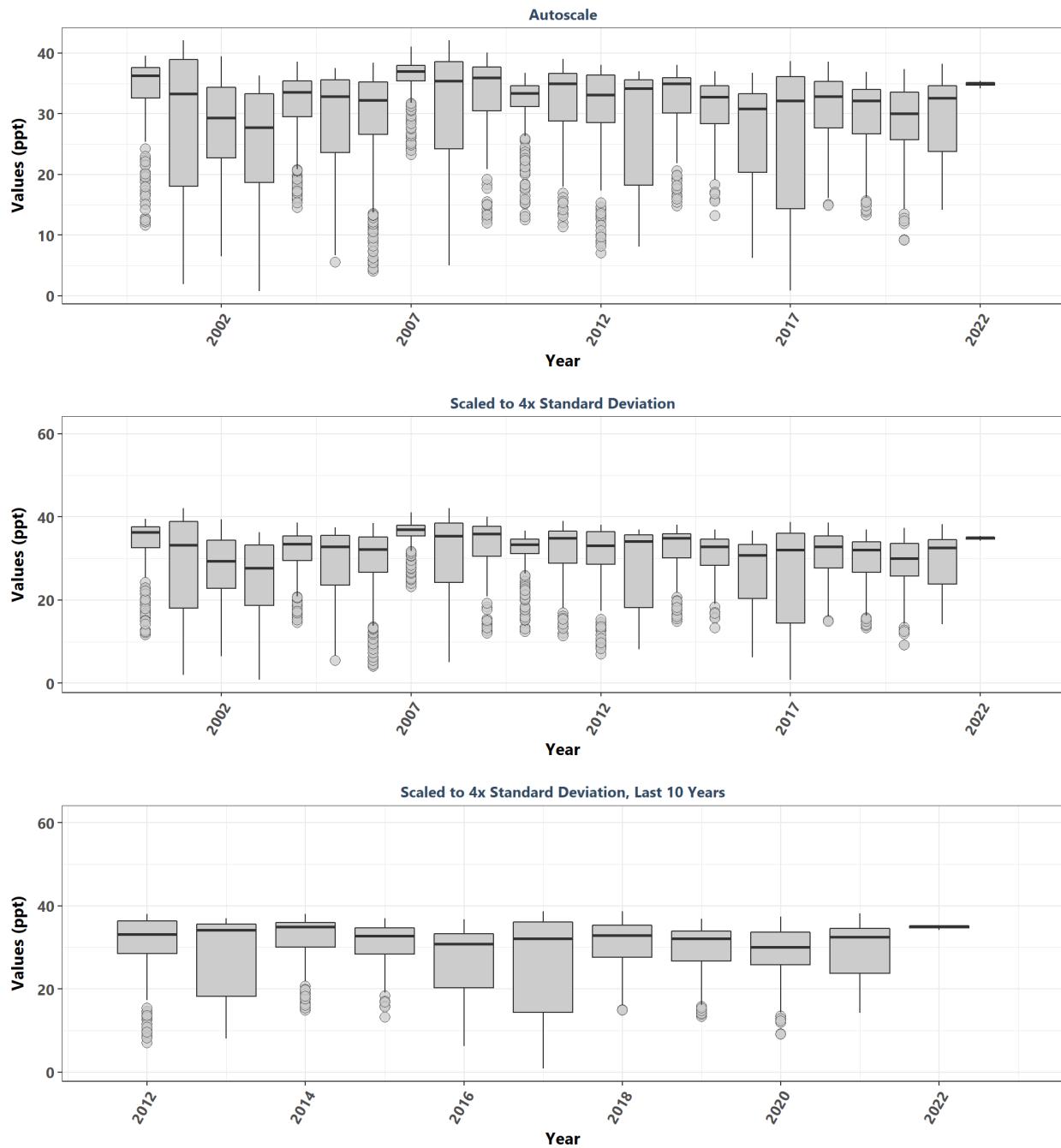
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbftuwq
By Year & Month



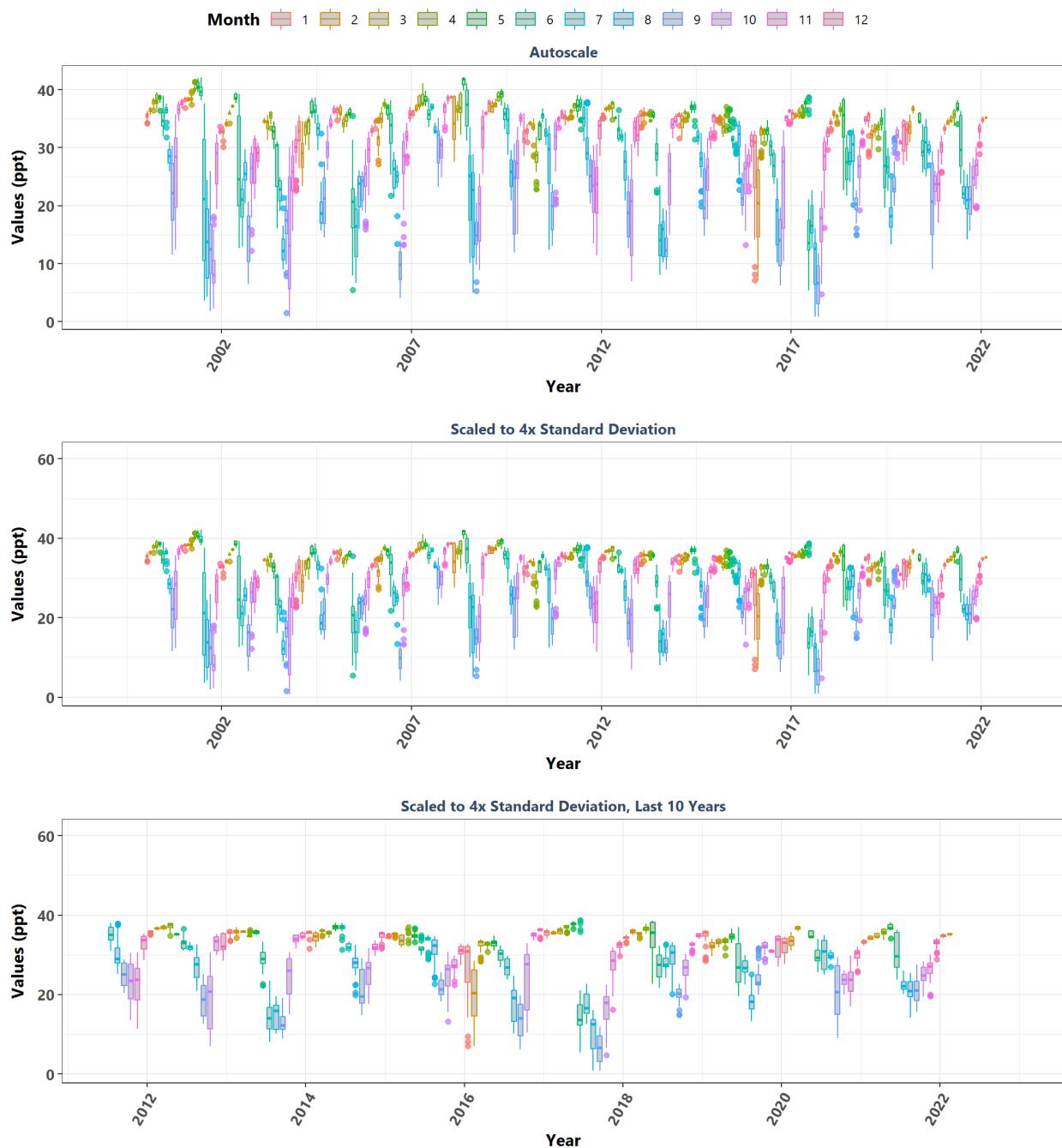
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbffuwq
By Month



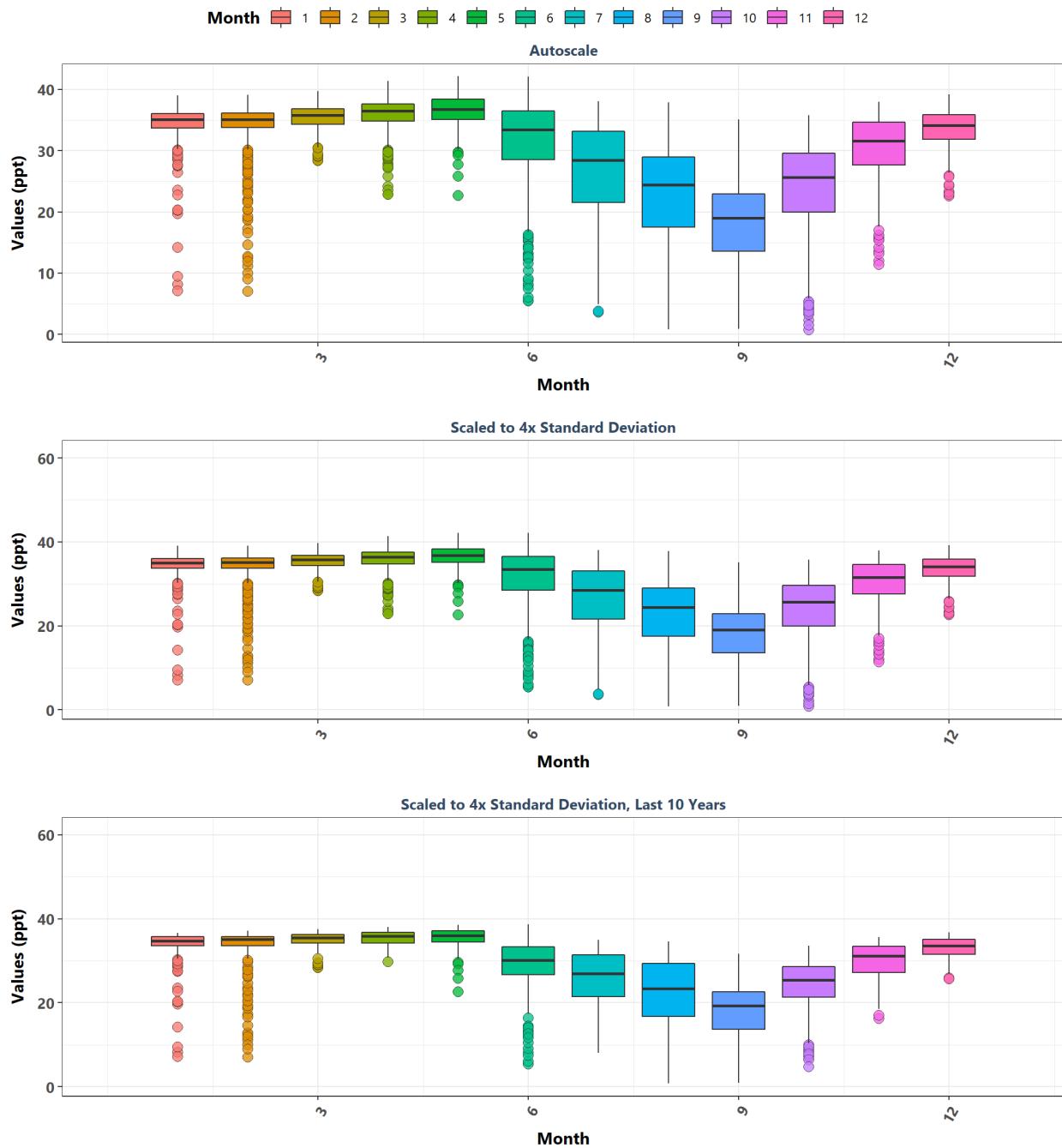
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbmbwq
By Year



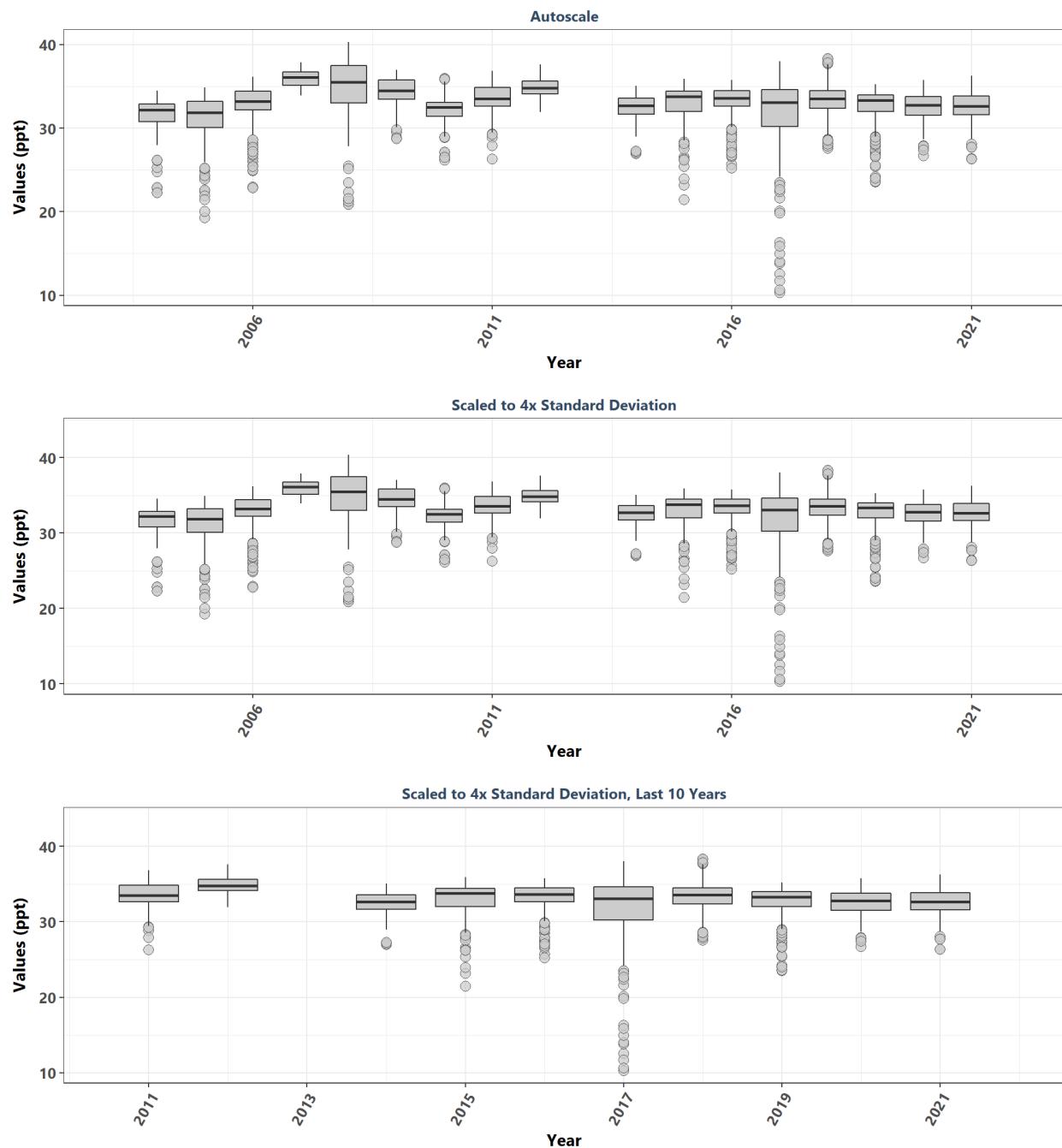
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbmbwq
By Year & Month



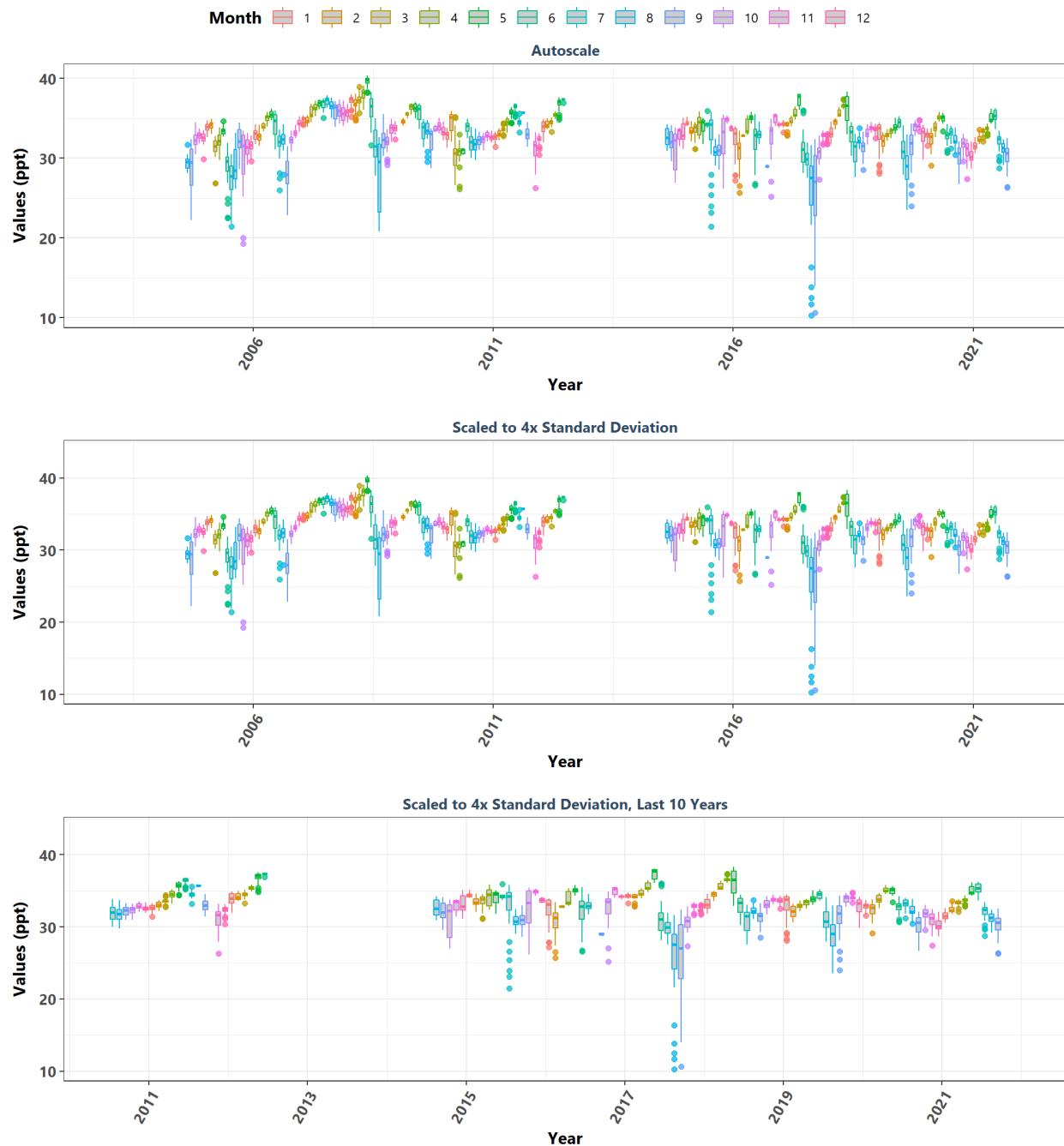
Cape Romano-Ten Thousand Islands Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbmbwq
By Month



