

SEACAR Continuous Water Quality Analysis: NW Region for pH

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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(plyr)
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,]

  #temporarily removing FKNMS Temp. data because I think it might be causing R to run out of memory.
  # data <- data[data$ManagedAreaName != "Florida Keys National Marine Sanctuary"]
} else{
  data <- data[data$ResultValue>=0,]
}

data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           SampleDate) %>%
  dplyr::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) %>%
  dplyr::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)
setDT(data)
data[, `:=` (relyear = Year - min(Year), relyear_dd = DecDate - min(DecDate)), by = "ManagedAreaName"]

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$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year, Month) %>%
  dplyr::summarize(ParameterName=parameter,
                   RelativeDepth=unique(RelativeDepth),
                   EarliestSampleDate=min(SampleDate),
                   LastSampleDate=max(SampleDate), N=length(ResultValue),
                   Min=min(ResultValue), Max=max(ResultValue),
                   Median=median(ResultValue), Mean=mean(ResultValue),
                   StandardDeviation=sd(ResultValue))
Mon_YM_Stats <- as.data.table(Mon_YM_Stats[order(Mon_YM_Stats$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$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year) %>%
  dplyr::summarize(ParameterName=parameter,
                   RelativeDepth=unique(RelativeDepth),
                   EarliestSampleDate=min(SampleDate),
                   LastSampleDate=max(SampleDate), N=length(ResultValue),
                   Min=min(ResultValue), Max=max(ResultValue),
                   Median=median(ResultValue), Mean=mean(ResultValue),
                   StandardDeviation=sd(ResultValue))
Mon_Y_Stats <- as.data.table(Mon_Y_Stats[order(Mon_Y_Stats$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$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Month) %>%
  dplyr::summarize(ParameterName=parameter,
                   RelativeDepth=unique(RelativeDepth),
                   EarliestSampleDate=min(SampleDate),
                   LastSampleDate=max(SampleDate), N=length(ResultValue),
                   Min=min(ResultValue), Max=max(ResultValue),
                   Median=median(ResultValue), Mean=mean(ResultValue),
                   StandardDeviation=sd(ResultValue))
Mon_M_Stats <- as.data.table(Mon_M_Stats[order(Mon_M_Stats$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, seasondata = Mon_M_Stats[Mon_M_Stats$ProgramLocationID==unique(d
setDT(data)
tau <- NULL
tryCatch({ken <- kendallSeasonalTrendTest(
  y=data$ResultValue,
  season=data$Month,
  year=data$relyear,
  independent.obs=independent)

tau <- ken$estimate[1]
z <- ken$statistic[2]
p_z <- ken$p.value[2]
chi_sq <- ken$statistic[1]
p_chi_sq <- ken$p.value[1]
slope <- ken$estimate[2]
intercept <- ken$estimate[3]
trend <- trend_calculator(slope, stats.median, p_z)

seasonresults <- as.data.table(ken$seasonal.estimates)
rm(ken)
}, warning = function(w) {
  print(w)
}, error = function(e) {
  print(e)
}, finally = {
  if (!exists("tau")) {
    tau <- NA
  }
  if (!exists("z")) {
    z <- NA
  }
}

```

```

    }
    if (!exists("p_z")) {
      p_z <- NA
    }
    if (!exists("chi_sq")) {
      chi_sq <- NA
    }
    if (!exists("p_chi_sq")) {
      p_chi_sq <- NA
    }
    if (!exists("slope")) {
      slope <- NA
    }
    if (!exists("intercept")) {
      intercept <- NA
    }
    if (!exists("trend")) {
      trend <- NA
    }
  })
KT <- data.table(MonitoringID = unique(data$MonitoringID),
                 season = "All",
                 stats.median = stats.median,
                 independent = independent,
                 tau = tau,
                 z = z,
                 p_z = p_z,
                 chi_sq = chi_sq,
                 p_chi_sq = p_chi_sq,
                 slope = slope,
                 intercept = intercept,
                 trend = trend)

seasonresults[, `:=` (MonitoringID = unique(data$MonitoringID),
                      season = sort(unique(data$Month)),
                      stats.median = as.numeric(NA),
                      independent = independent,
                      z = as.numeric(NA),
                      p_z = as.numeric(NA),
                      chi_sq = as.numeric(NA),
                      p_chi_sq = as.numeric(NA),
                      trend = as.integer(NA))]

for(s in as.integer(unique(seasonresults$season))){
  seasondat_s <- data[Month == s, ]
  if(!is.na(unique(seasondat_s$Month))){
    trend_s <- trend_calculator(seasonresults[season == s, slope], seasondata[Month == s, Median], p
    ken_s <- kendallTrendTest(ResultValue ~ relyear, data = seasondat_s)
    seasonresults[season == s, `:=` (stats.median = unique(seasondata[Month == s, Median]),
                                      z = ken_s$statistic,
                                      p_z = ken_s$p.value,
                                      chi_sq = NA,
                                      p_chi_sq = NA,

```

```

                trend = trend_s)]
} else{
  next
}
}

seasonresults[, season := as.character(season)]

KT <- rbind(KT, seasonresults)
KT[, season := factor(season, levels = c("All", seq(1:12)), ordered = TRUE)]
return(KT)
}

runStats <- function(data, Mon_M_Stats) {
  data$Index <- as.Date(data$SampleDate) # , "%Y-%m-%d")
  data$resultValue <- as.numeric(data$resultValue)
  # Calculate basic stats
  stats.median <- median(data$resultValue, na.rm=TRUE)
  stats.minYear <- min(data$relyear, na.rm=TRUE)
  stats.maxYear <- max(data$relyear, na.rm=TRUE)
  # Calculate Kendall Tau and Slope stats,
  # then update appropriate columns and table
  seasondata <- Mon_M_Stats[Mon_M_Stats$ProgramLocationID==unique(data$ProgramLocationID[data$MonitoringID]),]
  KT <- tauSeasonal(data, TRUE, stats.median,
                     stats.minYear, stats.maxYear, seasondata)
  #if (is.null(KT[8])) {
  if (is.na(KT$season == "All", trend)) {
    KT <- tauSeasonal(data, FALSE, stats.median,
                      stats.minYear, stats.maxYear, seasondata)
  }
  if (is.null(KT$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$ManagedAreaName
c_names <- c("MonitoringID", "Season", "Median", "Independent",
            "tau", "z", "p_z", "chi_sq", "p_chi_sq", "SennSlope", "SennIntercept", "Trend")
if(n==0){
  KT.Stats <- data.frame(matrix(ncol=length(c_names),
                                 nrow=nrow(Mon_Summ)))
  colnames(KT.Stats) <- c_names
  #KT.Stats[, c("MonitoringID")] <- Mon_Summ[, c("MonitoringID")]
} else{
  for (i in 1:n) {
    x <- nrow(data[data$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], ], Mon_M_Stats)
    }
  }
  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$z <- round(as.numeric(KT.Stats$z), digits=4)
  KT.Stats$p_z <- round(as.numeric(KT.Stats$p_z), digits=4)
  KT.Stats$chi_sq <- round(as.numeric(KT.Stats$chi_sq), digits=4)
  KT.Stats$p_chi_sq <- round(as.numeric(KT.Stats$p_chi_sq), 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.Stats2 <- copy(KT.Stats)
KT.Stats[, `:=` (Region = region, Units = unit)]
KT.Stats_all <- rbind(KT.Stats_all, KT.Stats)

KT.Stats2$MonitoringID <- NULL
fwrite(KT.Stats2, paste0(out_dir, "/", param_name, "_", region,
                         "_KendallTau_Stats.txt"), sep="|")
rm(KT.Stats2)

```

```
#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.x=element_text(face="bold"),
        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))) +

```

```

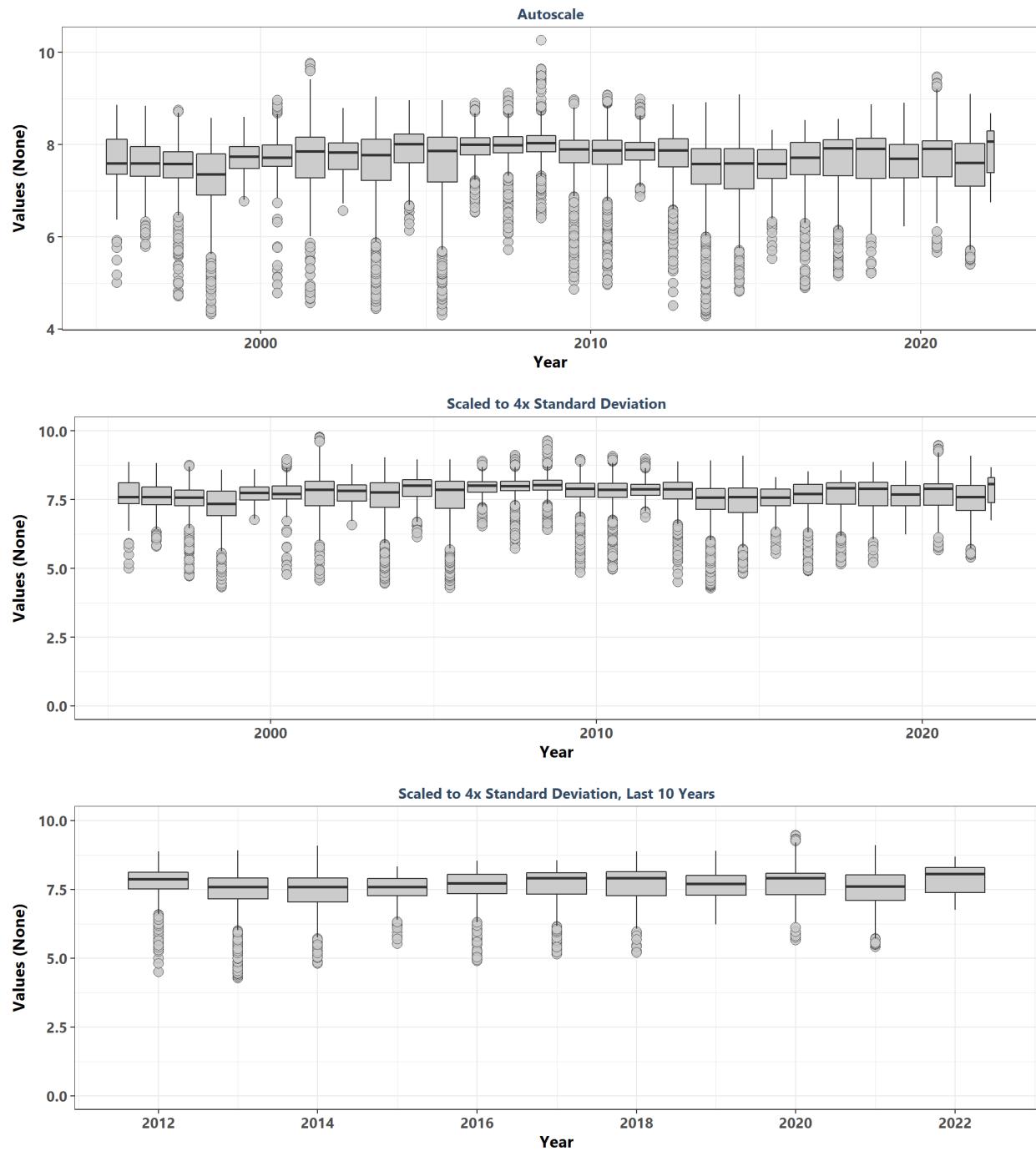
geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
             outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation, Last 10 Years",
       x="Month", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(0, 13), 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())

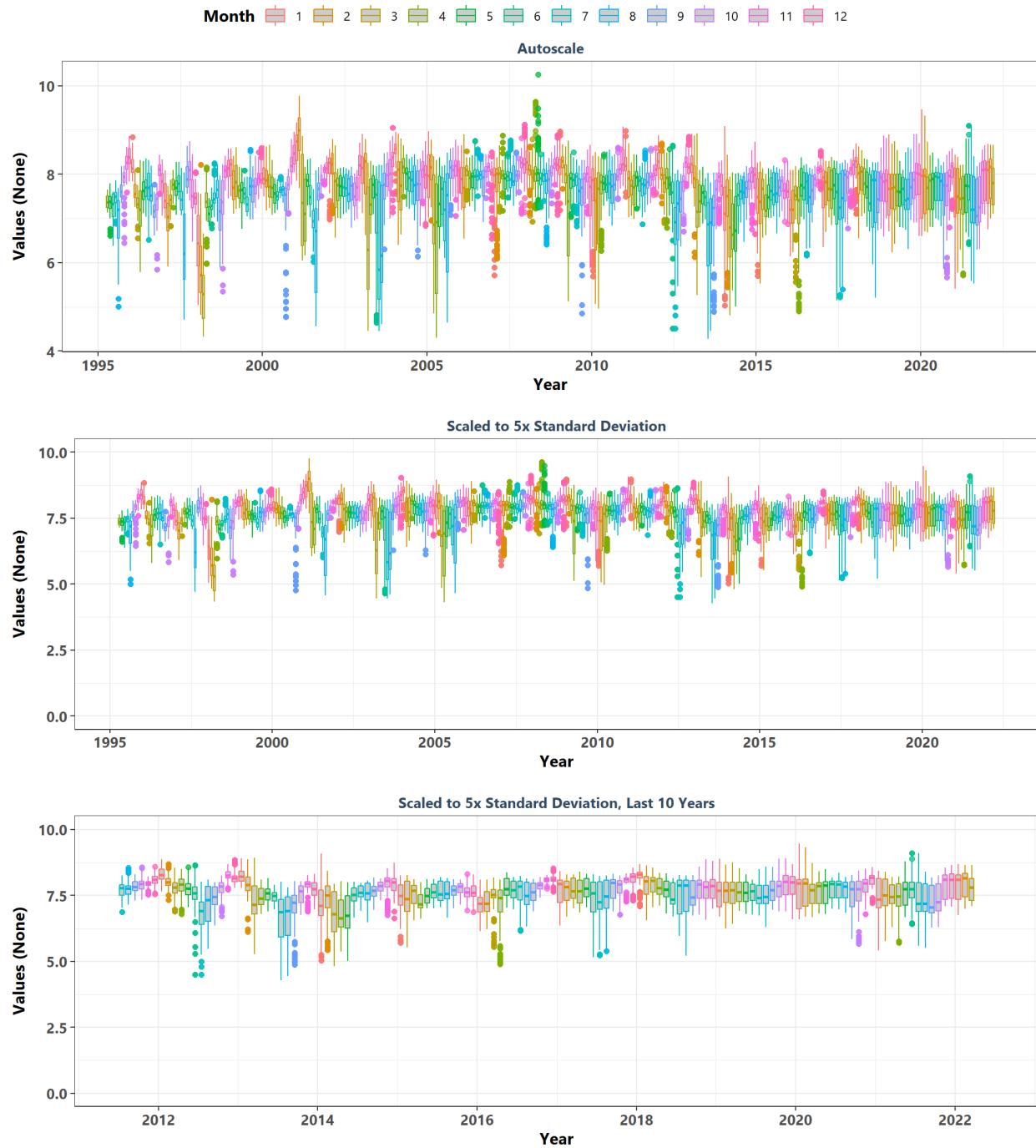
Mset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

```

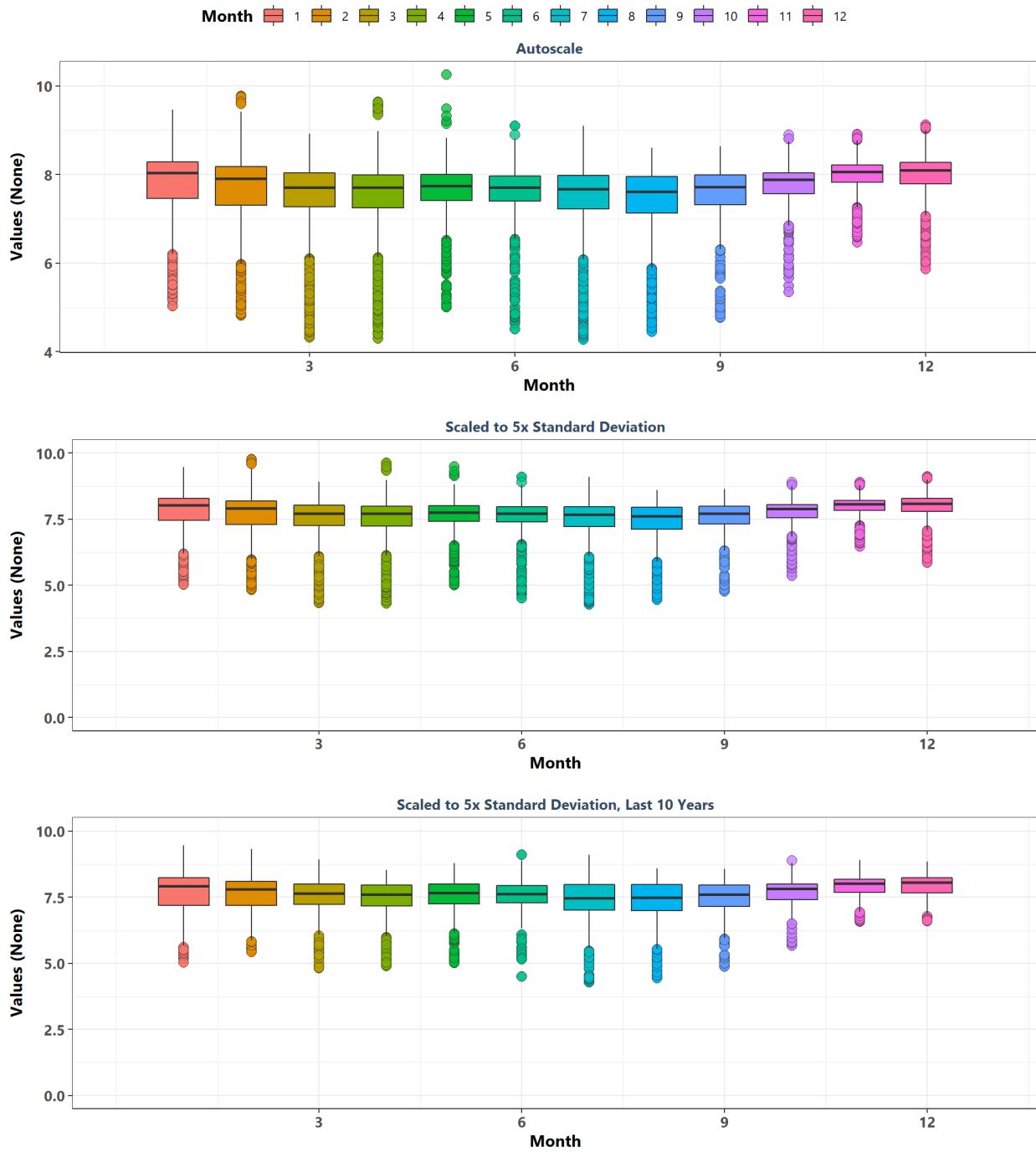
Summary Box Plots for Entire Data
By Year



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.

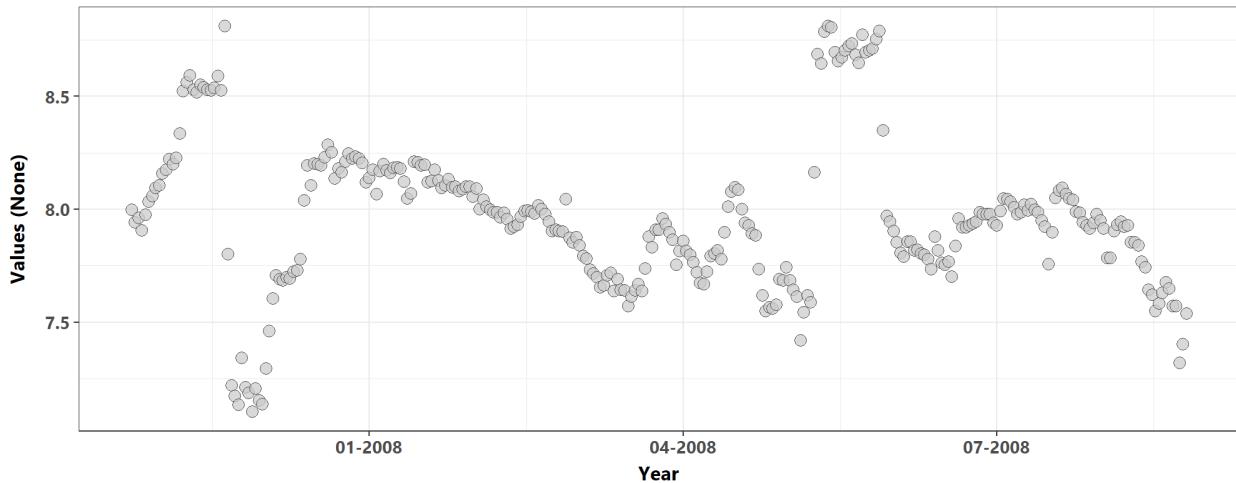
```

