

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)
opts_chunk$set(warning=FALSE, message=FALSE)

```

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 has an `Include` value of 1.

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

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

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

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

```

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

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

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

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

data$SampleDate <- as.Date(data$SampleDate)
data$YearMonth <- paste0(data$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_Summ <- data %>%
  group_by(MonitoringID, AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            N_Data=length(ResultValue[Include==TRUE & !is.na(ResultValue)]),
            N_Years=length(unique(Year[Include==TRUE & !is.na(Year)])),
            EarliestYear=min(Year[Include==TRUE]),
            LatestYear=max(Year[Include==TRUE]),
            SufficientData=ifelse(N_Data>0 & N_Years>=10, TRUE, FALSE))
#
# Mon_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_Summ <- as.data.table(Mon_Summ[order(Mon_Summ$MonitoringID), ])

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

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

```

Monitoring Location Statistics

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

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

```

Mon_YM_Stats <- data[data$Use_In_Analysis == TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year, Month) %>%
  summarize(ParameterName = parameter,
            RelativeDepth = unique(RelativeDepth),
            EarliestSampleDate = min(SampleDate),
            LastSampleDate = max(SampleDate), N = length(ResultValue),
            Min = min(ResultValue), Max = max(ResultValue),
            Median = median(ResultValue), Mean = mean(ResultValue),
            StandardDeviation = sd(ResultValue))

```

```

Mon_YM_Stats <- as.data.table(Mon_YM_Stats[order(Mon_YM_Stats$ManagedAreaName,
                                                 Mon_YM_Stats$ProgramID,
                                                 Mon_YM_Stats$ProgramName,
                                                 Mon_YM_Stats$ProgramLocationID,
                                                 Mon_YM_Stats$Year,
                                                 Mon_YM_Stats$Month), ])
fwrite(Mon_YM_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_YearMonth_Stats.txt"), sep = "|")

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

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

```

Seasonal Kendall Tau Analysis

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

The following steps are performed:

1. Define the trend function.
2. Take the `data` variable and only include rows that have a `Use_In_Analysis` value of `TRUE`
3. Group data that have the same `ManagedAreaName`, `ProgramID`, `ProgramName`, and `ProgramLocationID`.
4. For each group, provides the following information: Earliest Sample Date (`EarliestSampleDate`), Latest Sample Date (`LastSampleDate`), Number of Entries (`N`), Lowest Value (`Min`), Largest Value (`Max`), Median, Mean, Standard Deviation,
5. For each group, a temporary variable is created to run the `kendallSeasonalTrendTest` function using the `Year` values for year, and `Month` as the seasonal qualifier, and Trend.
 - An `independent.obs` value of `TRUE` indicates that the data should be treated as not being serially auto-correlated. An `independent.obs` value of `FALSE` indicates that it is treated as being serially auto-correlated, but also requires one observation per season per year for the full time of observation.
 - `tau`, Senn Slope (`SennSlope`), Senn Intercept (`SennIntercept`), and `p` are extracted from the model results.
6. The two stats tables are merged based on similar groups, and then Trend is determined from the user-defined function.
7. Write summary stats to a pipe-delimited .txt file in the output directory
 - Click this text to open Git directory with output files
8. Add the Monitoring IDS to `KTStats` for easier use while plotting.

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

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

```

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

```

```

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

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

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

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

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

```

```

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

```

Appendix I: Dataset Summary Box Plots

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

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

This set of box plots are grouped by year.

```

plot_theme <- theme_bw() + theme(text=element_text(family="Segoe UI"),
                                    title=element_text(face="bold"),
                                    plot.title=element_text(hjust=0.5,
                                                            size=14,
                                                            color="#314963"),
                                    plot.subtitle=element_text(hjust=0.5,
                                                               size=10,
                                                               color="#314963"),
                                    axis.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 = 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, ")")) +
  plot_theme

p2 <- 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", x = "Year",
     y = paste0("Values (", unit, ")")) +
ylim(0, y_scale) +
plot_theme

p3 <- ggplot(data = data[data$Include == TRUE, ],
             aes(x = as.integer(Year), y = ResultValue, group = Year)) +
geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
             outlier.size=3, outlier.color="#333333",
             outlier.fill="#cccccc", outlier.alpha=0.75) +
labs(subtitle = "Scaled to 4x Standard Deviation, Last 10 Years",
     x = "Year", y = paste0("Values (", unit, ")")) +
ylim(0, y_scale) +
scale_x_continuous(limits = c(max(data$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",

```

```

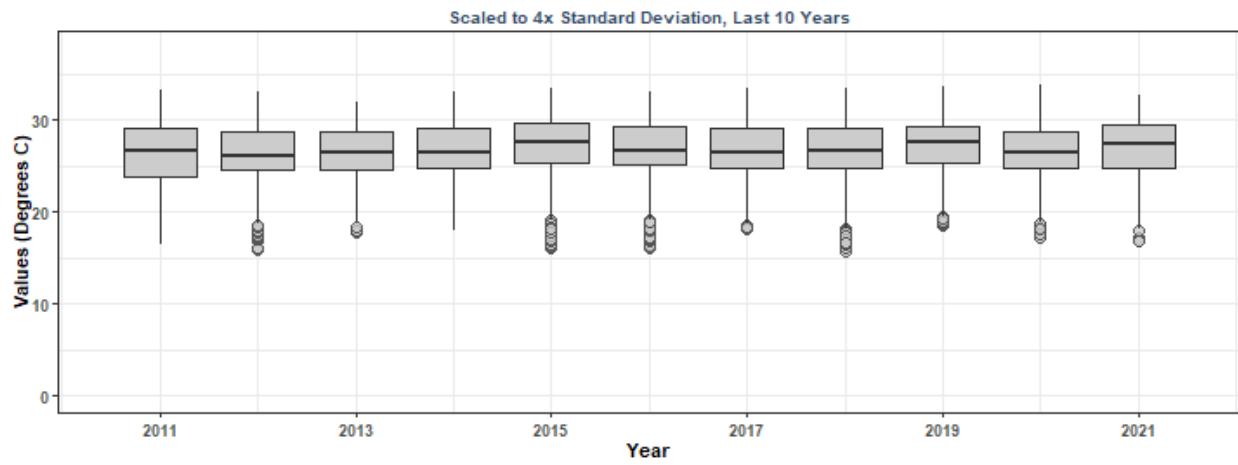
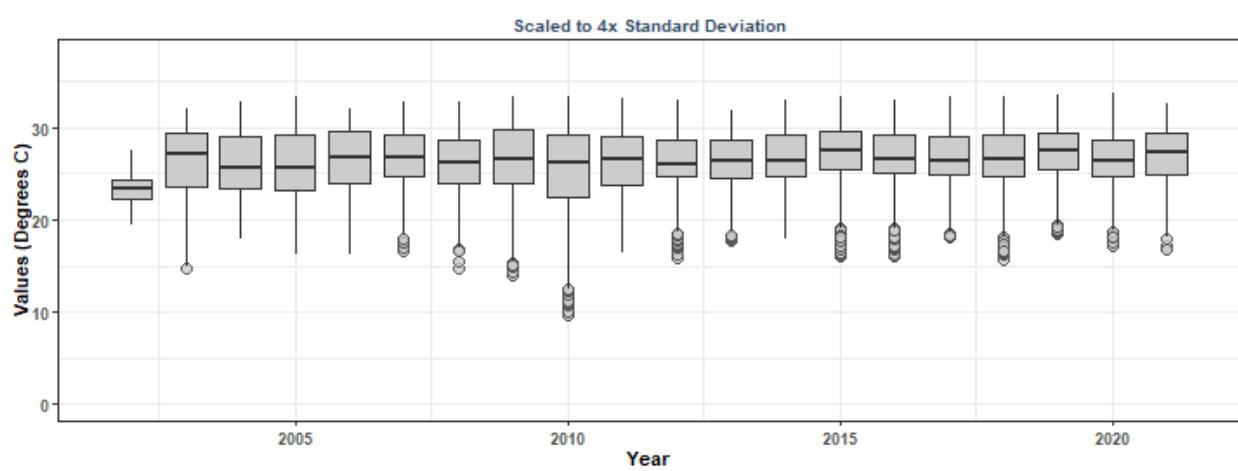
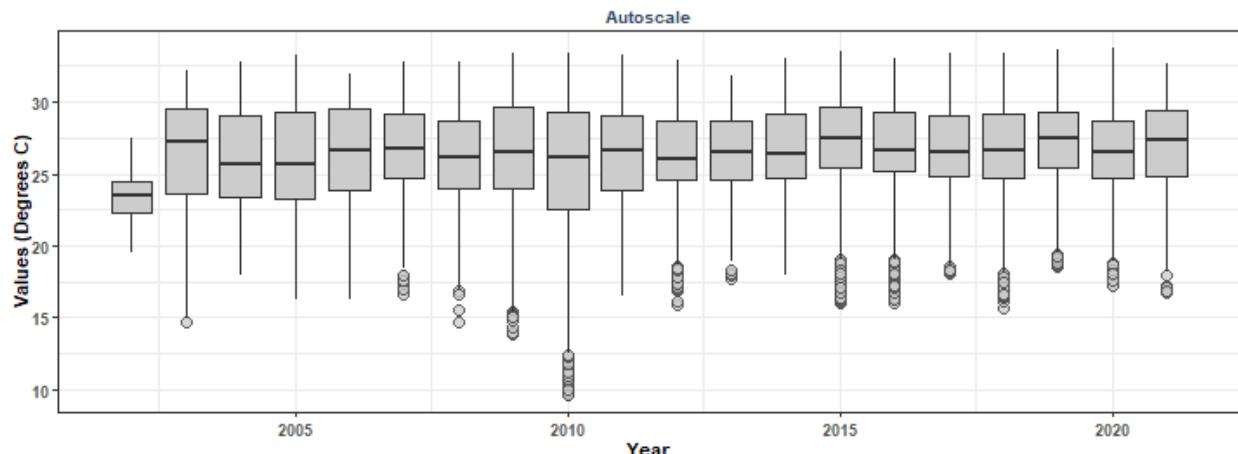
    x = "Month", y = paste0("Values (", unit, ")") +
  ylim(0, y_scale) +
  scale_x_continuous(limits = c(0, 13), breaks = seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position = "none")
leg <- get_legend(p1)
set <- ggarrange(leg, p1 + theme(legend.position = "none"), p2, p3, ncol = 1,
                 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())