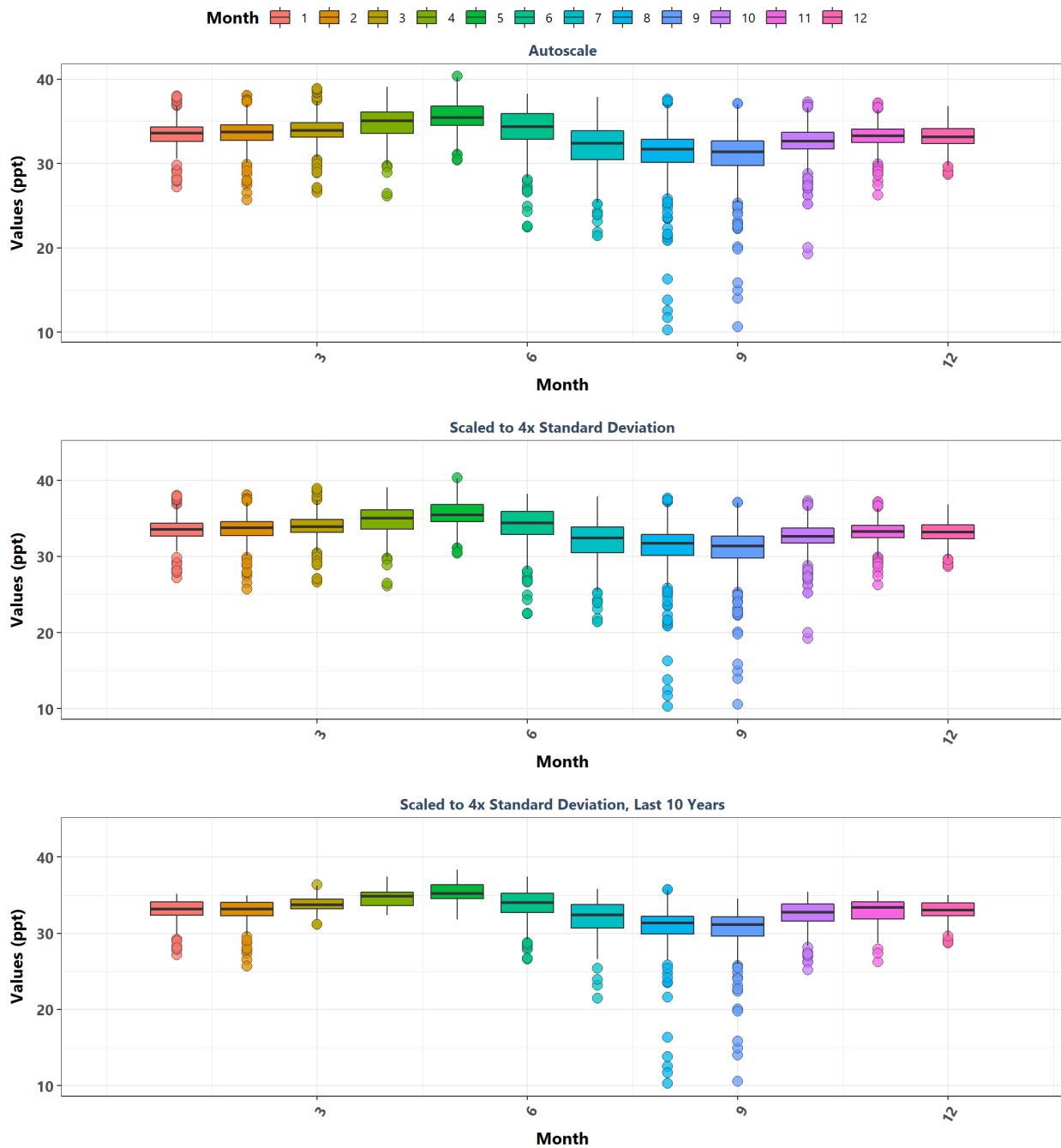
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB02
By Year



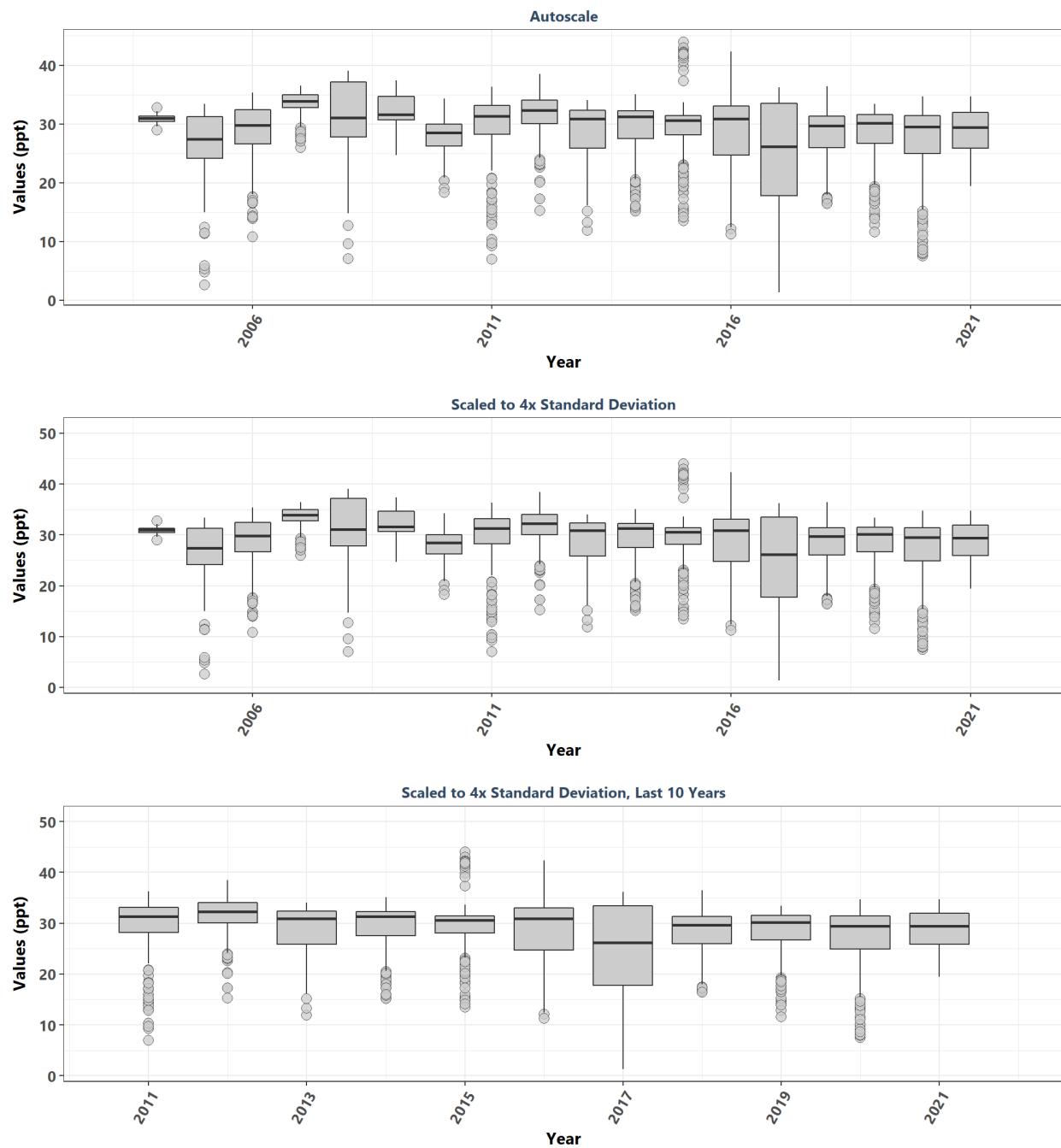
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB02
By Year & Month



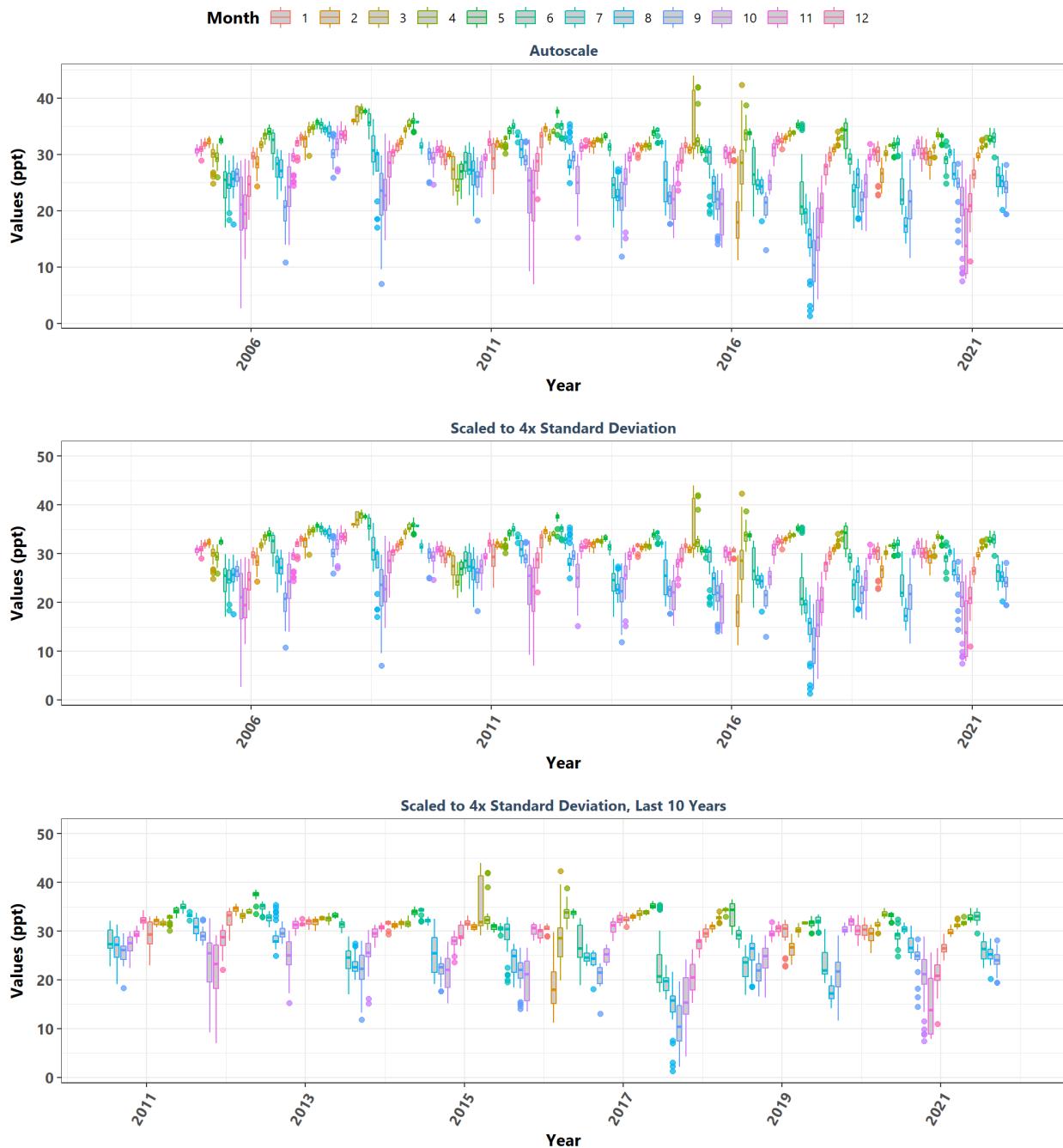
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB02
By Month



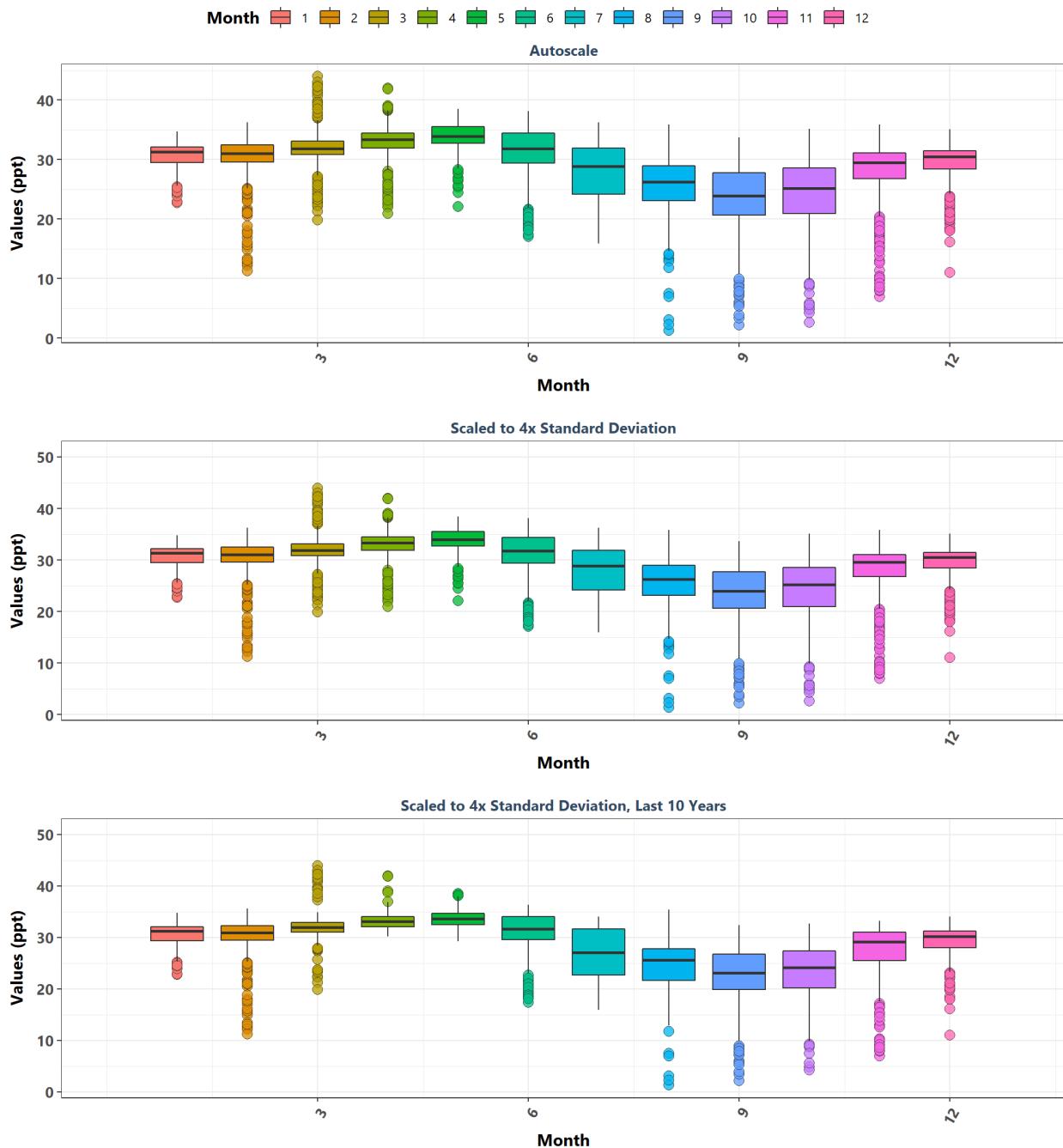
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB03
By Year



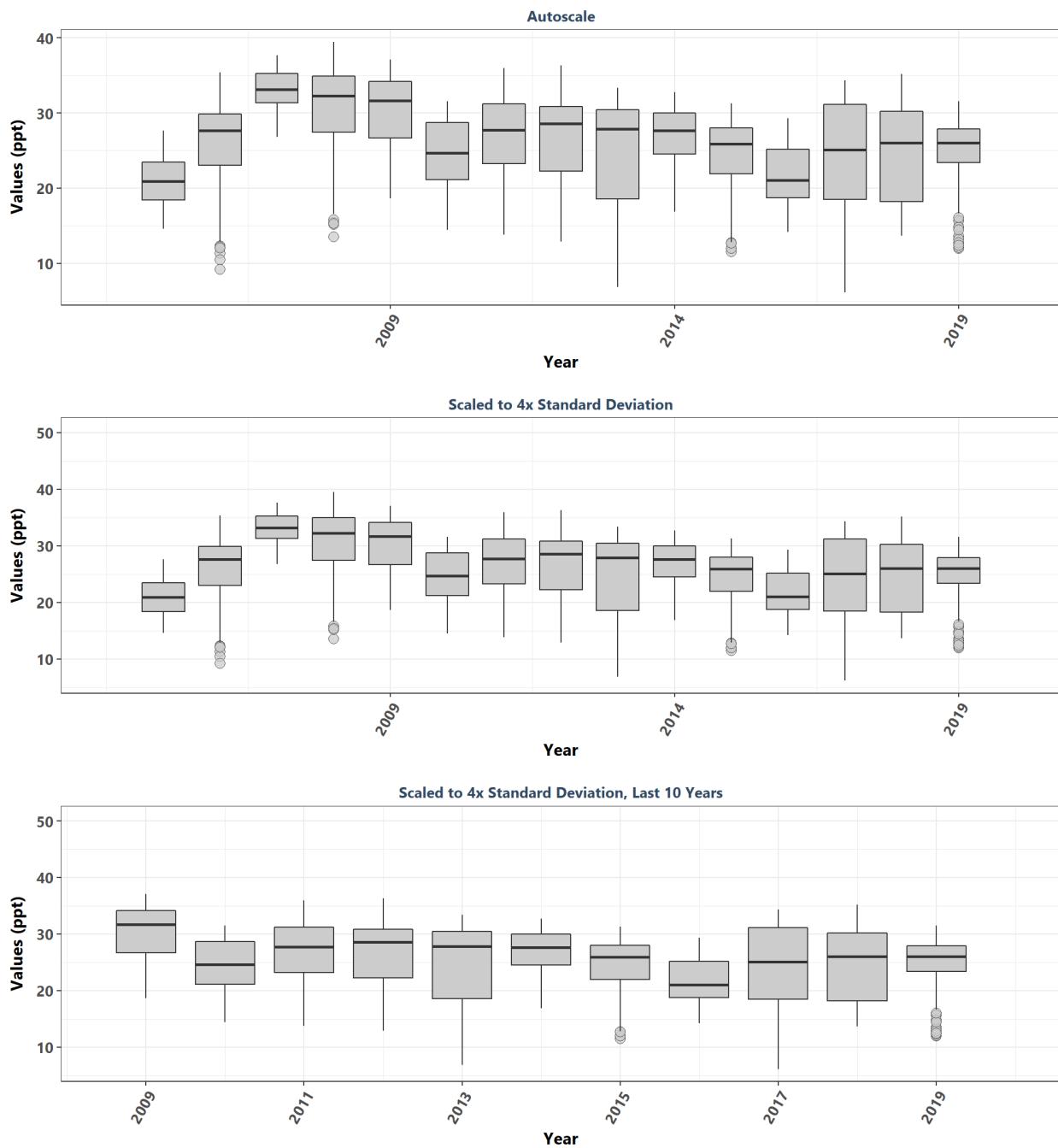
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB03
By Year & Month