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]])))
  }
}

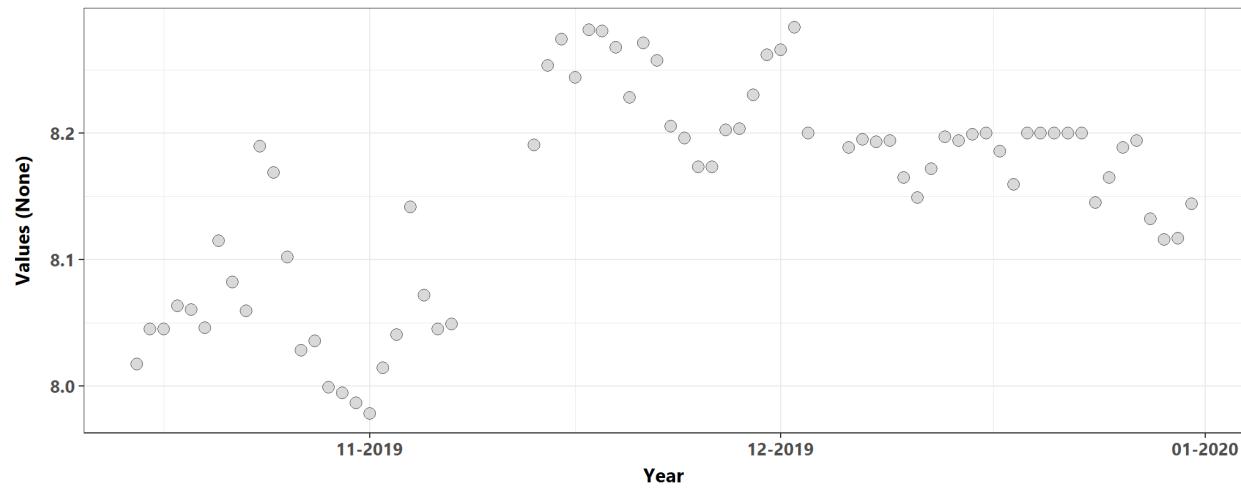
```

**Alligator Harbor Aquatic Preserve
468 | Central Panhandle Aquatic Preserves Continuous Water Quality Monitoring
CPAH (2 Unique Years)
Autoscale**



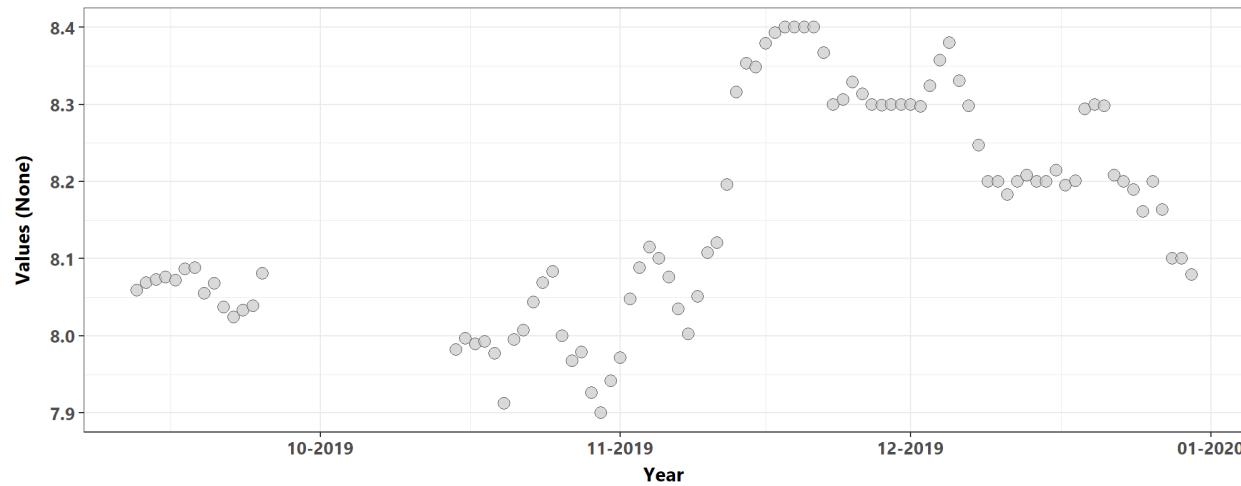
**Alligator Harbor Aquatic Preserve
468 | Central Panhandle Aquatic Preserves Continuous Water Quality Monitoring
CPAH2 (1 Unique Years)**

Autoscale



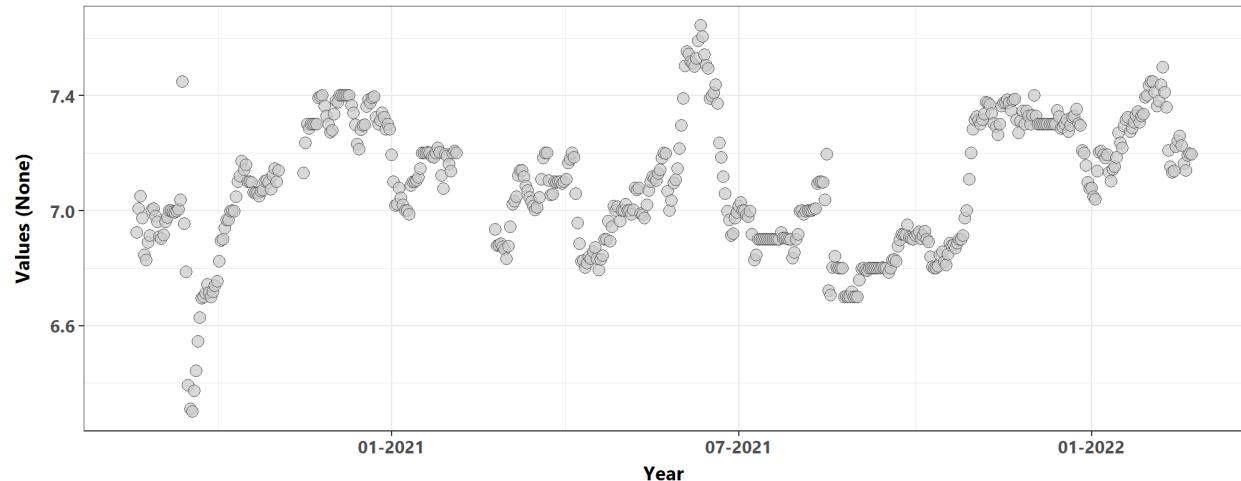
**Alligator Harbor Aquatic Preserve
468 | Central Panhandle Aquatic Preserves Continuous Water Quality Monitoring
CPFS (1 Unique Years)**

Autoscale



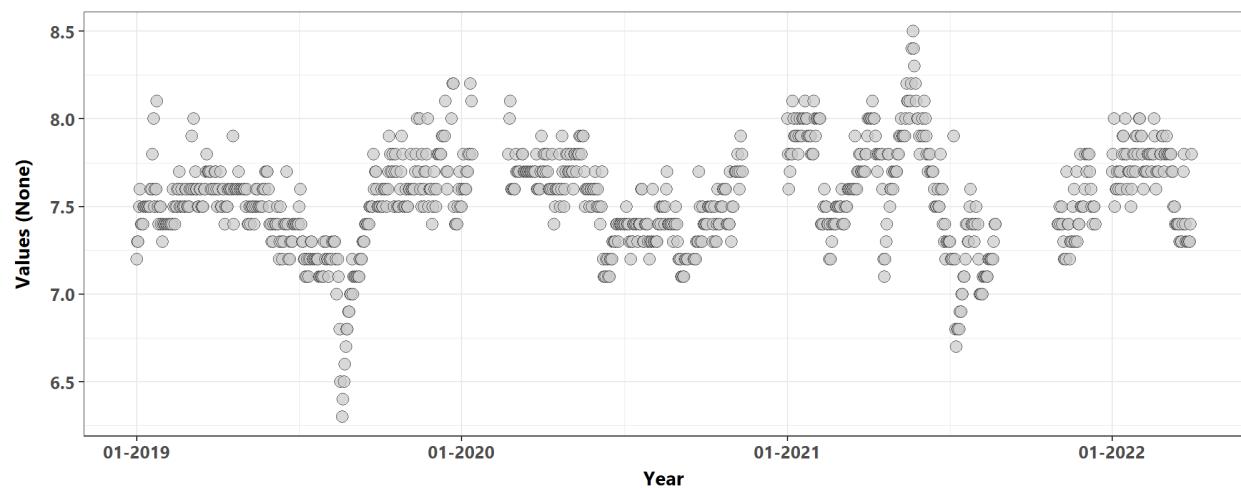
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apabpwq (3 Unique Years)

Autoscale



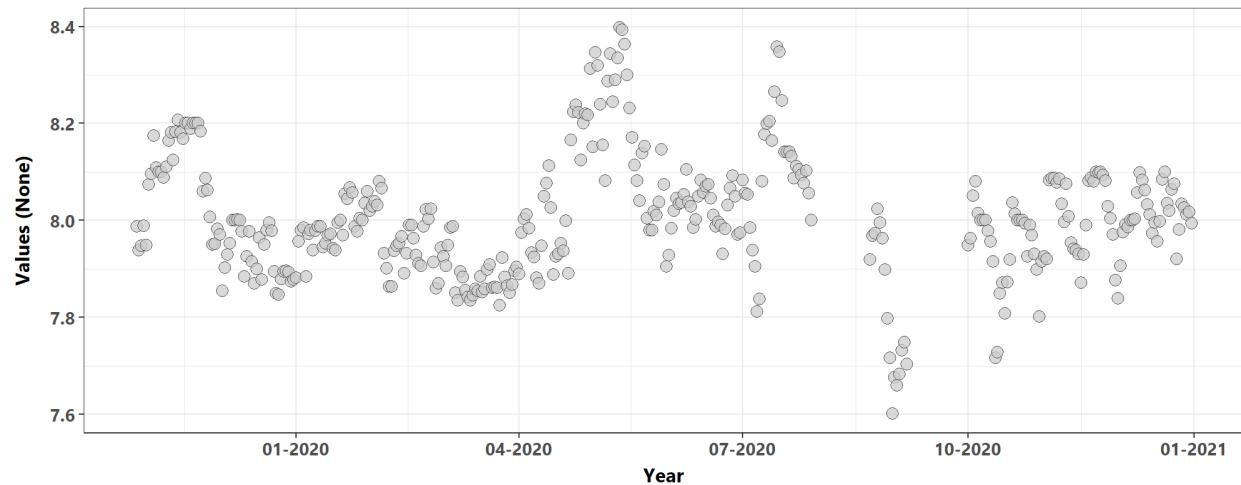
Big Bend Seagrasses Aquatic Preserve
7 | National Water Information System
02313700 (4 Unique Years)

Autoscale



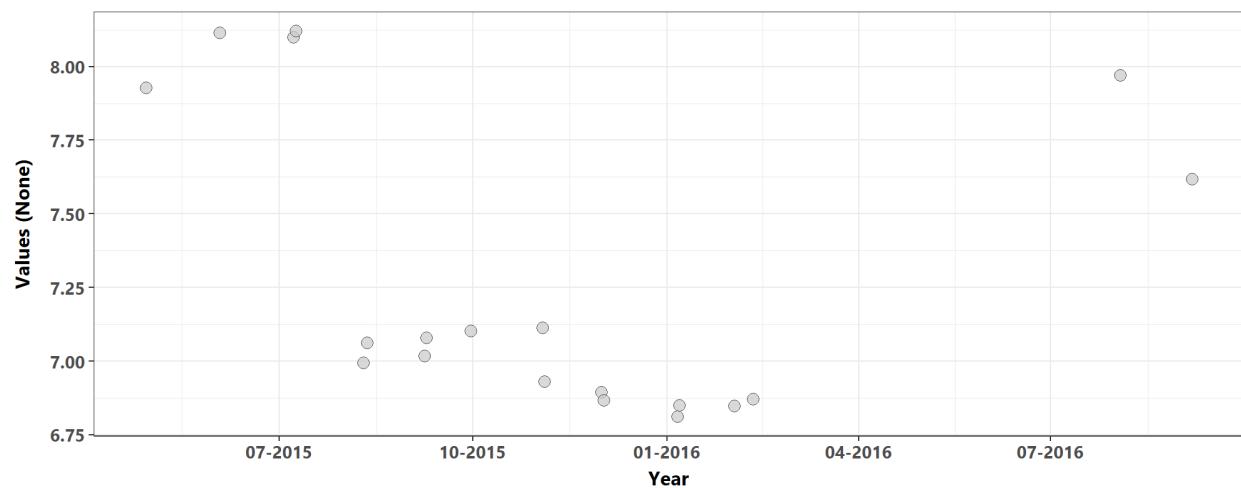
Big Bend Seagrasses Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSST (2 Unique Years)

Autoscale

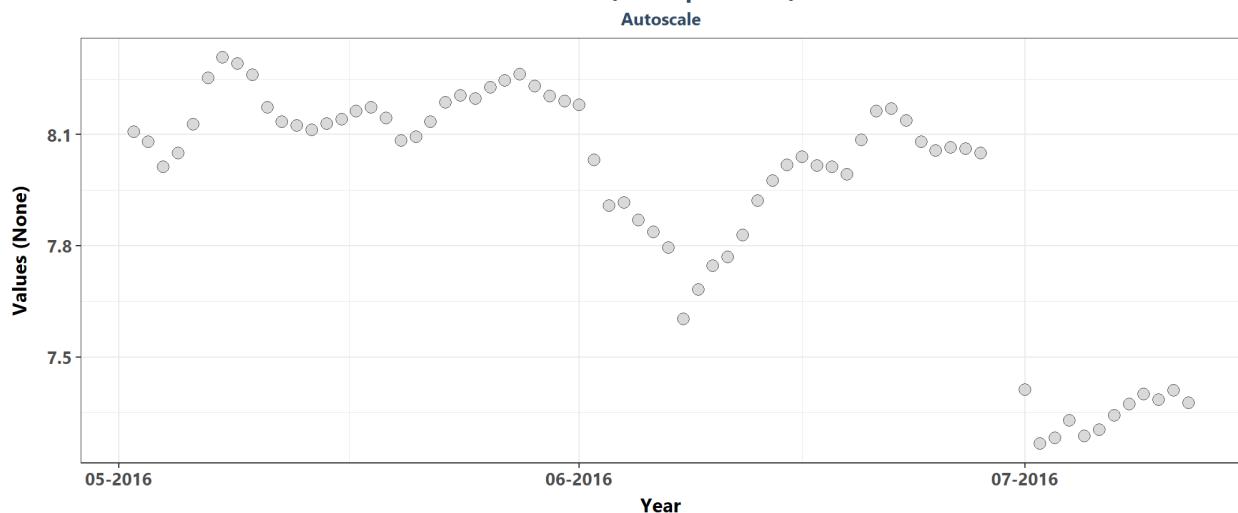


Fort Pickens State Park Aquatic Preserve
505 | Pensacola Bay Water Quality Monitoring Program
P09 (2 Unique Years)

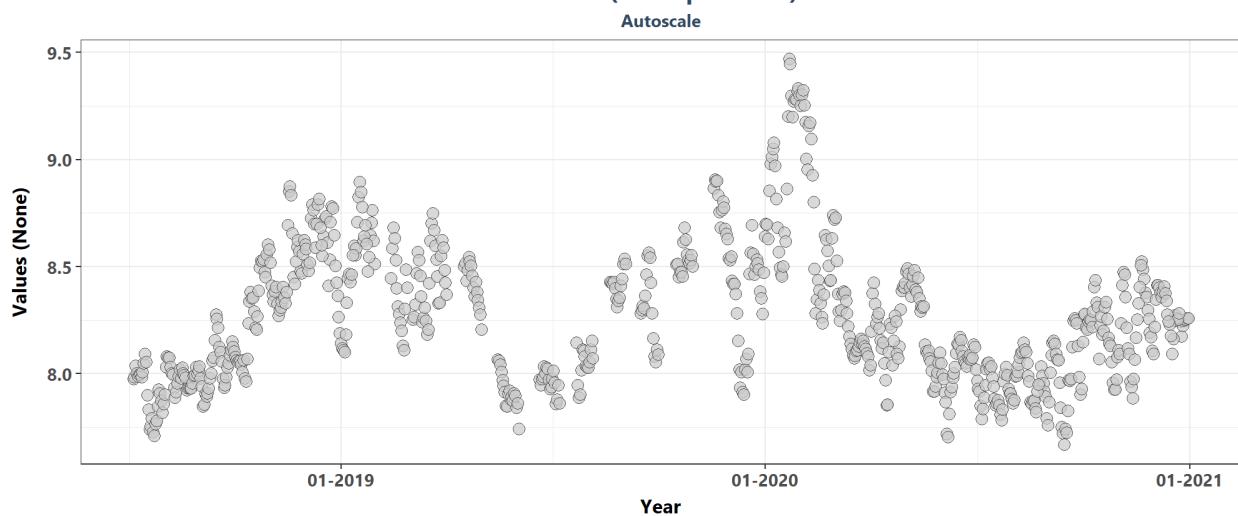
Autoscale



Nature Coast Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSHS (1 Unique Years)



St. Martins Marsh Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSCH (3 Unique Years)



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],]
    plot_data$Season <- factor(plot_data$Month, levels = c("All", seq(1, 12)), ordered = TRUE)
    year_lower <- min(plot_data$relyear)
    year_upper <- max(plot_data$relyear)
    # relyear_dd_lower <- min(plot_data$relyear_dd)
    # relyear_dd_upper <- max(plot_data$relyear_dd)
    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]]
    z <- KT.Stats$z[KT.Stats$MonitoringID==Mon_IDs[i]]
    p_z <- KT.Stats$p_z[KT.Stats$MonitoringID==Mon_IDs[i]]
    chi_sq <- KT.Stats$chi_sq[KT.Stats$MonitoringID==Mon_IDs[i]]
    p_chi_sq <- KT.Stats$p_chi_sq[KT.Stats$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]])

    xbrks <- seq(round_any(min(plot_data$relyear_dd), 5, floor), round_any(max(plot_data$relyear_dd),
                           by = (round_any(max(plot_data$relyear_dd), 5, ceiling) - round_any(min(plot_data$relyear_dd), 5, floor))))
    xlabs <- seq(max(plot_data$Year) - round_any(max(plot_data$relyear_dd), 5, ceiling),
                  max(plot_data$Year),
                  by = (max(plot_data$Year) - (max(plot_data$Year) - round_any(max(plot_data$relyear_dd), 5, ceiling)) / 5))

    # x1 <- min(unique(data$relyear_dd[data$Year == KT.Stats$ManagedAreaName==MA_Include[i] & Season == "All", SennSlope]))
    # y1 <- min(unique(data$relyear_dd[data$Year == KT.Stats$ManagedAreaName==MA_Include[i] & Season == "All", SennSlope]))
    # x_end1 <- max(unique(data$relyear_dd[data$Year == KT.Stats$ManagedAreaName==MA_Include[i] & Season == "All", SennSlope]))
    # y_end1 <- max(unique(data$relyear_dd[data$Year == KT.Stats$ManagedAreaName==MA_Include[i] & Season == "All", SennSlope]))
    # x1 <- relyear_dd_lower
    # y1 <- relyear_dd_lower * KT.Stats$ManagedAreaName==MA_Include[i] & Season == "All", SennSlope]
  }
}

```

```

# x_end1 <- relyear_dd_upper
# y_end1 <- relyear_dd_upper * KT.Stats[ManagedAreaName==MA_Include[i] & Season == "All", SennSlo

KT.Stats[, season := Season]
KT.Stats[MonitoringID == Mon_IDs[i] & season != "All", `:=` (N_Data = nrow(plot_data[Season == se
KT.Stats[MonitoringID == Mon_IDs[i] & season == "All", `:=` (relyear_dd_lower = min(plot_data[Mon
KT.Stats[, season := NULL]

p1 <- ggplot(data=plot_data,
             aes(x=relyear_dd, y=ResultValue)) +
  geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
             alpha=0.75) +
  #geom_abline(data = KT.Stats[ManagedAreaName==MA_Include[i] & Season == "All", ], aes(slope=Se
  #                           color="#000099", size=1.2, alpha=0.7) +
  geom_segment(data = KT.Stats[MonitoringID == Mon_IDs[i] & Season == "All", ], aes(x = relyear_
                                         color="#000099", size=1.2, alpha=0.7) +
  labs(subtitle="Autoscale",
       x="Year", y=paste0("Values (", unit, ")")) +
  plot_theme +
  scale_x_continuous(breaks = xbrks,
                     labels = xlabs)

p2 <- ggplot(data=plot_data,
             aes(x=relyear_dd, 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) +
  geom_segment(data = KT.Stats[MonitoringID == Mon_IDs[i] & Season == "All", ], aes(x = relyear_
                                         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 +
  scale_x_continuous(breaks = xbrks,
                     labels = xlabs)

splot <- ggplot(plot_data, aes(x = relyear_dd, y = ResultValue)) +
  geom_point(shape = 21, size = 1.5, color="#333333", fill="#cccccc", alpha=0.75) +
  geom_segment(data = KT.Stats[MonitoringID == Mon_IDs[i] & Season != "All", ], aes(x = relyear_
                                         color="#000099", size=1.2, alpha=0.7) +
  #ylim(min_RV-0.1*y_scale, y_scale) +

