SEACAR Continuous Water Quality Analysis: SE Region for Water Temperature

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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

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)
options(scipen = 999)
```

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))
```

```
## `summarise()` has grouped output by 'ManagedAreaName', 'ProgramID', 'ProgramName', 'ProgramLocationI
## `.groups` argument.
```

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

data$SampleDate <- as.Date(data$SampleDate)
data$YearMonth <- paste0(data$Month, "-", data$Year)
data$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())
# data <- data %>%
#    mutate(MonitoringID = group_indices(., ManagedAreaName, ProgramID,
#                                        ProgramName, ProgramLocationID))
Mon_Years <- data[data$Include == TRUE, ] %>%
   group_by(MonitoringID) %>%
   summarize(AreaID = unique(AreaID),
             ManagedAreaName = unique(ManagedAreaName),
             ProgramID = unique(ProgramID),
             ProgramName = unique(ProgramName),
             ProgramLocationID = unique(ProgramLocationID),
             ParameterName = parameter,
             RelativeDepth = unique(RelativeDepth),
             Y = length(unique(Year)))
```

```
Mon_Years <- as.data.table(Mon_Years[
   order(Mon_Years$MonitoringID), ])
Mon_Years$Enough_Time <- ifelse(Mon_Years$Y < 5, FALSE, TRUE)
data <- merge.data.frame(data, Mon_Years[,c("MonitoringID", "Enough_Time")],
                         by = "MonitoringID")
# data$Exclude_MonitoringID <- is.element(data$MonitoringID,
#                                         Mon_Years$MonitoringID[
#                                            Mon_Years$Enough_Time == FALSE])
data$Use_In_Analysis <- ifelse(data$Include == TRUE &
                                  data$Enough_Time == 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 `KT.Stats` 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)
   }, warning = function(w) {
      print(w)
   }, error = function(e) {
      print(e)
   }, finally = {
      if (!exists("tau")) {
         tau <- NULL
      }
      if (!exists("p")) {
         p <- NULL
      }
      if (!exists("slope")) {
         slope <- NULL
      }
      if (!exists("intercept")) {
         intercept <- NULL
```

```
      }
      if (!exists("trend")) {
         trend <- NULL
      }
   })
   KT <-c(unique(data$MonitoringID),
          independent,
          stats.median,
          nrow(data),
          stats.minYear,
          stats.maxYear,
          tau,
          p,
          slope,
          intercept,
          trend)
   return(KT)
}
runStats <- function(data) {
   data$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[11])) {
      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$ManagedAreaName
c_names <- c("MonitoringID", "Independent", "Median", "N", "EarliestYear",
             "LatestYear", "tau", "p", "SennSlope", "SennIntercept", "Trend")
if(n==0){
   c_names <- c("AreaID", "ManagedAreaName", "ProgramID", "ProgramName",
                "ProgramLocationID", "ParameterName", "RelativeDepth",
                "Independent", "Median", "N", "EarliestYear", "LatestYear",
                "tau", "p", "SennSlope", "SennIntercept", "Trend")
   KT.Stats <- data.frame(matrix(ncol=17, nrow=0))
   colnames(KT.Stats) <- c_names
   fwrite(KT.Stats, paste0(out_dir,"/", param_name, "_", region,
                           "_KendallTau_Stats.txt"), sep = "|")
} else{
   for (i in 1:n) {
      values <- data[data$Use_In_Analysis == TRUE &
                        data$MonitoringID == Mon_IDs[i], ]
      if (nrow(values) > 0) {
         KT.Stats <- runStats(values)
      }
   }
   KT.Stats <- as.data.frame(KT.Stats)
   if(dim(KT.Stats)[2]==1){
      KT.Stats <- as.data.frame(t(KT.Stats))
   }

   c_names <- c("MonitoringID", "Independent", "Median", "N", "EarliestYear",
                "LatestYear", "tau", "p", "SennSlope", "SennIntercept", "Trend")
   colnames(KT.Stats) <- c_names
   rownames(KT.Stats) <- seq(1:nrow(KT.Stats))
   KT.Stats$Independent <- as.logical(KT.Stats$Independent)
   KT.Stats$Median <- as.numeric(KT.Stats$Median)
   KT.Stats$N <- as.integer(KT.Stats$N)
   KT.Stats$EarliestYear <- as.integer(KT.Stats$EarliestYear)
   KT.Stats$LatestYear <- as.integer(KT.Stats$LatestYear)
   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_Years[,-c("Y", "Enough_Time")],
                                KT.Stats, by = "MonitoringID")
   KT.Stats$MonitoringID <- NULL
   fwrite(KT.Stats, paste0(out_dir,"/", param_name, "_", region,
```