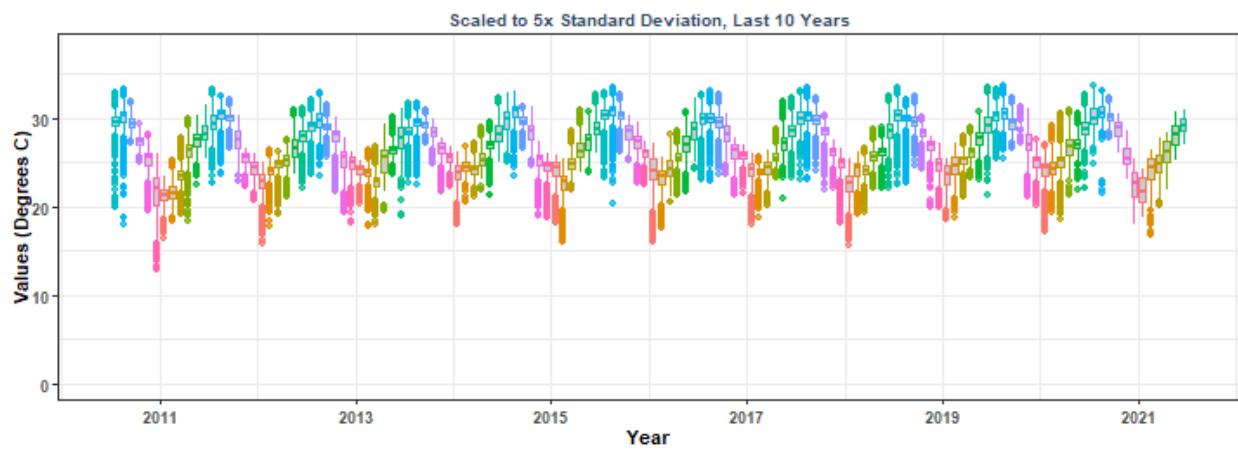
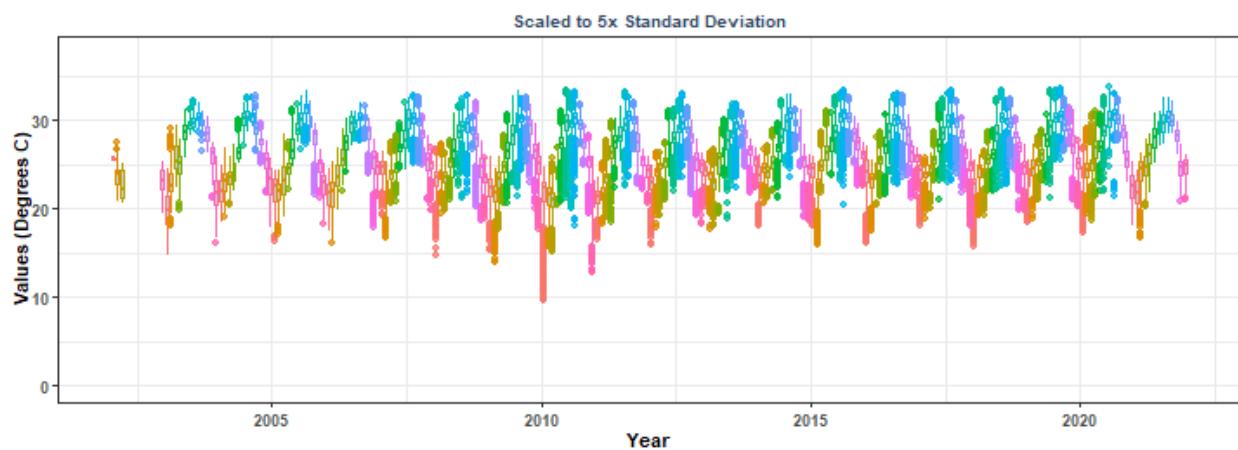
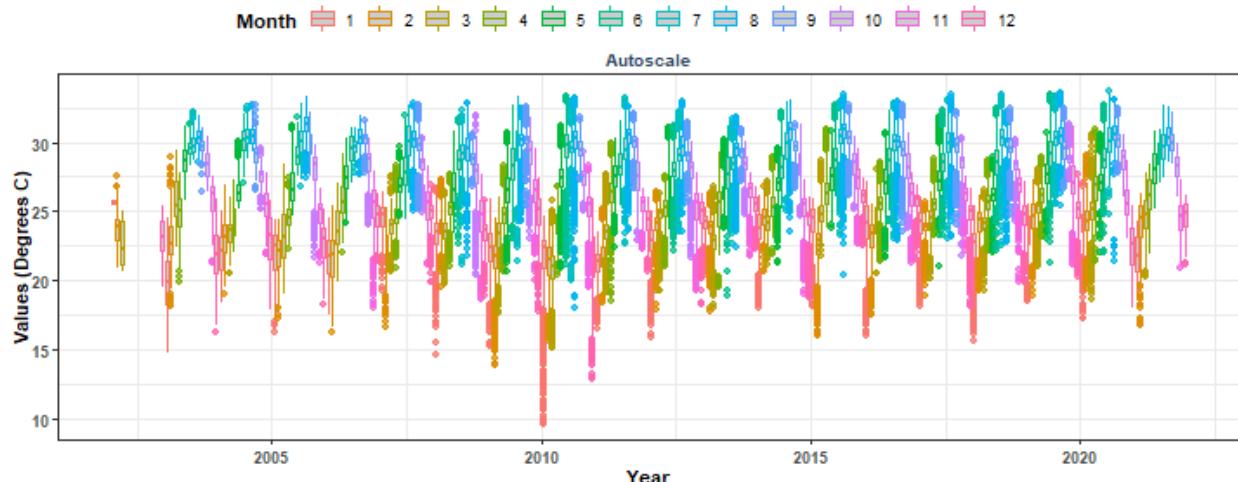
Mset <- ggarrange(p0, set, ncol=1, heights = c(0.07, 1))

```

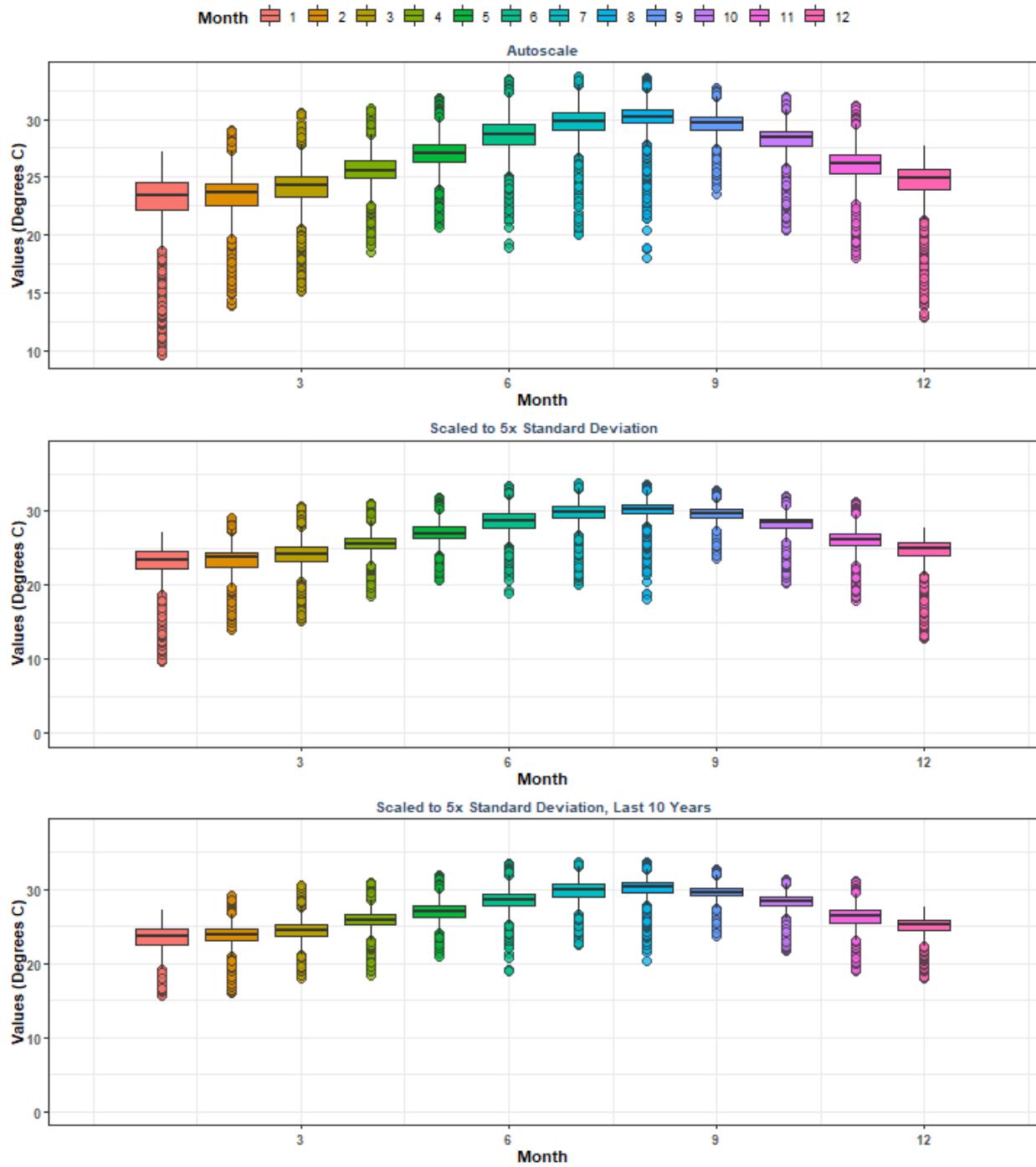
Summary Box Plots for Entire Data
By Year



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.

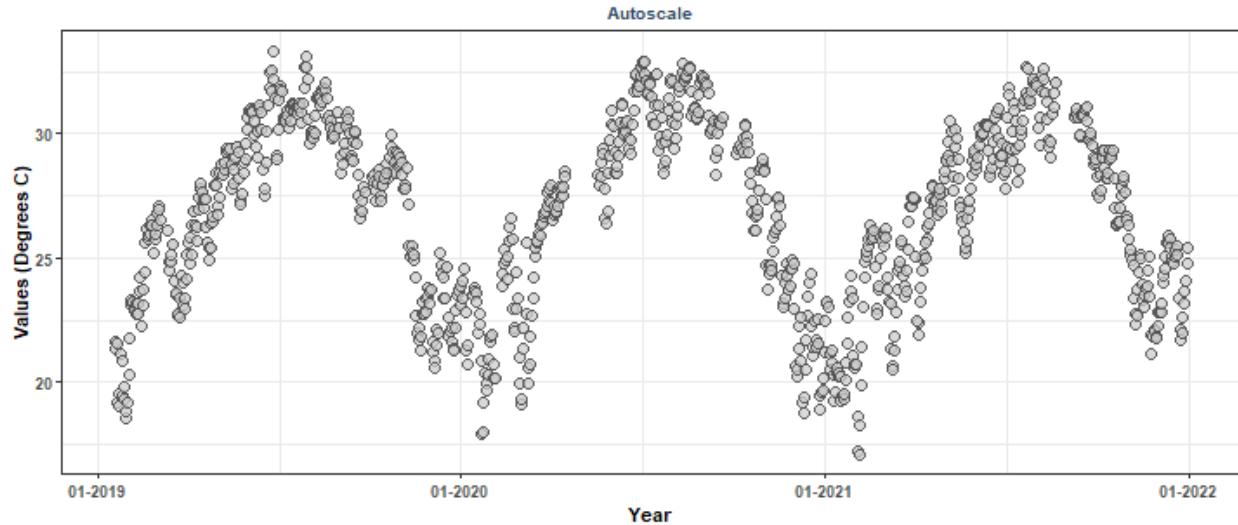
```