```

```

scale_x_continuous(breaks = xbrks,
                   labels = xlabs) +
  labs(y = paste0("Values (", unit, ")"), x = "Year", subtitle = "Results for Individual Seas",
       facet_wrap(~Season, ncol = 3) +
       plot_theme

KTset <- ggarrange(p1, p2, splot, ncol=1, heights=c(1, 1, 1.5))

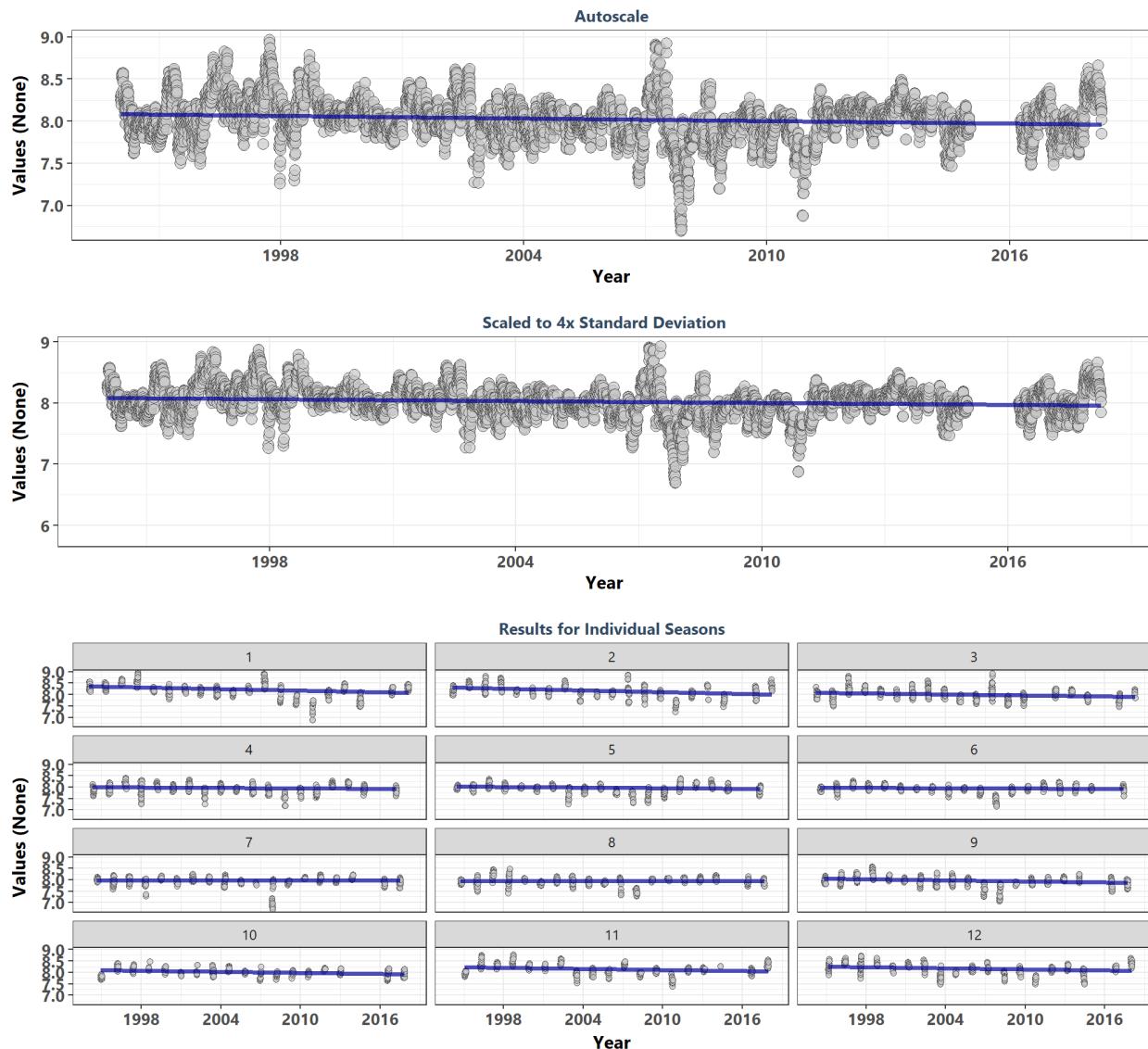
p0 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name)) +
  plot_theme + theme(panel.border=element_blank(),
                     panel.grid.major=element_blank(),
                     panel.grid.minor=element_blank(),
                     axis.line=element_blank())

KTStats[MonitoringID==Mon_IDs[i], `:=` (N = N_Data,
                                         Median = round(Median, 2),
                                         Slope = round(SennSlope, 4),
                                         Int. = round(SennIntercept, 4),
                                         z = round(z, 1),
                                         chi_sq = round(chi_sq, 1))]

print(ggarrange(p0, KTset, ncol=1, heights=c(0.1, 1.25)))
cat('\n')
print(KTStats[KTStats$MonitoringID==Mon_IDs[i], ] %>%
  select(Season, N, Median, tau, Slope, Int., z, p_z, chi_sq, p_chi_sq, Trend) %>%
  kable(format="latex") %>%
  row_spec(0, bold=TRUE) %>%
  kable_styling(latex_options = "HOLD_position",
                font_size = 7) %>%
  add_footnote(
    "p < 0.00005 appear as 0 due to rounding"))
cat('\n')
rm(plot_data)
rm(KTset, leg)
}
}

```

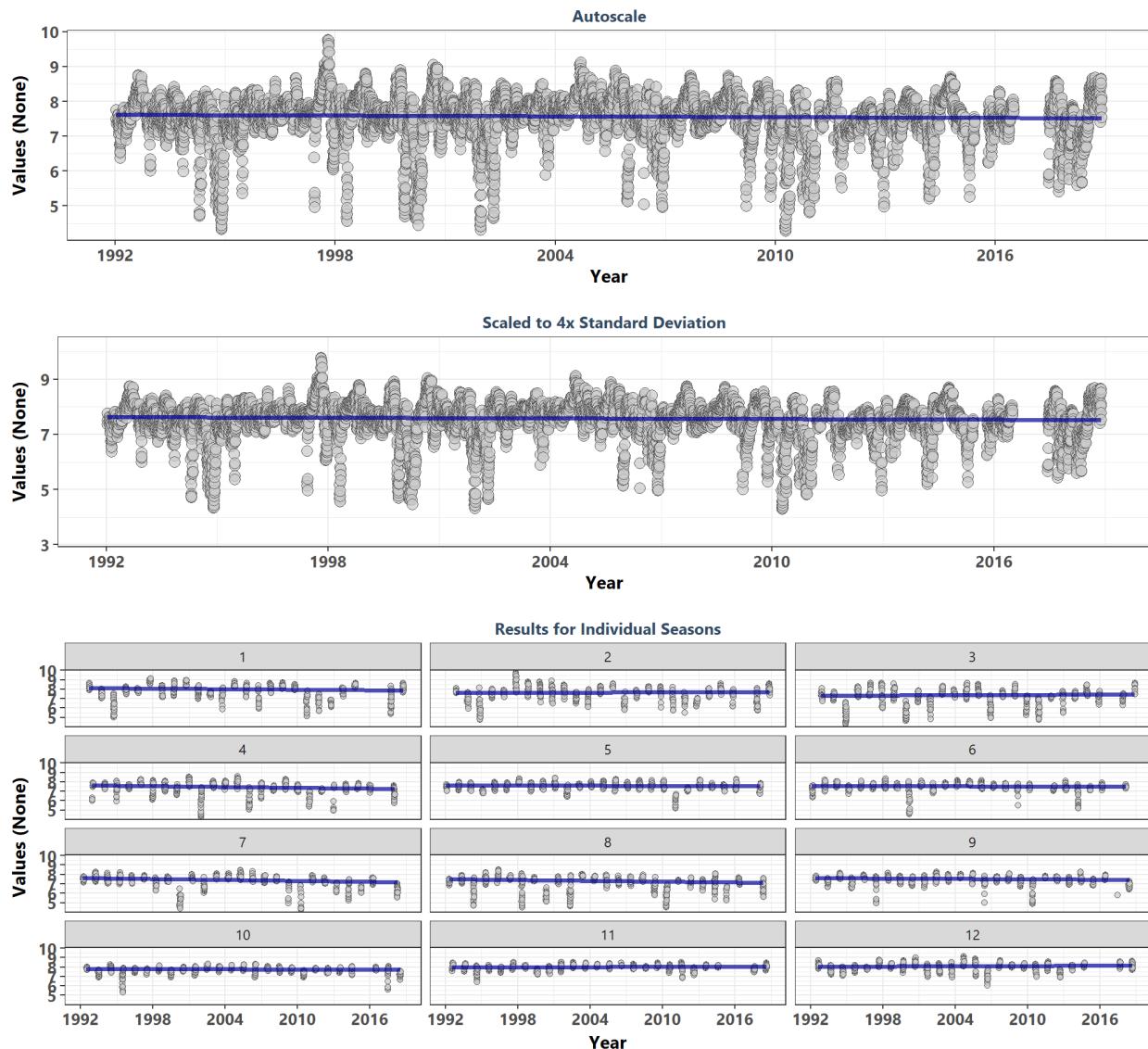
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	6115	8.02	-0.1276	-0.0063	8.1283	-14.6	0.0000	77.2	0	-1
1	520	8.21	-0.2279	-0.0146	8.4589	-7.8	0.0000	NA	NA	-1
2	439	8.16	-0.2448	-0.0152	8.4230	-7.7	0.0000	NA	NA	-1
3	526	8.00	-0.1502	-0.0091	8.1492	-5.2	0.0000	NA	NA	-1
4	507	7.96	-0.0841	-0.0044	8.0290	-2.8	0.0046	NA	NA	-1
5	566	7.97	-0.1069	-0.0053	8.0602	-3.8	0.0001	NA	NA	-1
6	544	7.95	-0.0576	-0.0021	7.9854	-2.0	0.0442	NA	NA	-1
7	526	7.98	-0.0128	-0.0004	7.9838	-0.4	0.6604	NA	NA	-1
8	522	7.96	0.0052	0.0002	7.9535	0.2	0.8602	NA	NA	1
9	505	7.97	-0.1985	-0.0092	8.1073	-6.7	0.0000	NA	NA	-1
10	456	8.01	-0.1959	-0.0093	8.1595	-6.3	0.0000	NA	NA	-1
11	504	8.15	-0.1402	-0.0098	8.3030	-4.7	0.0000	NA	NA	-1
12	500	8.18	-0.1531	-0.0091	8.3209	-5.1	0.0000	NA	NA	-1

^a p < 0.00005 appear as 0 due to rounding

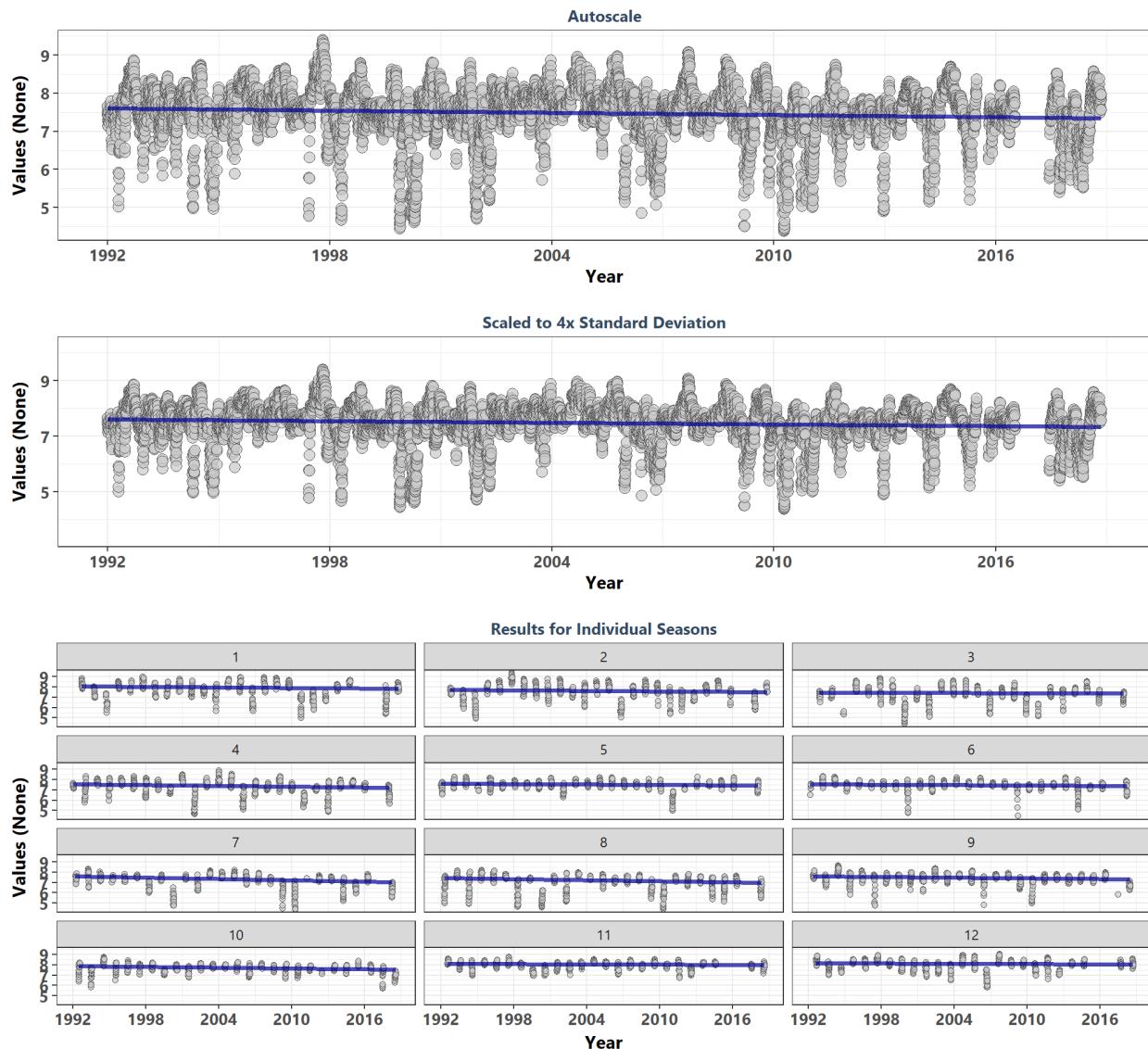
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	8459	7.61	-0.0464	-0.0038	7.6214	-6.3	0.0000	114.6	0	-1
1	709	8.00	-0.0615	-0.0090	8.1174	-2.5	0.0142	NA	NA	-1
2	660	7.67	0.0108	0.0015	7.6468	0.4	0.6786	NA	NA	1
3	723	7.37	0.0400	0.0048	7.3048	1.6	0.1076	NA	NA	1
4	677	7.43	-0.1382	-0.0141	7.6099	-5.4	0.0000	NA	NA	-1
5	749	7.57	-0.0491	-0.0033	7.6171	-2.0	0.0443	NA	NA	-1
6	689	7.54	-0.0599	-0.0035	7.5811	-2.4	0.0186	NA	NA	-1
7	705	7.43	-0.1916	-0.0179	7.6256	-7.6	0.0000	NA	NA	-1
8	711	7.32	-0.1298	-0.0144	7.4824	-5.2	0.0000	NA	NA	-1
9	680	7.52	-0.0812	-0.0063	7.5994	-3.2	0.0015	NA	NA	-1
10	713	7.75	-0.0245	-0.0015	7.7714	-1.0	0.3280	NA	NA	-1
11	703	8.03	0.0391	0.0021	8.0036	1.6	0.1206	NA	NA	1
12	740	8.09	0.0795	0.0062	8.0135	3.2	0.0012	NA	NA	1

^a p < 0.00005 appear as 0 due to rounding

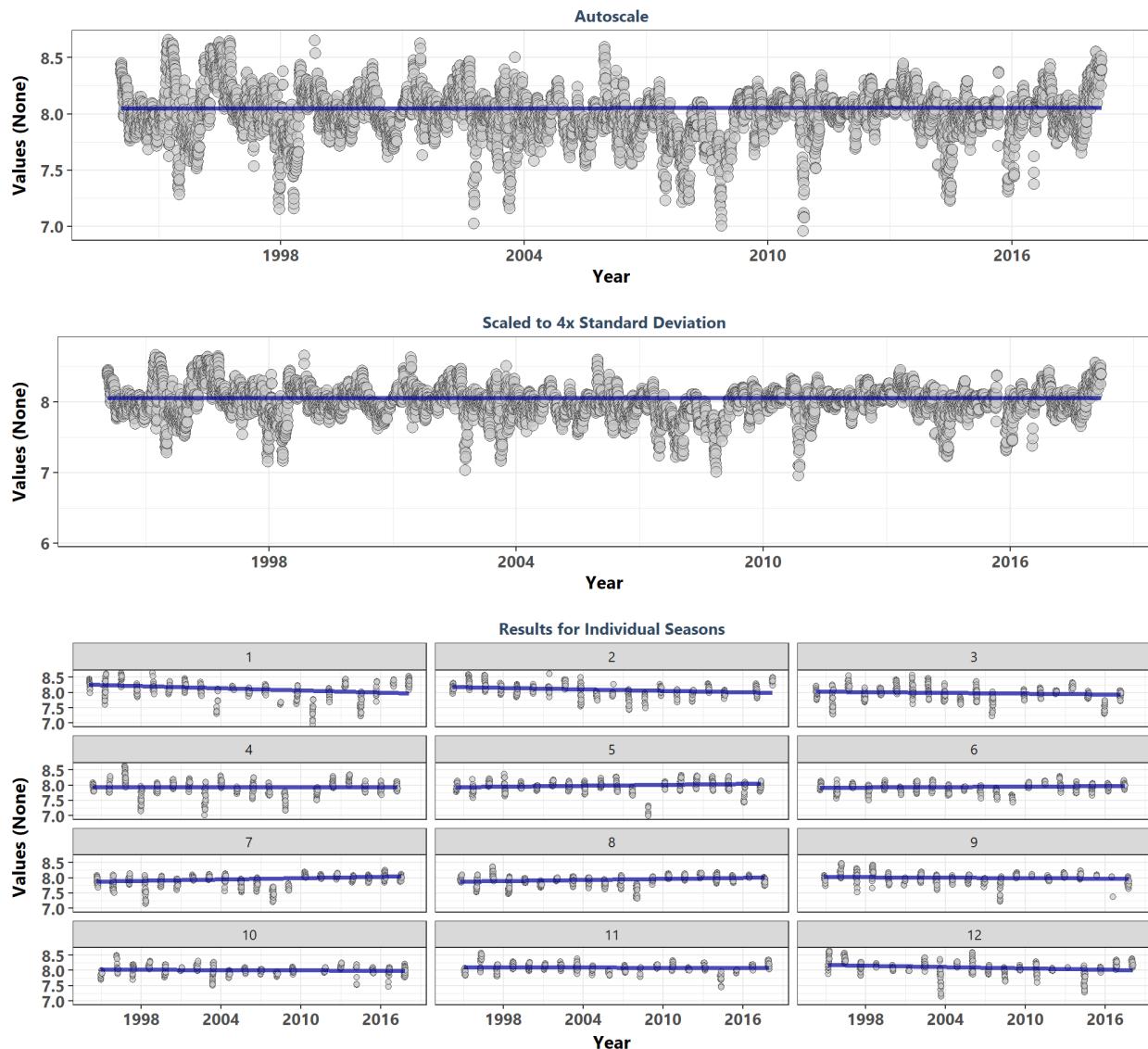
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	8553	7.56	-0.1051	-0.0096	7.6026	-14.6	0.0000	56.9	0	-1
1	712	7.97	-0.0728	-0.0094	8.0891	-2.9	0.0036	NA	NA	-1
2	707	7.62	-0.0635	-0.0098	7.7446	-2.5	0.0115	NA	NA	-1
3	710	7.43	-0.0097	-0.0012	7.4450	-0.4	0.6991	NA	NA	-1
4	753	7.39	-0.1281	-0.0140	7.5752	-5.3	0.0000	NA	NA	-1
5	686	7.53	-0.0901	-0.0061	7.6000	-3.5	0.0004	NA	NA	-1
6	700	7.48	-0.1208	-0.0077	7.5719	-4.8	0.0000	NA	NA	-1
7	708	7.34	-0.2076	-0.0214	7.5945	-8.3	0.0000	NA	NA	-1
8	699	7.21	-0.1459	-0.0174	7.4167	-5.8	0.0000	NA	NA	-1
9	738	7.47	-0.1291	-0.0109	7.6052	-5.3	0.0000	NA	NA	-1
10	719	7.75	-0.1756	-0.0130	7.9042	-7.1	0.0000	NA	NA	-1
11	715	8.03	-0.0690	-0.0043	8.0771	-2.8	0.0057	NA	NA	-1
12	706	8.09	-0.0461	-0.0042	8.1391	-1.8	0.0668	NA	NA	-1

^a p < 0.00005 appear as 0 due to rounding

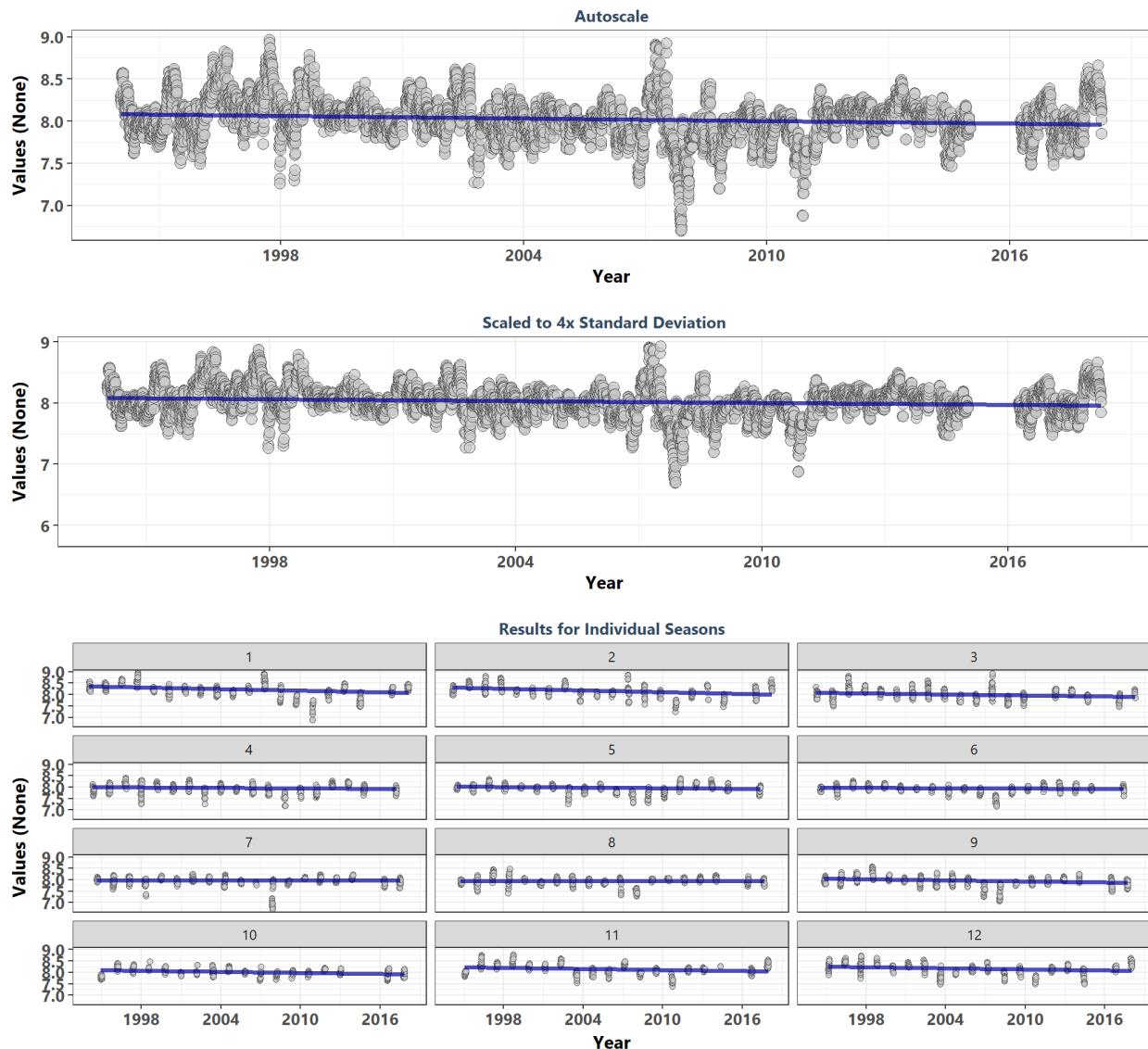
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apacpwq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	6263	8.00	-0.0021	0.0003	8.0495	0.9	0.3797	269.4	0	0
1	443	8.12	-0.1945	-0.0148	8.3680	-6.1	0.0000	NA	NA	0
2	505	8.09	-0.1770	-0.0093	8.2407	-6.0	0.0000	NA	NA	0
3	517	7.99	-0.0824	-0.0045	8.0573	-2.8	0.0050	NA	NA	0
4	533	7.94	0.0119	0.0006	7.9259	0.4	0.6817	NA	NA	0
5	556	7.99	0.1388	0.0055	7.9055	4.9	0.0000	NA	NA	0
6	544	7.94	0.0905	0.0029	7.8950	3.2	0.0016	NA	NA	0
7	589	7.96	0.2460	0.0090	7.8132	8.9	0.0000	NA	NA	0
8	570	7.93	0.1649	0.0064	7.8318	5.9	0.0000	NA	NA	0
9	490	8.00	-0.0901	-0.0038	8.0658	-3.0	0.0028	NA	NA	0
10	509	8.01	-0.0514	-0.0017	8.0417	-1.7	0.0827	NA	NA	0
11	526	8.10	-0.0404	-0.0010	8.1167	-1.4	0.1655	NA	NA	0
12	481	8.10	-0.1564	-0.0090	8.2465	-5.1	0.0000	NA	NA	0