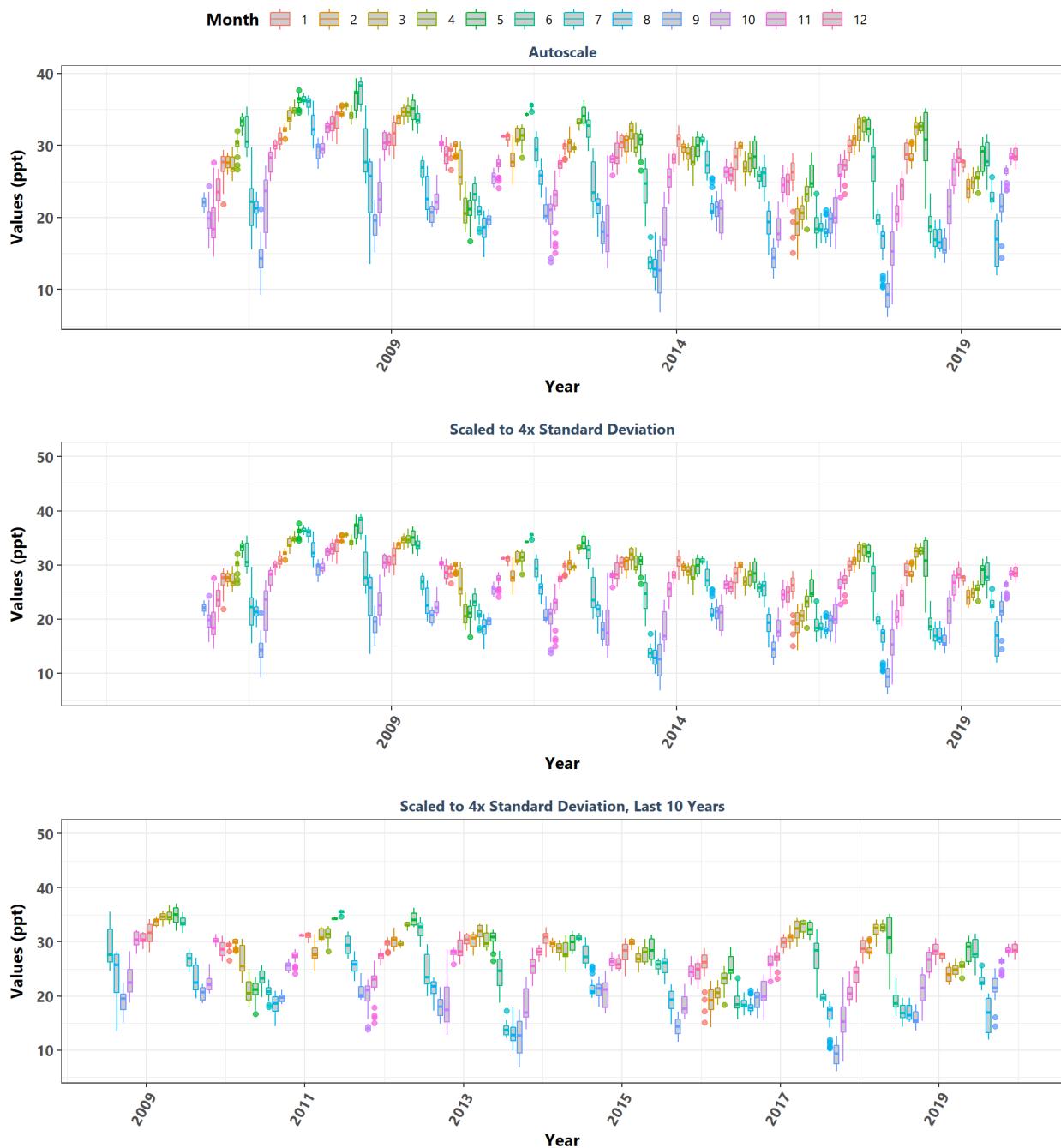
Estero Bay Aquatic Preserve
474 | Estero Bay Aquatic Preserve Continuous Water Quality Monitoring
EB03
By Month



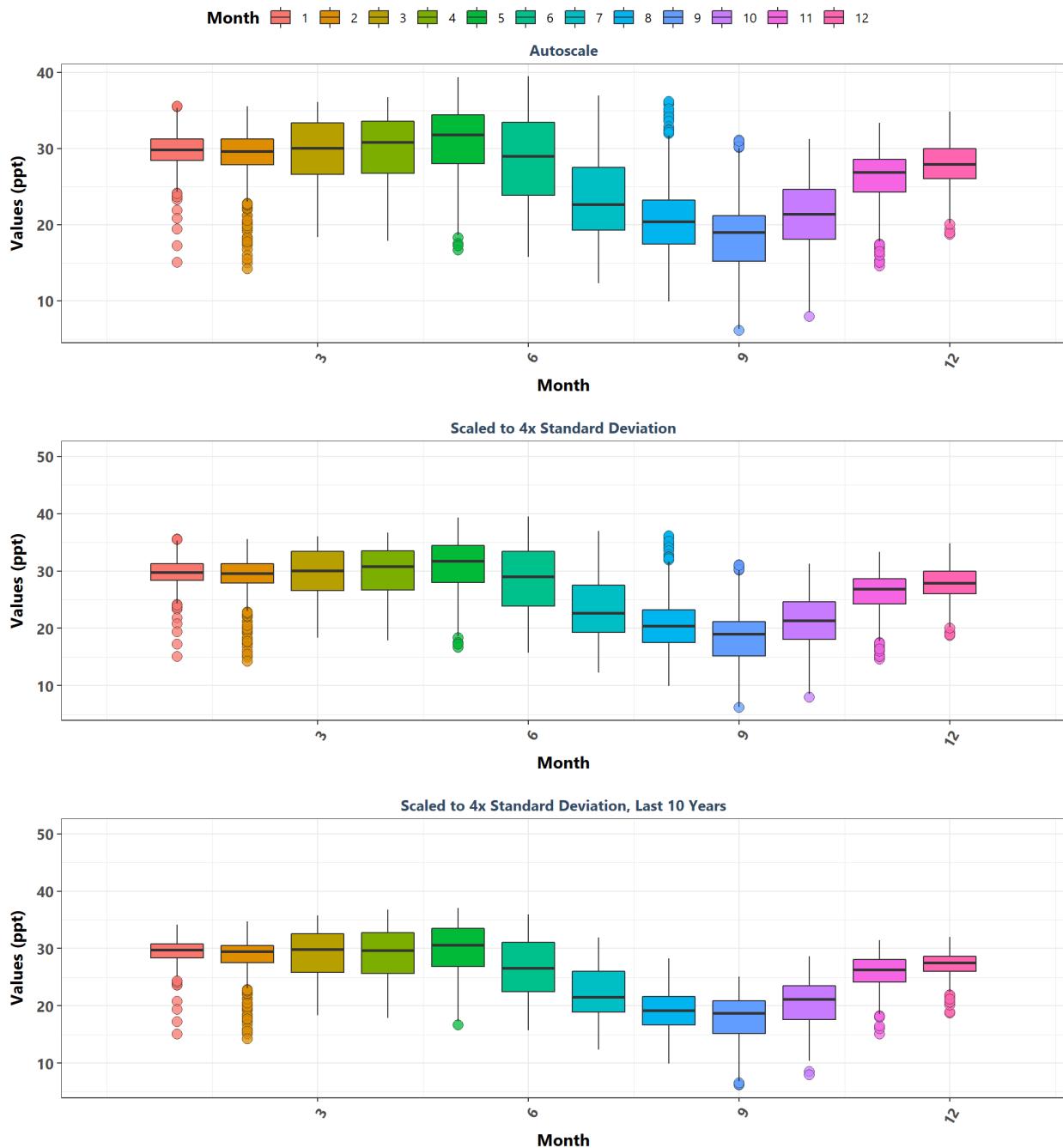
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP1A
By Year



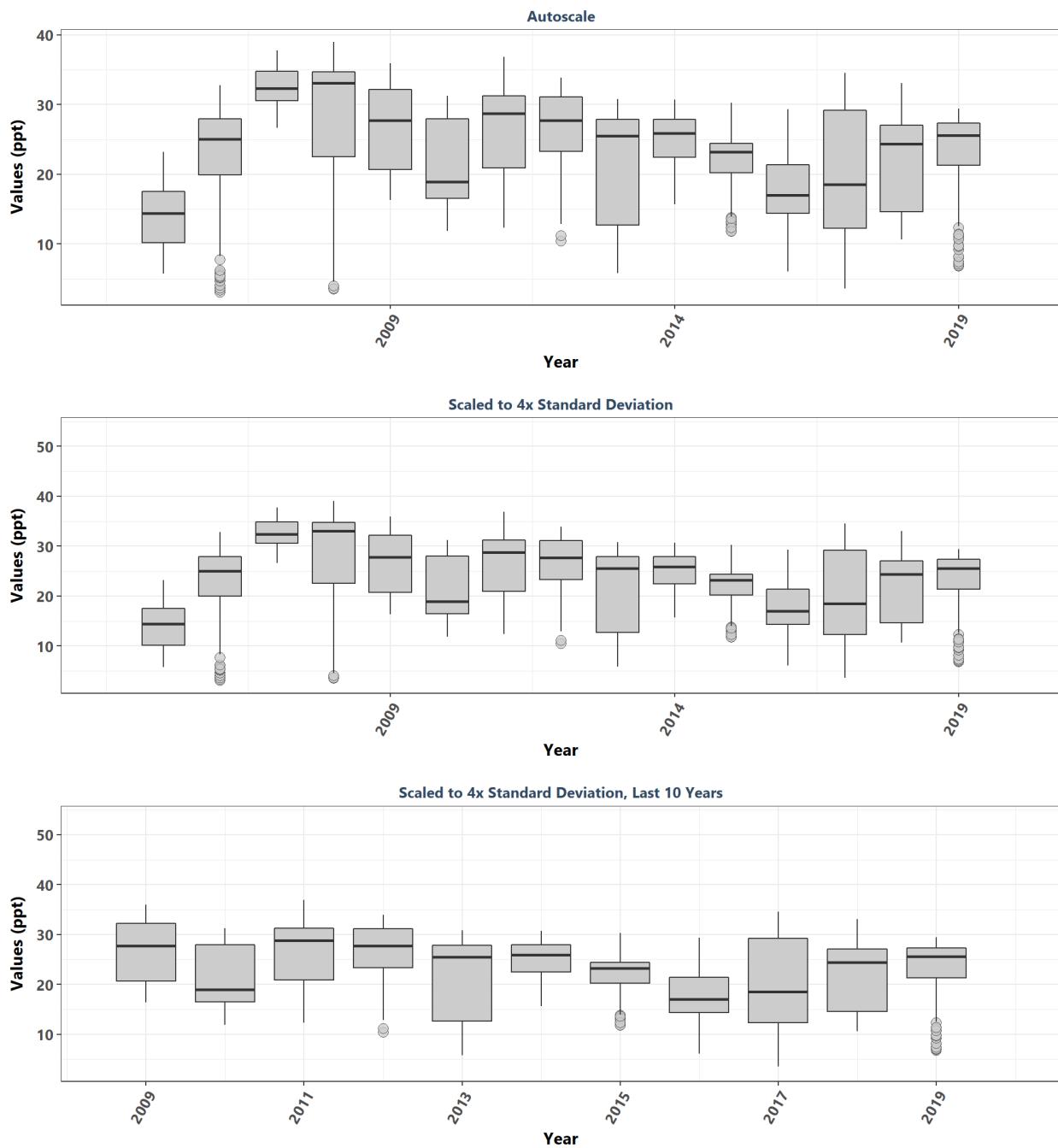
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP1A
By Year & Month



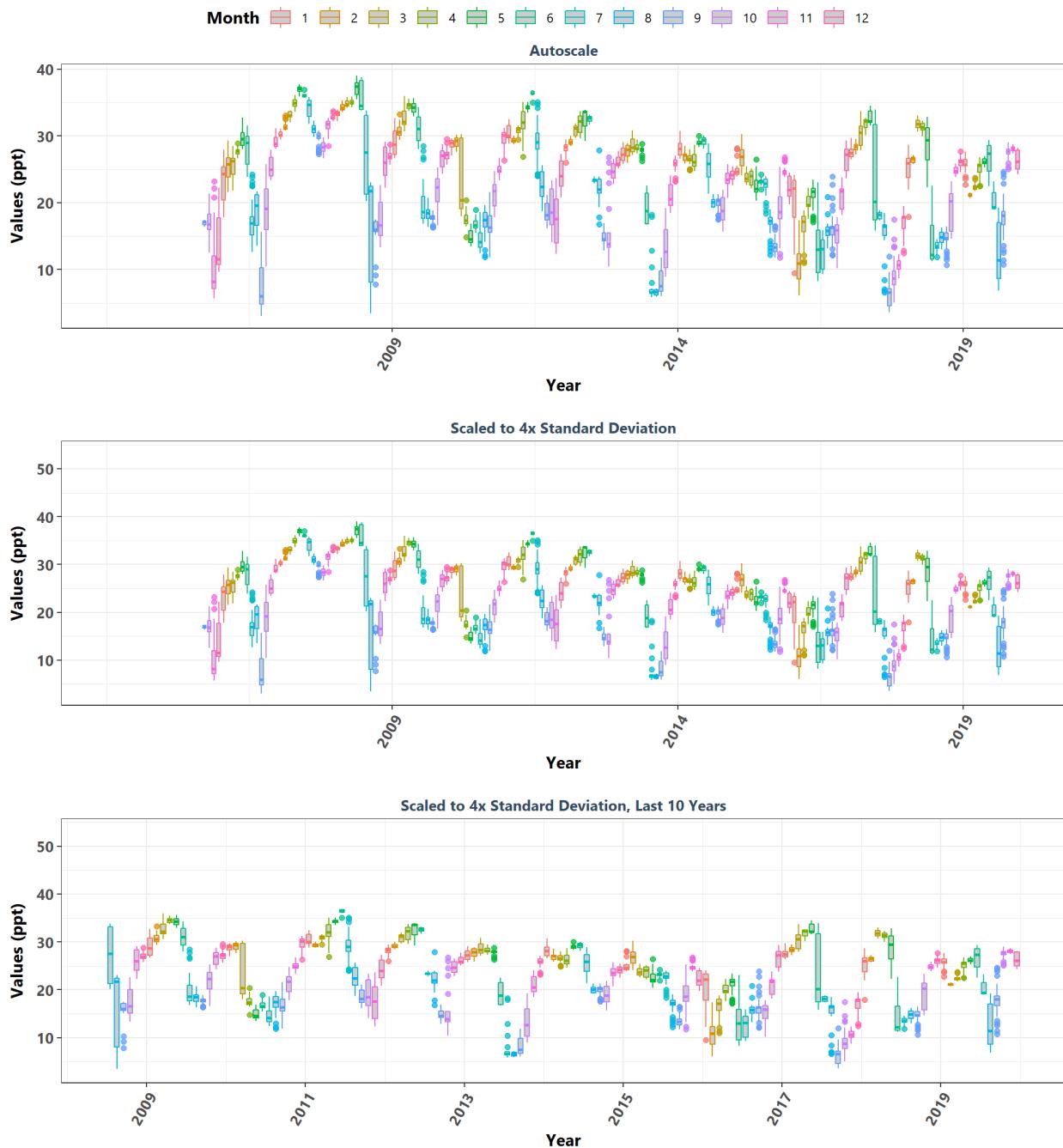
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP1A
By Month



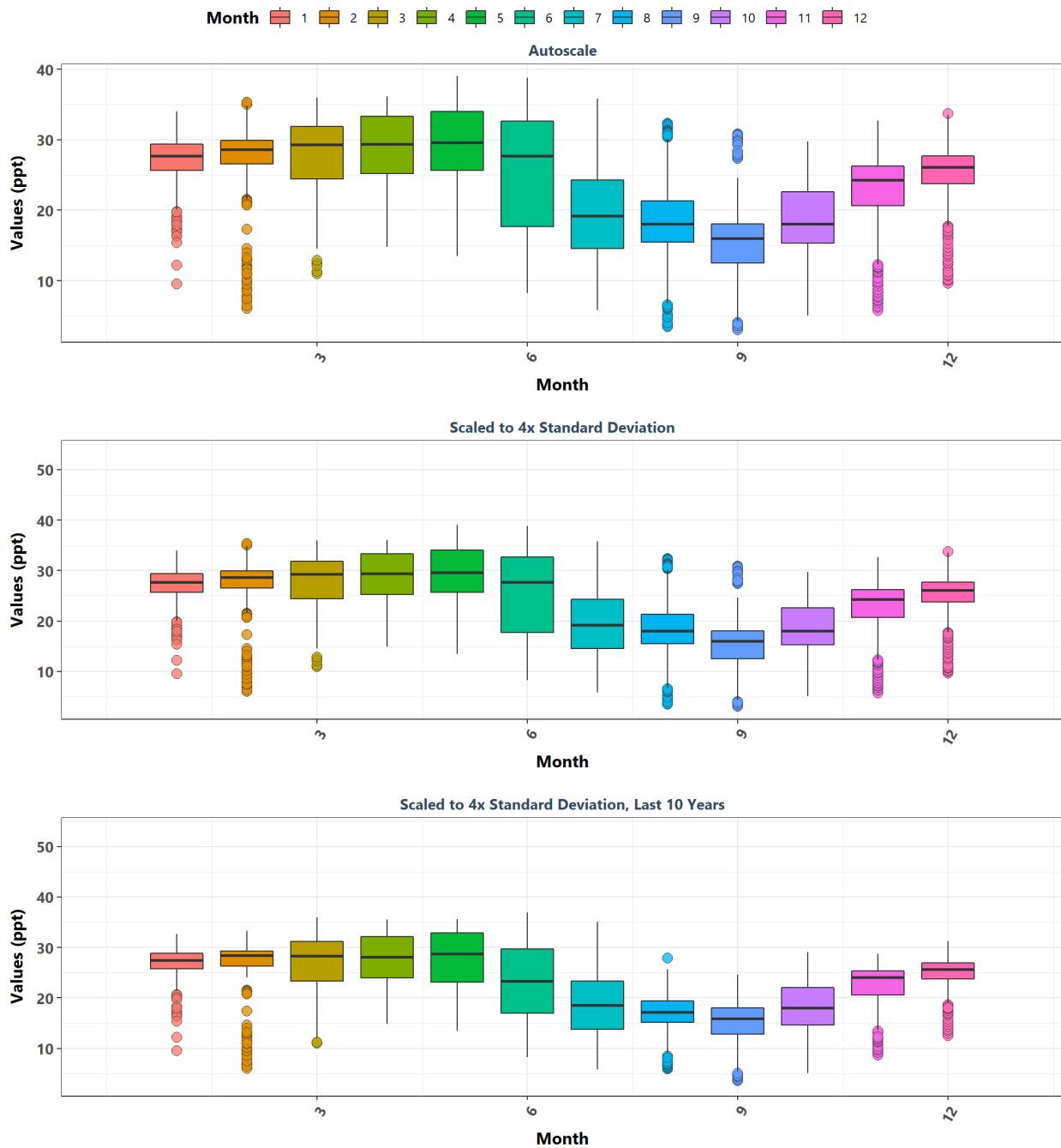
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP2B
By Year