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)

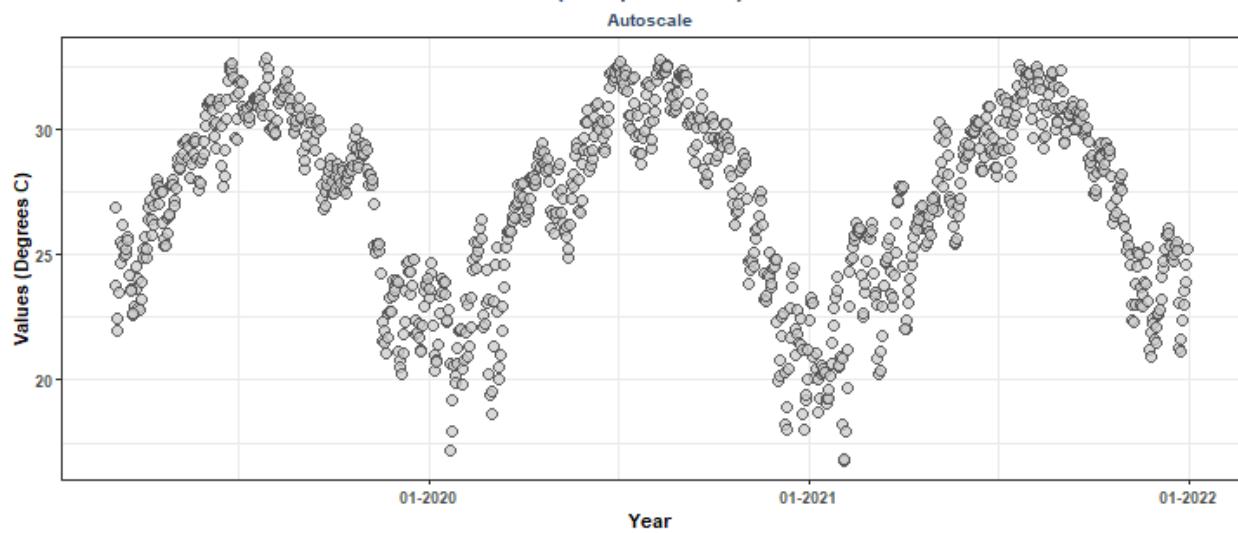
if(z==0){
  print("There are no monitoring locations that qualify.")
} else {
  for(i in 1:z){
    MA_name <- unique(data$ManagedAreaName[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]])
    Mon_name <- paste(unique(data$ProgramID[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]]),
      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$Include == TRUE, ],
      aes(x = SampleDate, y = ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
      alpha=0.75) +
      labs(title=
        paste0("Scatter Plot of Excluded Monitoring Location ",
          MA_name, "\n", Mon_name, "\n(", Mon_Exclude$Y[i],
          " Unique Years"),
        subtitle="Autoscale", x = "Year",
        y = paste0("Values (", unit, ")")) +
      plot_theme +
      scale_x_date(labels = date_format("%m-%Y"))
    print(p1)
  }
}

```

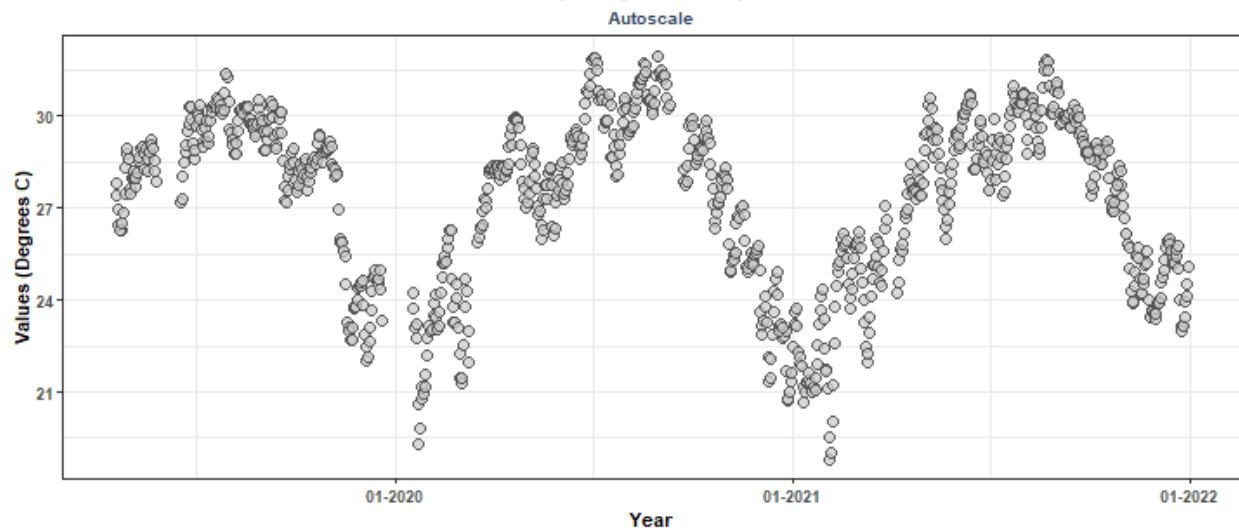
**Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBBB14
(Unique Years)**



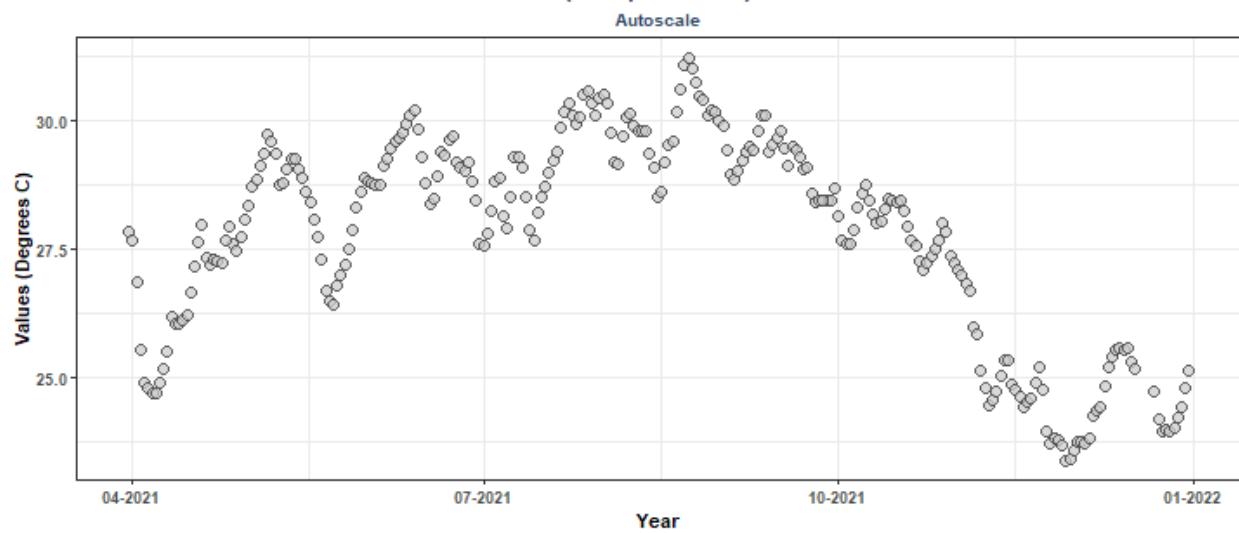
**Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBJT71
(Unique Years)**