^a p < 0.00005 appear as 0 due to rounding

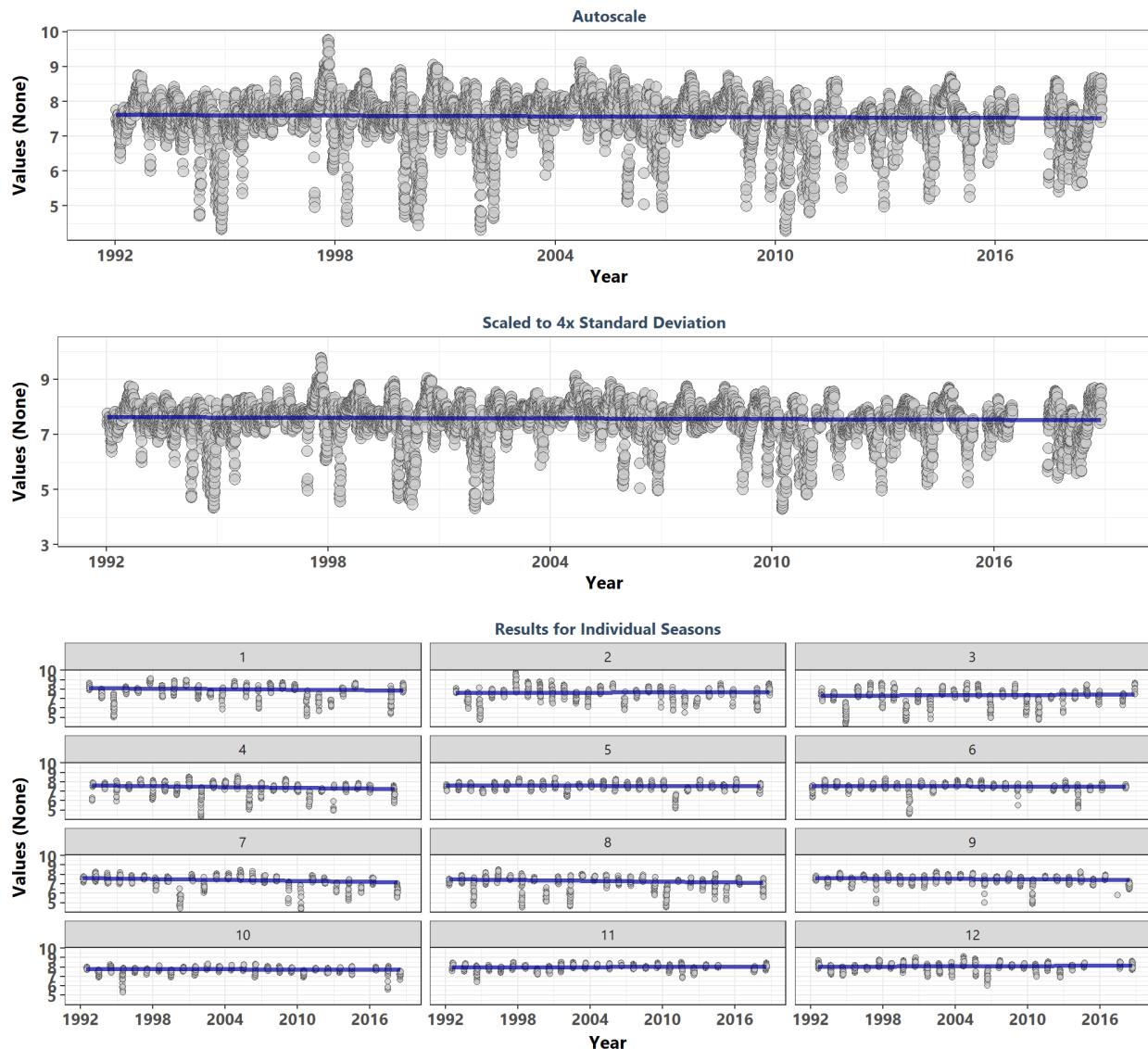
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	6115	8.02	-0.1276	-0.0063	8.1283	-14.6	0.0000	77.2	0	-1
1	520	8.21	-0.2279	-0.0146	8.4589	-7.8	0.0000	NA	NA	-1
2	439	8.16	-0.2448	-0.0152	8.4230	-7.7	0.0000	NA	NA	-1
3	526	8.00	-0.1502	-0.0091	8.1492	-5.2	0.0000	NA	NA	-1
4	507	7.96	-0.0841	-0.0044	8.0290	-2.8	0.0046	NA	NA	-1
5	566	7.97	-0.1069	-0.0053	8.0602	-3.8	0.0001	NA	NA	-1
6	544	7.95	-0.0576	-0.0021	7.9854	-2.0	0.0442	NA	NA	-1
7	526	7.98	-0.0128	-0.0004	7.9838	-0.4	0.6604	NA	NA	-1
8	522	7.96	0.0052	0.0002	7.9535	0.2	0.8602	NA	NA	1
9	505	7.97	-0.1985	-0.0092	8.1073	-6.7	0.0000	NA	NA	-1
10	456	8.01	-0.1959	-0.0093	8.1595	-6.3	0.0000	NA	NA	-1
11	504	8.15	-0.1402	-0.0098	8.3030	-4.7	0.0000	NA	NA	-1
12	500	8.18	-0.1531	-0.0091	8.3209	-5.1	0.0000	NA	NA	-1

^a p < 0.00005 appear as 0 due to rounding

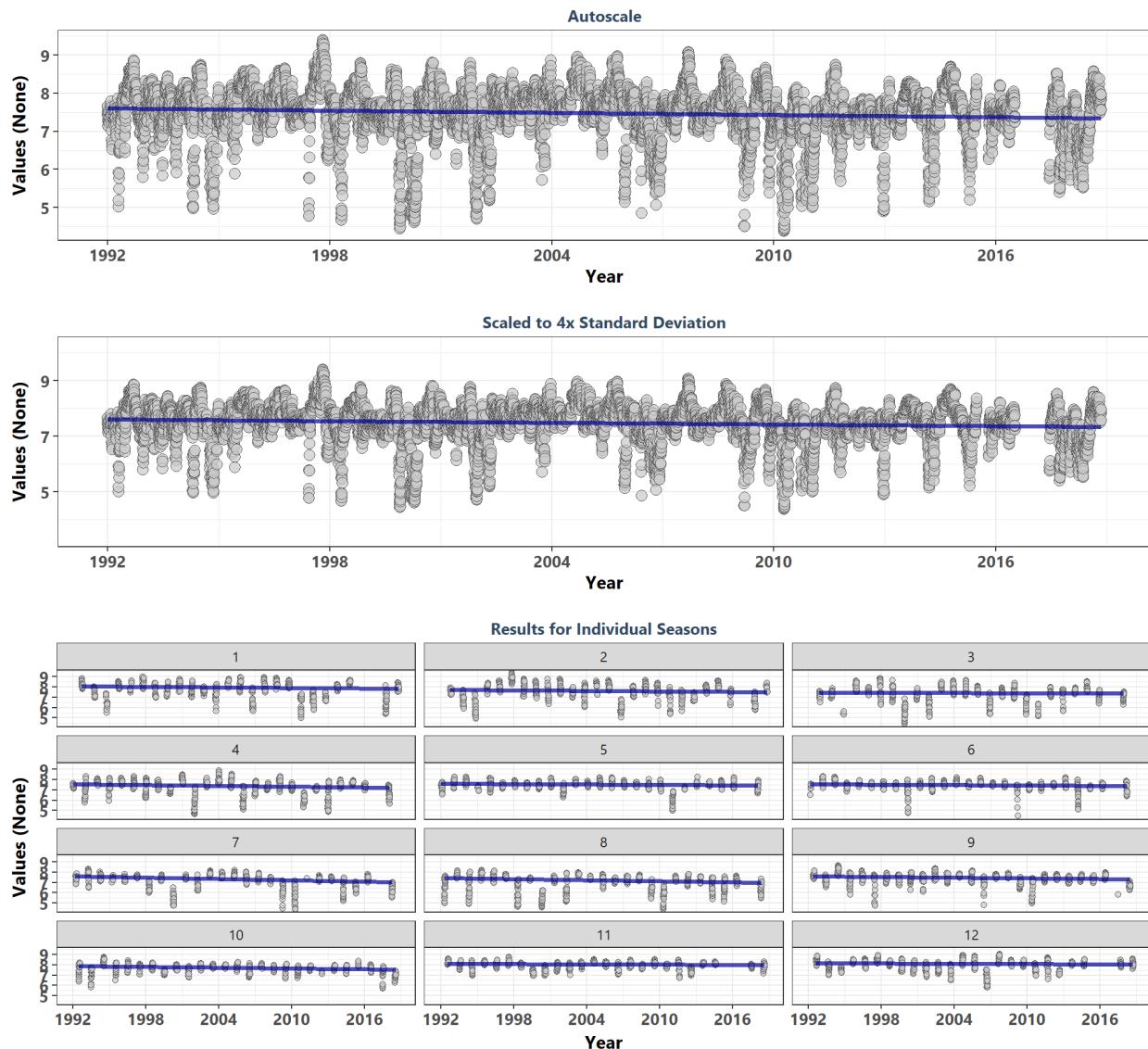
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	8459	7.61	-0.0464	-0.0038	7.6214	-6.3	0.0000	114.6	0	-1
1	709	8.00	-0.0615	-0.0090	8.1174	-2.5	0.0142	NA	NA	-1
2	660	7.67	0.0108	0.0015	7.6468	0.4	0.6786	NA	NA	1
3	723	7.37	0.0400	0.0048	7.3048	1.6	0.1076	NA	NA	1
4	677	7.43	-0.1382	-0.0141	7.6099	-5.4	0.0000	NA	NA	-1
5	749	7.57	-0.0491	-0.0033	7.6171	-2.0	0.0443	NA	NA	-1
6	689	7.54	-0.0599	-0.0035	7.5811	-2.4	0.0186	NA	NA	-1
7	705	7.43	-0.1916	-0.0179	7.6256	-7.6	0.0000	NA	NA	-1
8	711	7.32	-0.1298	-0.0144	7.4824	-5.2	0.0000	NA	NA	-1
9	680	7.52	-0.0812	-0.0063	7.5994	-3.2	0.0015	NA	NA	-1
10	713	7.75	-0.0245	-0.0015	7.7714	-1.0	0.3280	NA	NA	-1
11	703	8.03	0.0391	0.0021	8.0036	1.6	0.1206	NA	NA	1
12	740	8.09	0.0795	0.0062	8.0135	3.2	0.0012	NA	NA	1

^a p < 0.00005 appear as 0 due to rounding

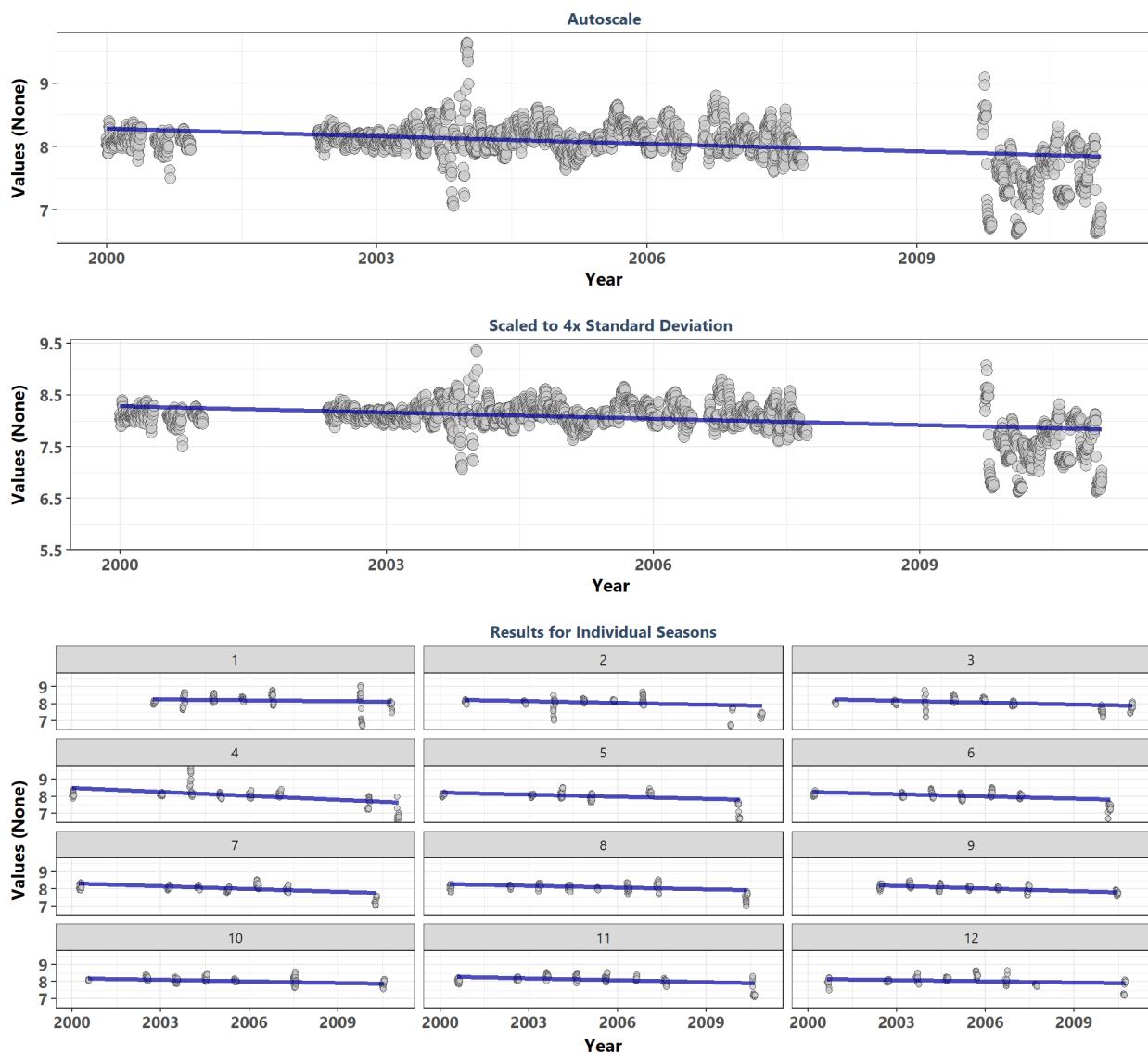
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	8553	7.56	-0.1051	-0.0096	7.6026	-14.6	0.0000	56.9	0	-1
1	712	7.97	-0.0728	-0.0094	8.0891	-2.9	0.0036	NA	NA	-1
2	707	7.62	-0.0635	-0.0098	7.7446	-2.5	0.0115	NA	NA	-1
3	710	7.43	-0.0097	-0.0012	7.4450	-0.4	0.6991	NA	NA	-1
4	753	7.39	-0.1281	-0.0140	7.5752	-5.3	0.0000	NA	NA	-1
5	686	7.53	-0.0901	-0.0061	7.6000	-3.5	0.0004	NA	NA	-1
6	700	7.48	-0.1208	-0.0077	7.5719	-4.8	0.0000	NA	NA	-1
7	708	7.34	-0.2076	-0.0214	7.5945	-8.3	0.0000	NA	NA	-1
8	699	7.21	-0.1459	-0.0174	7.4167	-5.8	0.0000	NA	NA	-1
9	738	7.47	-0.1291	-0.0109	7.6052	-5.3	0.0000	NA	NA	-1
10	719	7.75	-0.1756	-0.0130	7.9042	-7.1	0.0000	NA	NA	-1
11	715	8.03	-0.0690	-0.0043	8.0771	-2.8	0.0057	NA	NA	-1
12	706	8.09	-0.0461	-0.0042	8.1391	-1.8	0.0668	NA	NA	-1

^a p < 0.00005 appear as 0 due to rounding

Big Bend Seagrasses Aquatic Preserve
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BBSSK



Season	N	Median	tau	Slope	Int.	z	p_z	chi_sq	p_chi_sq	Trend
All	2453	8.08	-0.2613	-0.0399	8.2827	-19.4	0.0000	55.8	0	-1
1	206	8.20	-0.0985	-0.0180	8.3054	-2.1	0.0336	NA	NA	-1
2	192	8.10	-0.1917	-0.0340	8.2664	-4.0	0.0001	NA	NA	-1
3	215	8.06	-0.2587	-0.0355	8.2753	-5.7	0.0000	NA	NA	-1
4	230	8.04	-0.4045	-0.0749	8.4869	-9.2	0.0000	NA	NA	-1
5	186	8.04	-0.2687	-0.0427	8.2357	-5.5	0.0000	NA	NA	-1
6	209	8.04	-0.3091	-0.0439	8.2634	-6.7	0.0000	NA	NA	-1
7	212	8.06	-0.3983	-0.0556	8.3408	-8.7	0.0000	NA	NA	-1
8	207	8.16	-0.1867	-0.0326	8.2901	-4.0	0.0001	NA	NA	-1
9	187	8.08	-0.4030	-0.0466	8.3163	-8.3	0.0000	NA	NA	-1
10	177	8.08	-0.2708	-0.0290	8.1984	-5.4	0.0000	NA	NA	-1
11	218	8.17	-0.2017	-0.0372	8.3149	-4.5	0.0000	NA	NA	-1
12	214	8.07	-0.1420	-0.0237	8.1683	-3.1	0.0018	NA	NA	-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$Use_In_Analysis==TRUE &
                      data$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())

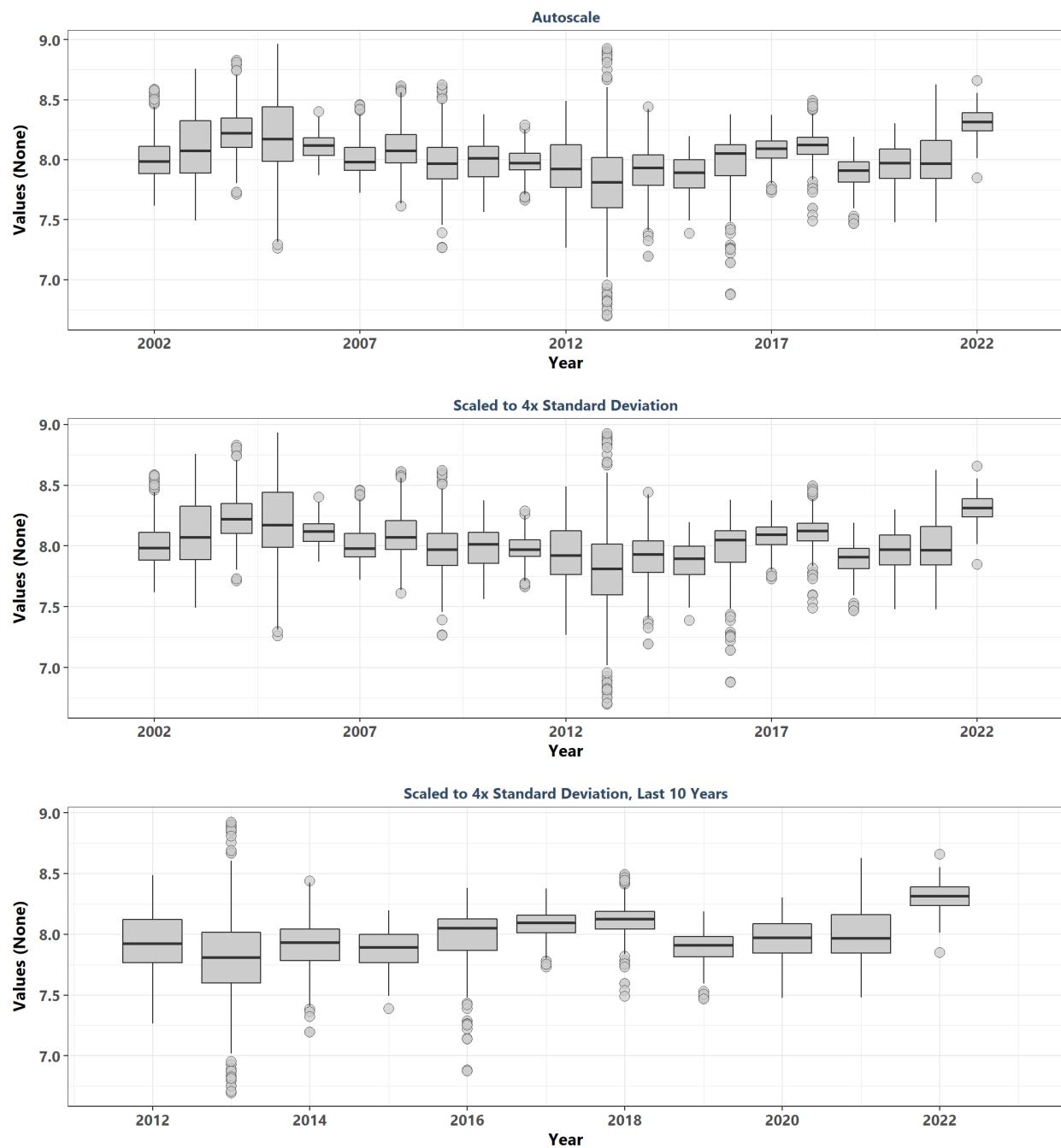
print(ggarrange(p0, Yset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p00, YMset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p000, Mset, ncol=1, heights=c(0.1, 1)))