```
                              "_KendallTau_Stats.txt"), sep = "|")
   KT.Stats$MonitoringID <- Mon_IDs
}
```

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.

```
   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 = Year, y = ResultValue, group = Year)) +
      geom_boxplot(outlier.size = 0.5) +
      labs(subtitle = "Autoscale", x = "Year",
           y = paste0("Values (", unit, ")")) +
      theme_bw() +
      theme(axis.text.x = element_text(face = "bold"),
            axis.text.y = element_text(face = "bold"))

   p2 <- ggplot(data = data[data$Include == TRUE, ],
                aes(x = Year, y = ResultValue, group = Year)) +
      geom_boxplot(outlier.size = 0.5) +
      labs(subtitle = "Scaled to 4x Standard Deviation", x = "Year",
           y = paste0("Values (", unit, ")")) +
      ylim(0, y_scale) +
      theme_bw() + theme(axis.text.x = element_text(face = "bold"),
                         axis.text.y = element_text(face = "bold"))

   p3 <- ggplot(data = data[data$Include == TRUE, ],
                aes(x = as.integer(Year), y = ResultValue, group = Year)) +
      geom_boxplot(outlier.size = 0.5) +
      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)) +
   theme_bw() +
   theme(axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))

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

p0 <- ggplot() + labs(title = "Summary Box Plots for Entire Data",
                      subtitle = "By Year") + theme_bw() +
   theme(plot.title = element_text(face="bold", hjust=0.5),
         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(outlier.size = 0.5) +
   labs(subtitle = "Autoscale", x = "Year",
        y = paste0("Values (", unit, ")"), color="Month") +
   theme_bw() +
   theme(legend.position = "top", legend.box = "horizontal",
         axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold")) +
   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(outlier.size = 0.5) +
   labs(subtitle = "Scaled to 5x Standard Deviation",
        x = "Year", y = paste0("Values (", unit, ")")) +
   ylim(0, y_scale) +
   theme_bw() +
   theme(legend.position = "none", axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))

p3 <- ggplot(data = data[data$Include == TRUE, ],
             aes(x = YearMonthDec, y = ResultValue,
                 group = YearMonth, color = as.factor(Month))) +
   geom_boxplot(outlier.size = 0.5) +
   labs(subtitle = "Scaled to 5x Standard Deviation, Last 10 Years",
        x = "Year", y = paste0("Values (", unit, ")")) +
   ylim(0, y_scale) +
   scale_x_continuous(limits = c(max(data$Year) - 10.5, max(data$Year)+0.5),
                      breaks = seq(max(data$Year) - 10, max(data$Year), 2)) +
   theme_bw() +
```

```
   theme(legend.position = "none", axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))
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") + theme_bw() +
   theme(plot.title = element_text(face="bold", hjust=0.5),
         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(outlier.size = 0.5) +
   labs(subtitle = "Autoscale", x = "Month",
        y = paste0("Values (", unit, ")"), fill="Month") +
   scale_x_continuous(limits = c(0, 13), breaks = seq(3, 12, 3)) +
   theme_bw() +
   theme(legend.position = "top", legend.box = "horizontal",
         axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold")) +
   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(outlier.size = 0.5) +
   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)) +
   theme_bw() +
   theme(legend.position = "none", axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))

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(outlier.size = 0.5) +
   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)) +
   theme_bw() +
   theme(legend.position = "none", axis.text.x = element_text(face = "bold"),
```