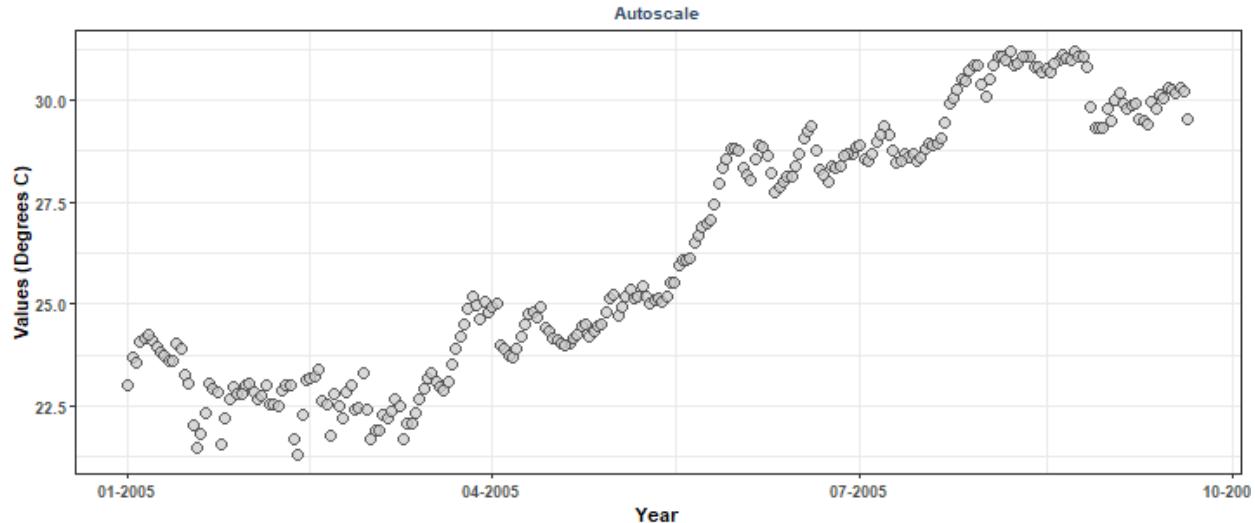
**Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBLR03
(Unique Years)**



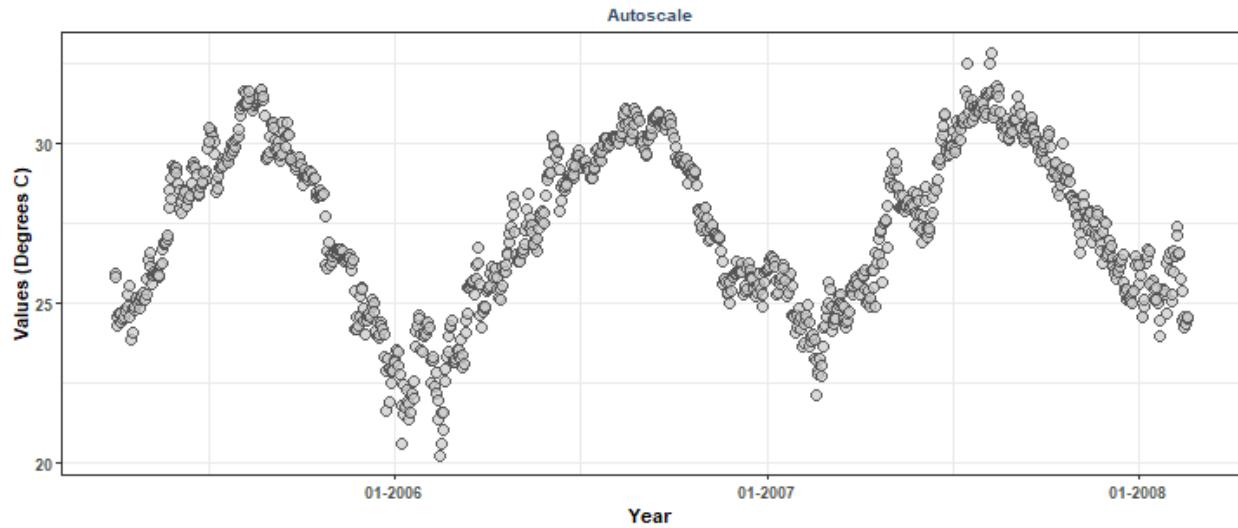
**Scatter Plot of Excluded Monitoring Location Biscayne Bay Aquatic Preserve
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring | BBMRDw
(Unique Years)**



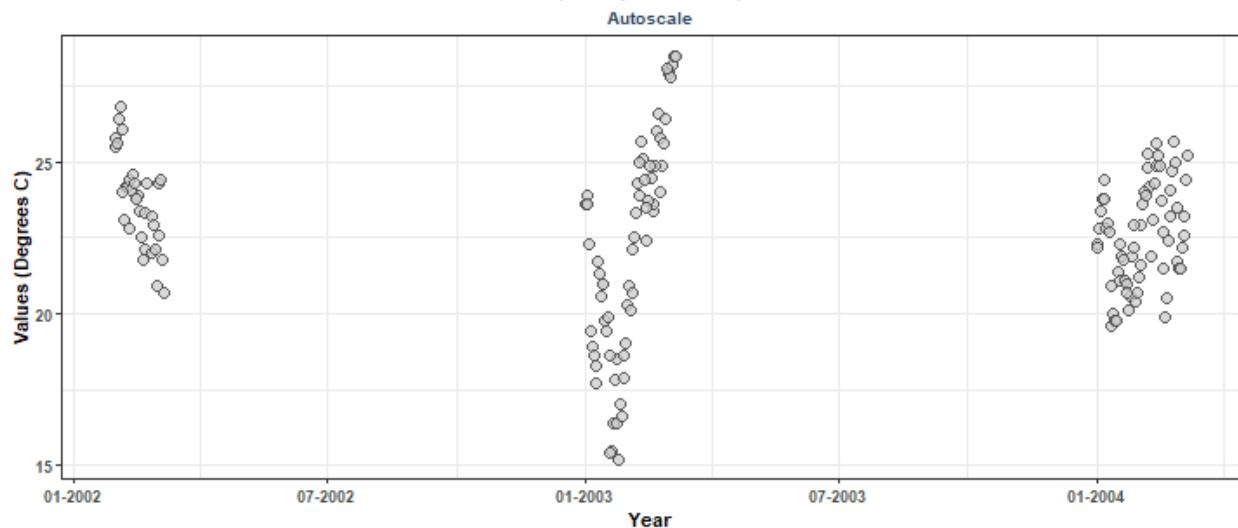
**Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | SANF1
(Unique Years)**



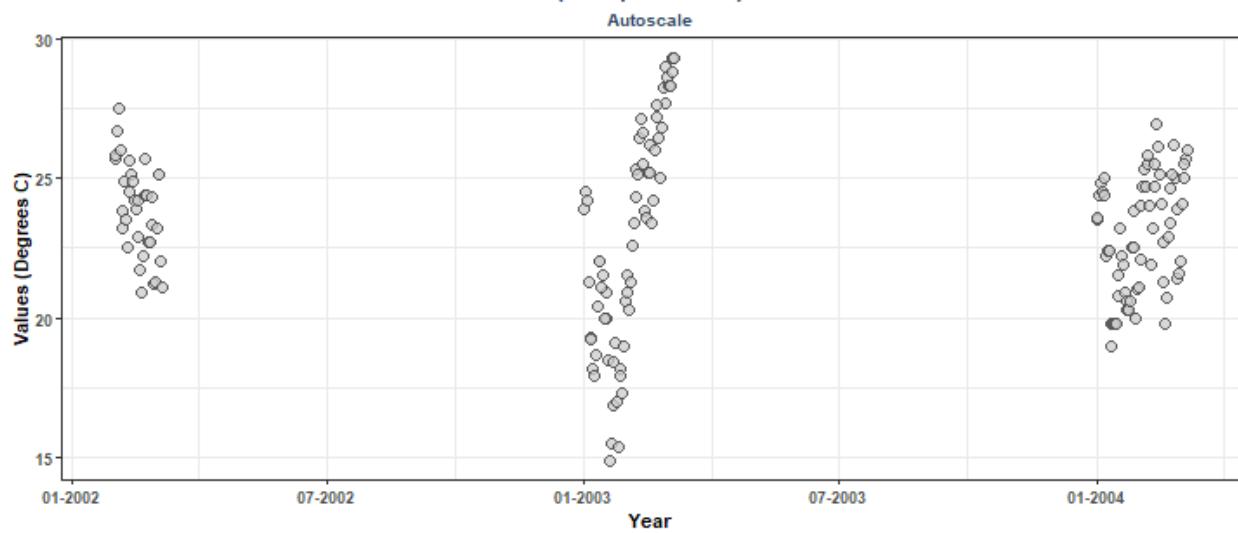
**Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | SMKF1
(Unique Years)**



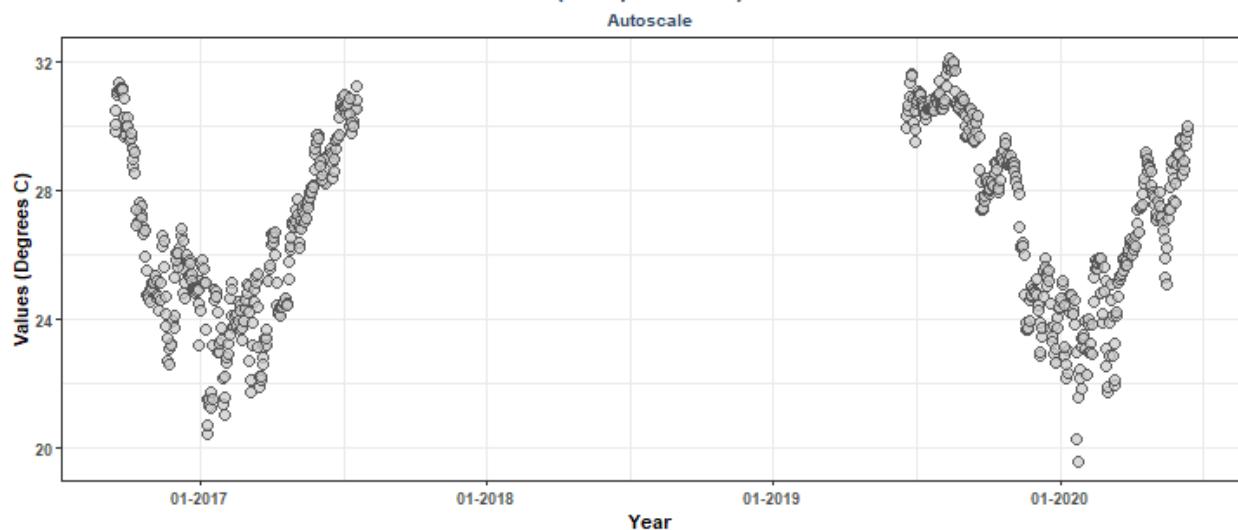
Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
7 | National Water Information System | 245323080410100
(Unique Years)



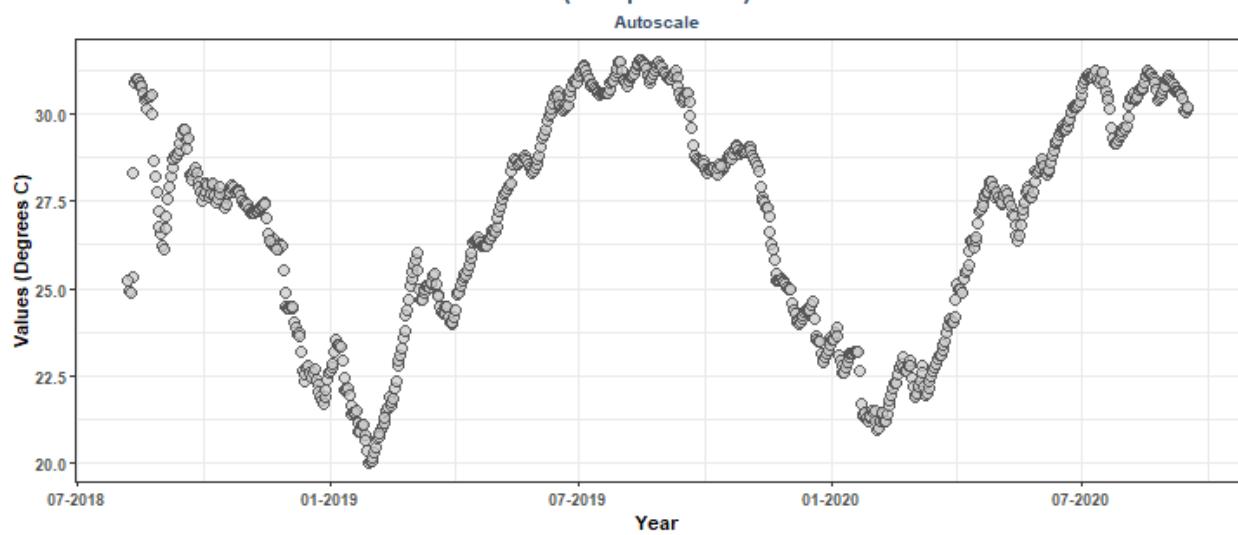
Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
7 | National Water Information System | 245622080364200
(Unique Years)

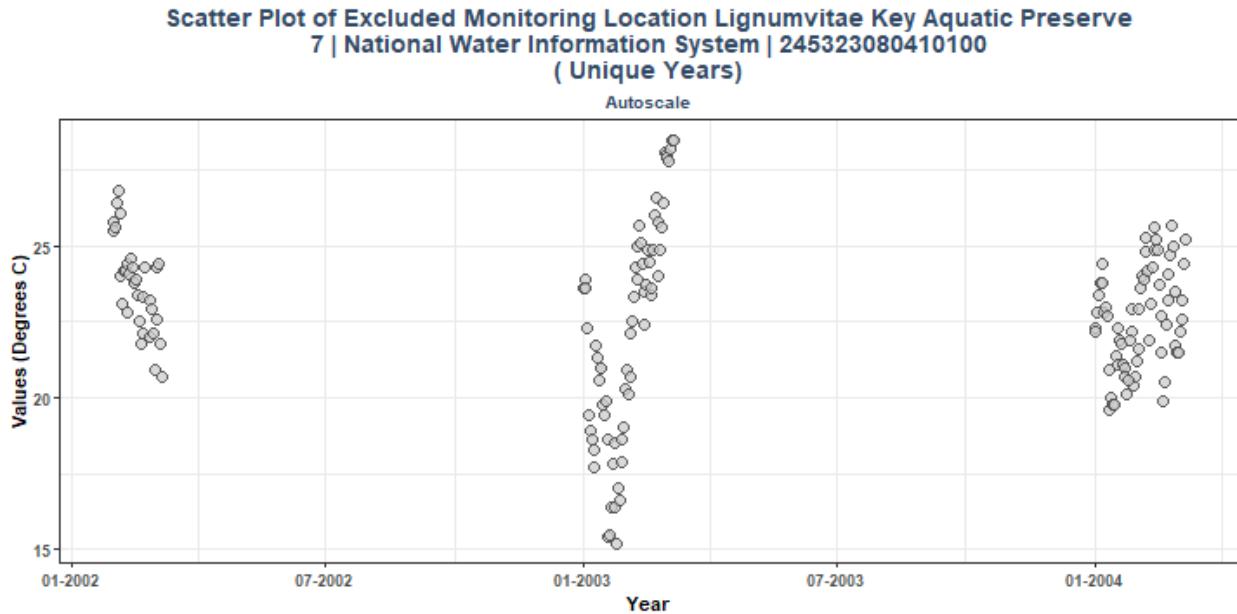


**Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 33
(Unique Years)**



**Scatter Plot of Excluded Monitoring Location Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 39
(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],]