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

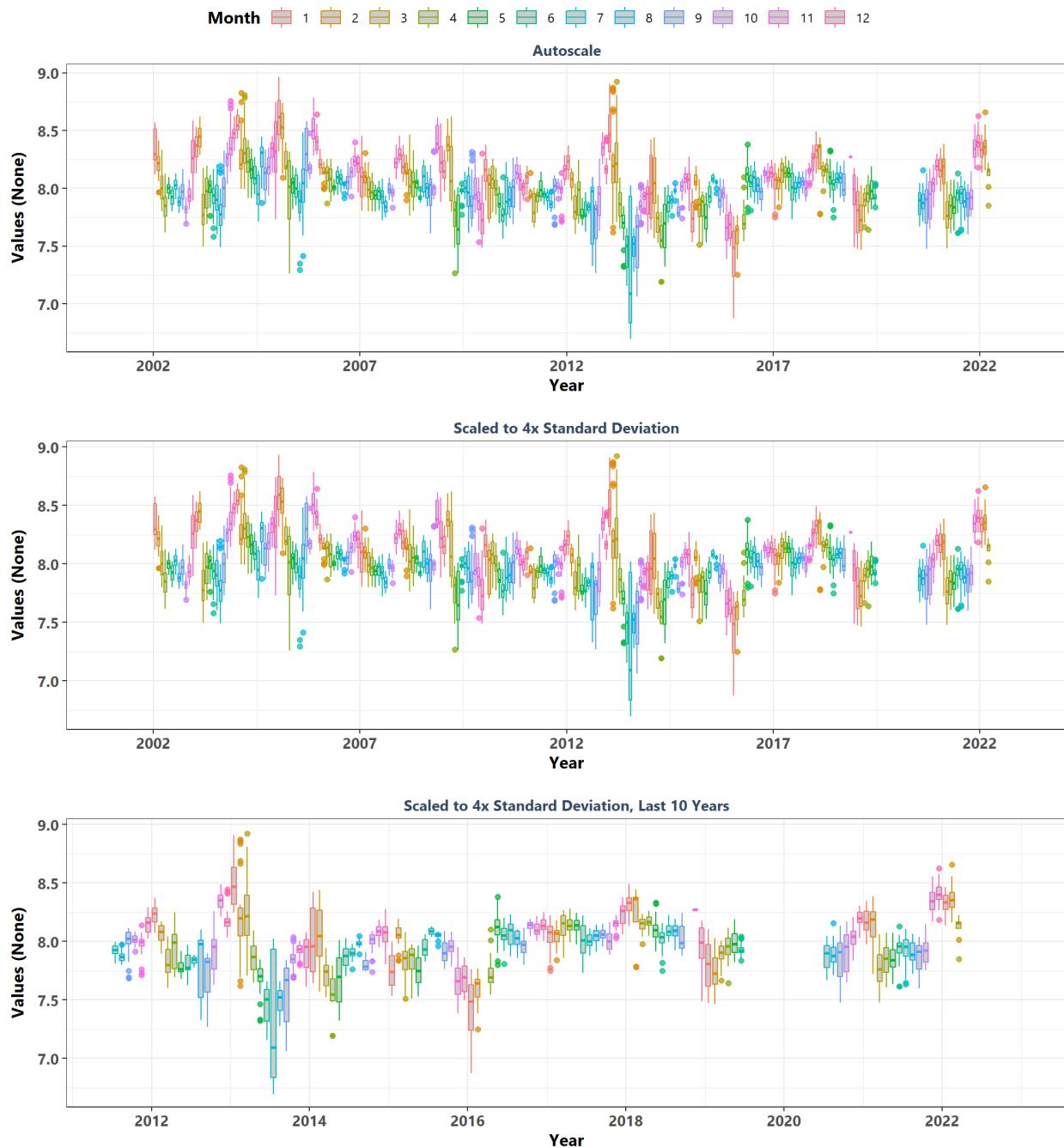
```

```
}
```

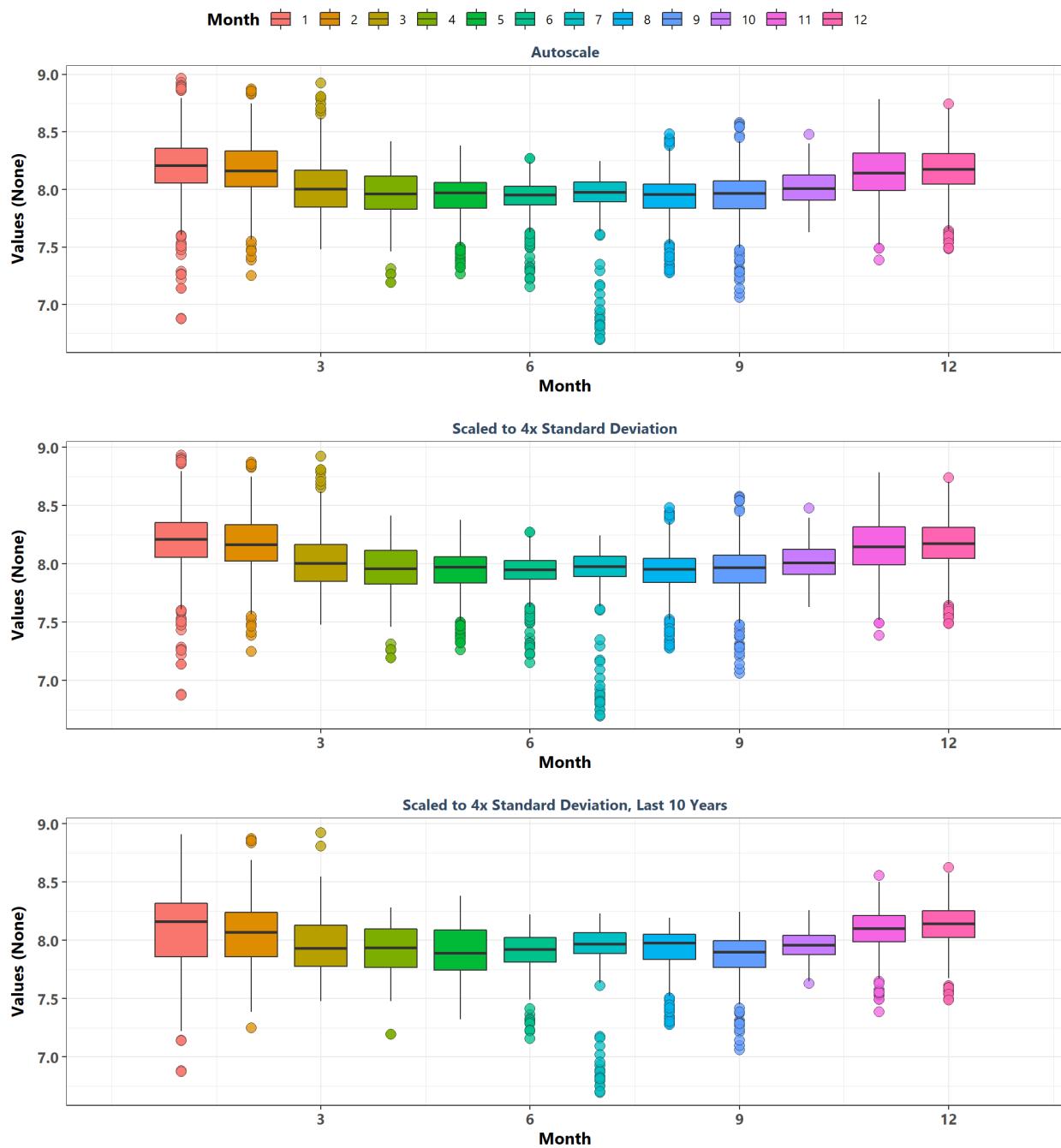
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Year



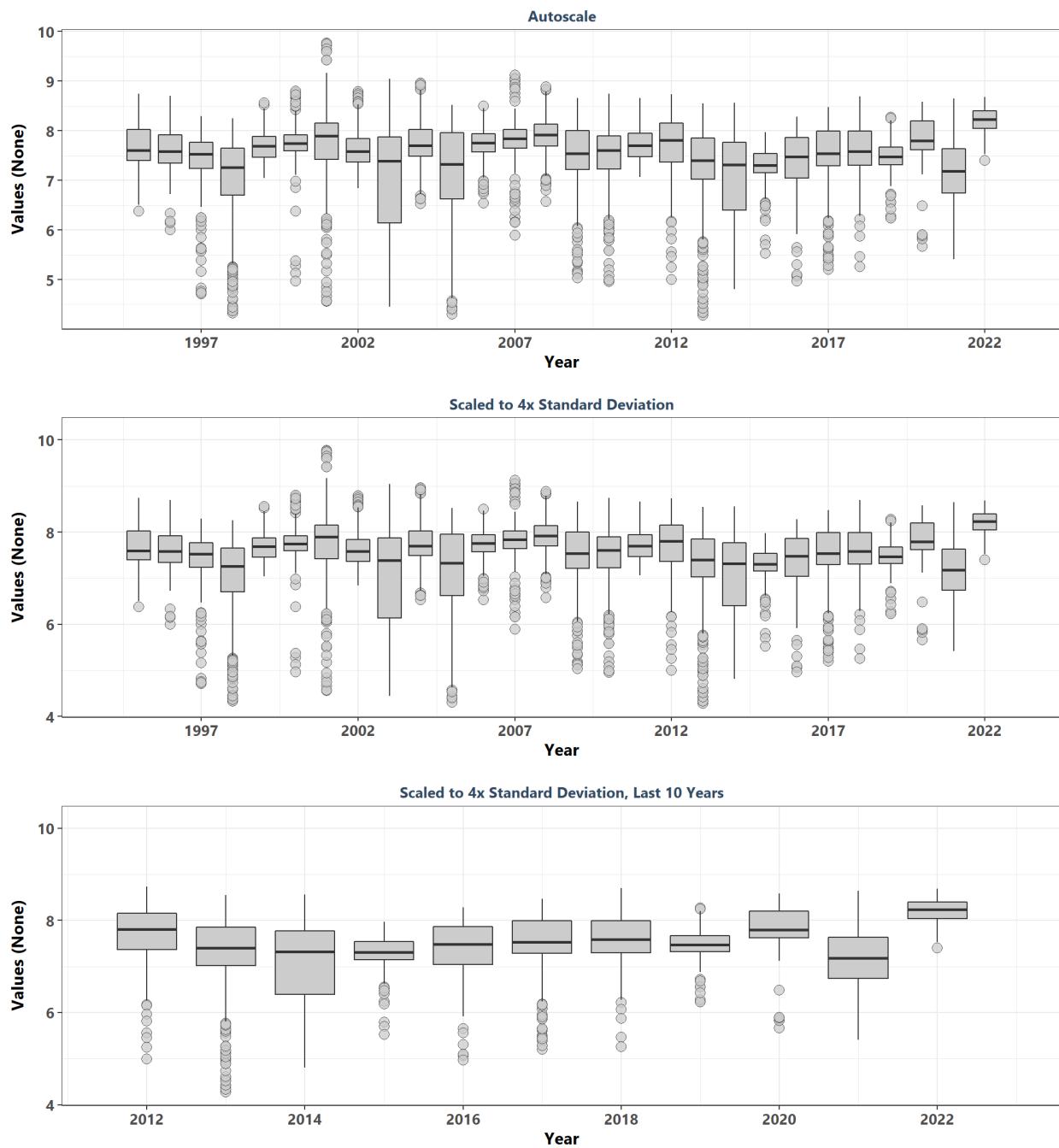
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Year & Month



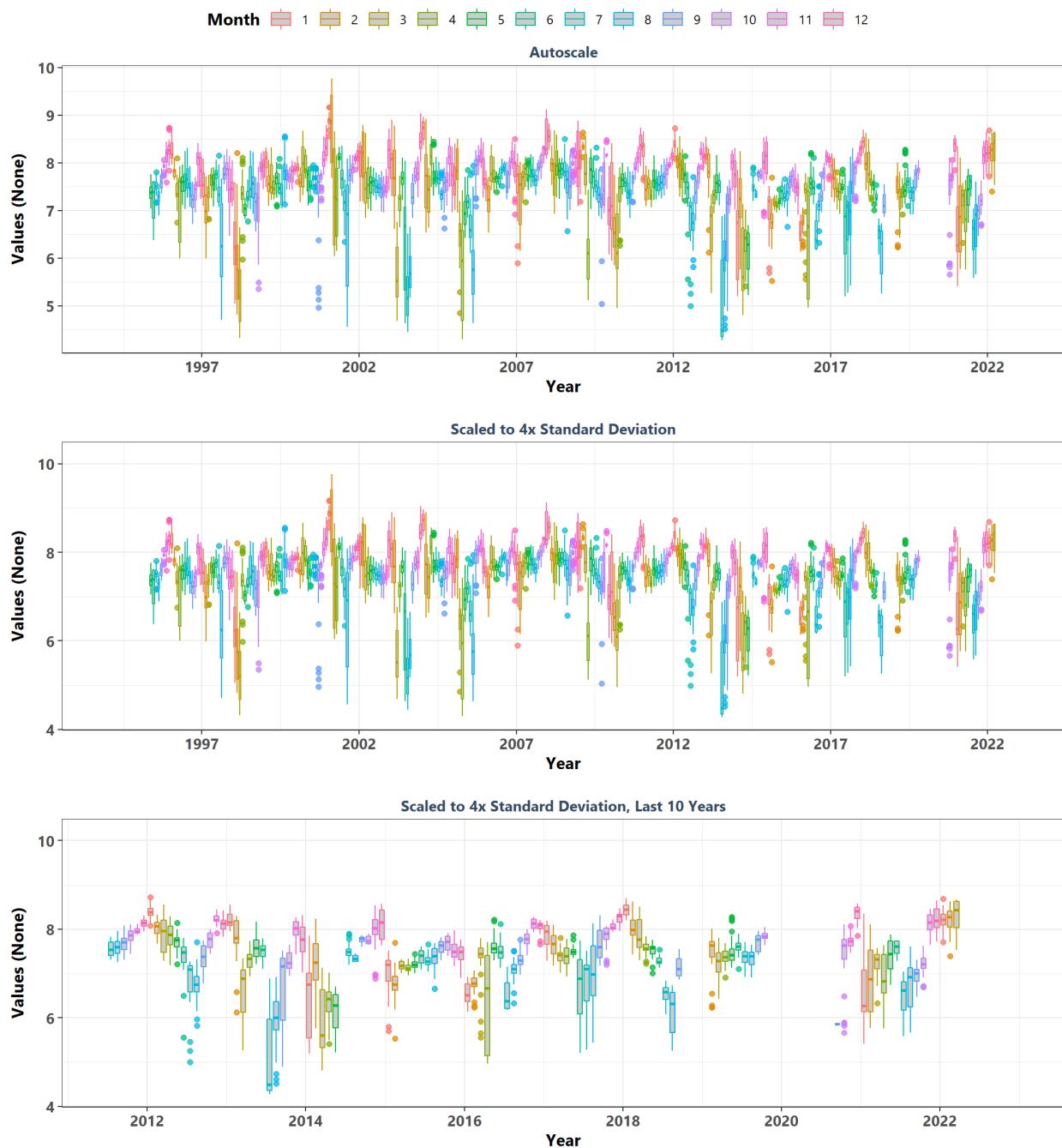
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Month



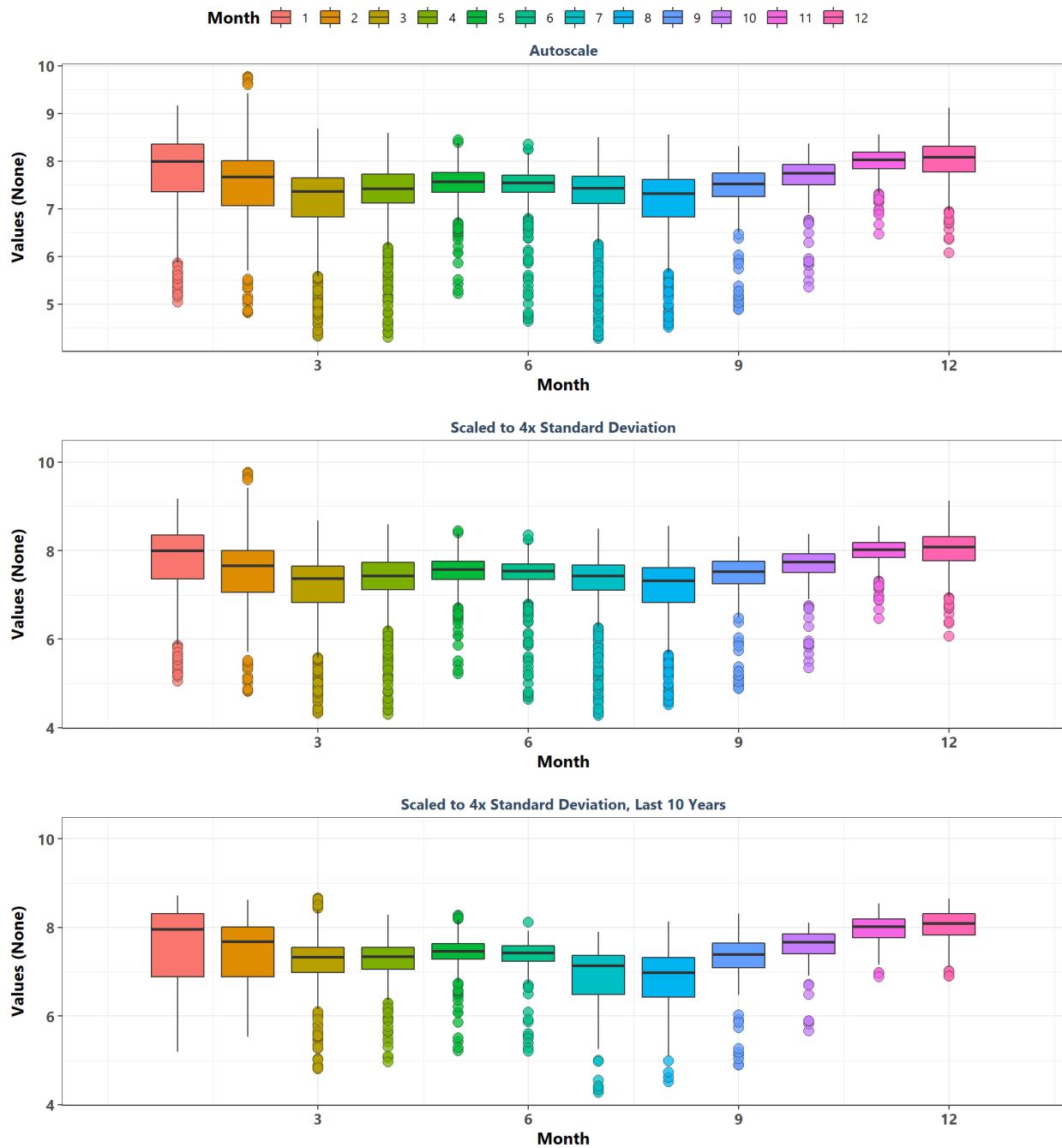
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Year



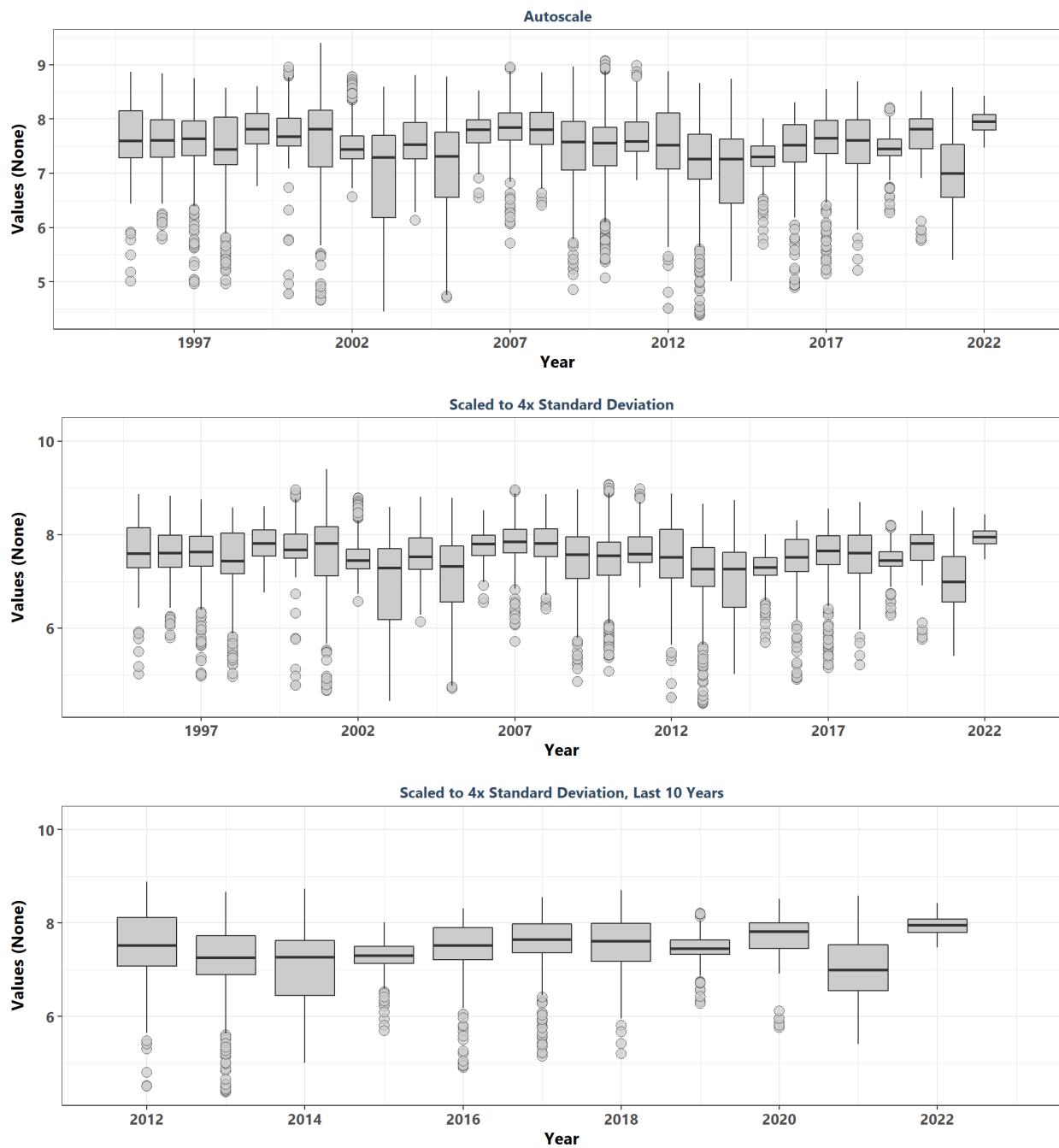
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Year & Month



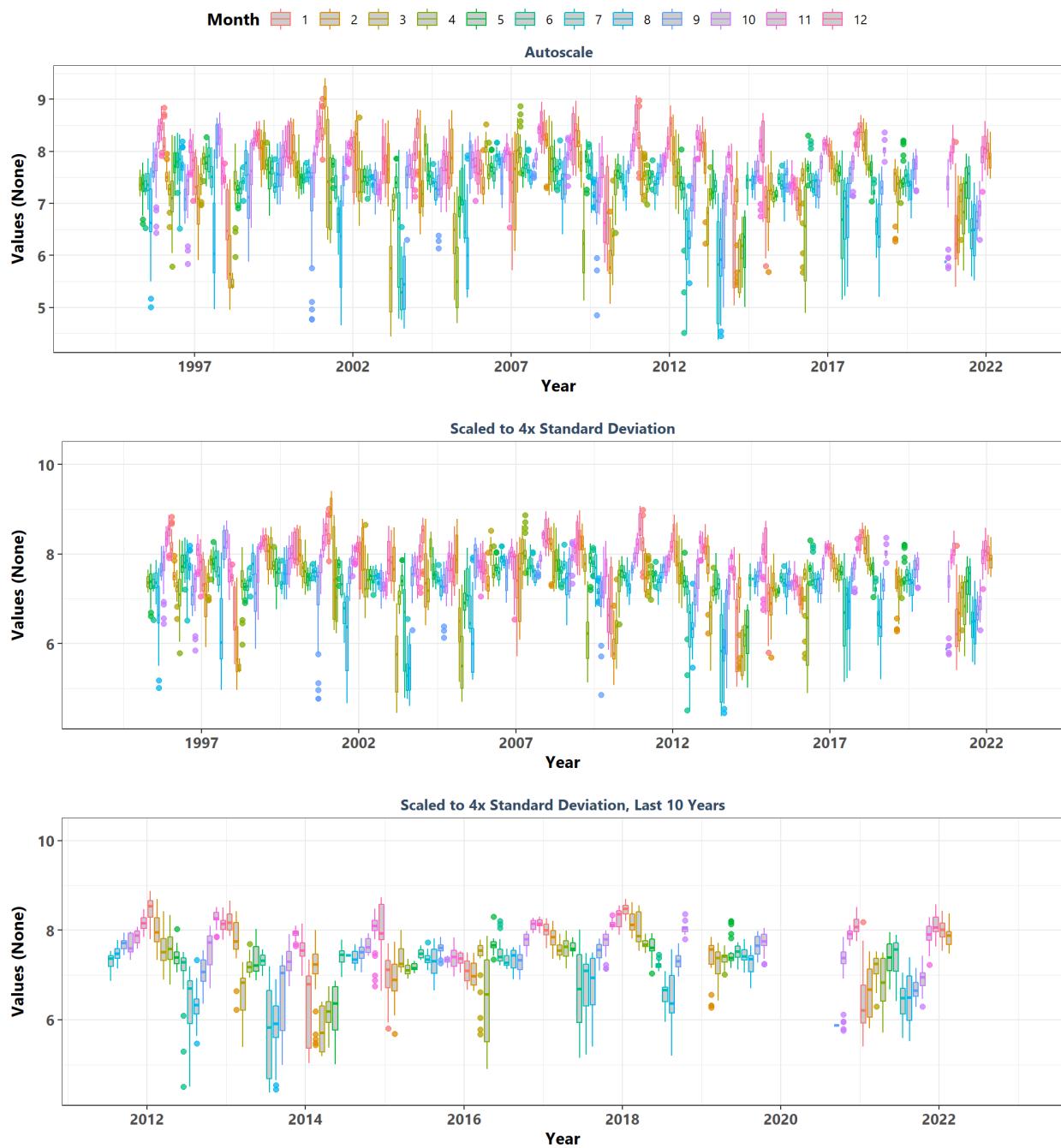
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Month