```
          axis.text.y = element_text(face = "bold"))
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") + theme_bw() +
   theme(plot.title = element_text(face="bold", hjust=0.5),
         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
Month 1 2 3 4 5 6 7 8 9 10 11 12
Autoscale
Values (Degrees C)
Year
Scaled to 5x Standard Deviation
Values (Degrees C)
Year
Scaled to 5x Standard Deviation, Last 10 Years
Values (Degrees C)
Year

Appendix II: Excluded Monitoring Locations

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

```r
Mon_Exclude <- Mon_Years[Mon_Years$Enough_Time==FALSE,]
Mon_Exclude <- Mon_Exclude[order(Mon_Exclude$MonitoringID),]
z=length(Mon_Exclude$MonitoringID)

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$MonitoringID[i]])
      Mon_name <- paste(unique(data$ProgramID[
         data$MonitoringID==Mon_Exclude$MonitoringID[i]]),
         unique(data$ProgramName[
            data$MonitoringID==Mon_Exclude$MonitoringID[i]]),
         unique(data$ProgramLocationID[
            data$MonitoringID==Mon_Exclude$MonitoringID[i]]),
         sep = " | ")

      p1<-ggplot(data=data[data$MonitoringID==Mon_Exclude$MonitoringID[i]&
                              data$Include == TRUE, ],
                 aes(x = SampleDate, y = ResultValue)) +
         geom_point() +
         labs(title=
                 paste0("Scatter Plot of Excluded Monitoring Location ",
                        MA_name, "\n", Mon_name, "\n(", Mon_Exclude$Y[i],
                        " Unique Years)"),
              subtitle="Autoscale", x = "Year",
              y = paste0("Values (", unit, ")")) +
         theme_bw() +
         theme(plot.title = element_text(face="bold", hjust=0.5),
               axis.text.x = element_text(face = "bold")) +
         scale_x_date(labels = date_format("%m-%Y"))
      print(p1)
   }
}
```

Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBBB14
(3 Unique Years)
Autoscale
Values (Degrees C)
30
25
20
01-2019
01-2020
01-2021
01-2022
Year

Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBJT71
(3 Unique Years)
Autoscale
Values (Degrees C)
30
25
20
01-2020
01-2021
01-2022
Year

Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBLR03
(3 Unique Years)
Autoscale
Values (Degrees C)
30
27
24
21
01-2020
01-2021
01-2022
Year

Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBMRDW
(1 Unique Years)
Autoscale
Values (Degrees C)
30.0
27.5
25.0
04-2021
07-2021
10-2021
01-2022
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | SANF1
(1 Unique Years)
Autoscale
Values (Degrees C)
30.0
27.5
25.0
22.5
01-2005
04-2005
07-2005
10-200
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | SMKF1
(4 Unique Years)
Autoscale
Values (Degrees C)
30
25
20
01-2006
01-2007
01-2008
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
7 | National Water Information System | 245323080410100
(3 Unique Years)
Autoscale
Values (Degrees C)
25
20
15
01-2002
07-2002
01-2003
07-2003
01-2004
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
7 | National Water Information System | 245622080364200
(3 Unique Years)
Autoscale
Values (Degrees C)
30
25
20
15
01-2002
07-2002
01-2003
07-2003
01-2004
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 33
(4 Unique Years)
Autoscale
Values (Degrees C)
32
28
24
20
01-2017
01-2018
01-2019
01-2020
Year

Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 39
(3 Unique Years)
Autoscale
Values (Degrees C)
30.0
27.5
25.0
22.5
20.0
07-2018
01-2019
07-2019
01-2020
07-2020
Year

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]]

model <- lm(ResultValue ~ DecDate,
            data = plot_data)
m_int <- coef(model)[[1]]
m_slope <- coef(model)[[2]]
MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID == Mon_IDs[i]]
Mon_name <- paste(KT.Stats$ProgramID[KT.Stats$MonitoringID == Mon_IDs[i]],
   KT.Stats$ProgramName[KT.Stats$MonitoringID == Mon_IDs[i]],
   KT.Stats$ProgramLocationID[KT.Stats$MonitoringID == Mon_IDs[i]],
   sep = " | ")