    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]]
rm(model)
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(shape=21, size=3, color="#333333", fill="#cccccc",
             alpha=0.75) +
  geom_abline(aes(slope=s_slope, intercept=s_int),
              color="#000099", size=1.2, alpha=0.7) +
  labs(subtitle = "Autoscale",
       x = "Year", y = paste0("Values (", unit, ")")) +
  plot_theme

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

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

p0 <- ggplot() + labs(title = paste0("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: ",
                                         ))

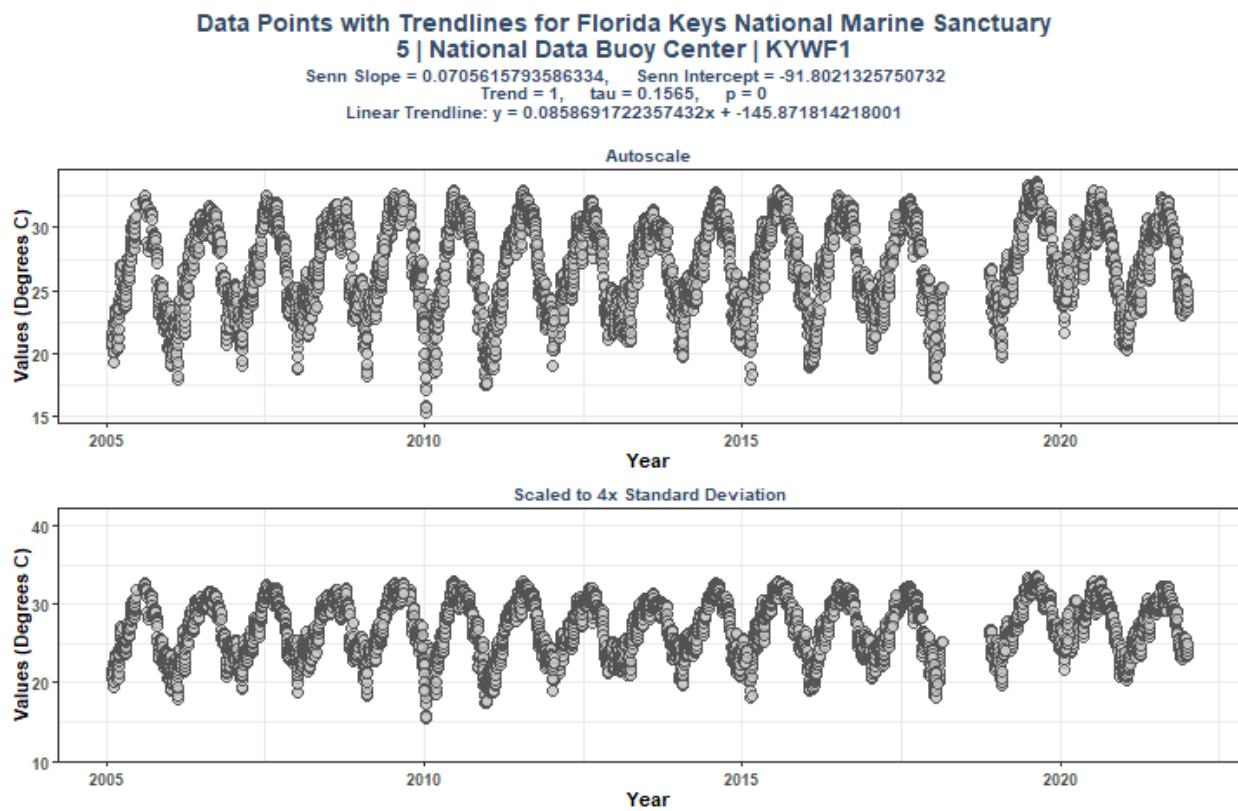
```

```

        "y = ", m_slope, "x + ", m_int)) +
plot_theme + theme(panel.border = element_blank(),
                   panel.grid.major = element_blank(),
                   panel.grid.minor = element_blank(),
                   axis.line = element_blank())

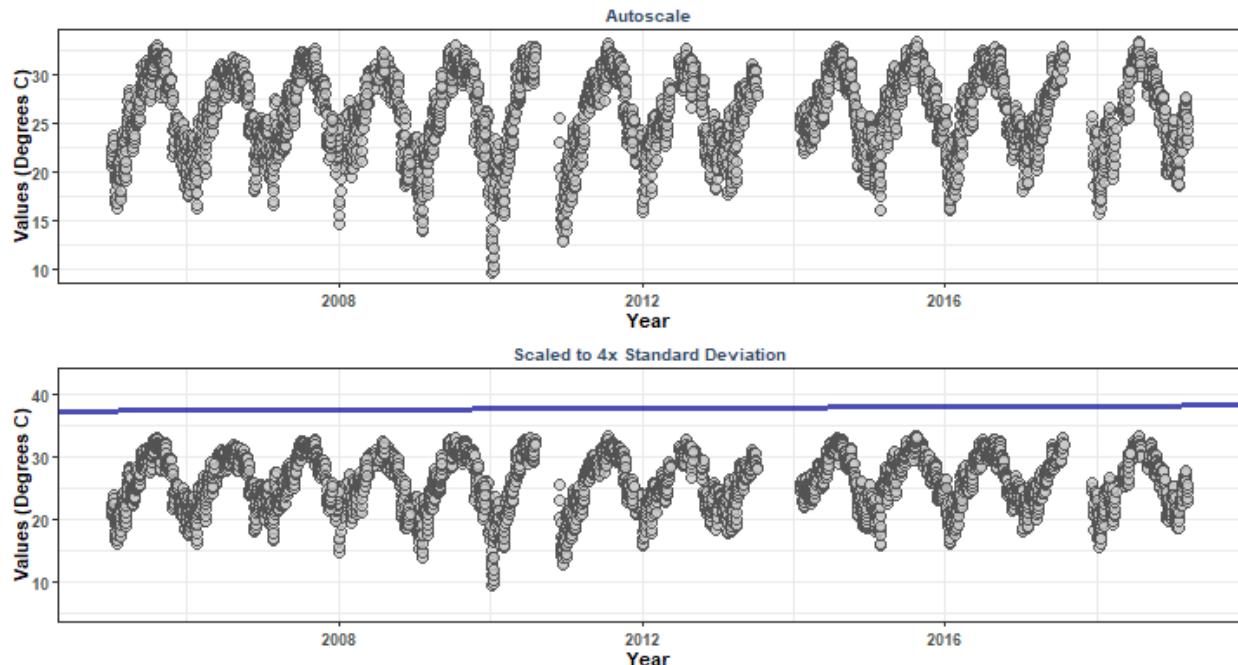
print(ggarrange(p0, KTset, ncol = 1, heights = c(0.20, 1)))
rm(plot_data)
rm(KTset, leg)
}
}