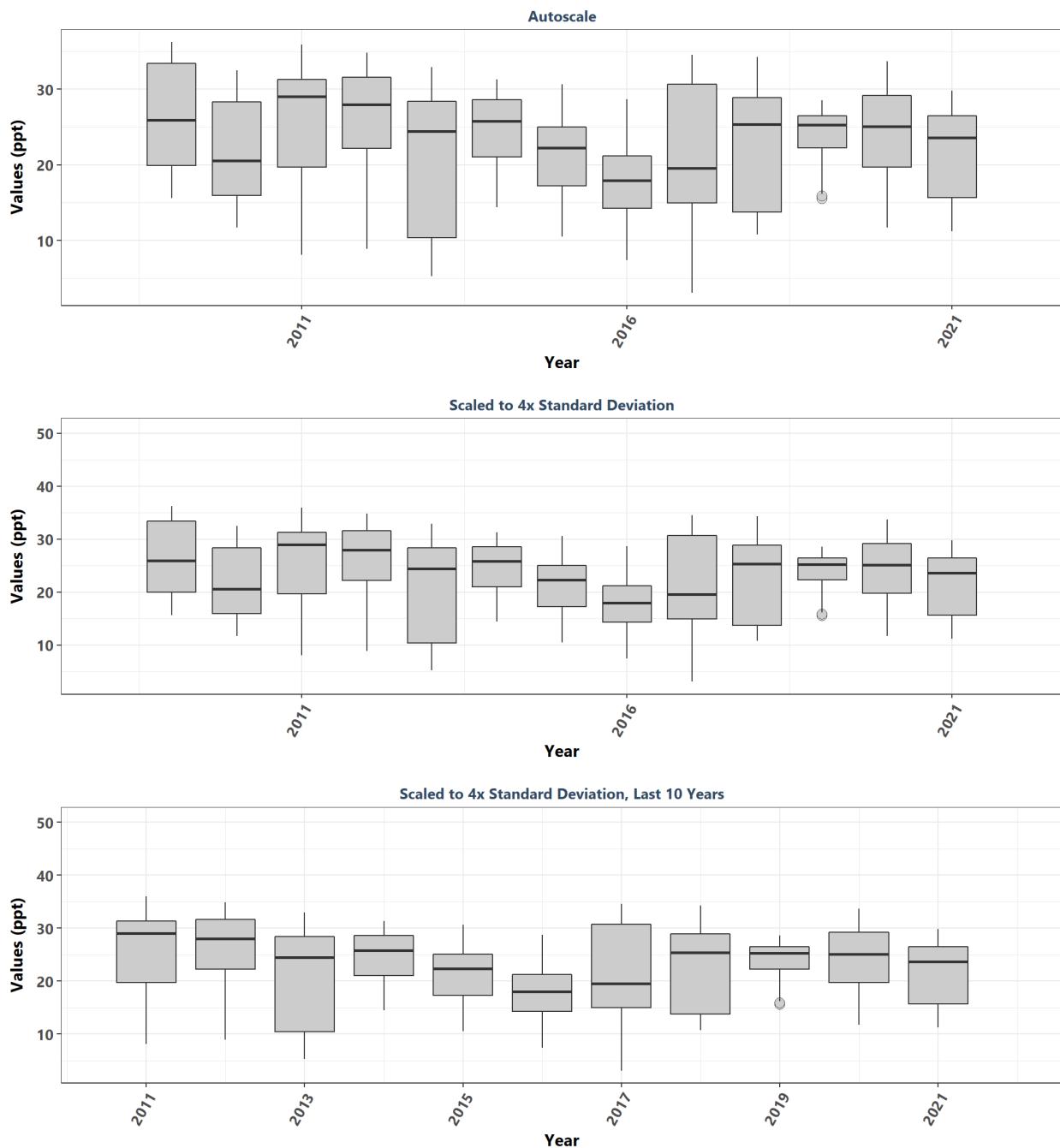
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP2B
By Year & Month



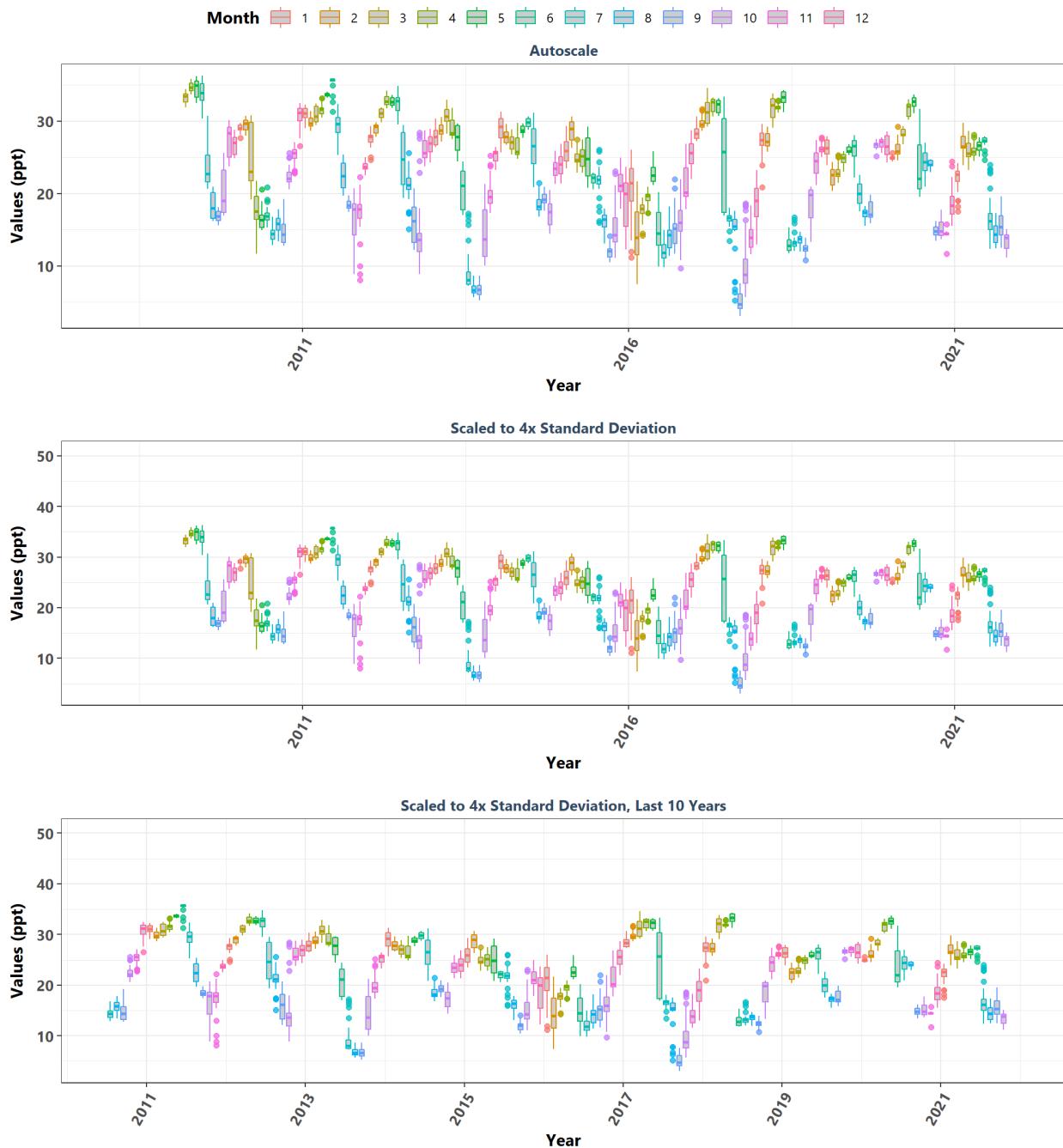
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP2B
By Month



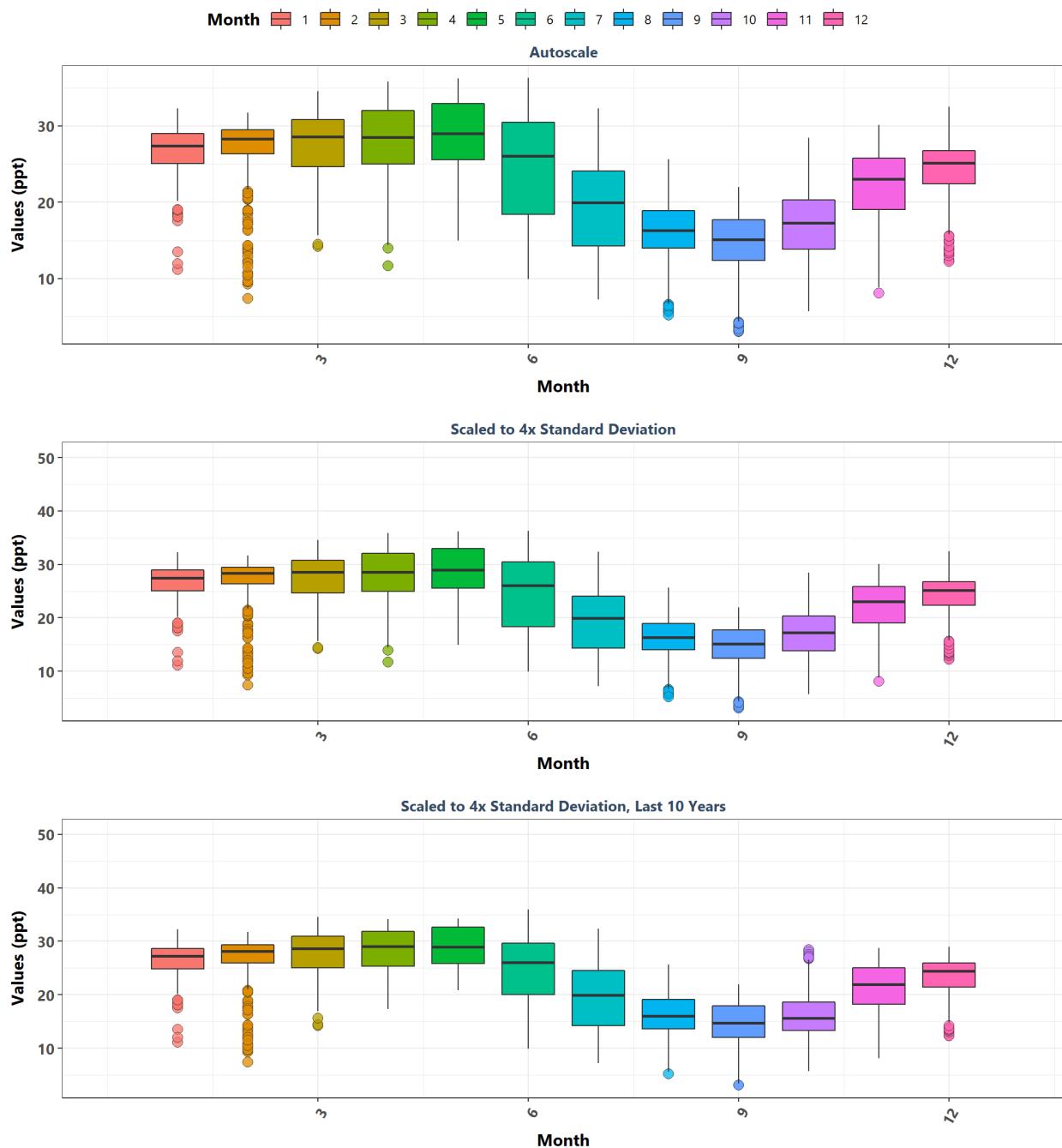
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP3C
By Year



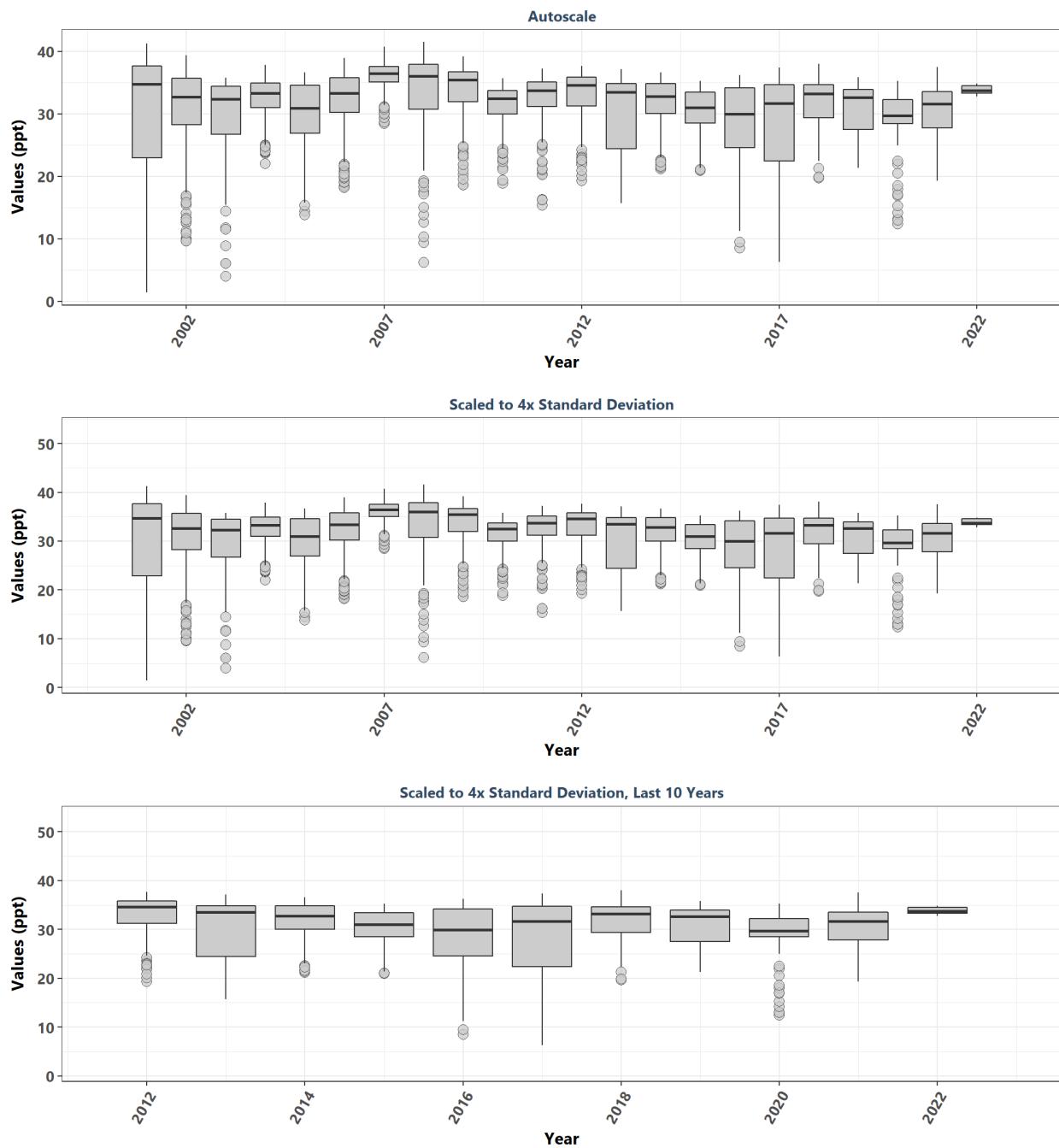
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP3C
By Year & Month



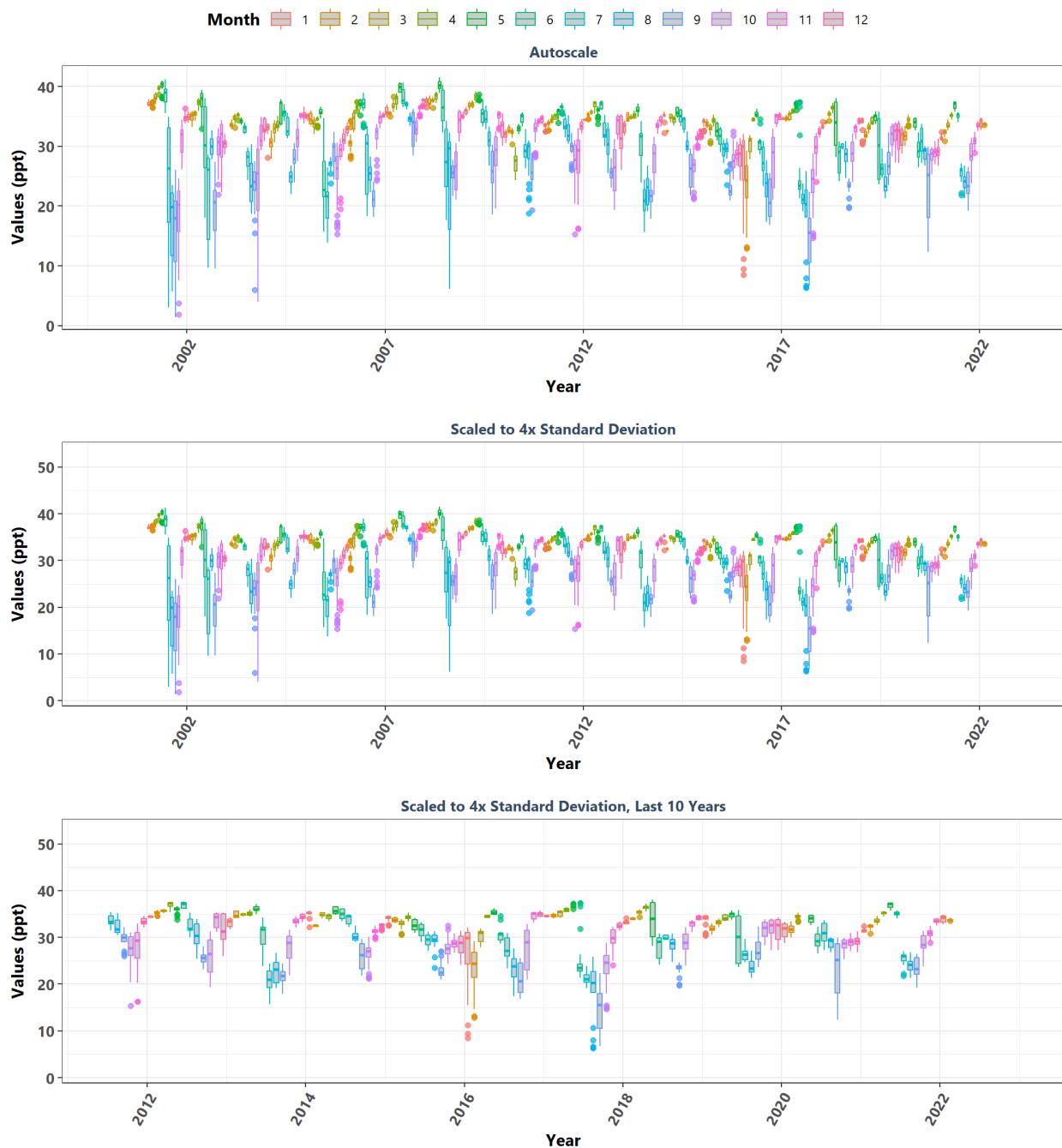
Matlacha Pass Aquatic Preserve
512 | Matlacha Pass Aquatic Preserve Continuous Water Quality Monitoring Program
MP3C
By Month