p1 <- ggplot(data = plot_data,
             aes(x = DecDate, y = ResultValue)) +
   geom_point(size = 1.5) +
   geom_abline(aes(slope=s_slope, intercept=s_int),
               color="red", size=1.5) +
   labs(subtitle = "Autoscale",
        x = "Year", y = paste0("Values (", unit, ")")) +
   theme_bw() +
   theme(axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face="bold"))

p2 <- ggplot(data = plot_data,
             aes(x = DecDate, y = ResultValue)) +
   geom_point(size = 1.5) +
   geom_abline(aes(slope=s_slope, intercept=s_int),
               color="red", size=1.5) +
   ylim(min_RV-0.1*y_scale, y_scale) +
   labs(subtitle = "Scaled to 4x Standard Deviation",
        x = "Year", y = paste0("Values (", unit, ")")) +
   theme_bw() +
   theme(axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face="bold"))
KTset <- ggarrange(p1, p2, ncol = 1, heights = c(1, 1))

p0 <- ggplot() + labs(title = paste0("Data Points with Trendlines for ",
                                     MA_name, "\n", Mon_name),
                      subtitle =paste0("Senn Slope = ", s_slope,
                                       ",     Senn Intercept = ", s_int,
                                       "\nTrend = ", trend,
                                       ",     tau = ", tau,
                                       ",     p = ", p,
                                       "\nLinear Trendline: ",
```