```



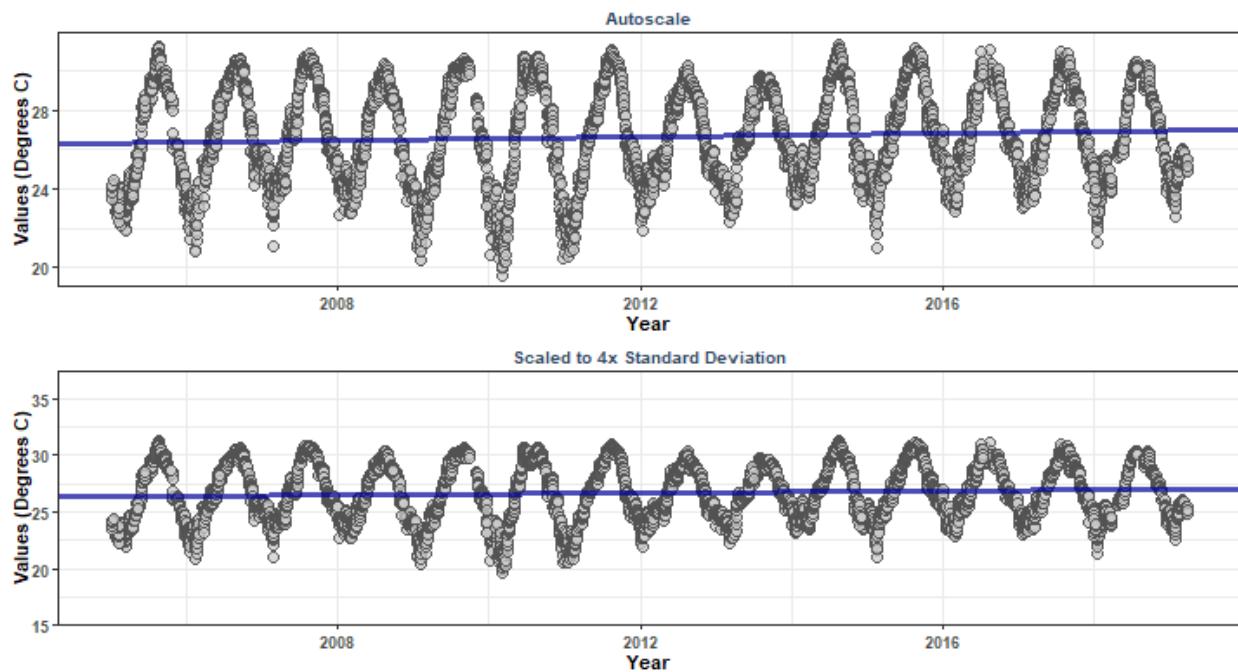
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1**

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



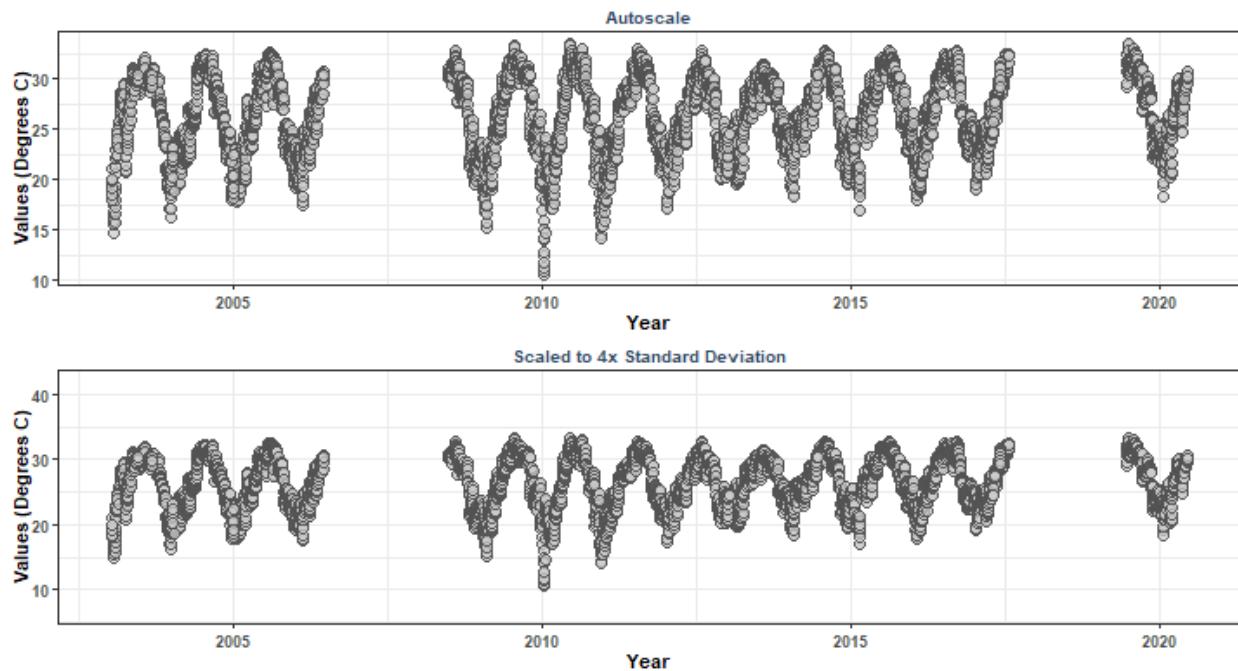
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1**

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



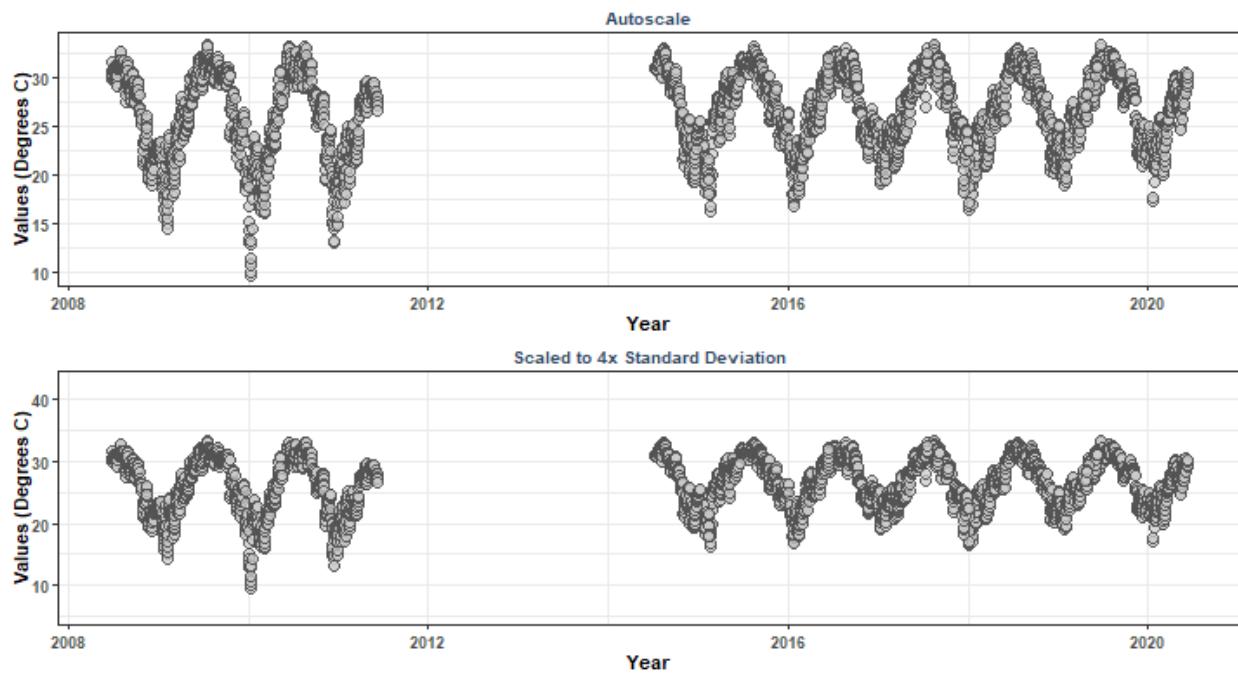
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11**