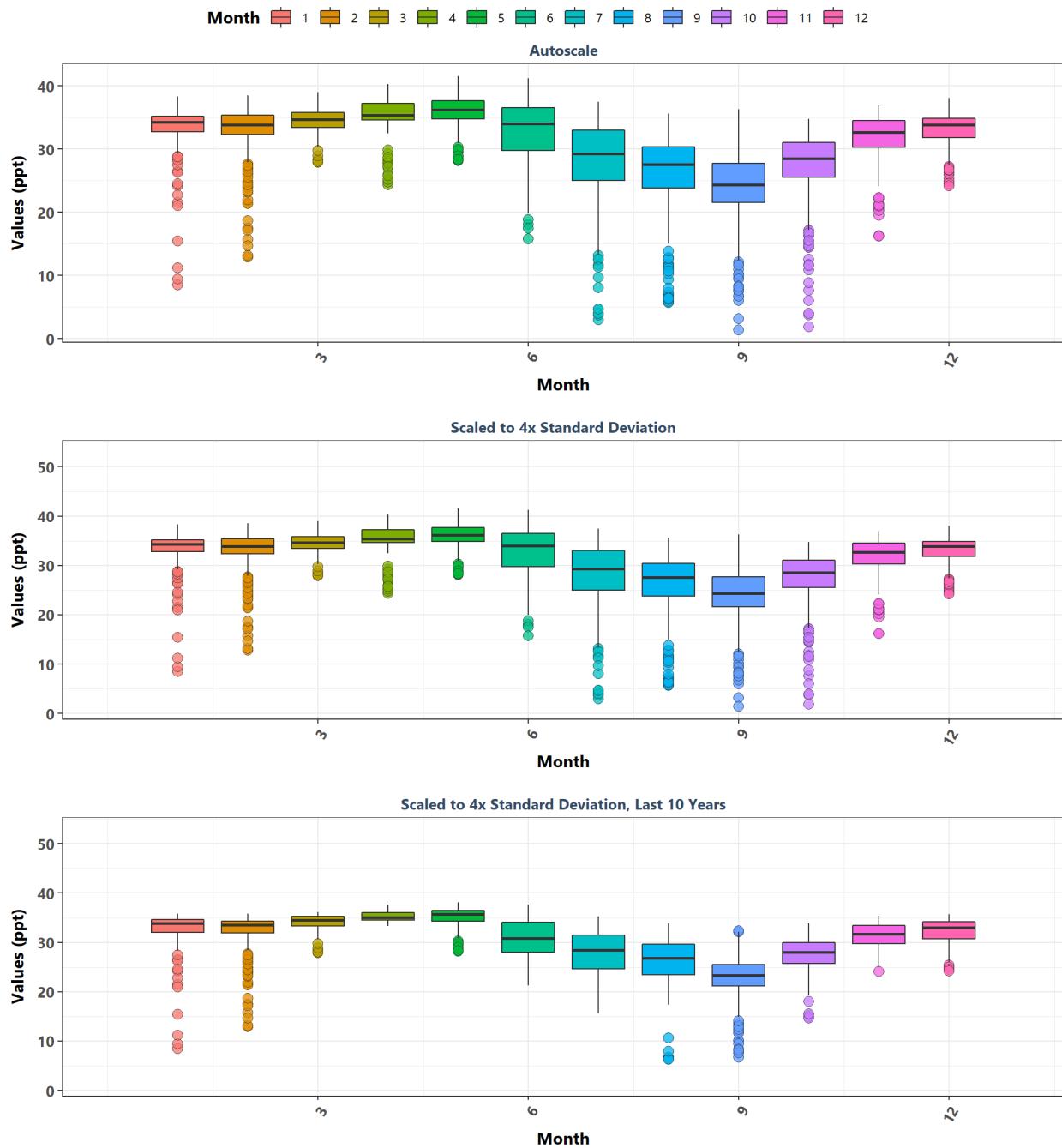
Rookery Bay Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbhwq
By Year



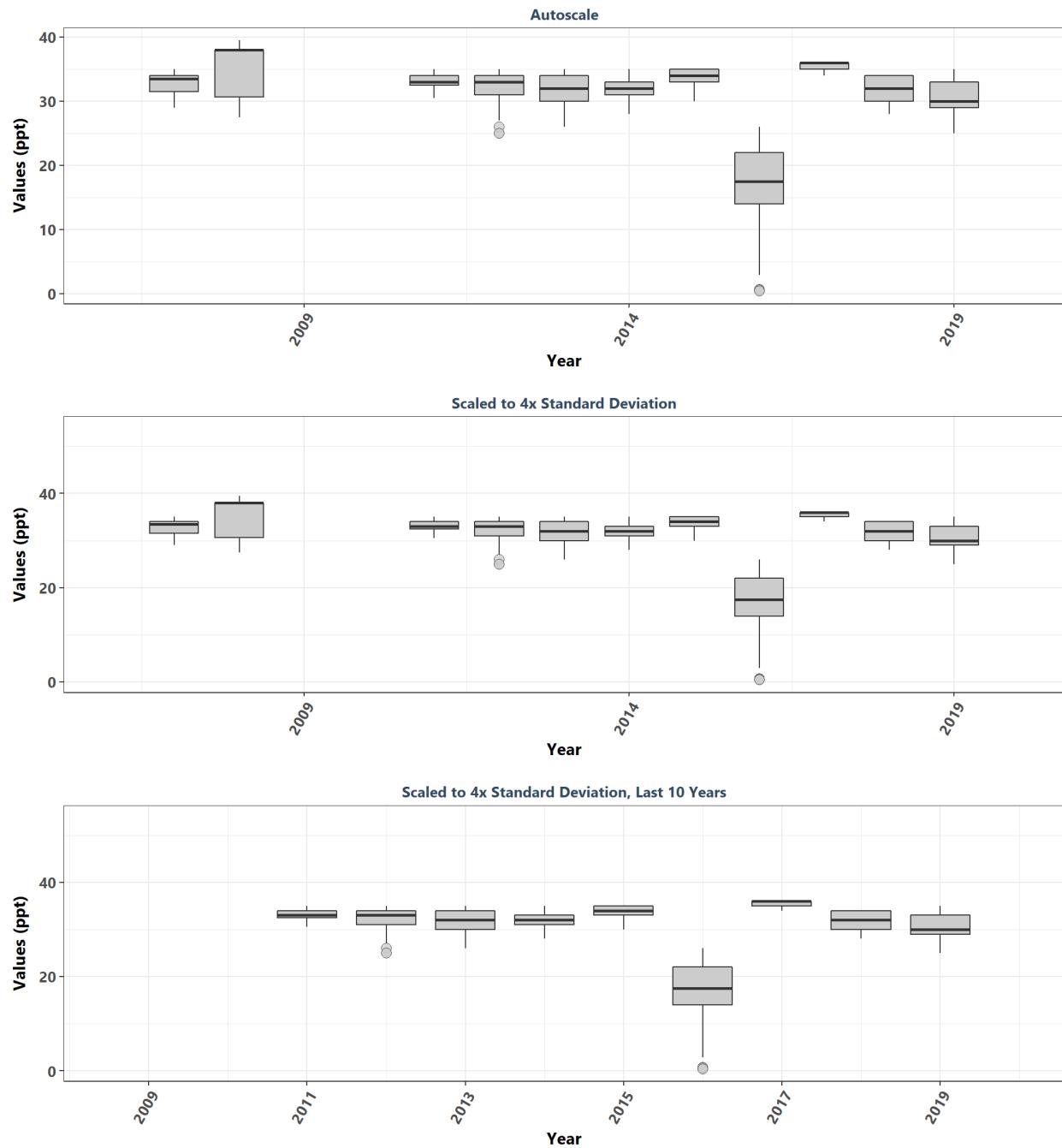
Rookery Bay Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbhwq
By Year & Month



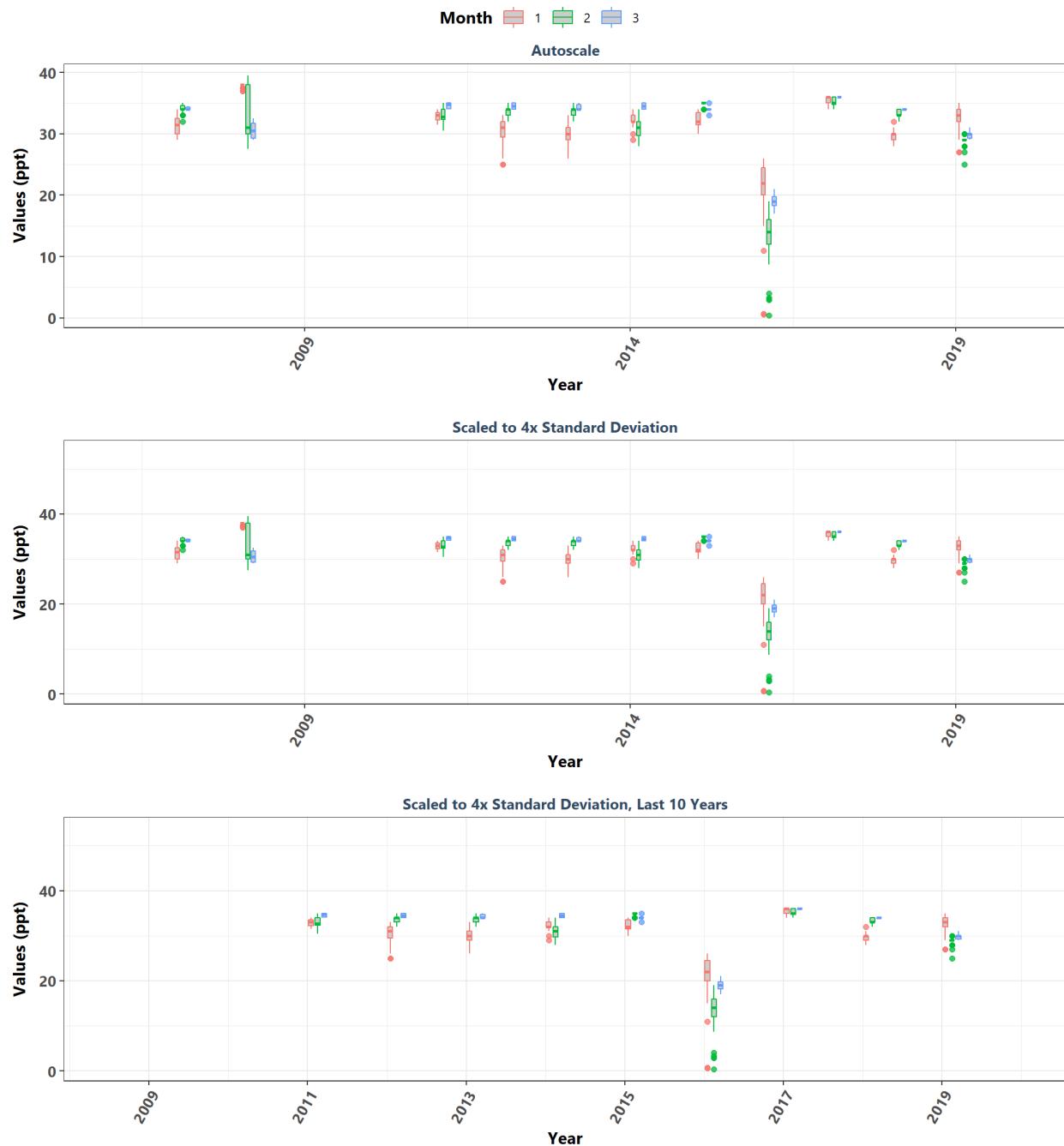
Rookery Bay Aquatic Preserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
rkbhwq
By Month



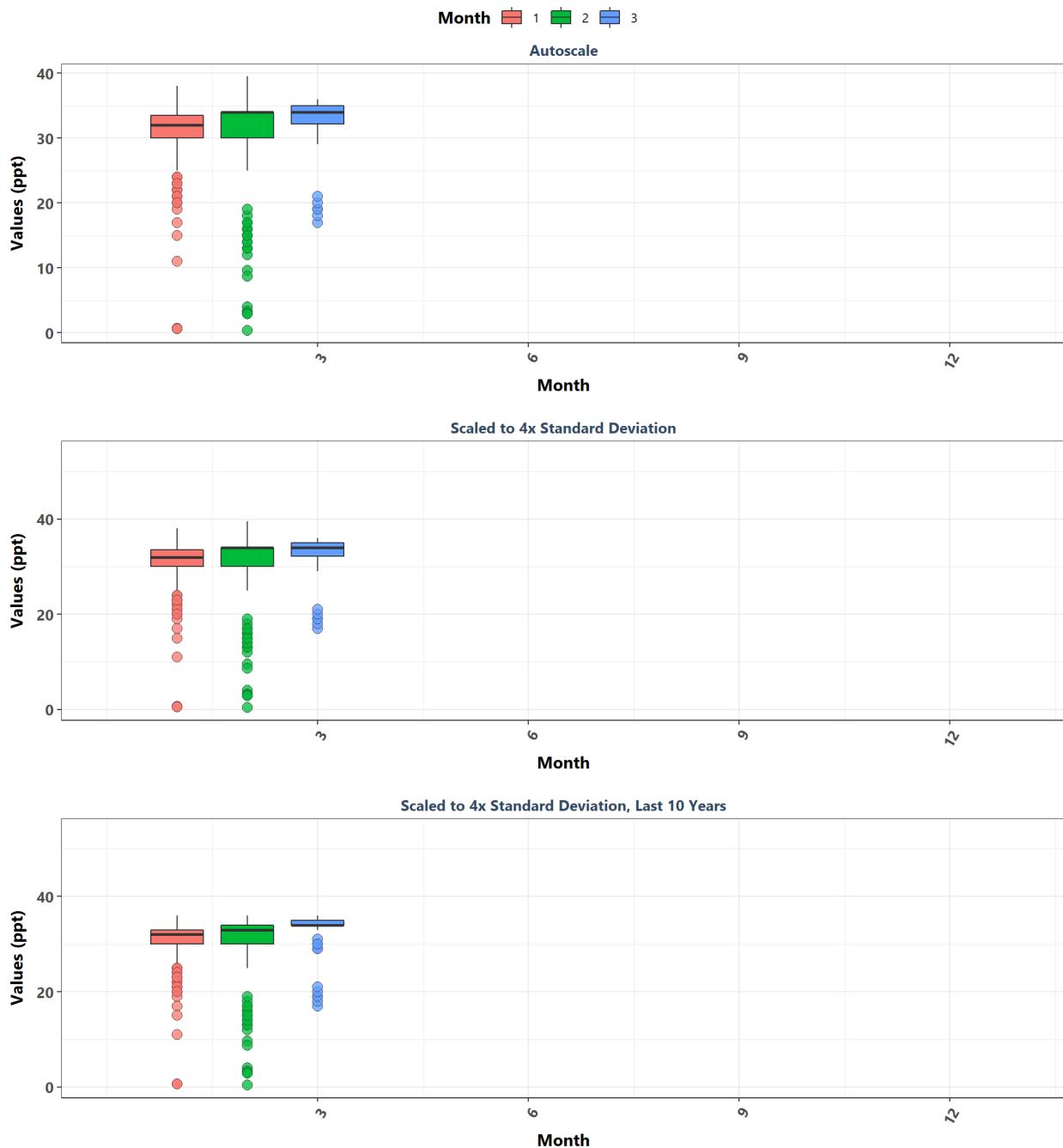
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255432081303900
By Year



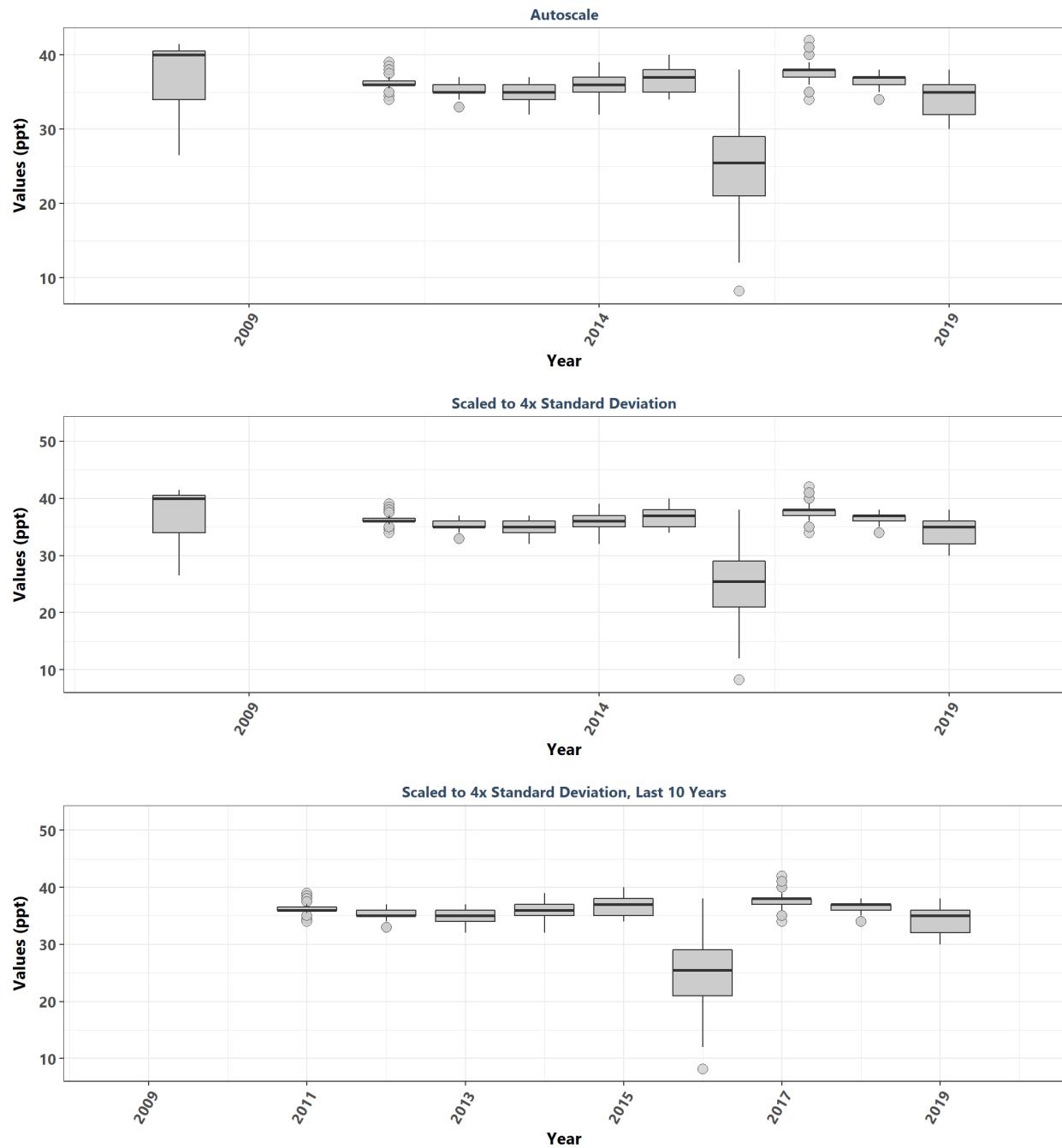
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255432081303900
By Year & Month



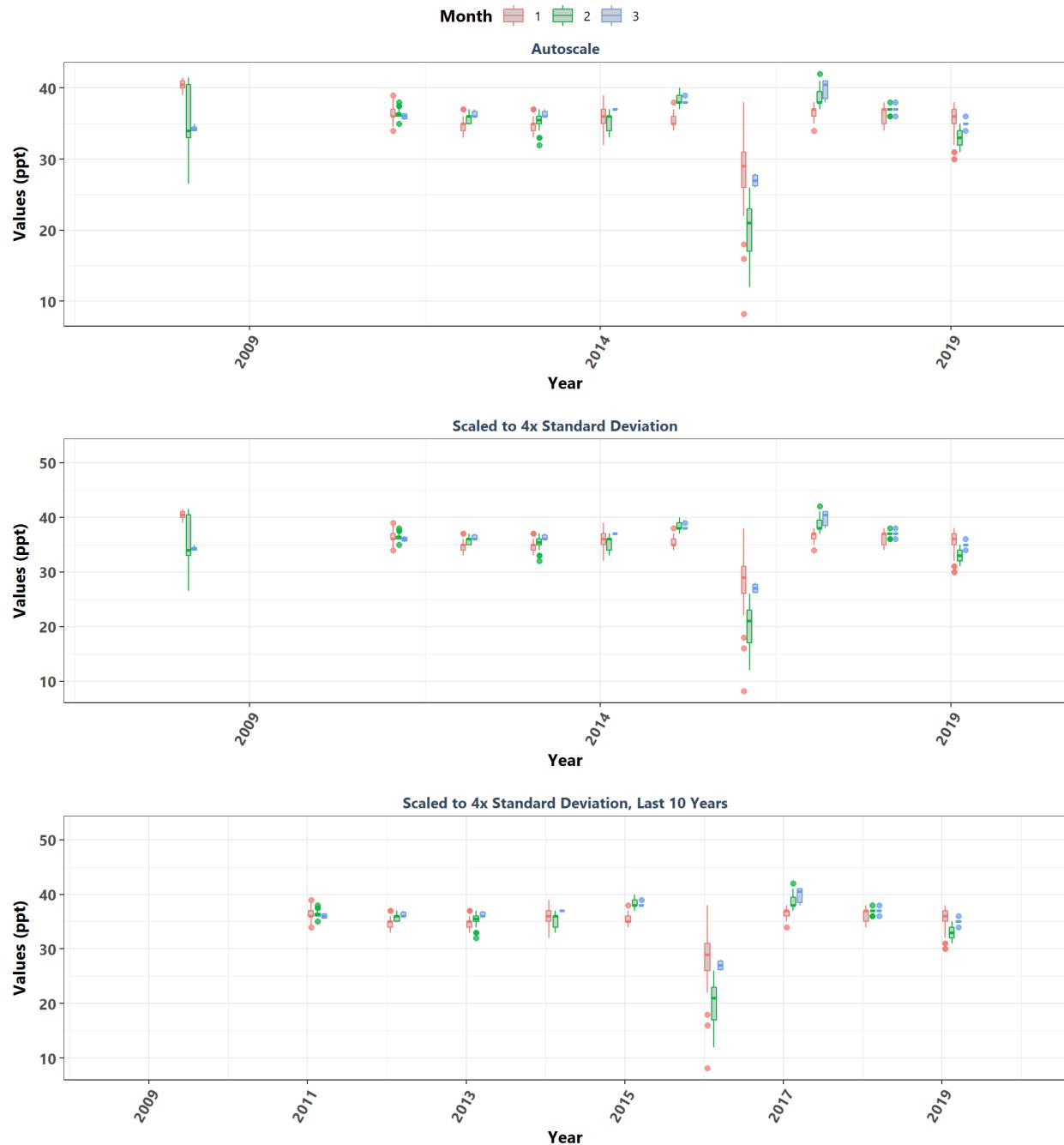
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255432081303900
By Month