```
                                                "y = ", m_slope,"x + ",m_int)) +
        theme_bw() + theme(plot.title = element_text(face="bold", hjust=0.5),
                           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(0.20, 1)))
   }
}
```

Data Points with Trendlines for Florida Keys National Marine Sanctuary
Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array |

Senn Slope = 0.170783333333334, Senn Intercept = -368.898959895833
Trend = 1, tau = 0.1096, p = 0
Linear Trendline: y = -0.0638644439071869x + 154.418371263875

Data Points with Trendlines for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1

Senn Slope = 0.0705615793586334, Senn Intercept = -91.8021325750732
Trend = 1, tau = 0.1565, p = 0
Linear Trendline: y = 0.0858691722357432x + -145.871814218001

Data Points with Trendlines for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1

Senn Slope = 0.0593750000000002, Senn Intercept = -81.6939091435192
Trend = 1, tau = 0.087, p = 0
Linear Trendline: y = 0.0349386735100876x + -44.1825806234067

Data Points with Trendlines for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1

Senn Slope = 0.0458333333333325, Senn Intercept = -65.5895793863366
Trend = 1, tau = 0.1486, p = 0
Linear Trendline: y = 0.0451366243465702x + -64.0903715455315

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11

Senn Slope = 0.0652314422057264, Senn Intercept = -47.2063146018897
Trend = 1, tau = 0.13, p = 0
Linear Trendline: y = 0.0782306018900364x + -130.913575246288

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12

Senn Slope = 0.0945062798250262, Senn Intercept = -210.248181945906
Trend = 1, tau = 0.1381, p = 0
Linear Trendline: y = 0.104960245275298x + -184.902056955162

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14

Senn Slope = 0.0594758191294719, Senn Intercept = -71.1883232955373
Trend = 1, tau = 0.1295, p = 0
Linear Trendline: y = 0.114196853886312x + -202.88567502512

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15

Senn Slope = 0.0569884510869567, Senn Intercept = -44.8981200589673
Trend = 1, tau = 0.1056, p = 0
Linear Trendline: y = 0.102835878623701x + -180.35330474011

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 18

Senn Slope = 0.107916666666667, Senn Intercept = -118.198298611113
Trend = 1, tau = 0.0935, p = 0
Linear Trendline: y = 0.254924650804264x + -487.464528973468

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 21

Senn Slope = 0.161249999999999, Senn Intercept = -334.999973958334
Trend = 1, tau = 0.1069, p = 0
Linear Trendline: y = -0.0960136907216547x + 220.804531644215

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22

Senn Slope = 0.0825765239783858, Senn Intercept = -199.532971256039
Trend = 1, tau = 0.1386, p = 0
Linear Trendline: y = 0.0800472143134875x + -134.554309987558

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 23

Senn Slope = 0.10933630952381, Senn Intercept = -183.22863867817
Trend = 1, tau = 0.1618, p = 0
Linear Trendline: y = 0.118054107356493x + -210.603550625651

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 24

Senn Slope = 0.119027777777778, Senn Intercept = -341.129368766569
Trend = 1, tau = 0.2304, p = 0
Linear Trendline: y = 0.19182506146054x + -359.717072813812

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25

Senn Slope = 0.0775189125295513, Senn Intercept = -148.622469973905
Trend = 1, tau = 0.125, p = 0
Linear Trendline: y = 0.140723253005384x + -256.579925977441

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26

Senn Slope = 0.103100064350064, Senn Intercept = -222.013830118996
Trend = 1, tau = 0.1783, p = 0
Linear Trendline: y = 0.187739417157693x + -351.396437236672

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 30

Senn Slope = 0.0850292735042735, Senn Intercept = -138.426941666665
Trend = 1, tau = 0.1253, p = 0
Linear Trendline: y = 0.108934220386078x + -192.835225241786

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32

Senn Slope = 0.0636216971544719, Senn Intercept = -113.415300461396
Trend = 1, tau = 0.186, p = 0
Linear Trendline: y = 0.0650944562905393x + -104.379804431141

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34

Senn Slope = 0.0661096084169452, Senn Intercept = -119.06661095329
Trend = 1, tau = 0.1999, p = 0
Linear Trendline: y = 0.0947280118823716x + -163.809630206336

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35

Senn Slope = 0.059851851851852, Senn Intercept = -69.2340661776998
Trend = 1, tau = 0.1356, p = 0
Linear Trendline: y = 0.0996872302873165x + -173.832662907493

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 36

Senn Slope = 0.0798956117021277, Senn Intercept = -186.480751309918
Trend = 1, tau = 0.1673, p = 0
Linear Trendline: y = 0.114659911763577x + -204.041621048773

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 37

Senn Slope = 0.141666666666669, Senn Intercept = -216.790052083334
Trend = 1, tau = 0.1103, p = 0
Linear Trendline: y = 0.429850658015567x + -840.630275333977

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 38

Senn Slope = 0.0663659297711331, Senn Intercept = -121.388240313642
Trend = 1, tau = 0.1975, p = 0