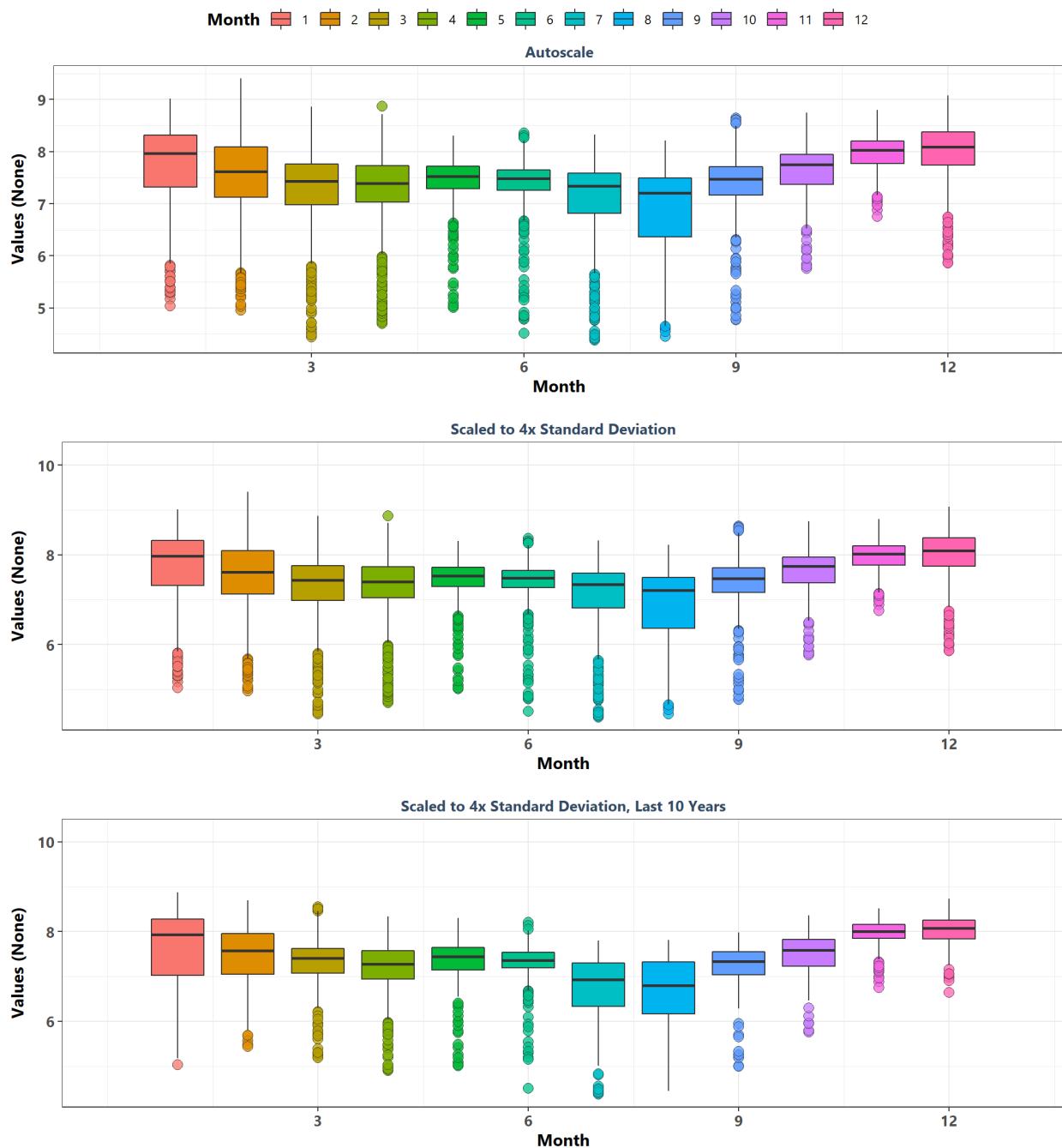
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Year



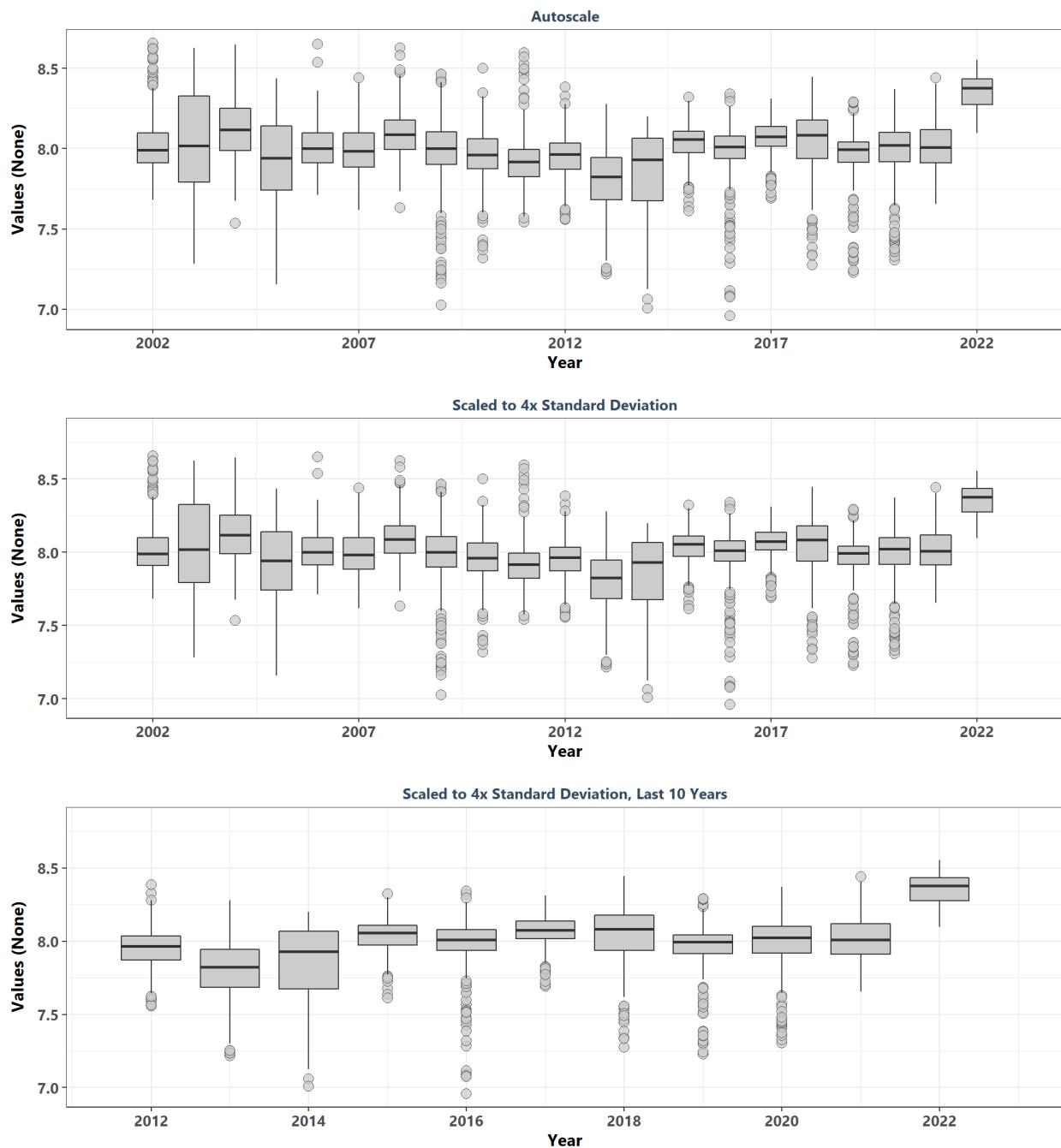
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Year & Month



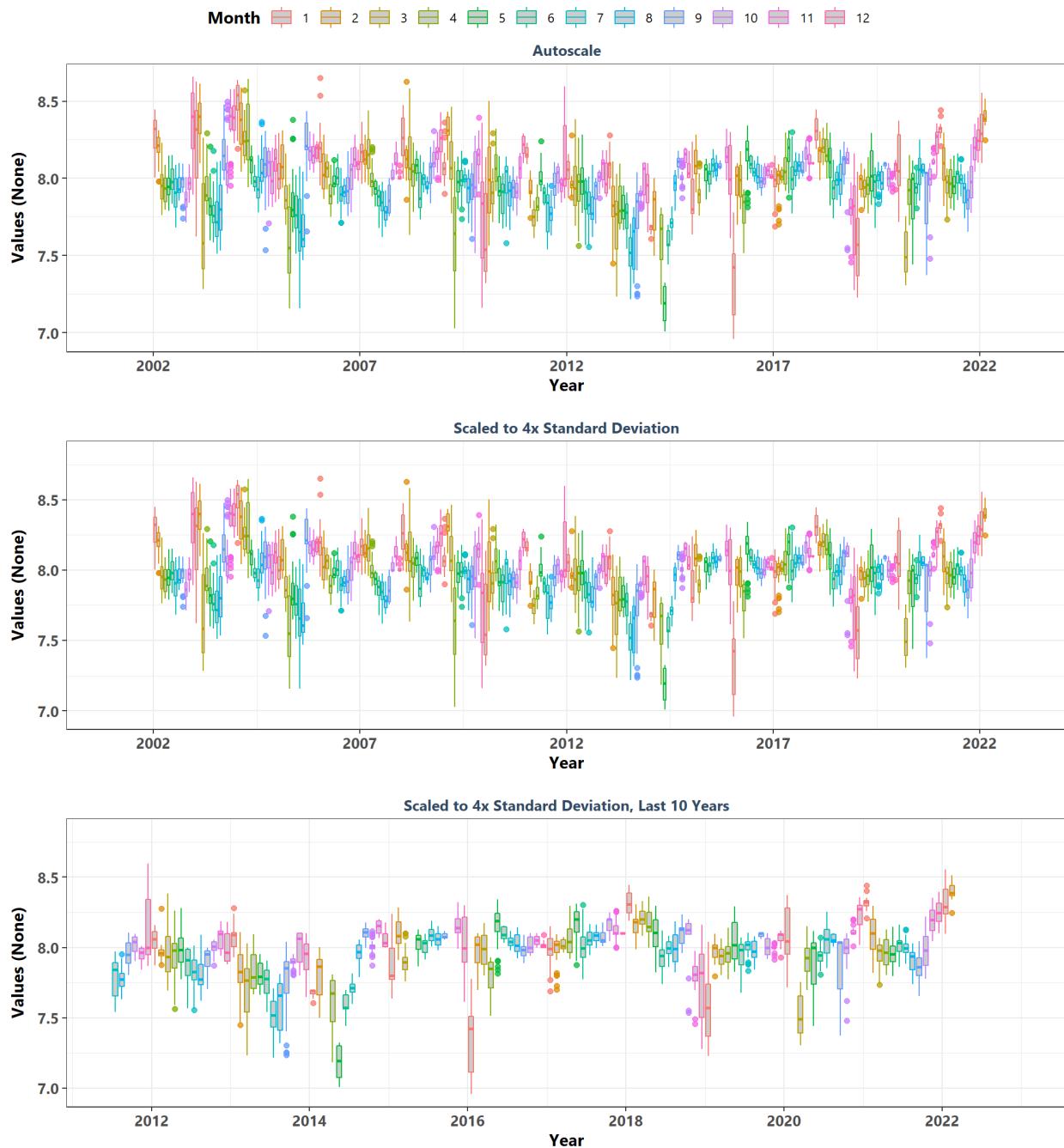
Apalachicola Bay Aquatic Preserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Month



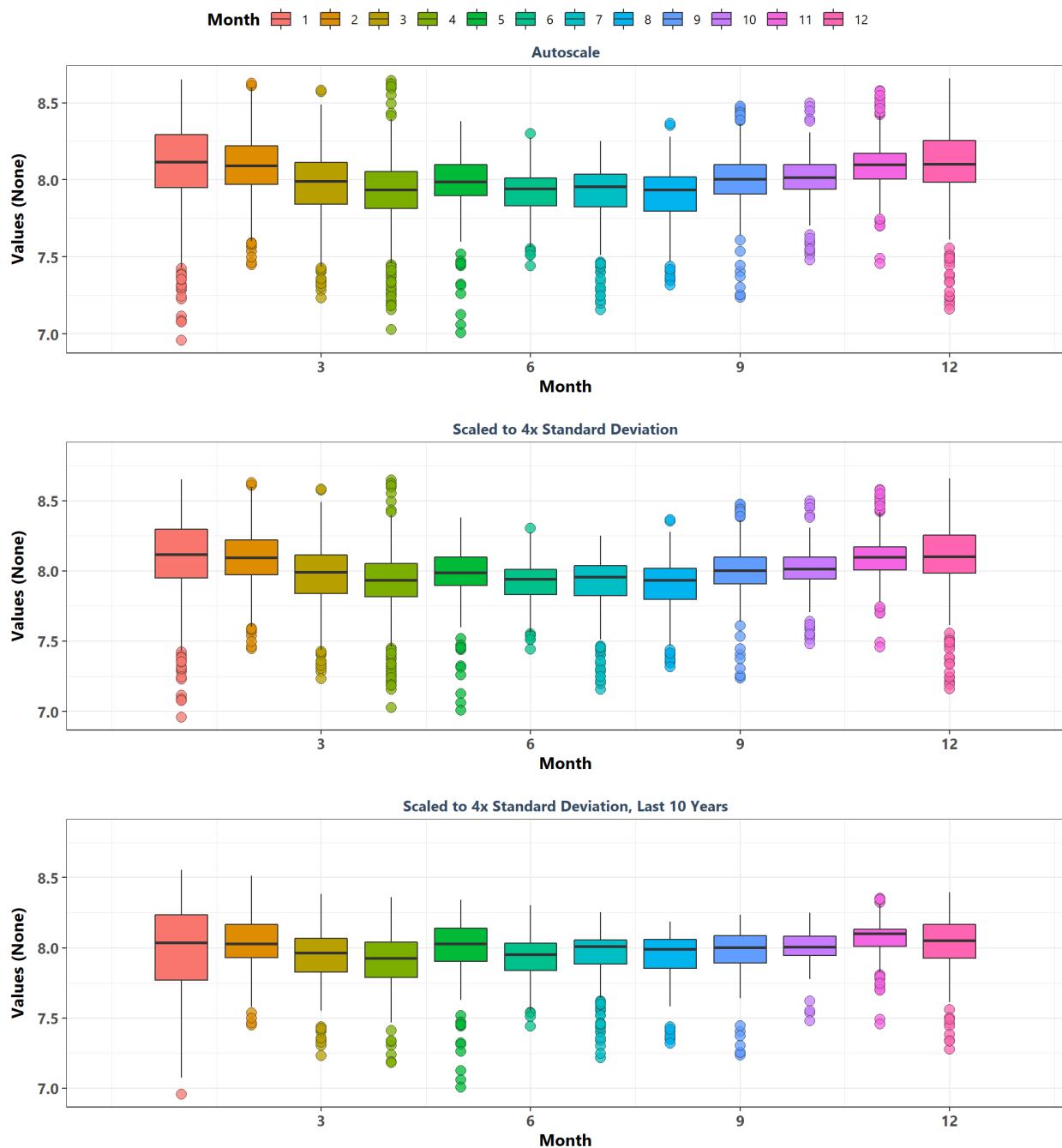
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apacpwq
By Year



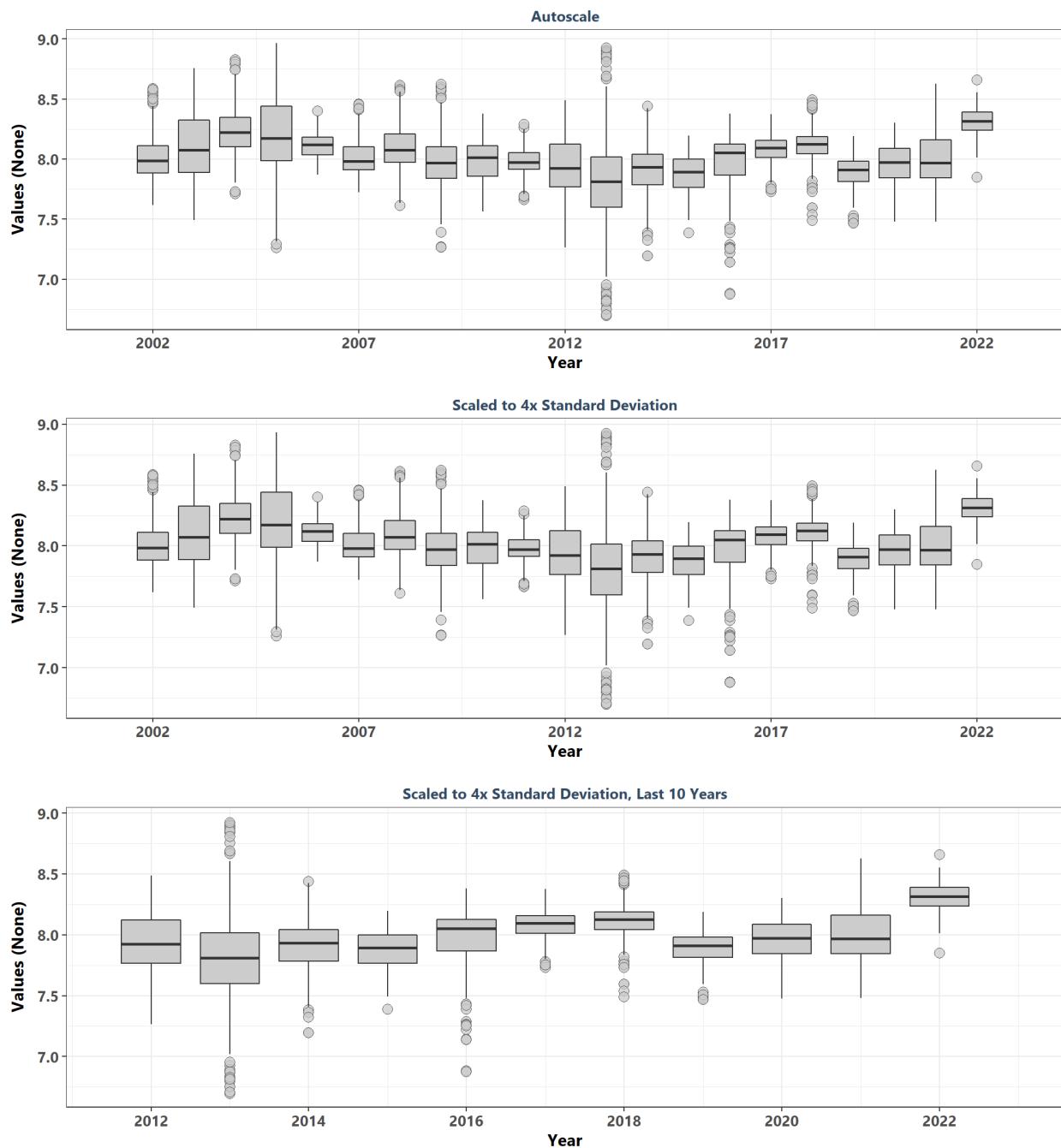
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apacpwq
By Year & Month



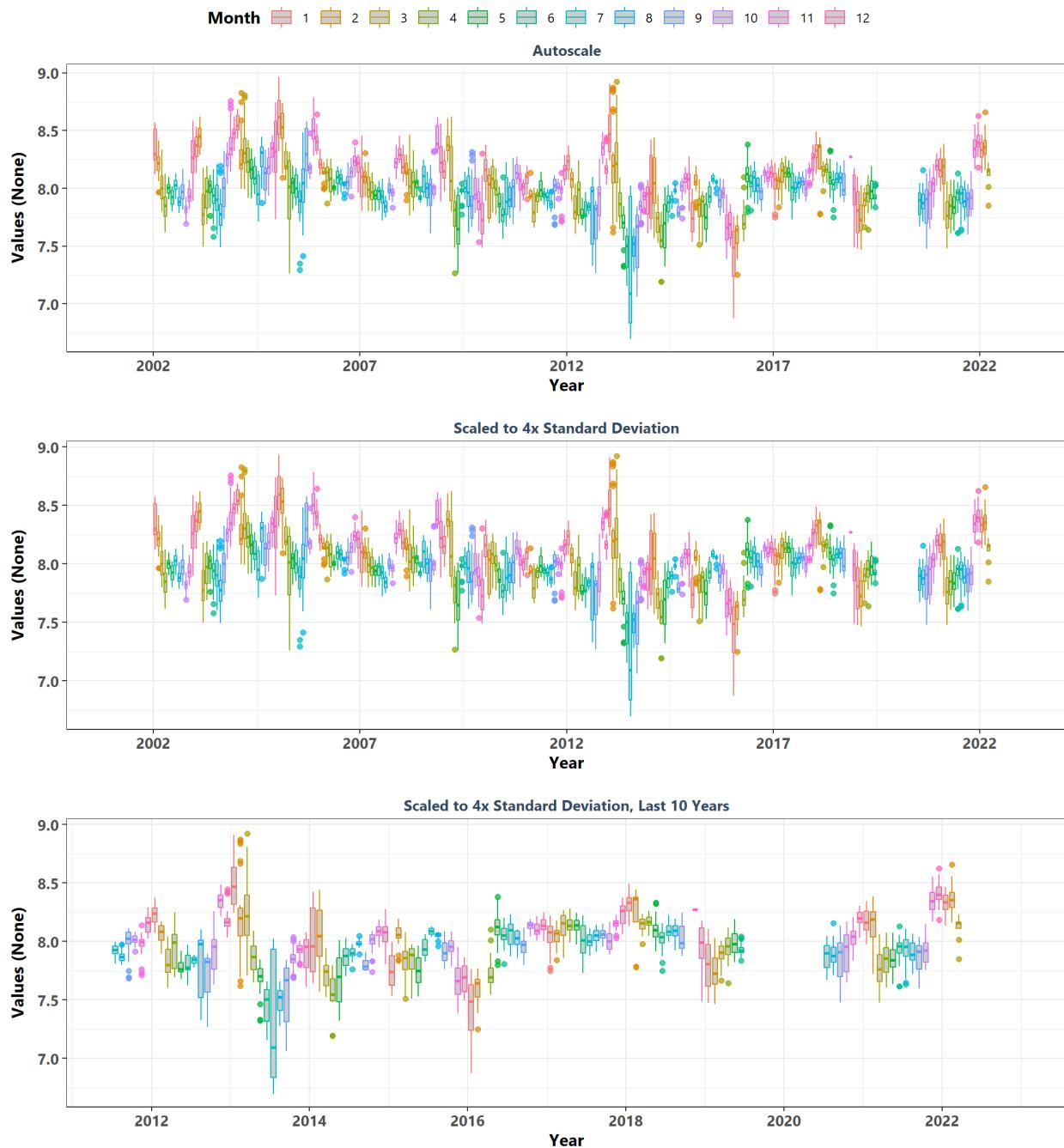
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apacpwq
By Month



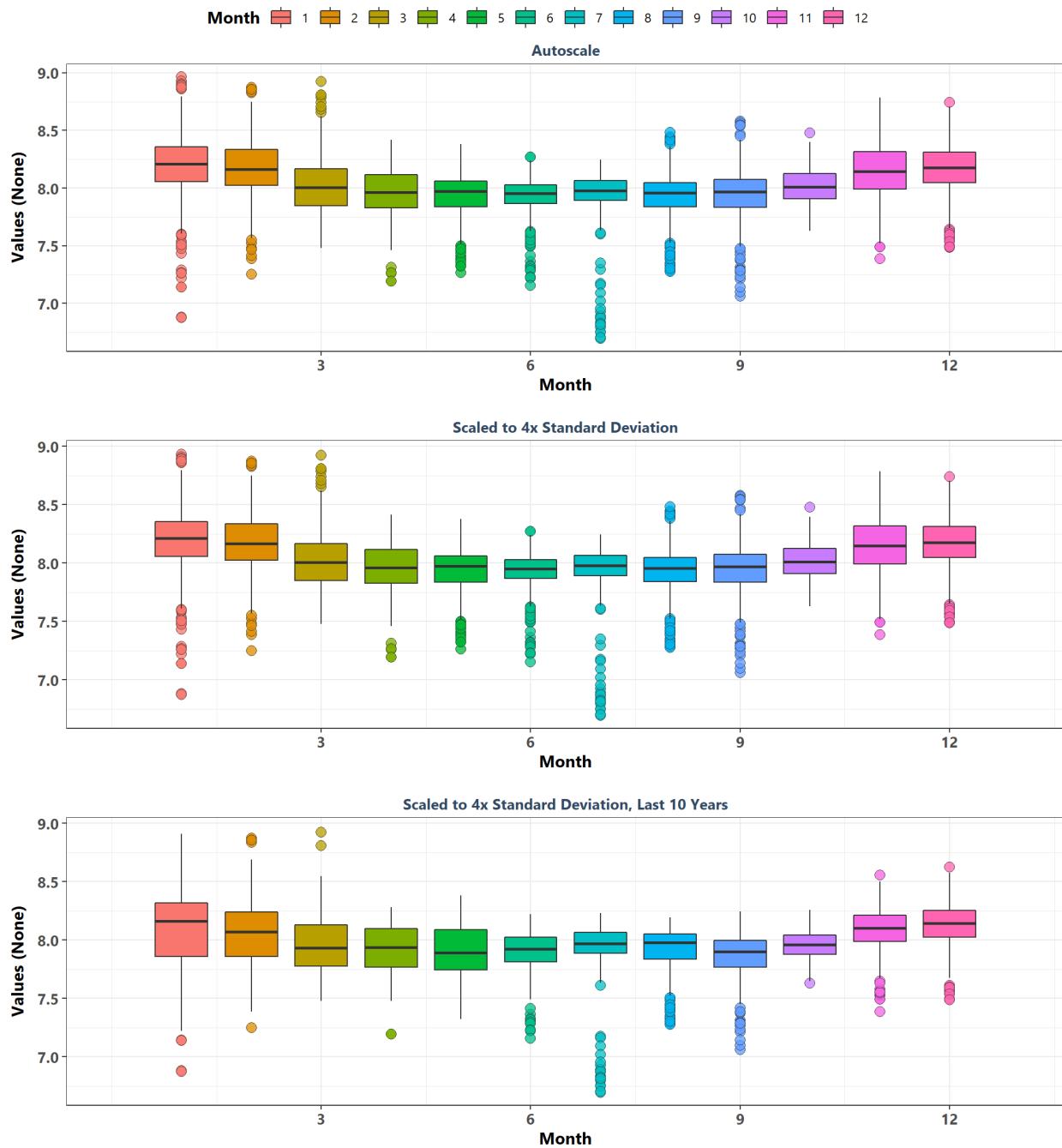