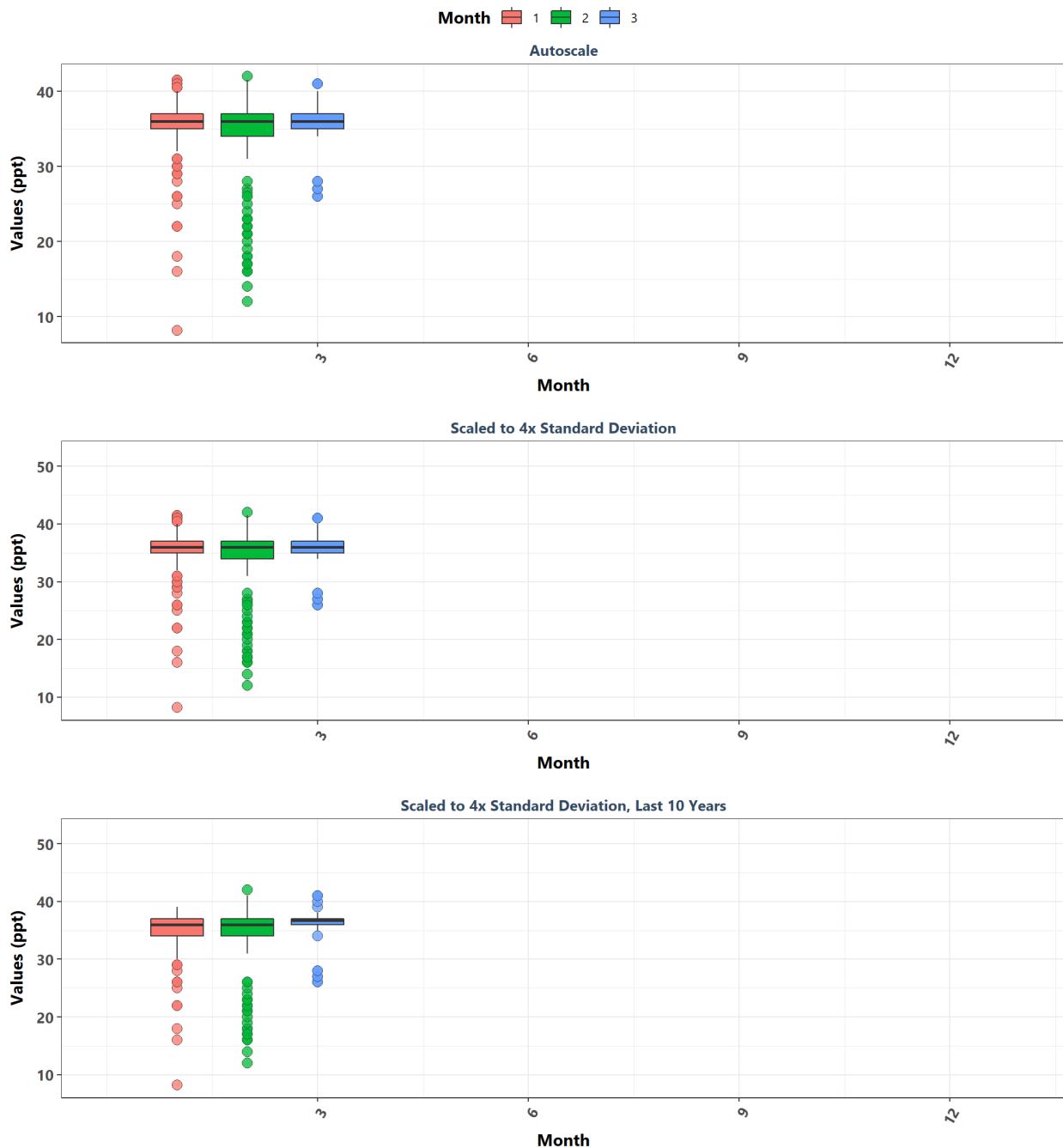
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255534081324000
 By Year



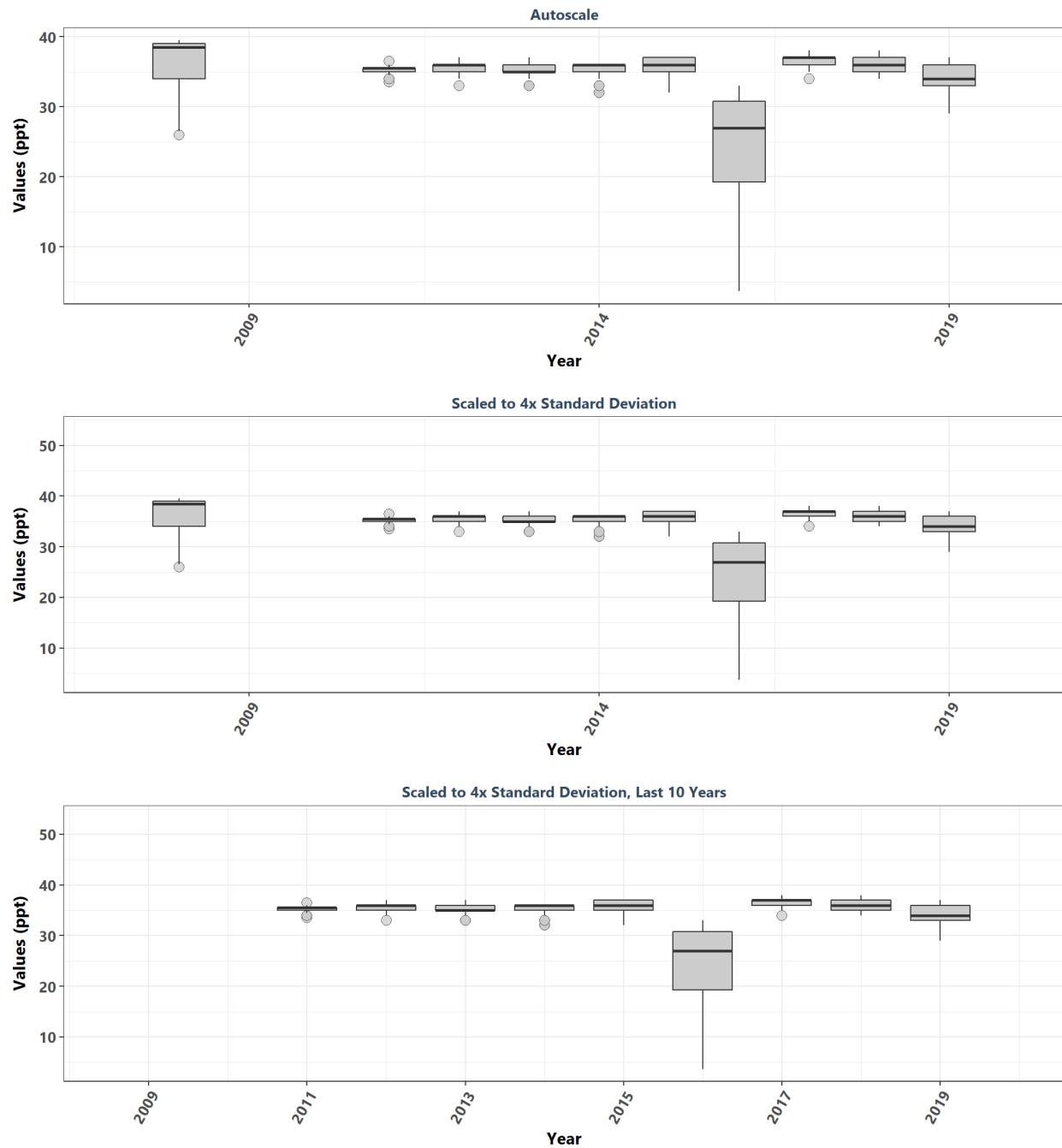
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255534081324000
By Year & Month



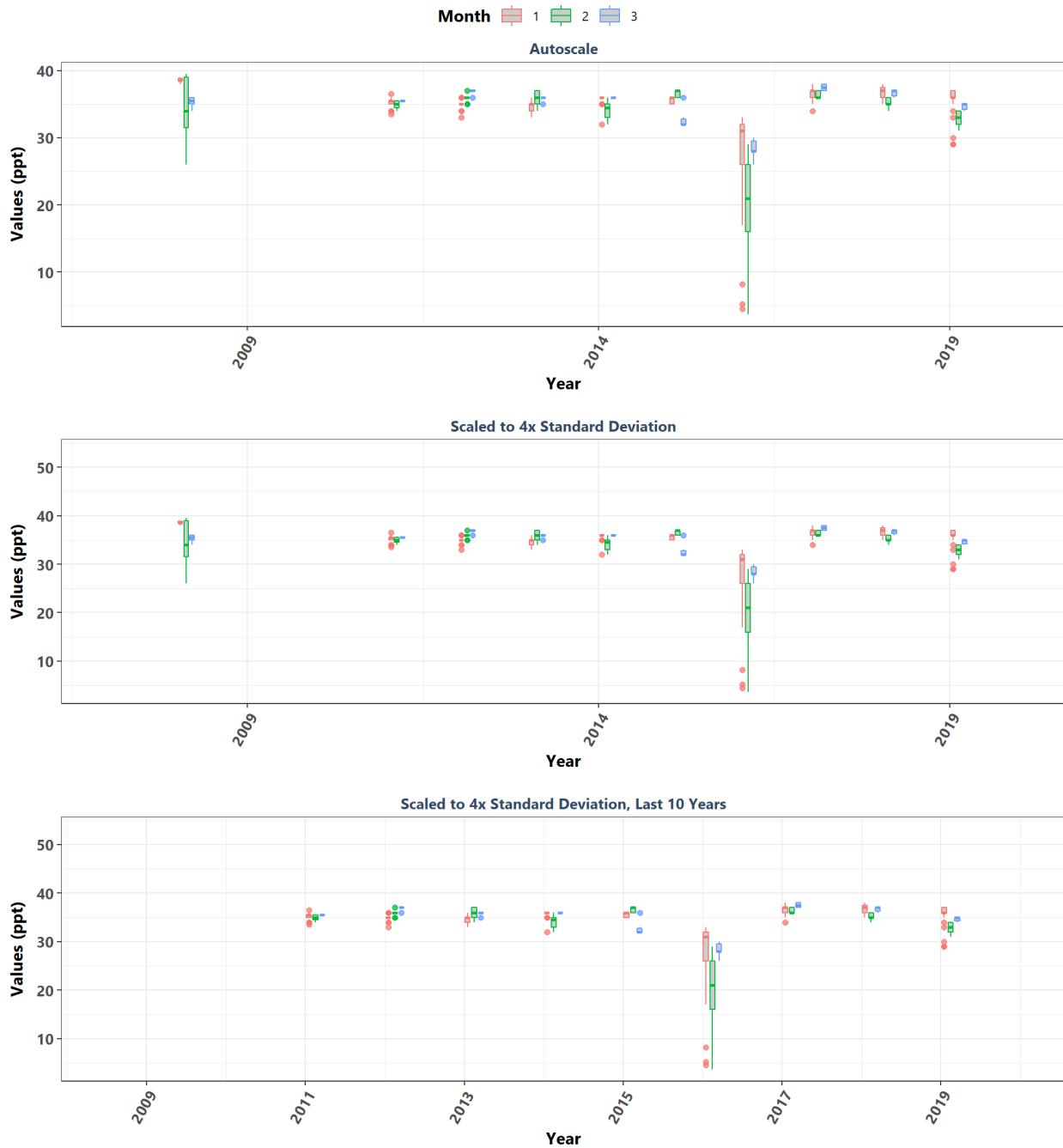
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255534081324000
By Month



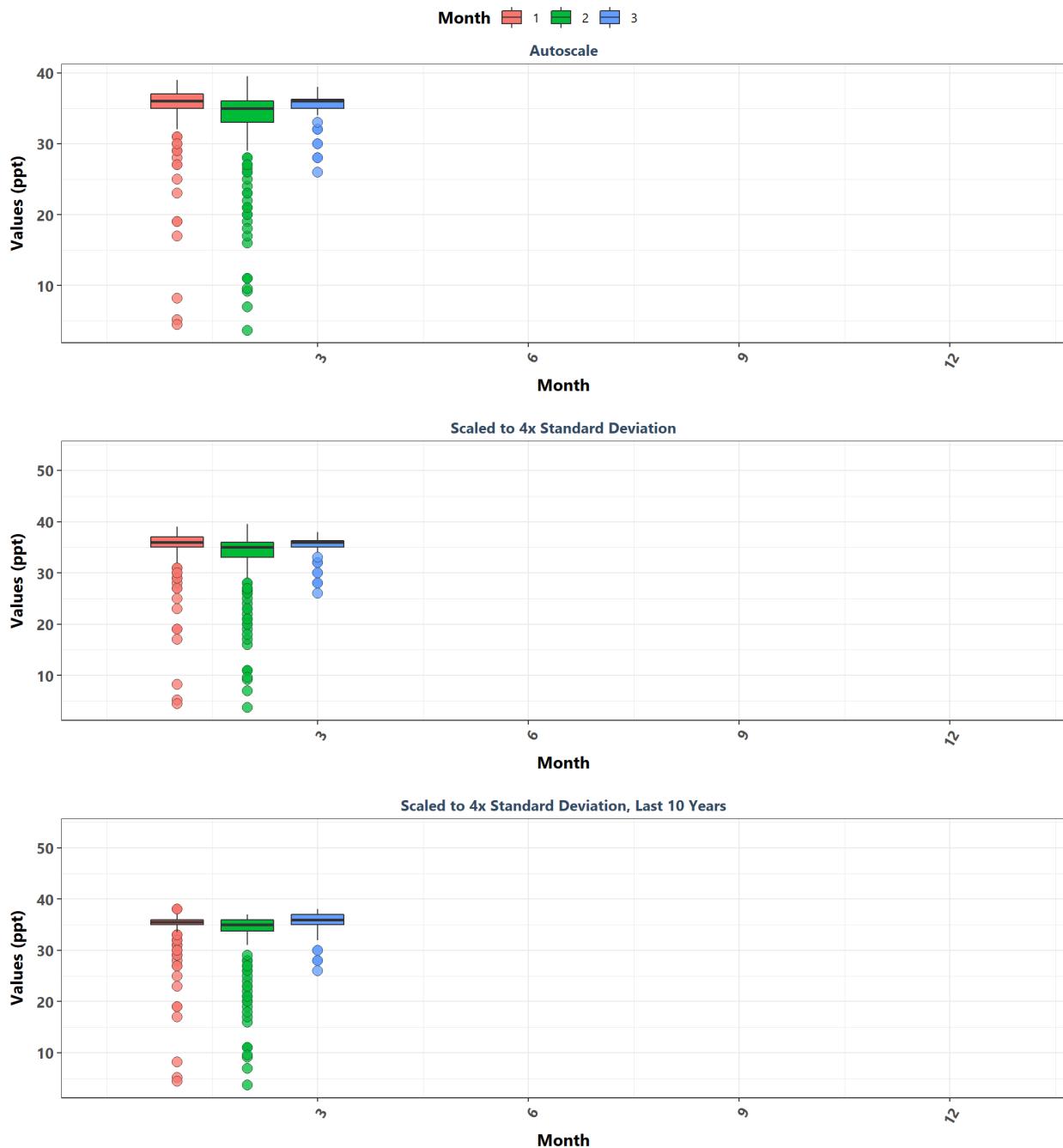
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
255654081350200
By Year



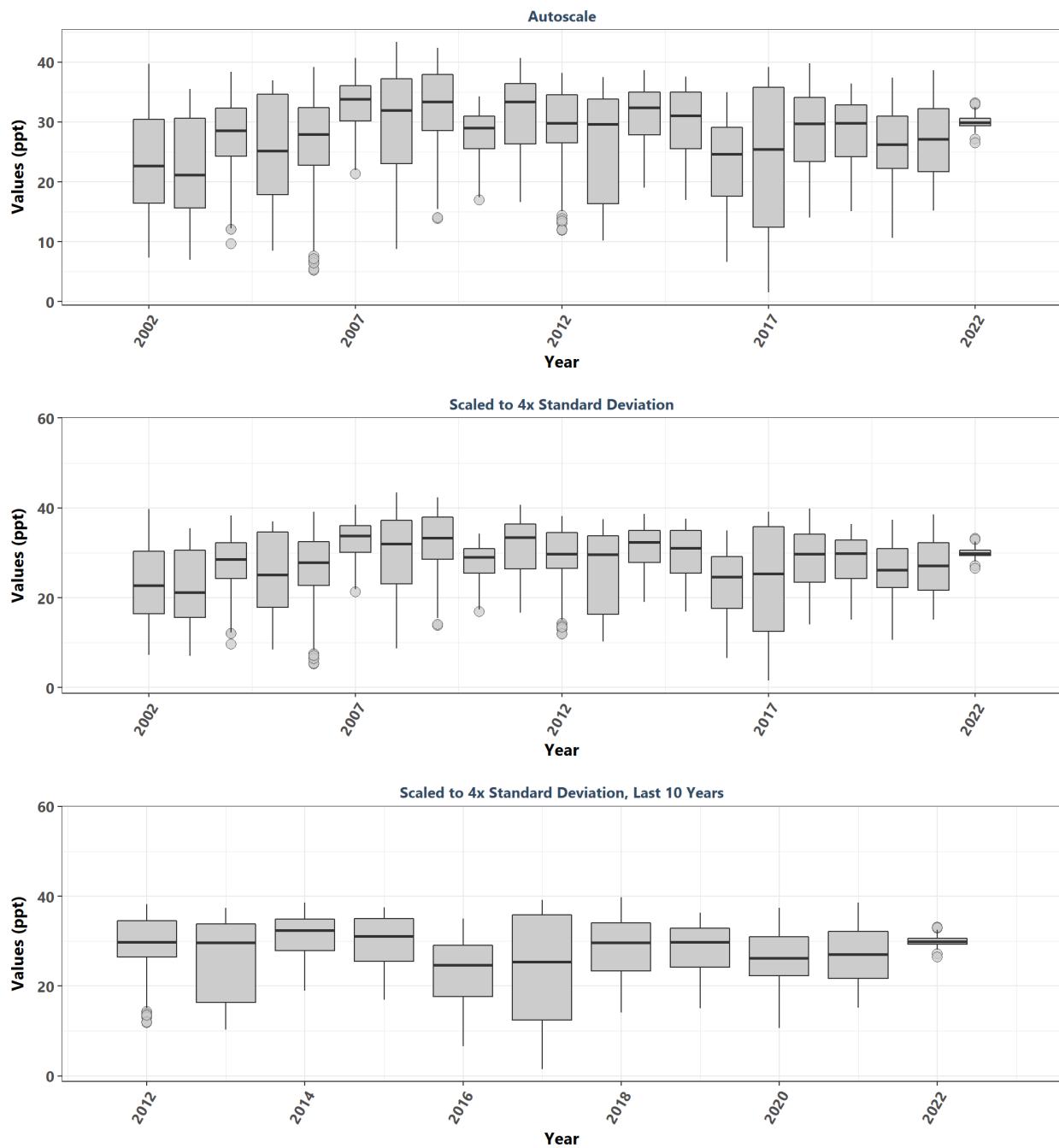
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
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By Year & Month