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



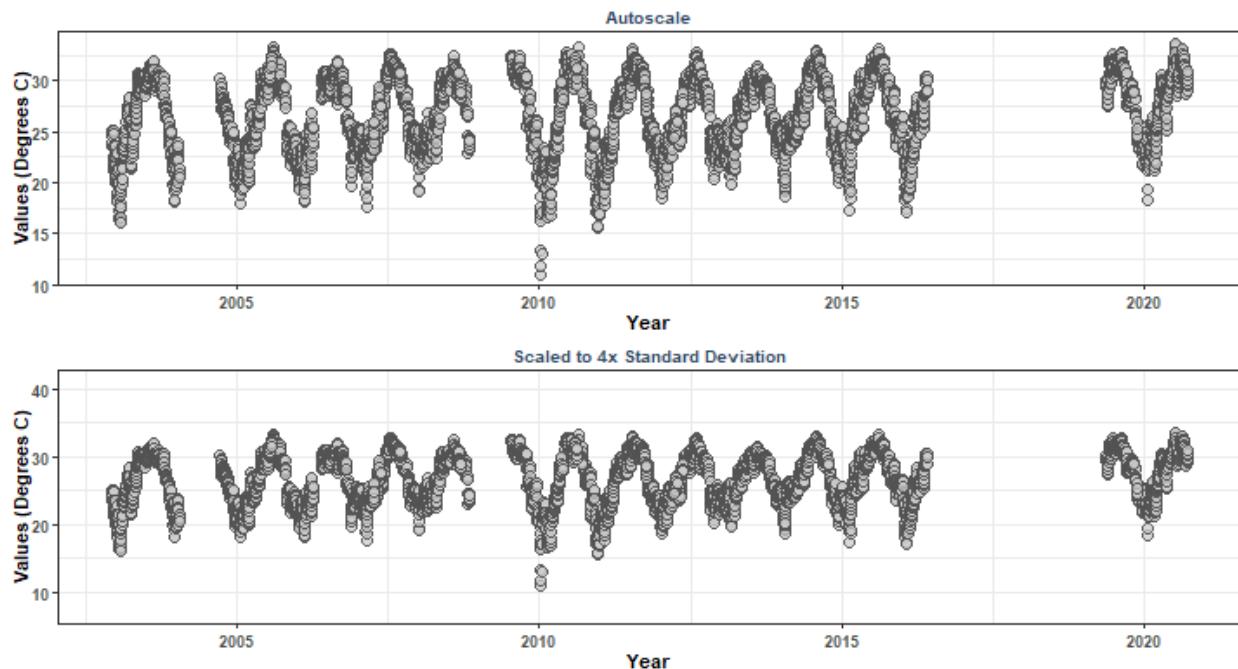
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12**

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



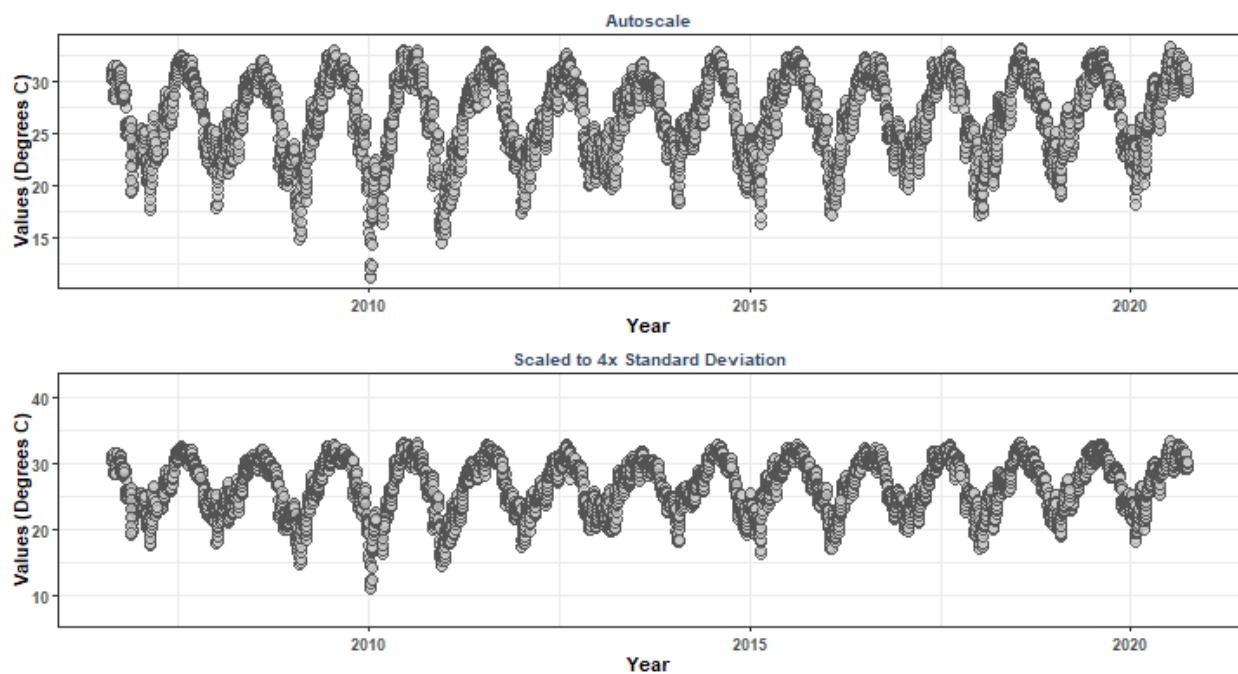
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14**

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



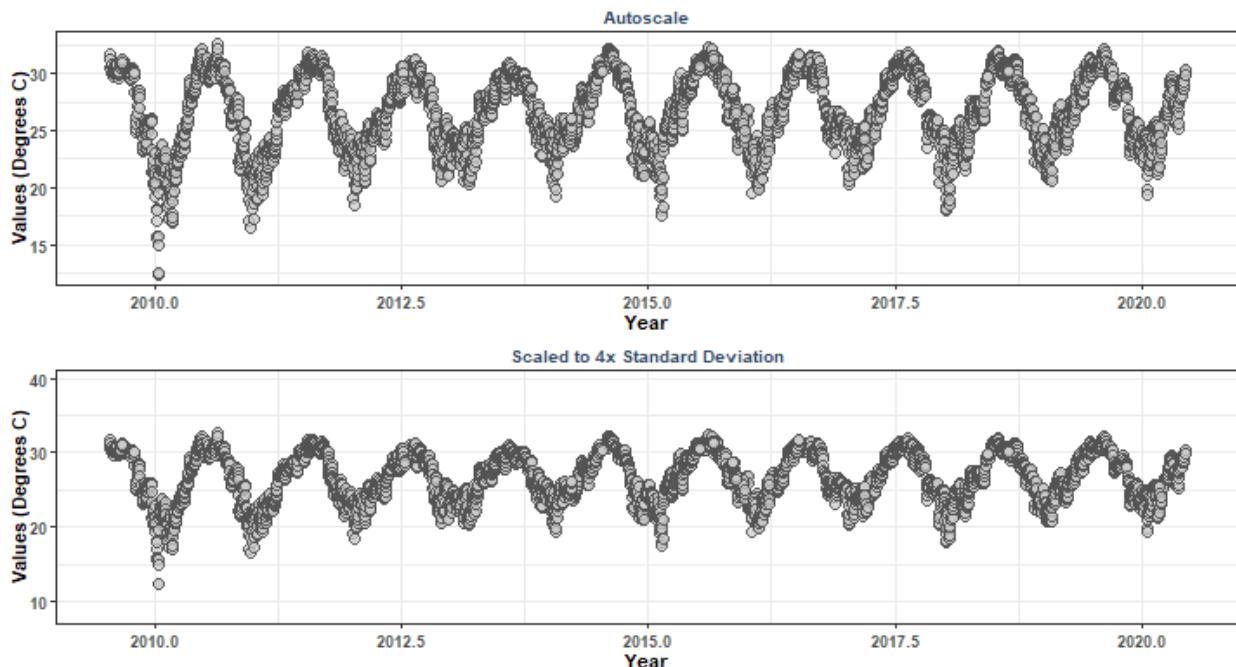
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15**

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



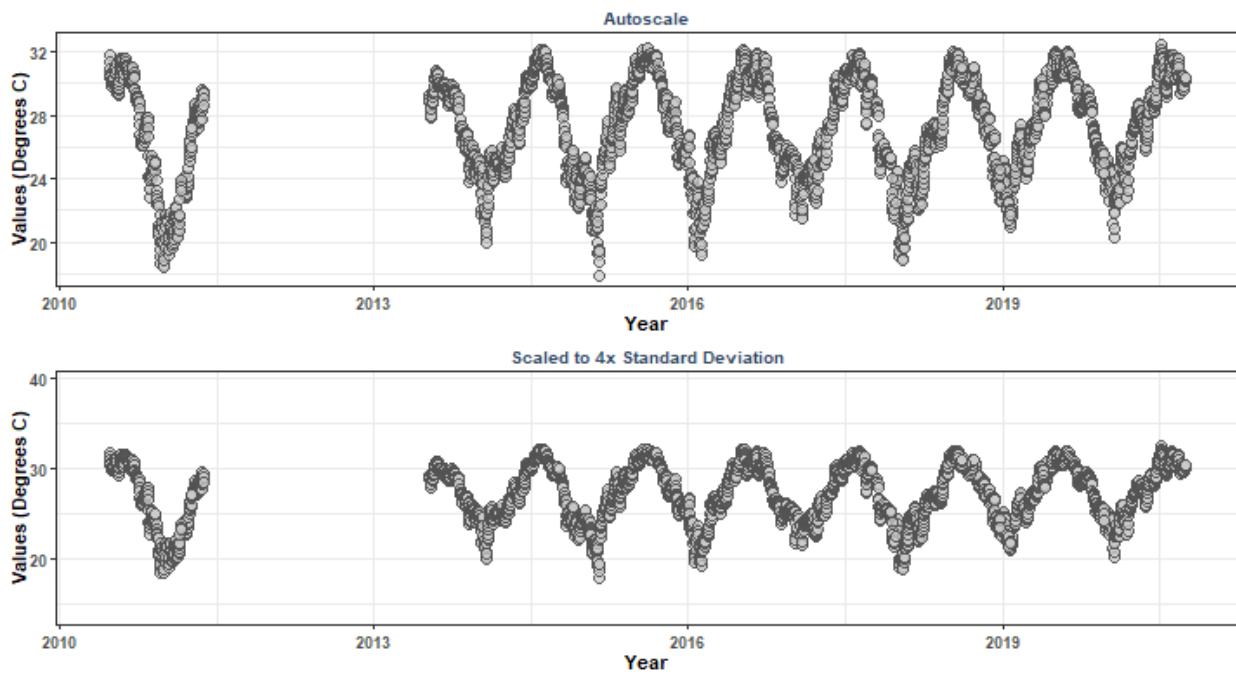
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22**