Linear Trendline: y = 0.10379994151316x + -182.240503095938

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 40

Senn Slope = 0.0719111907114622, Senn Intercept = -98.4502824661609
Trend = 1, tau = 0.1476, p = 0
Linear Trendline: y = 0.0973591701757025x + -169.197583612648

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 50

Senn Slope = 0.0596398148148148, Senn Intercept = -119.95479275266
Trend = 1, tau = 0.106, p = 0
Linear Trendline: y = 0.00420124812575853x + 18.6944426759007

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 51

Senn Slope = 0.0588069069069064, Senn Intercept = -102.734509585574
Trend = 1, tau = 0.2012, p = 0
Linear Trendline: y = 0.0577884166951392x + -89.6158986596463

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 52

Senn Slope = 0.0843993055555554, Senn Intercept = -160.25014283364
Trend = 1, tau = 0.2355, p = 0
Linear Trendline: y = 0.0659370727181466x + -105.850208395981

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 53

Senn Slope = 0.0974120172294168, Senn Intercept = -186.631075346386
Trend = 1, tau = 0.2527, p = 0
Linear Trendline: y = 0.0756847686054585x + -125.472171595292

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 54

Senn Slope = 0.075480303030303, Senn Intercept = -111.05125214604
Trend = 1, tau = 0.1453, p = 0
Linear Trendline: y = 0.052790657687268x + -79.2686425705503

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 55

Senn Slope = 0.0537424242424242, Senn Intercept = -70.4432350975873
Trend = 1, tau = 0.1877, p = 0
Linear Trendline: y = 0.0878023721678491x + -149.714121624234

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 56

Senn Slope = 0.0418452380952381, Senn Intercept = -53.1868761957782
Trend = 1, tau = 0.1111, p = 0
Linear Trendline: y = 0.0547544719857269x + -83.3223792557164

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 57

Senn Slope = 0.0904456521739128, Senn Intercept = -197.098385335792
Trend = 1, tau = 0.2325, p = 0
Linear Trendline: y = 0.099968454757393x + -174.369448351523

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 58

Senn Slope = 0.0670682971014496, Senn Intercept = -2.32576699168534
Trend = 1, tau = 0.0841, p = 0
Linear Trendline: y = 0.0145096258290336x + -1.97357589701205

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 59

Senn Slope = 0.0632916666666668, Senn Intercept = -84.6015864972624
Trend = 1, tau = 0.204, p = 0
Linear Trendline: y = 0.0754068625811446x + -124.897556186156

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 60

Senn Slope = 0.0624950429087627, Senn Intercept = -77.2302308979741
Trend = 1, tau = 0.1295, p = 0
Linear Trendline: y = 0.0879428516562769x + -150.13306188699

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 61

Senn Slope = 0.137083333333333, Senn Intercept = -236.186145833333
Trend = 1, tau = 0.1348, p = 0
Linear Trendline: y = 0.0512383985922675x + -76.225032923499

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 70

Senn Slope = 0.0569191239316247, Senn Intercept = -123.978032487105
Trend = 1, tau = 0.1044, p = 0
Linear Trendline: y = -0.0227601196342252x + 72.9664622827206

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 72

Senn Slope = 0.0958500000000001, Senn Intercept = -183.282164563089
Trend = 1, tau = 0.2687, p = 0
Linear Trendline: y = 0.076703570214553x + -127.68389506016

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 73

Senn Slope = 0.0936004628446489, Senn Intercept = -175.145164957089
Trend = 1, tau = 0.2473, p = 0
Linear Trendline: y = 0.0711034489852239x + -116.439964759151

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 74

Senn Slope = 0.0785375295508276, Senn Intercept = -117.973152529893
Trend = 1, tau = 0.1503, p = 0
Linear Trendline: y = 0.0547825598071014x + -83.4241429862059

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 75

Senn Slope = 0.0880341988912435, Senn Intercept = -167.399444998522
Trend = 1, tau = 0.209, p = 0
Linear Trendline: y = 0.0930418020948807x + -160.38958510412

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 76

Senn Slope = 0.077307556935817, Senn Intercept = -159.27703496017
Trend = 1, tau = 0.1886, p = 0
Linear Trendline: y = 0.116107761370359x + -206.956631305797

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 77

Senn Slope = 0.089392543859649, Senn Intercept = -186.737916675576
Trend = 1, tau = 0.2244, p = 0
Linear Trendline: y = 0.101223511404019x + -176.957678984098

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 78

Senn Slope = 0.0275000000000004, Senn Intercept = 10.749447482903
Trend = 1, tau = 0.0444, p = 0.0117
Linear Trendline: y = 0.0817498699899322x + -137.69937930652

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 79

Senn Slope = 0.0607638888888893, Senn Intercept = -100.140754981052
Trend = 1, tau = 0.1651, p = 0
Linear Trendline: y = 0.0710845190260051x + -116.232022934495

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 80

Senn Slope = 0.0672597099502838, Senn Intercept = -133.025089409567
Trend = 1, tau = 0.1536, p = 0
Linear Trendline: y = 0.113756512685588x + -202.248546006589

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 81