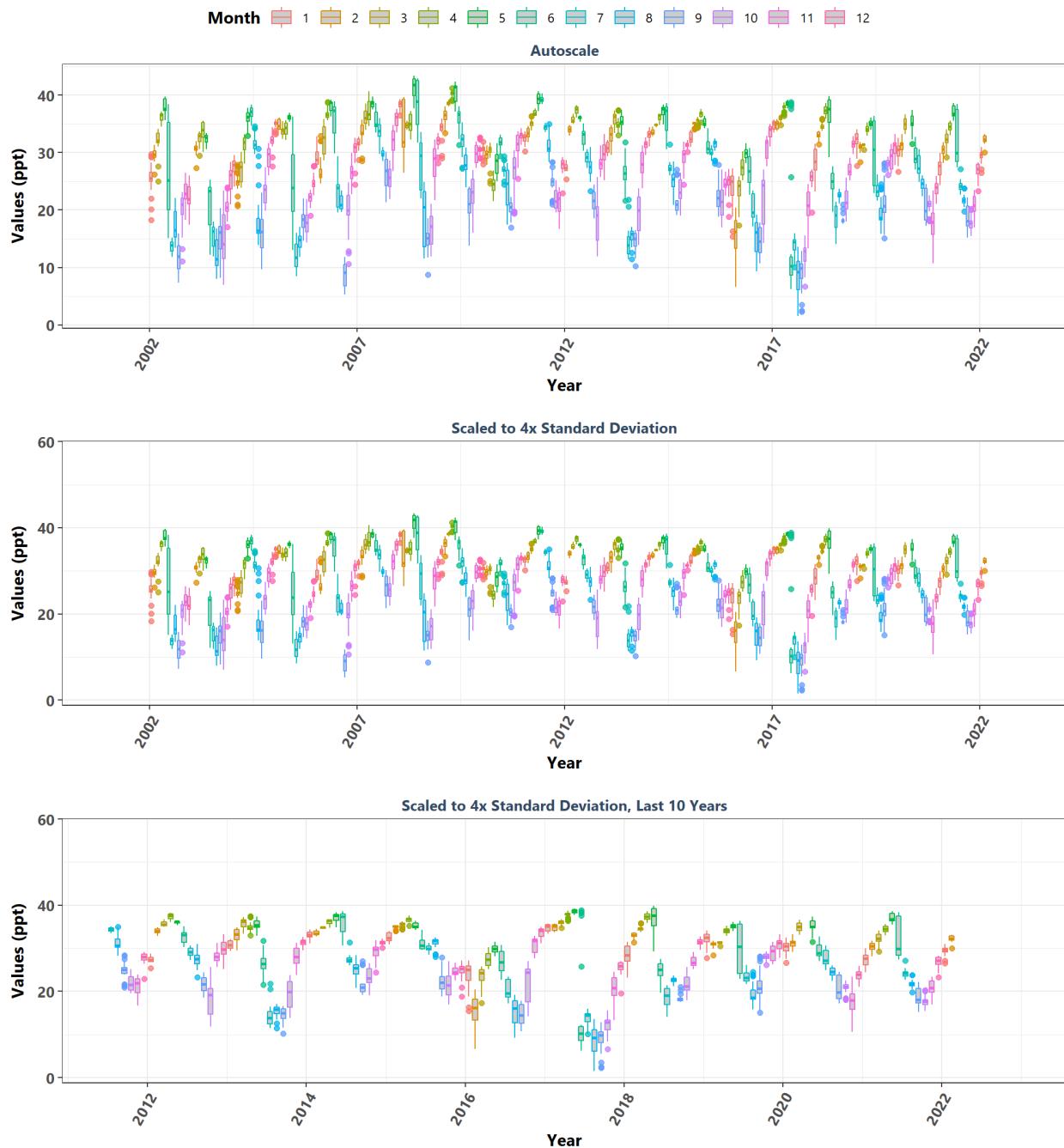
Rookery Bay National Estuarine Research Reserve
7 | National Water Information System
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By Month



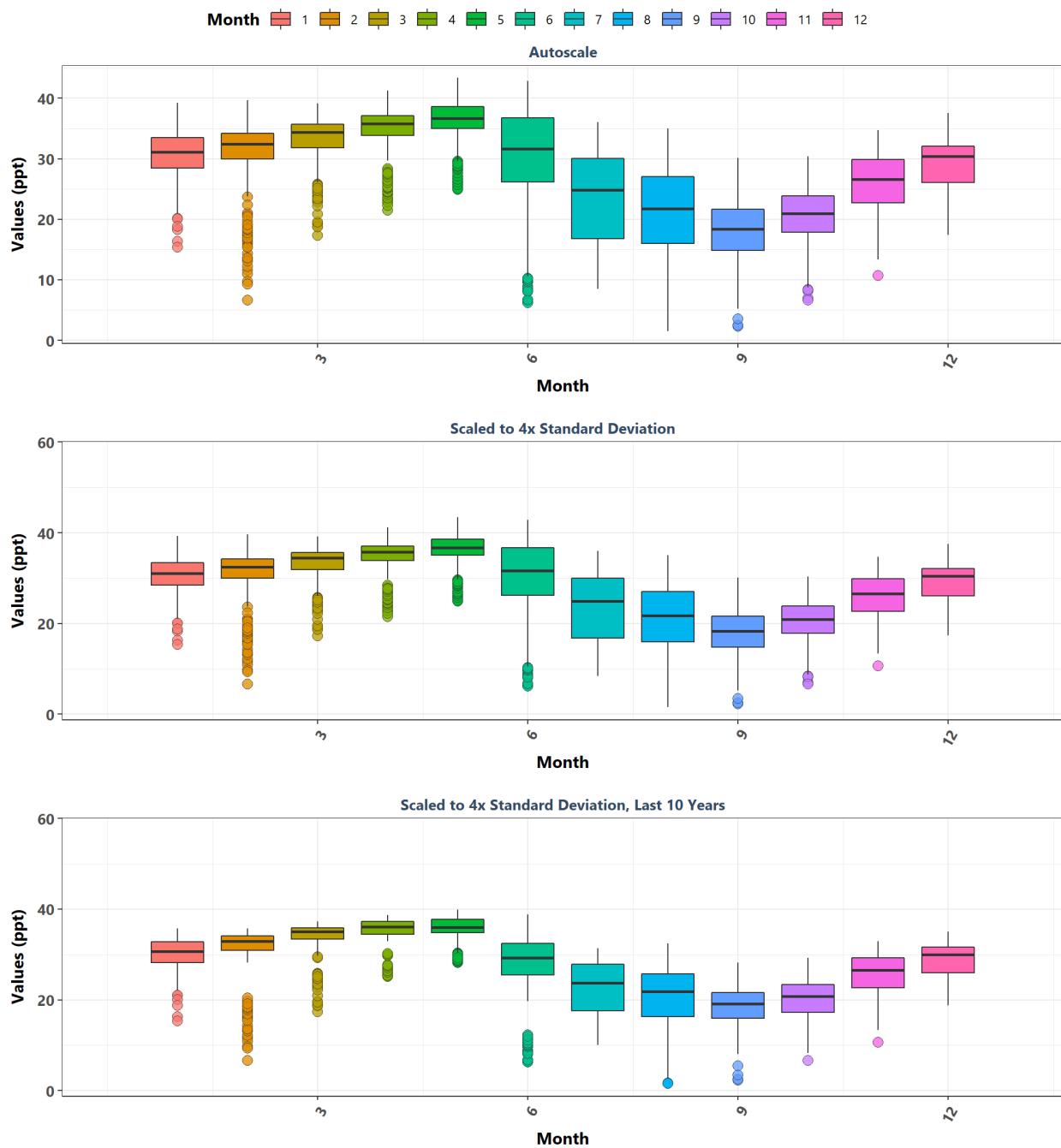
Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
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By Year



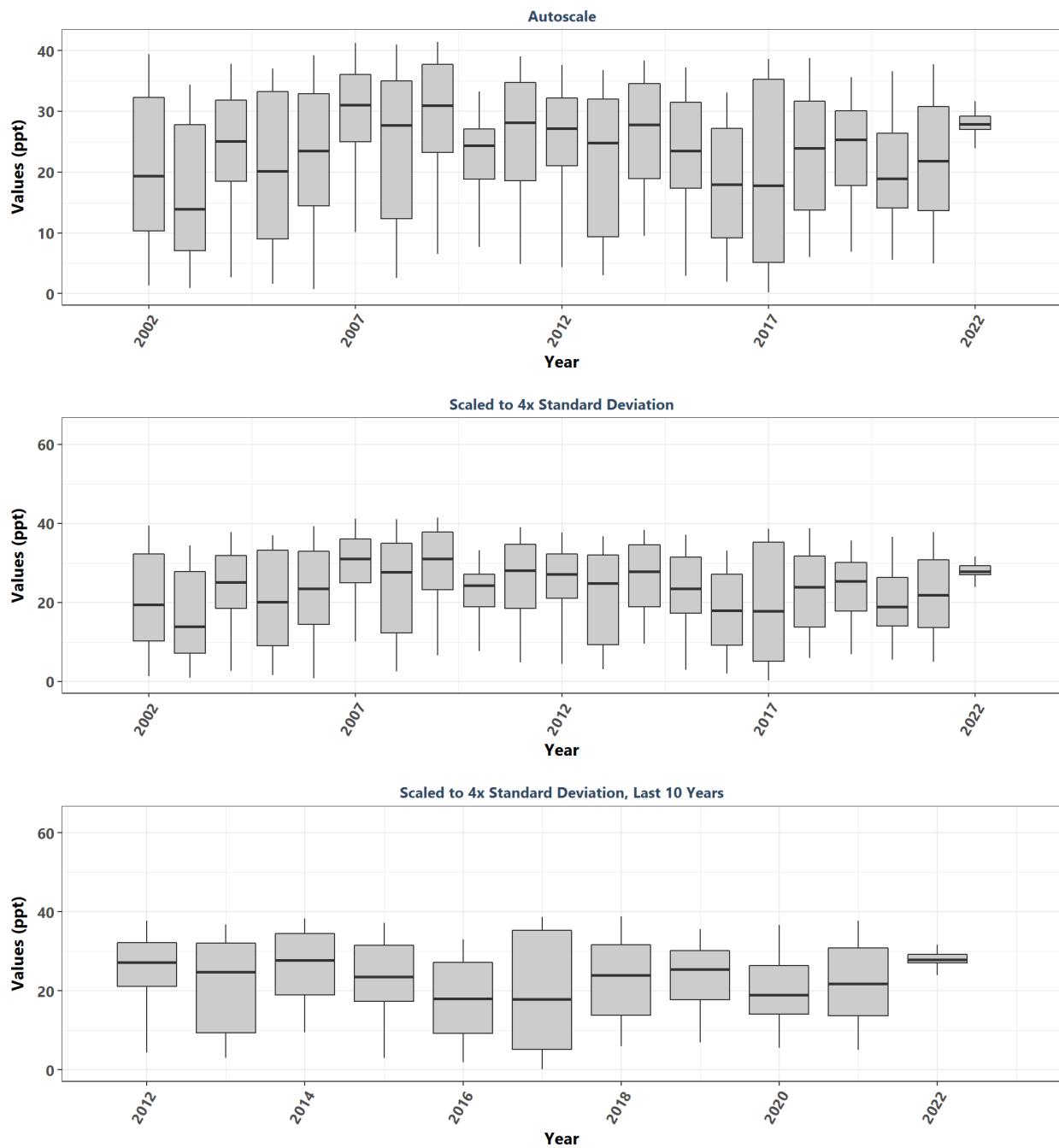
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By Year & Month



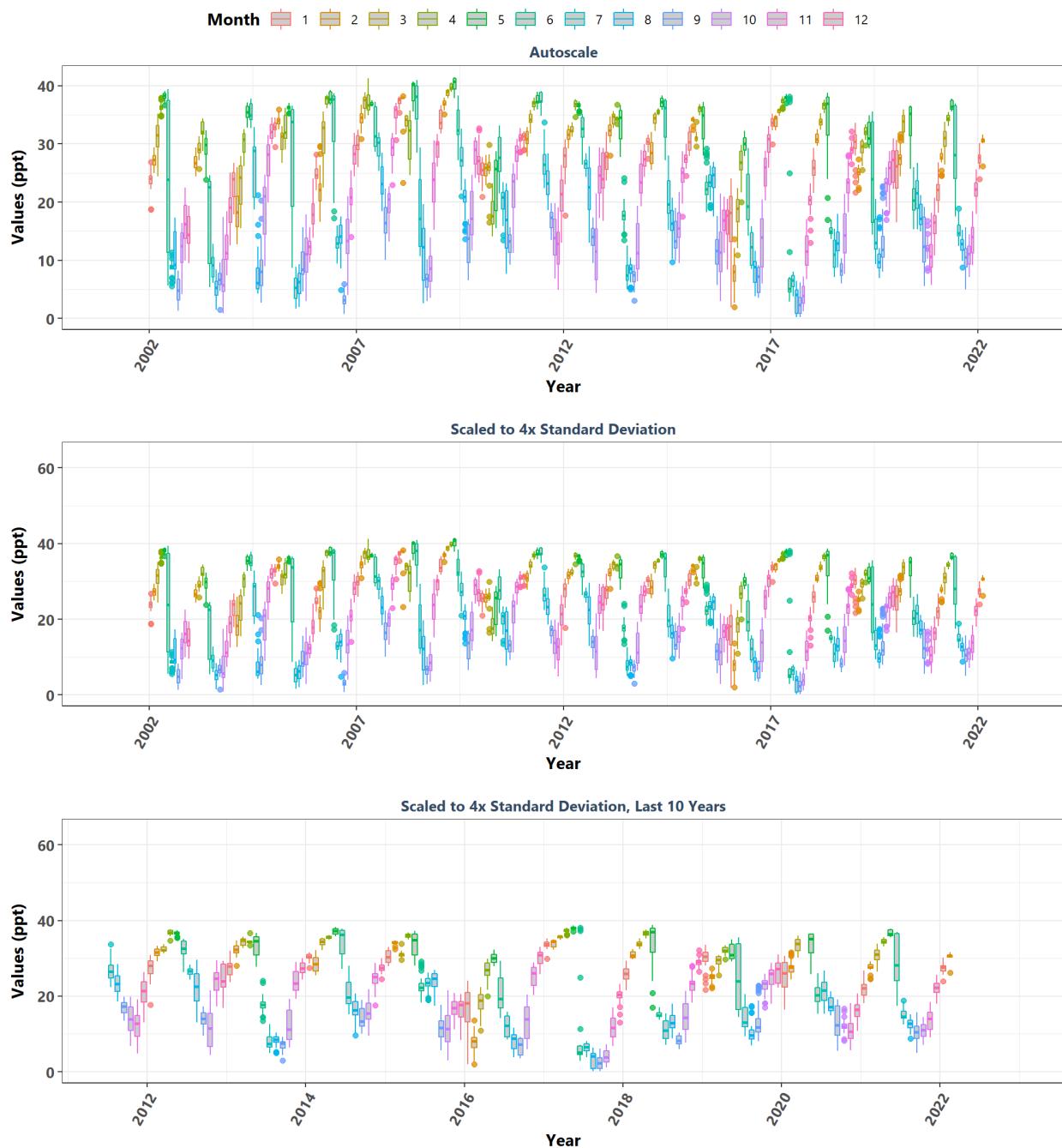
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By Month



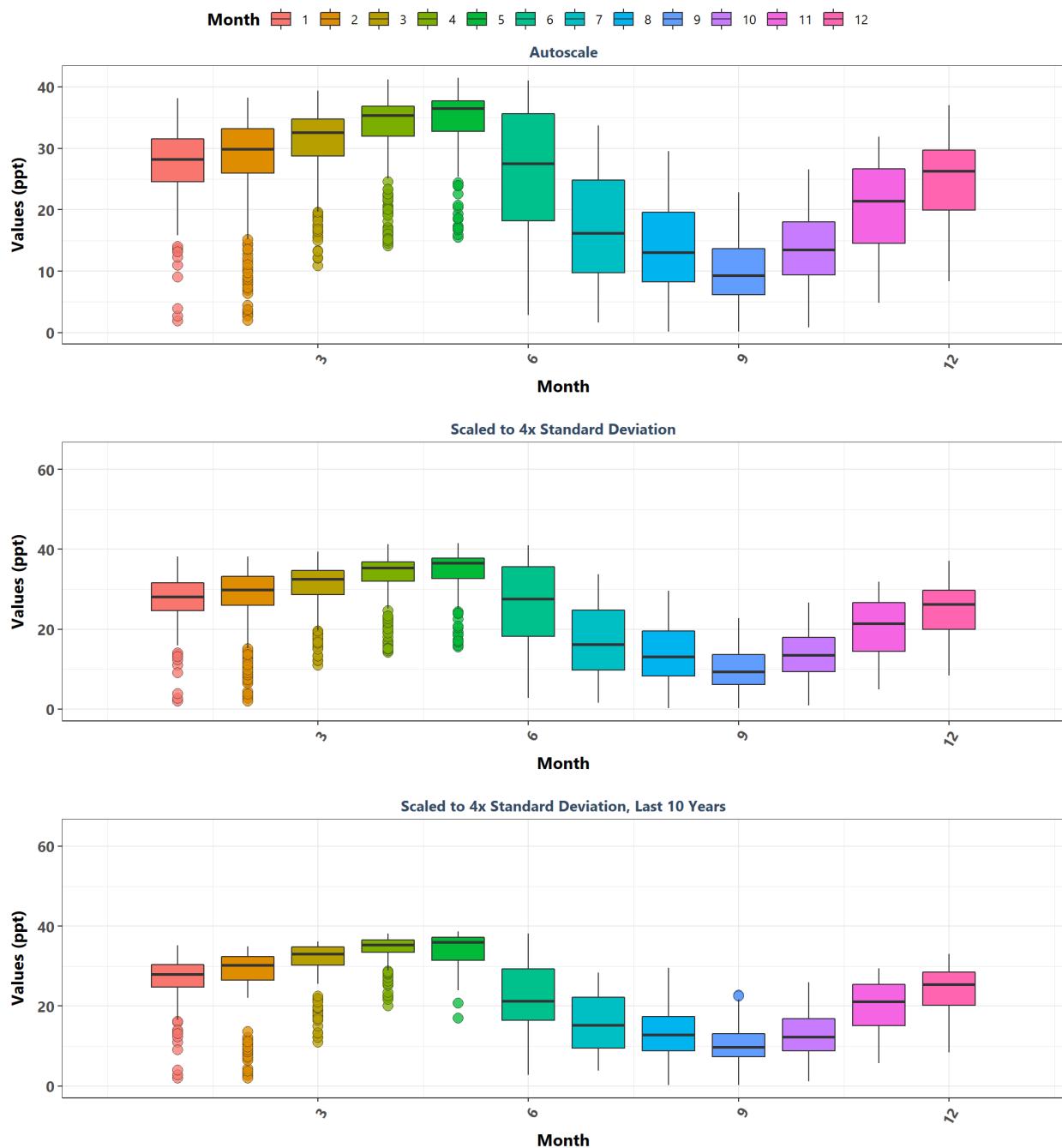
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354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
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By Year