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Year



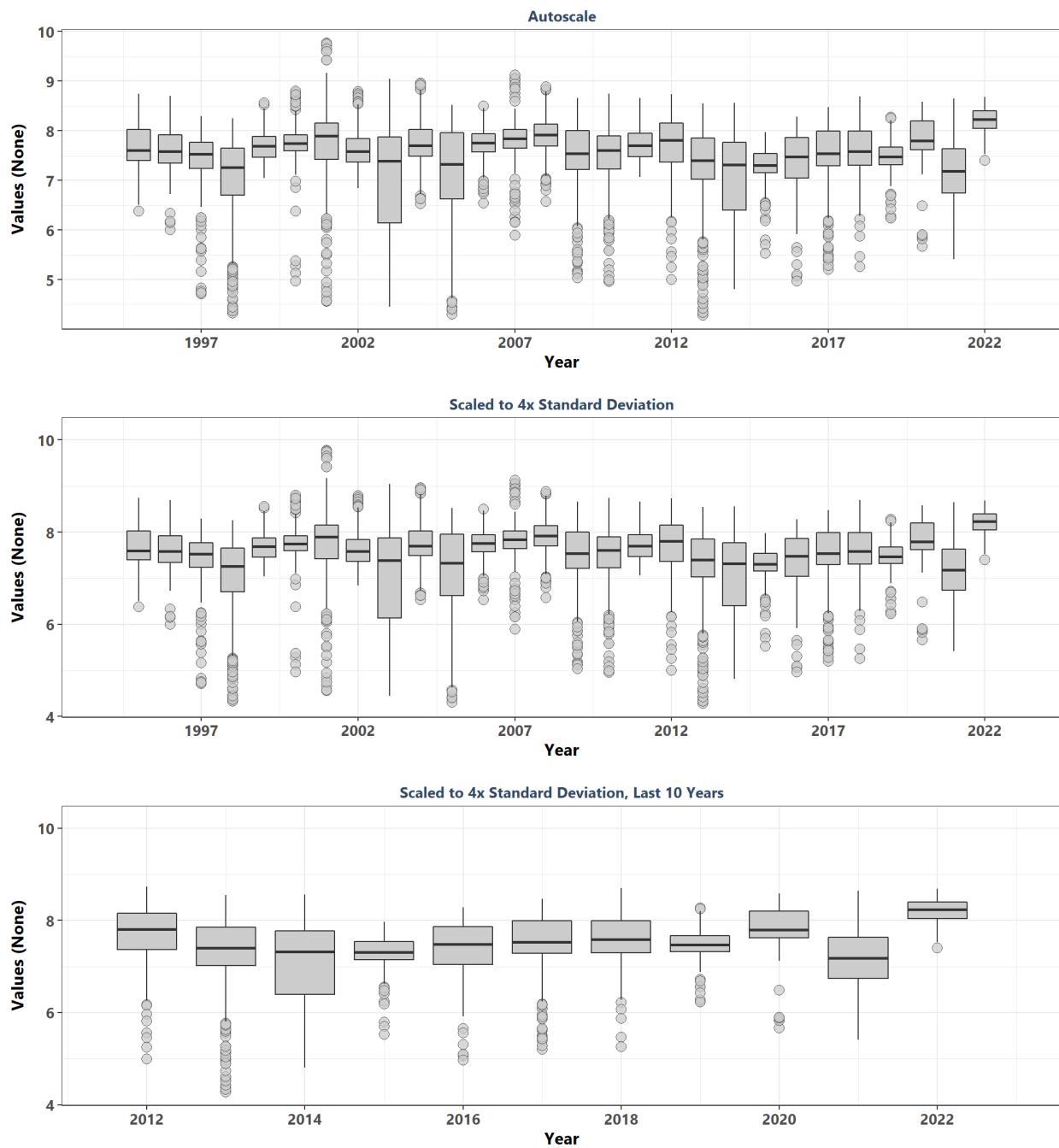
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Year & Month



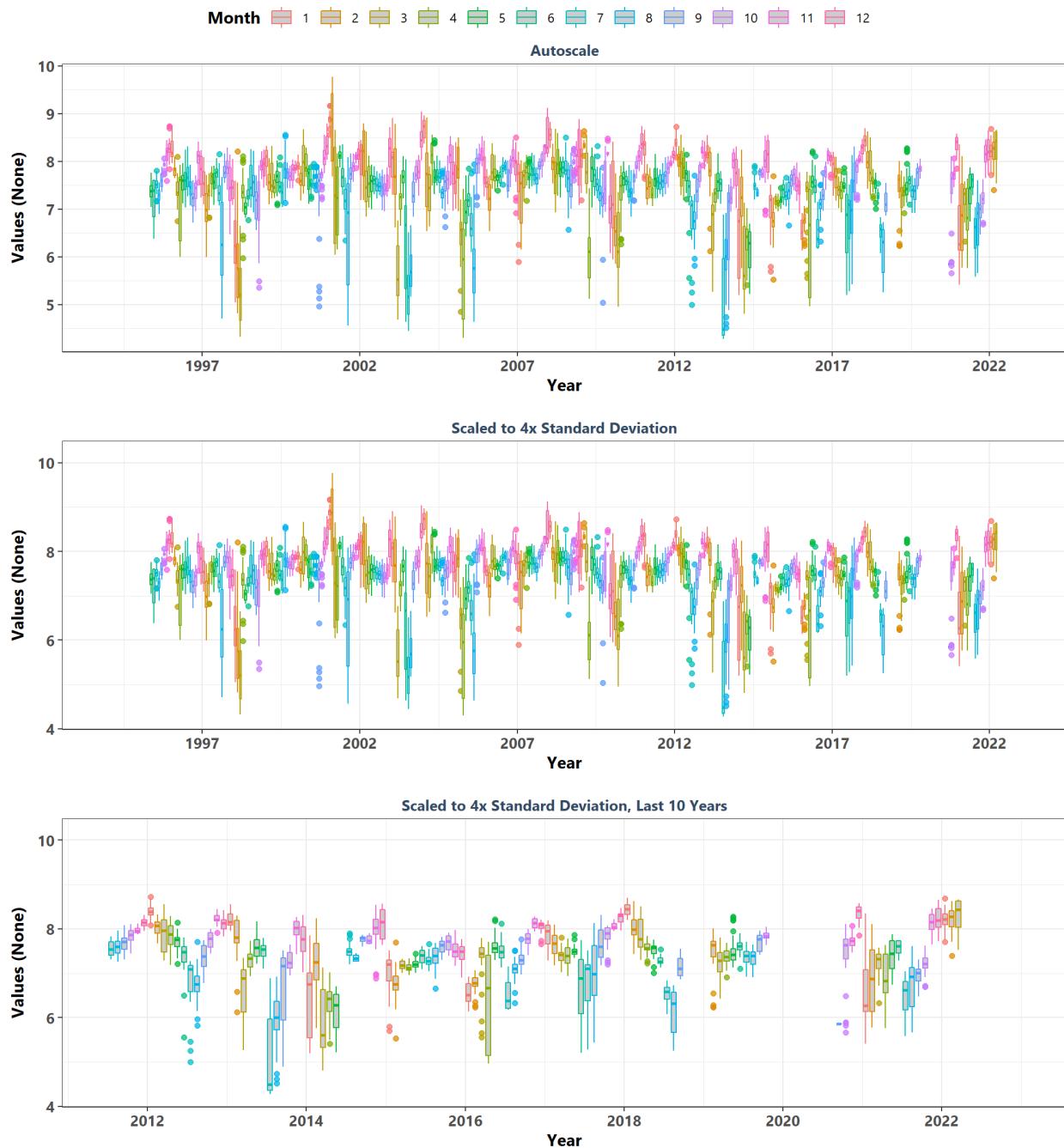
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apadbwq
By Month



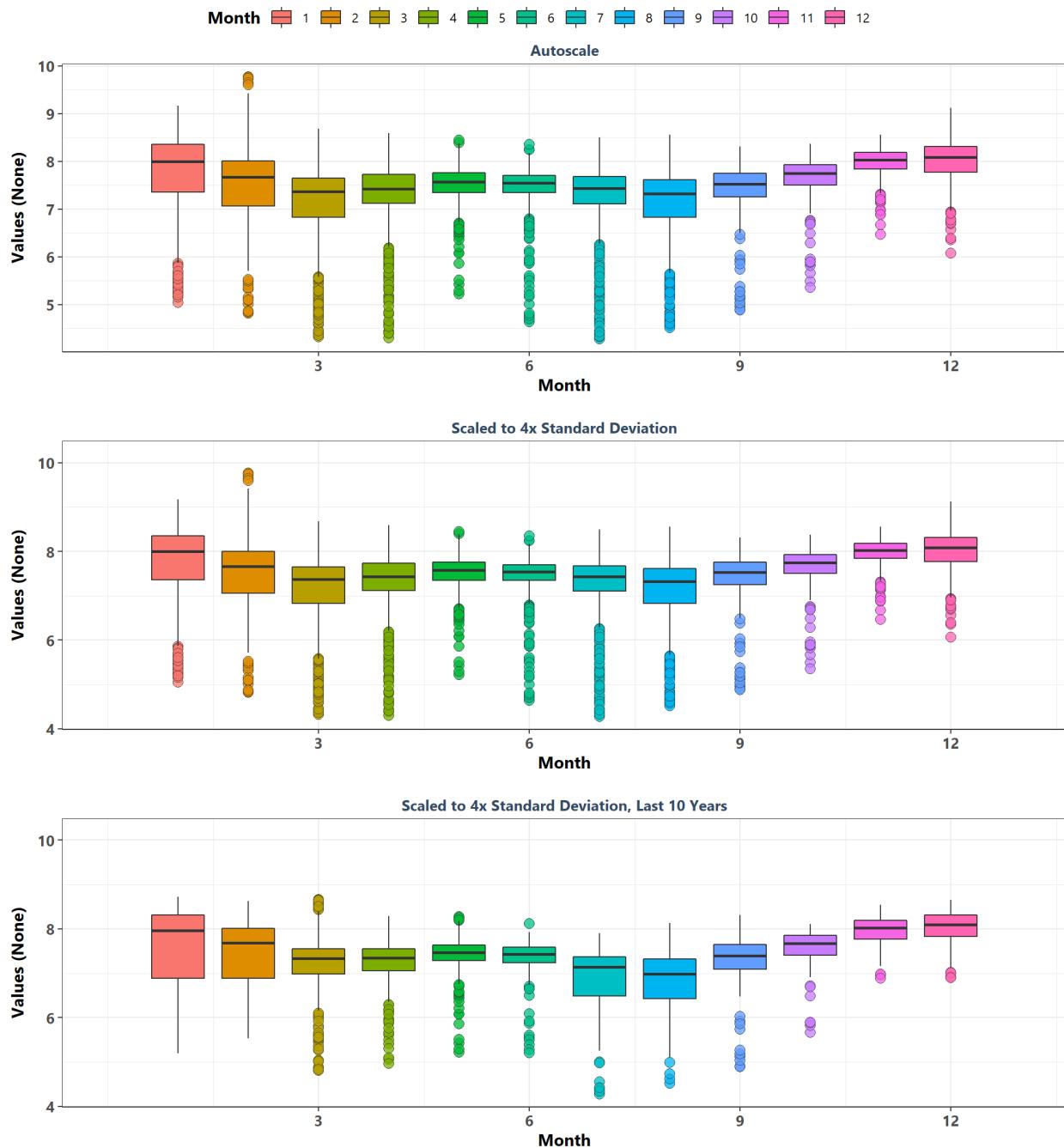
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Year



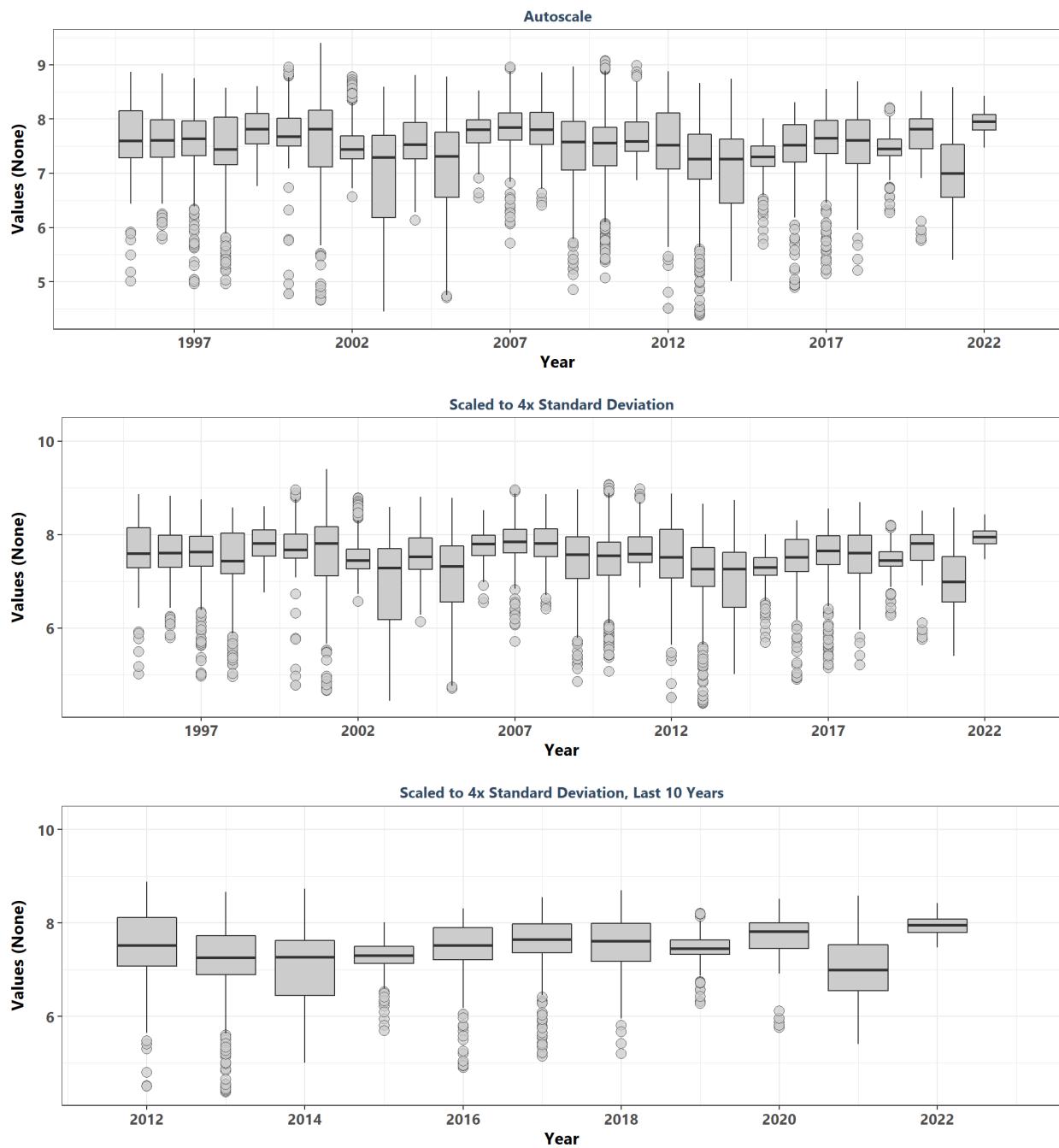
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355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Year & Month



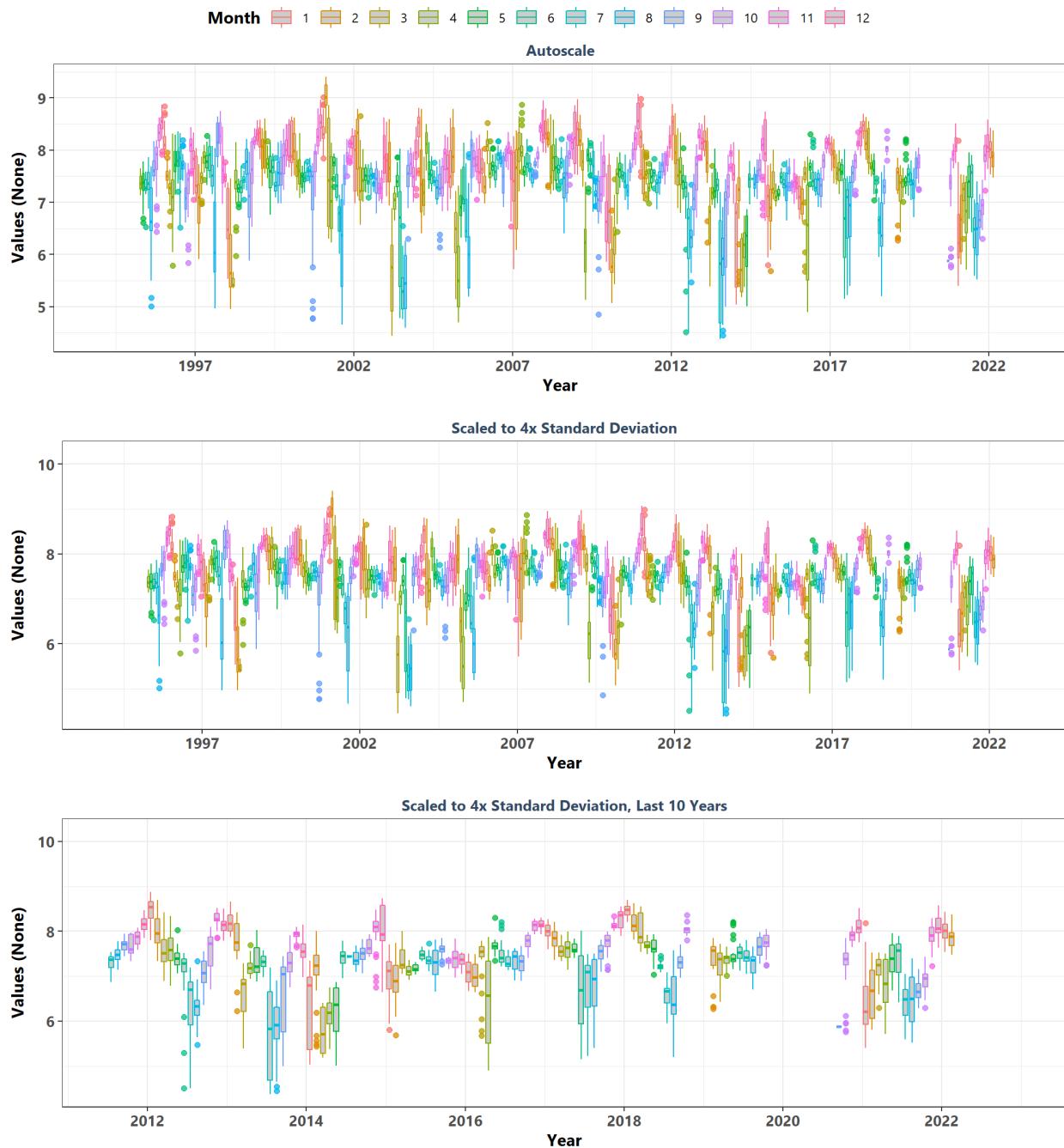
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaebwq
By Month



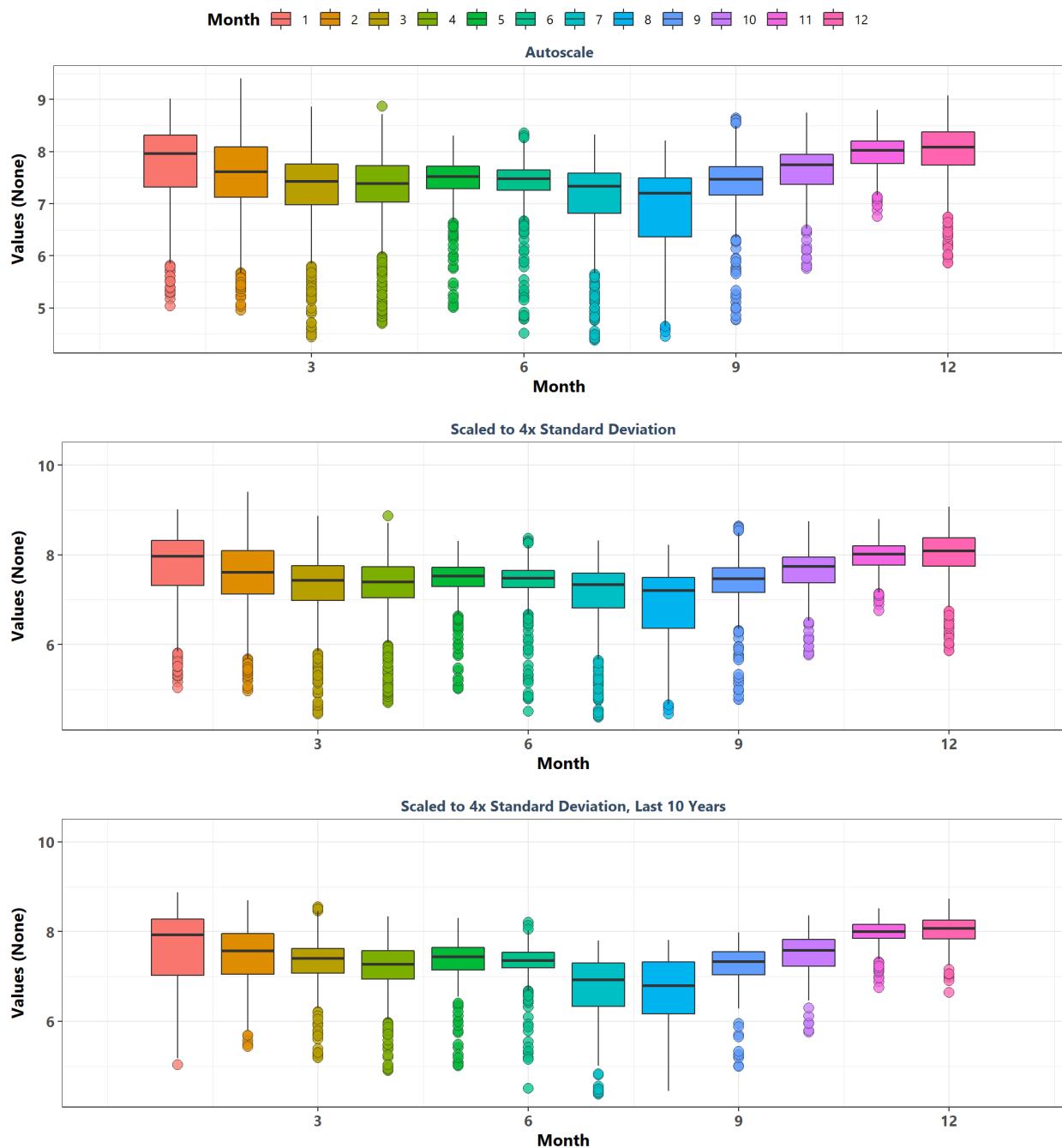
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Year