Senn Slope = 0.127291666666666, Senn Intercept = -233.741345486112
Trend = 1, tau = 0.1263, p = 0
Linear Trendline: y = 0.0405179739876112x + -54.5819735992704

Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 83

Senn Slope = 0.0147222222222219, Senn Intercept = -28.1147619047619
Trend = 1, tau = 0.0331, p = 0.0005
Linear Trendline: y = 0.00624063038632372x + 13.2694828263907

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
5 | National Data Buoy Center | LKWF1

Senn Slope = 0.0595354678819871, Senn Intercept = -108.101706490969
Trend = 1, tau = 0.1684, p = 0
Linear Trendline: y = 0.027491993485422x + -28.8007051376882

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 1

Senn Slope = 0.0526651785714286, Senn Intercept = -67.2783219285242
Trend = 1, tau = 0.0938, p = 0
Linear Trendline: y = -0.0511041625657506x + 129.748820009864

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 2

Senn Slope = 0.0453513071895427, Senn Intercept = -32.6690674840507
Trend = 1, tau = 0.0782, p = 0
Linear Trendline: y = 0.0643433721173794x + -102.978790086214

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 3

Senn Slope = 0.0476703722002637, Senn Intercept = -29.6830267857154
Trend = 1, tau = 0.0815, p = 0
Linear Trendline: y = 0.0640244046229368x + -102.462450230241

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 4

Senn Slope = 0.019166666666667, Senn Intercept = -10.7704242601201
Trend = 1, tau = 0.0242, p = 0.04
Linear Trendline: y = 0.0349947536341019x + -43.8262071418555

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 5

Senn Slope = 0.0277777777777774, Senn Intercept = 12.5047703598479
Trend = 1, tau = 0.0452, p = 0.0005
Linear Trendline: y = 0.02066244343143x + -15.0866812321226

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 6

Senn Slope = 0.0408571428571432, Senn Intercept = -64.3890819099388
Trend = 1, tau = 0.0602, p = 0
Linear Trendline: y = 0.0187250769342494x + -10.7965425188784

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 84

Senn Slope = 0.0698611111111109, Senn Intercept = -113.015892762342
Trend = 1, tau = 0.1995, p = 0
Linear Trendline: y = 0.0752556268073296x + -125.137569159384

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 85

Senn Slope = 0.0698611111111115, Senn Intercept = -111.423735054349
Trend = 1, tau = 0.1913, p = 0
Linear Trendline: y = 0.0738408932760551x + -122.404717163921

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 86

Senn Slope = 0.0672651515151514, Senn Intercept = -119.042320628157
Trend = 1, tau = 0.1948, p = 0
Linear Trendline: y = 0.0701908497848003x + -115.110132887015

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 87

Senn Slope = 0.0751413043478262, Senn Intercept = -154.05234375
Trend = 1, tau = 0.2106, p = 0
Linear Trendline: y = 0.0713616123954723x + -117.17982546088

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 88

Senn Slope = 0.0664015151515152, Senn Intercept = -113.17714375
Trend = 1, tau = 0.1915, p = 0
Linear Trendline: y = 0.0705595460621327x + -115.713731941191

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 89

Senn Slope = 0.0651785714285715, Senn Intercept = -111.696088741987
Trend = 1, tau = 0.1839, p = 0
Linear Trendline: y = 0.0720581923656167x + -118.762711969415

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 90

Senn Slope = 0.0752499999999998, Senn Intercept = -162.210683562599
Trend = 1, tau = 0.207, p = 0
Linear Trendline: y = 0.0616033614284789x + -97.5148712516378

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 91

Senn Slope = 0.0695, Senn Intercept = -138.262995923913
Trend = 1, tau = 0.1919, p = 0
Linear Trendline: y = 0.0675511404339929x + -109.483020223426

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 92

Senn Slope = 0.0795238095238096, Senn Intercept = -165.936577302632
Trend = 1, tau = 0.2254, p = 0
Linear Trendline: y = 0.0817134630326932x + -138.14408842809

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 93

Senn Slope = 0.0584999999999995, Senn Intercept = -108.031704312866
Trend = 1, tau = 0.184, p = 0
Linear Trendline: y = 0.0633856800046505x + -101.148325427102

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 94

Senn Slope = 0.0687878787878789, Senn Intercept = -136.398074426329
Trend = 1, tau = 0.133, p = 0
Linear Trendline: y = 0.0629320879243104x + -101.280803397563

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 95

Senn Slope = 0.0666666666666664, Senn Intercept = -130.146247282609
Trend = 1, tau = 0.1302, p = 0
Linear Trendline: y = 0.0623890221318365x + -100.162512906554

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 96

Senn Slope = -0.106249999999999, Senn Intercept = 256.997630208333
Trend = -1, tau = -0.0722, p = 0
Linear Trendline: y = -0.122808892976529x + 271.78544767957

Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area 986 | Water Temperature on Coral Reefs in the Florida Keys | 97

Senn Slope = 0.0743980566534915, Senn Intercept = -99.1984689764493
Trend = 1, tau = 0.1695, p = 0
Linear Trendline: y = 0.0617384145388289x + -97.9442171339689

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