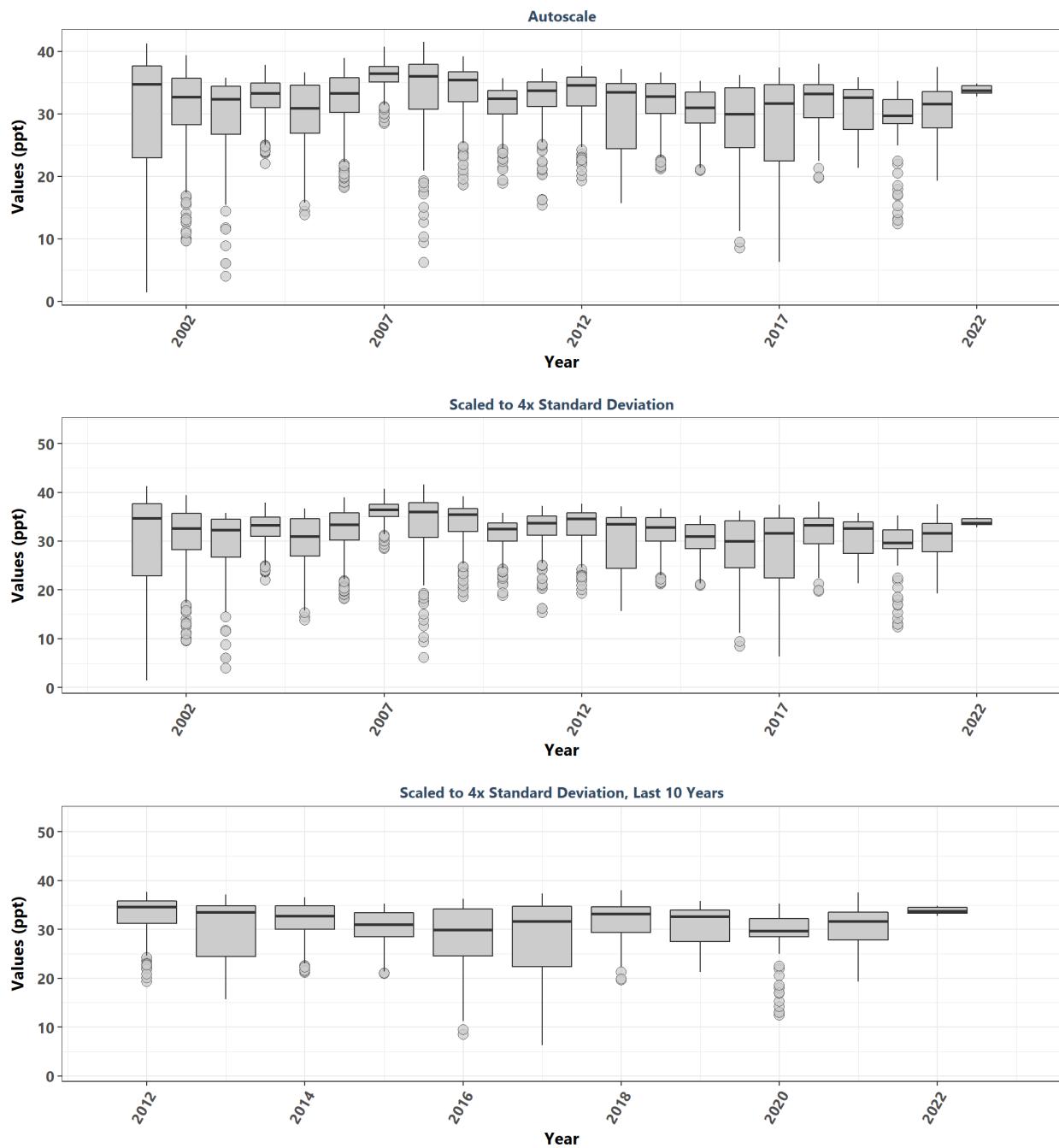
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354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
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By Year & Month



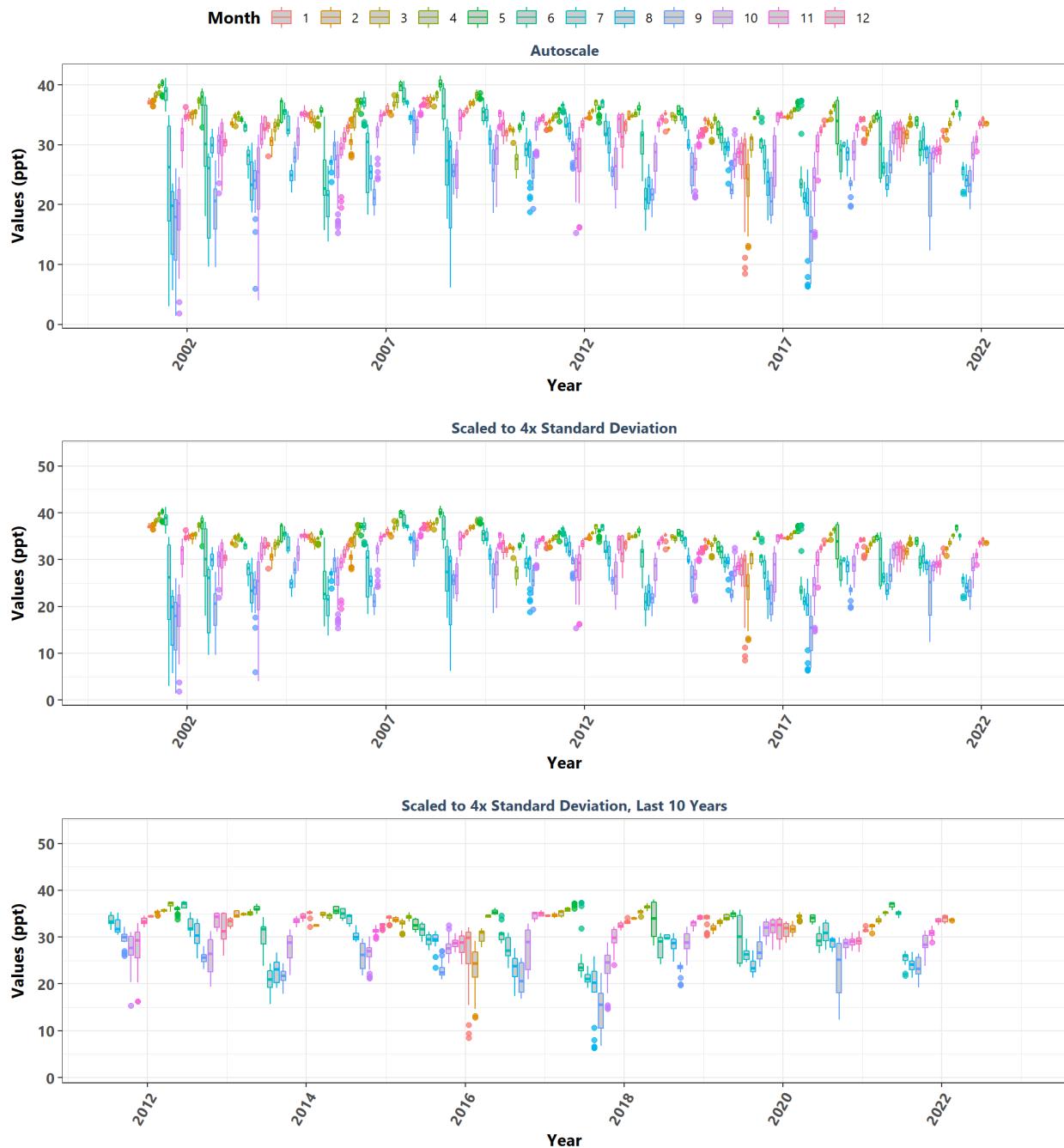
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By Month



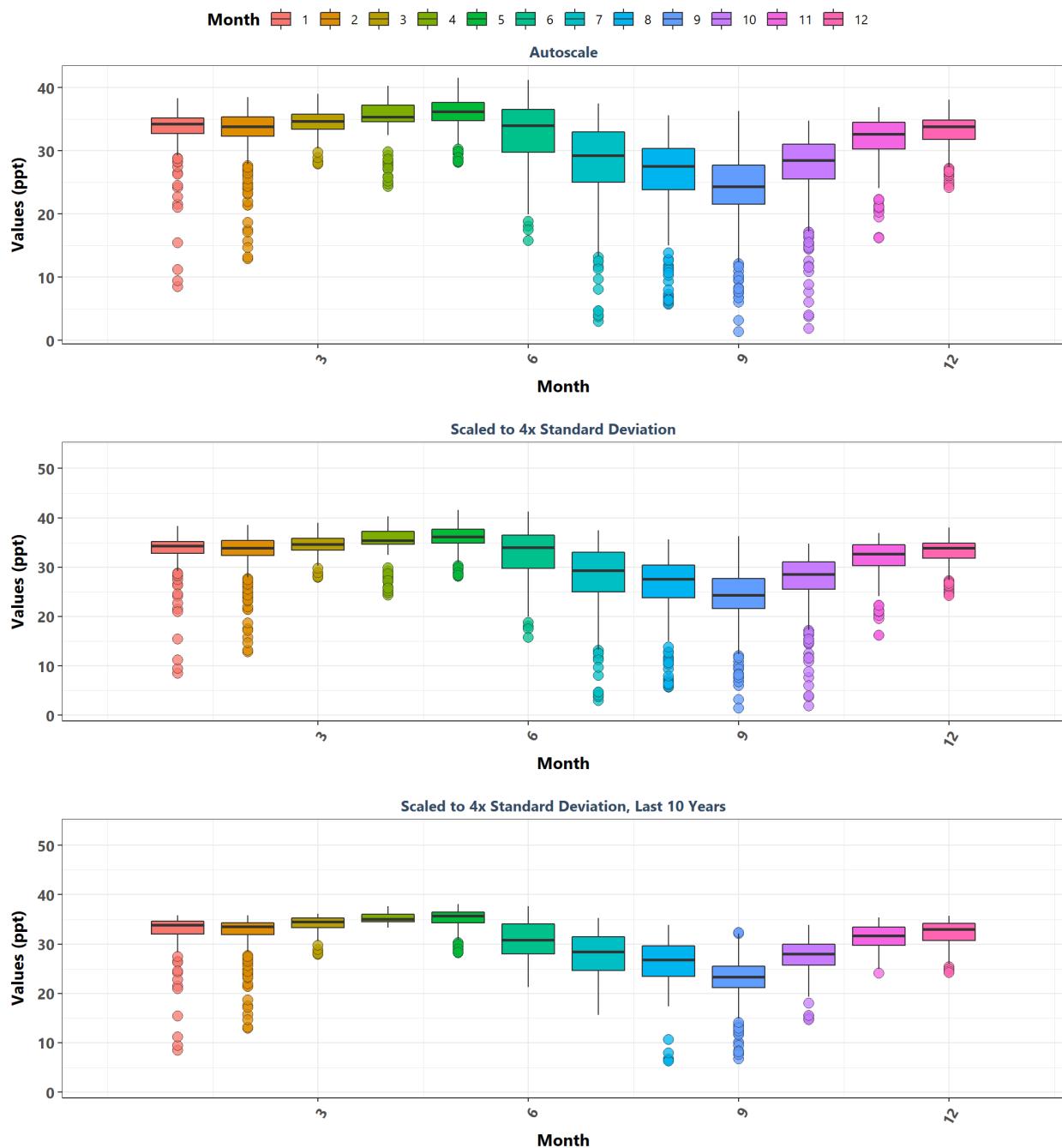
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By Year



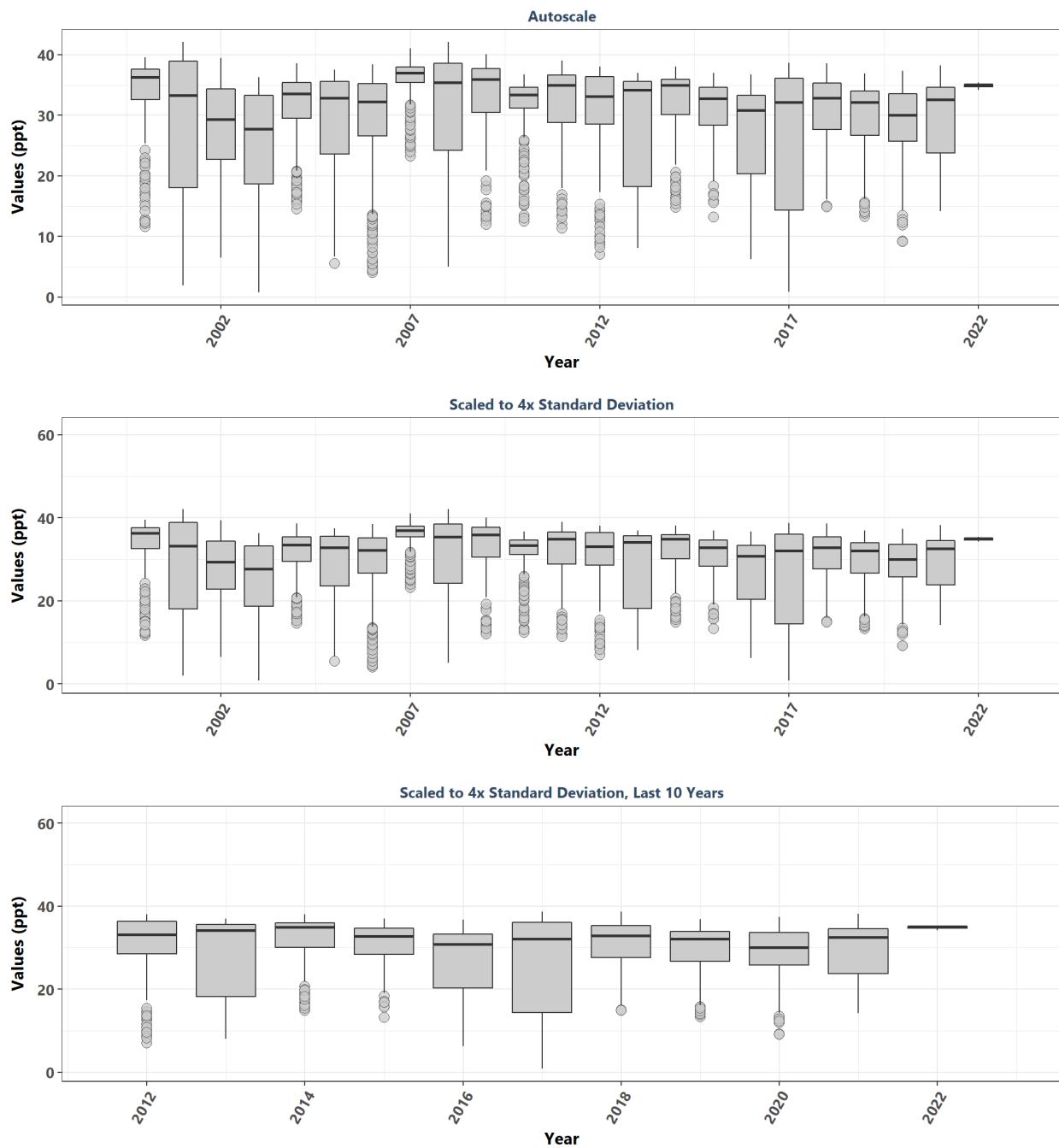
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By Year & Month



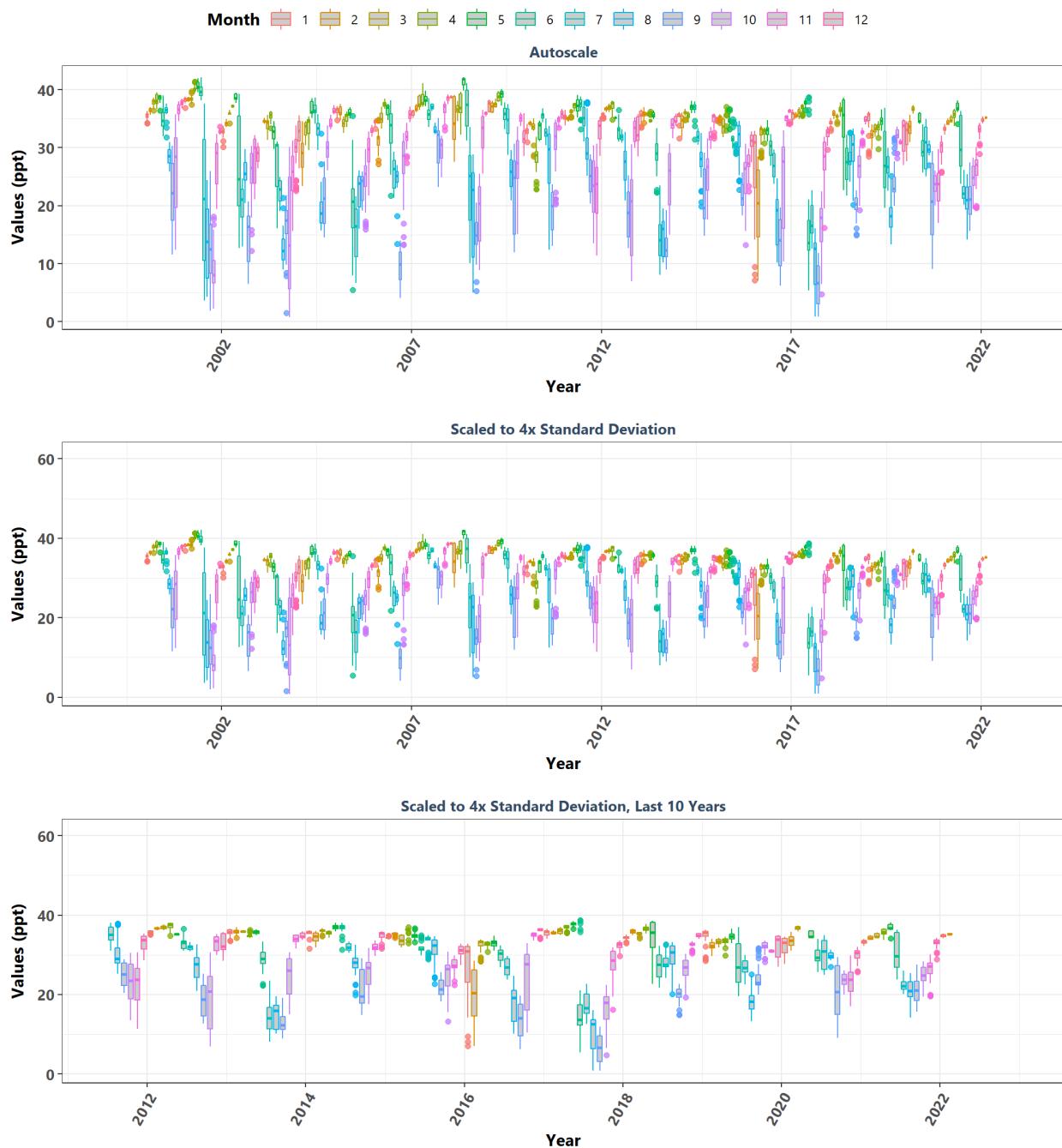
Rookery Bay National Estuarine Research Reserve
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By Month



Rookery Bay National Estuarine Research Reserve
354 | Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program
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By Year



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