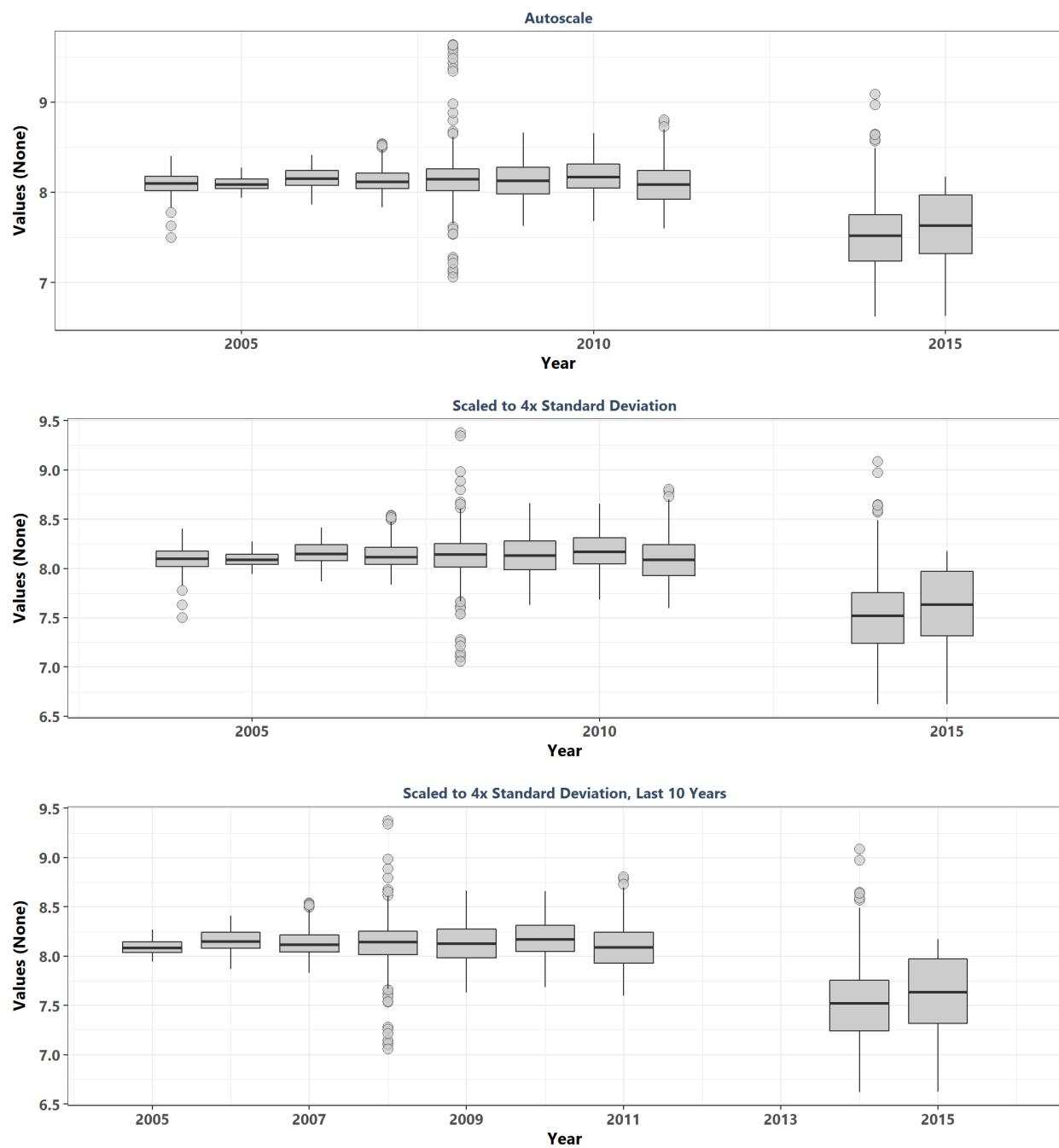
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Year & Month



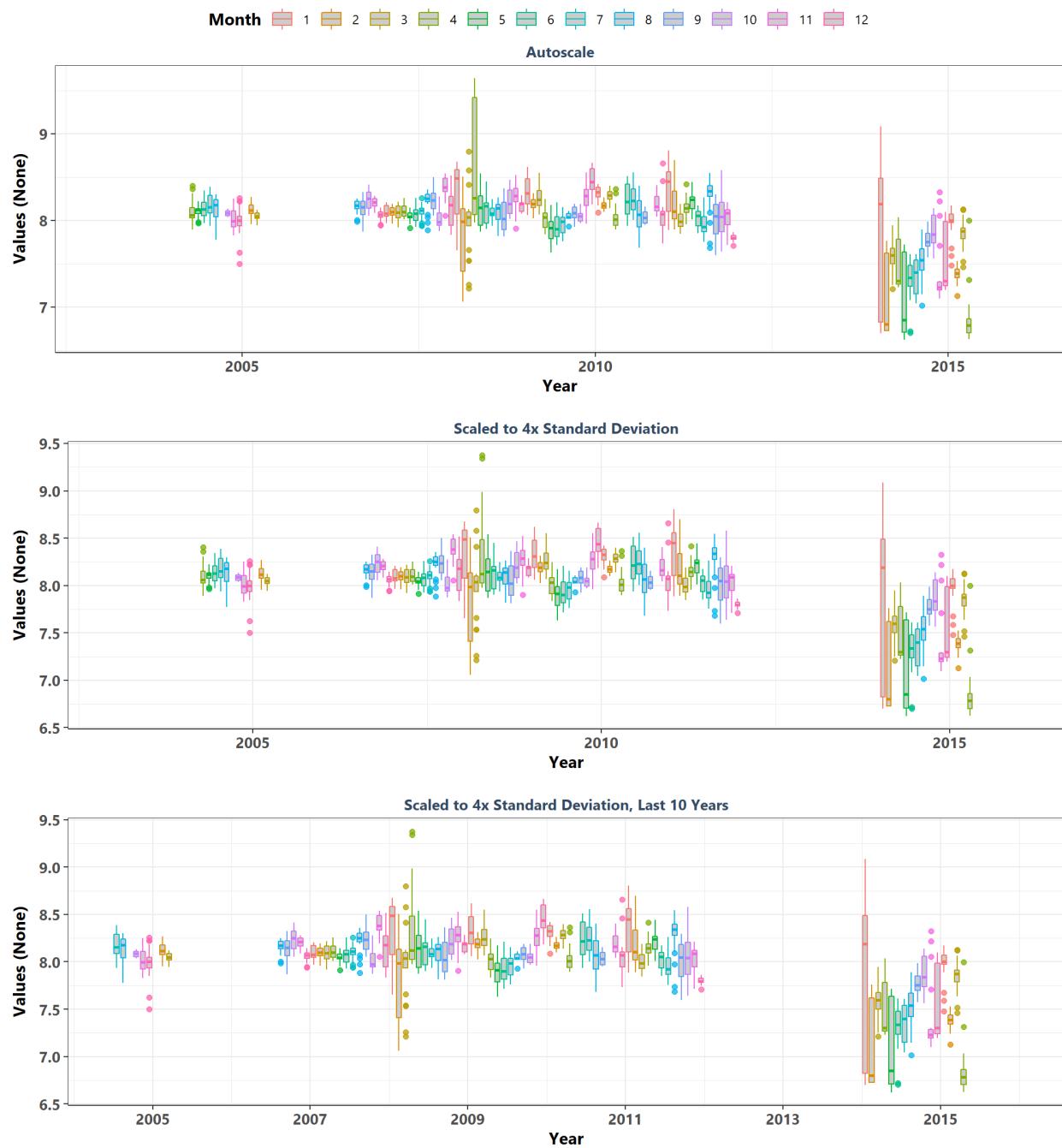
Apalachicola National Estuarine Research Reserve
355 | Apalachicola National Estuarine Research Reserve System-Wide Monitoring Program
apaeswq
By Month



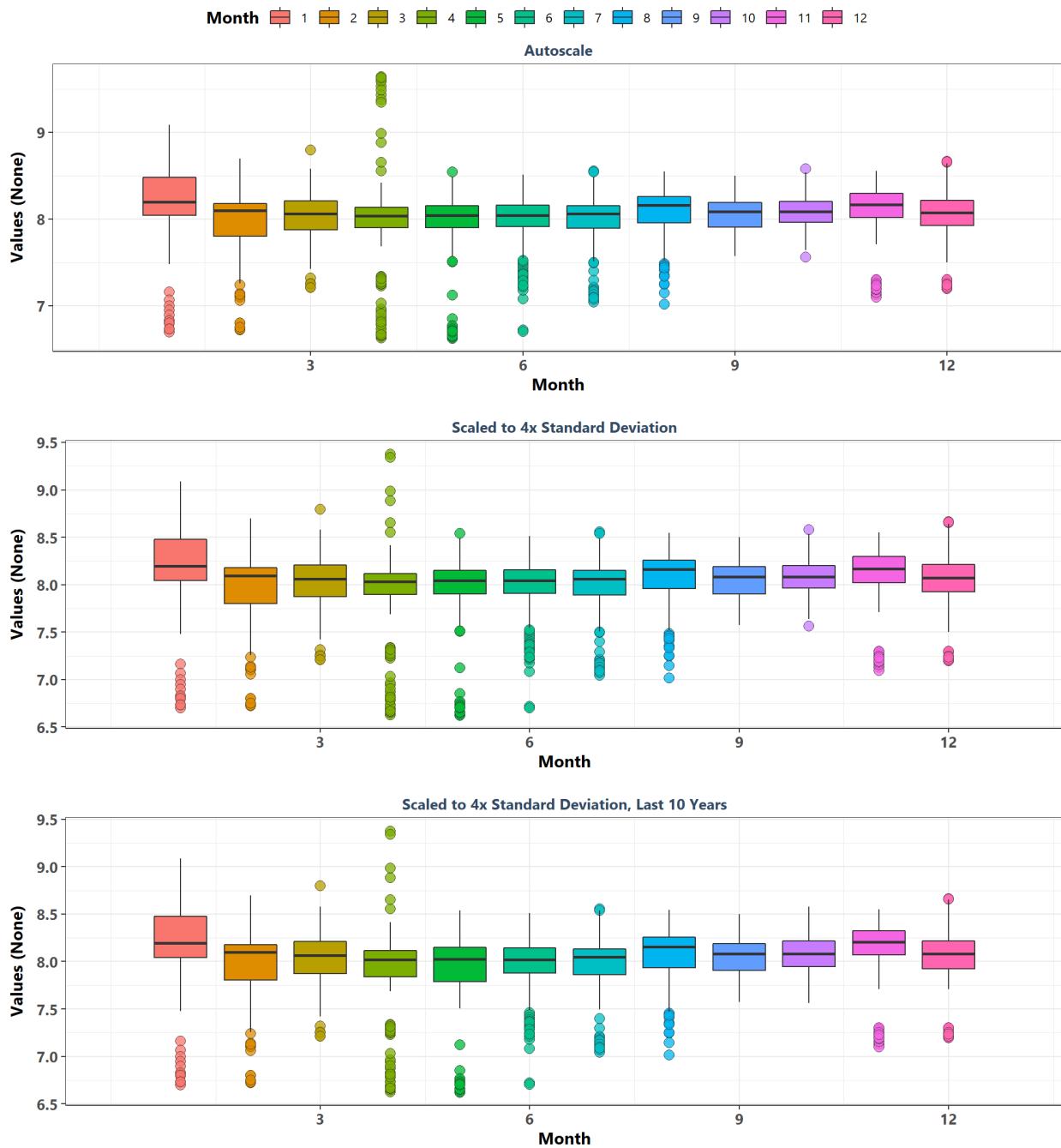
Big Bend Seagrasses Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSSK
By Year



Big Bend Seagrasses Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSSK
By Year & Month



Big Bend Seagrasses Aquatic Preserve
471 | Big Bend Seagrasses Aquatic Preserves Continuous Water Quality Monitoring
BBSSK
By Month



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