```r
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$MonitoringID == Mon_IDs[i]]
      Mon_name <- paste(KT.Stats$ProgramID[KT.Stats$MonitoringID == Mon_IDs[i]],
         KT.Stats$ProgramName[KT.Stats$MonitoringID == Mon_IDs[i]],
         KT.Stats$ProgramLocationID[KT.Stats$MonitoringID == Mon_IDs[i]],
         sep = " | ")

      ##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(outlier.size = 0.5) +
         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))) +
         theme_bw() +
         theme(axis.text.x = element_text(face = "bold"),
               axis.text.y = element_text(face = "bold"))

      p2 <- ggplot(data = data[data$Use_In_Analysis == TRUE &
                               data$MonitoringID == Mon_IDs[i], ],
                   aes(x = Year, y = ResultValue, group = Year)) +
         geom_boxplot(outlier.size = 0.5) +
         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))) +
         theme_bw() +
         theme(axis.text.x = element_text(face = "bold"),
               axis.text.y = element_text(face = "bold"))
```

```
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(outlier.size = 0.5) +
   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))) +
   theme_bw() +
   theme(axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))

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

p0 <- ggplot() + labs(title = paste0("Summary Box Plots for ",
                                     MA_name, "\n", Mon_name),
                      subtitle = "By Year") +
   theme_bw() + theme(plot.title = element_text(face="bold", hjust=0.5),
         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(outlier.size = 0.5) +
   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))) +
   theme_bw() +
   theme(legend.position = "none",
         axis.text.x = element_text(face = "bold"),
         axis.text.y = element_text(face = "bold"))

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(outlier.size = 0.5) +
   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))) +
   theme_bw() +
```

```
    theme(legend.position = "top", legend.box = "horizontal",
          axis.text.x = element_text(face = "bold"),
          axis.text.y = element_text(face = "bold")) +
    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(outlier.size = 0.5) +
    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))) +
    theme_bw() +
    theme(legend.position = "none",
          axis.text.x = element_text(face = "bold"),
          axis.text.y = element_text(face = "bold"))

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("Summary Box Plots for ",
                                      MA_name, "\n", Mon_name),
                       subtitle = "By Year & Month") + theme_bw() +
    theme(plot.title = element_text(face="bold", hjust=0.5),
          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(outlier.size = 0.5) +
    labs(subtitle = "Autoscale",
         x = "Month", y = paste0("Values (", unit, ")"), fill = "Month") +
    scale_x_continuous(limits = c(0, 13), breaks = seq(3, 12, 3)) +
    theme_bw() +
    theme(legend.position = "none",
          axis.text.x = element_text(face = "bold"),
          axis.text.y = element_text(face = "bold"))

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(outlier.size = 0.5) +
    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)) +
        theme_bw() +
        theme(legend.position = "top", legend.box = "horizontal",
              axis.text.x = element_text(face = "bold"),
              axis.text.y = element_text(face = "bold")) +
        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(outlier.size = 0.5) +
        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)) +
        theme_bw() +
        theme(legend.position = "none",
              axis.text.x = element_text(face = "bold"),
              axis.text.y = element_text(face = "bold"))

      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("Summary Box Plots for ",
                                             MA_name, "\n", Mon_name),
                              subtitle = "By Month") + theme_bw() +
        theme(plot.title = element_text(face="bold", hjust=0.5),
              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)))
   }
}
```

Summary Box Plots for Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve
986 | Water Temperature on Coral Reefs in the Florida Keys | 6

By Year

Summary Box Plots for Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve
986 | Water Temperature on Coral Reefs in the Florida Keys | 6

By Year & Month

Summary Box Plots for Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve
986 | Water Temperature on Coral Reefs in the Florida Keys | 6

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array |

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array |

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array |

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 18

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 18

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 18

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 21

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 21

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 21

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 23

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 23

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 23

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 24

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 24

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 24

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 30

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 30

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 30

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34

By Year

Autoscale

Scaled to 4x Standard Deviation

Scaled to 4x Standard Deviation, Last 10 Years

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35

By Year

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35

By Year & Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35

By Month

Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 36

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