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



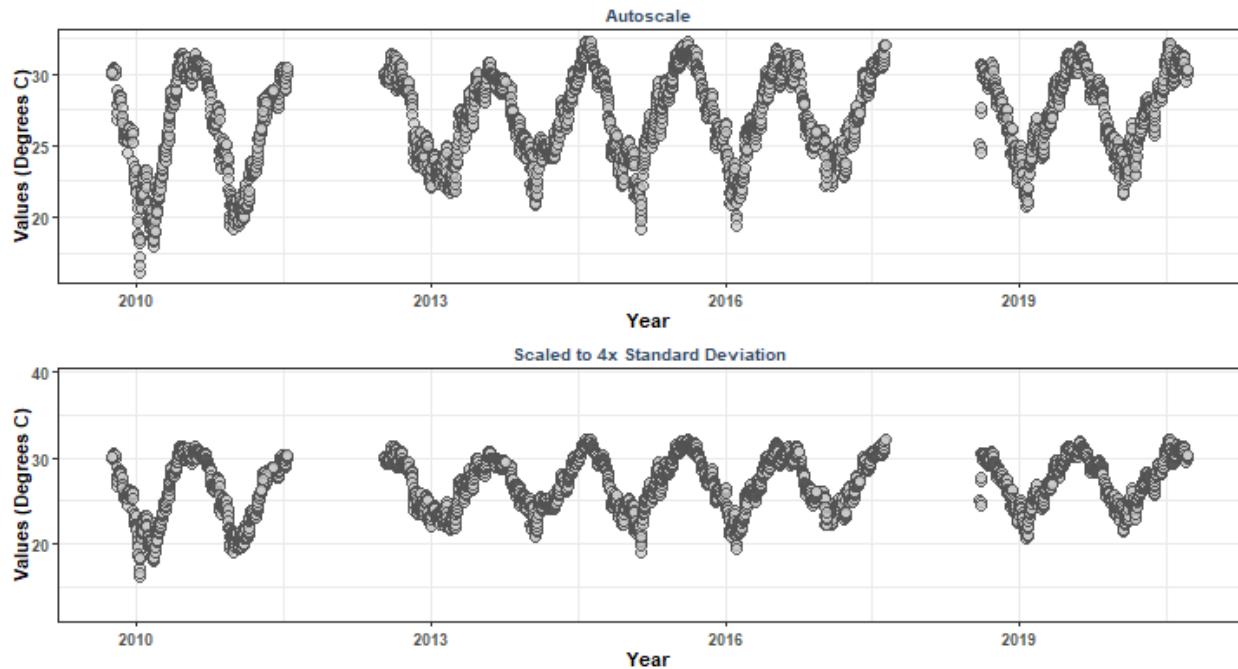
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25**

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



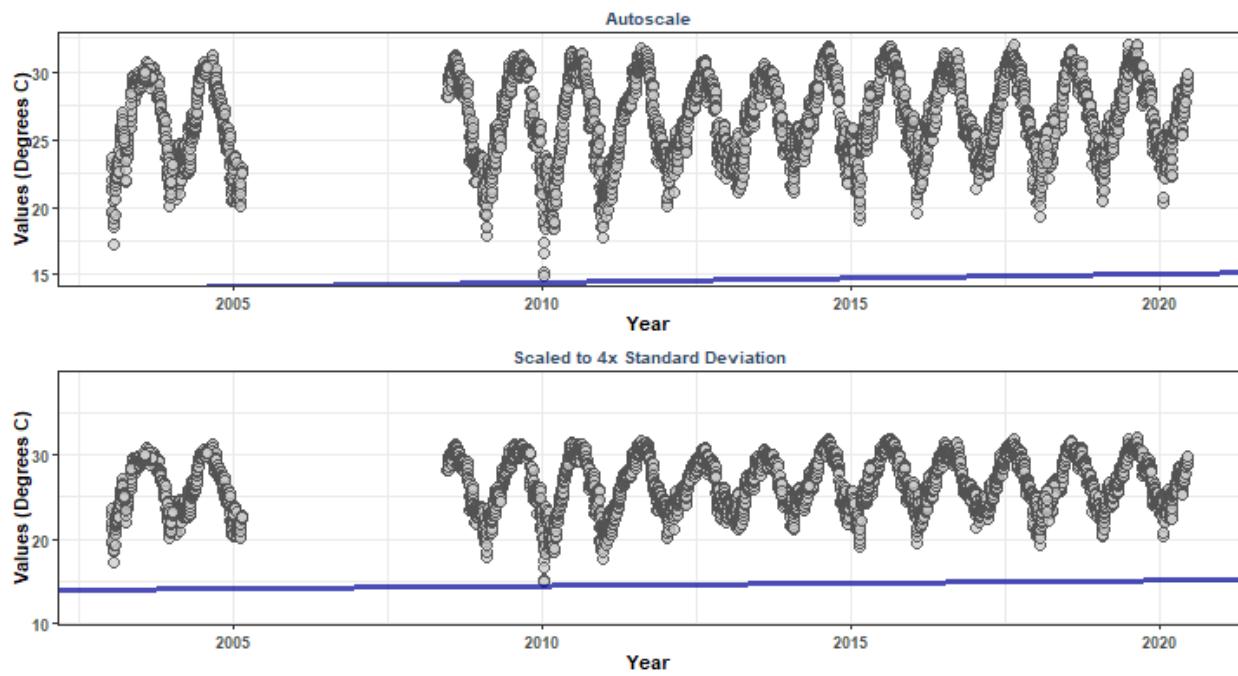
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26**

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



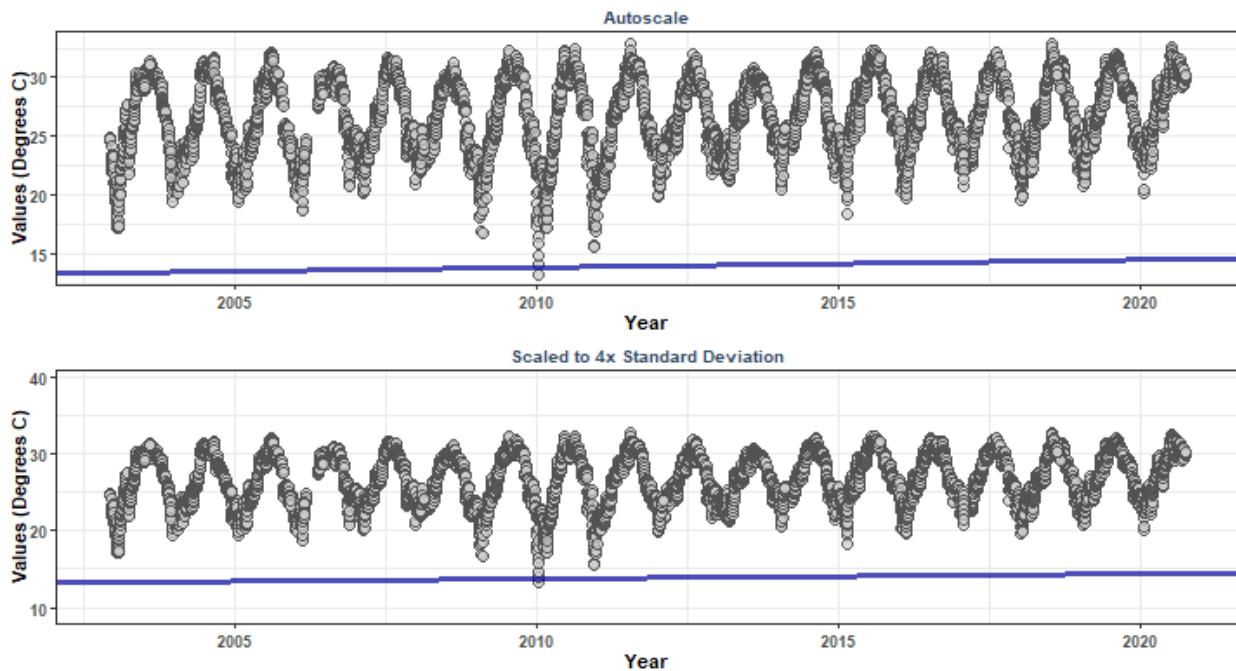
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32**

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



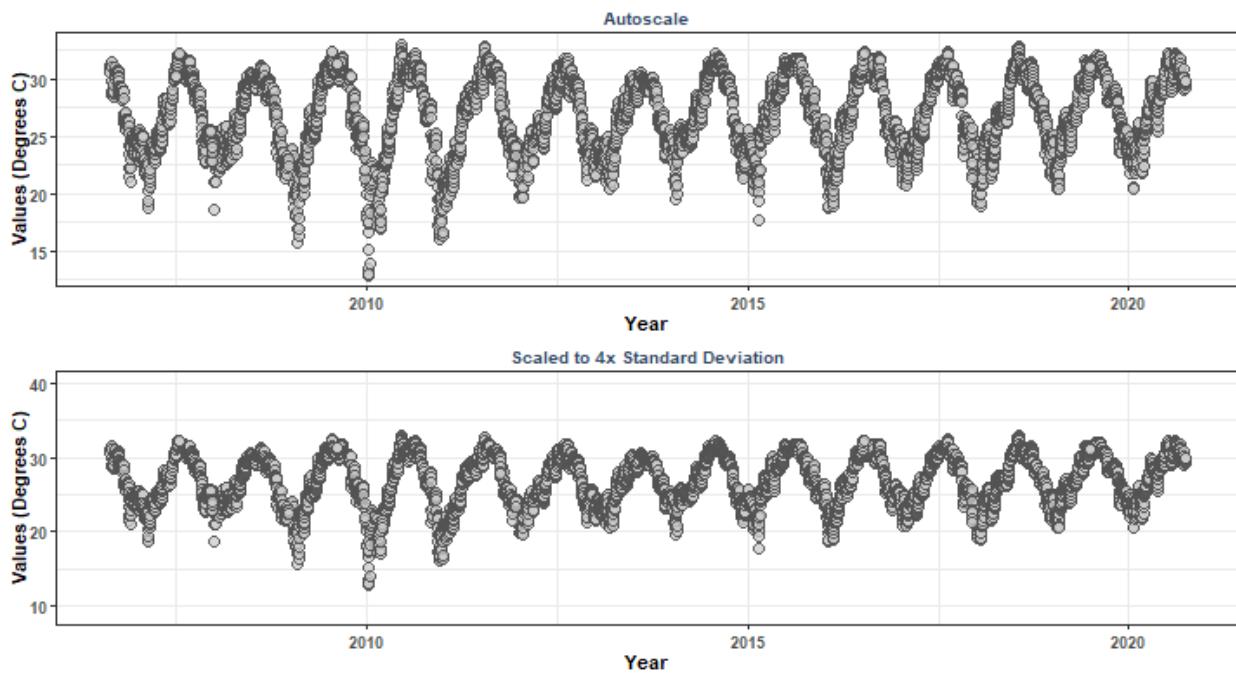
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34**

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



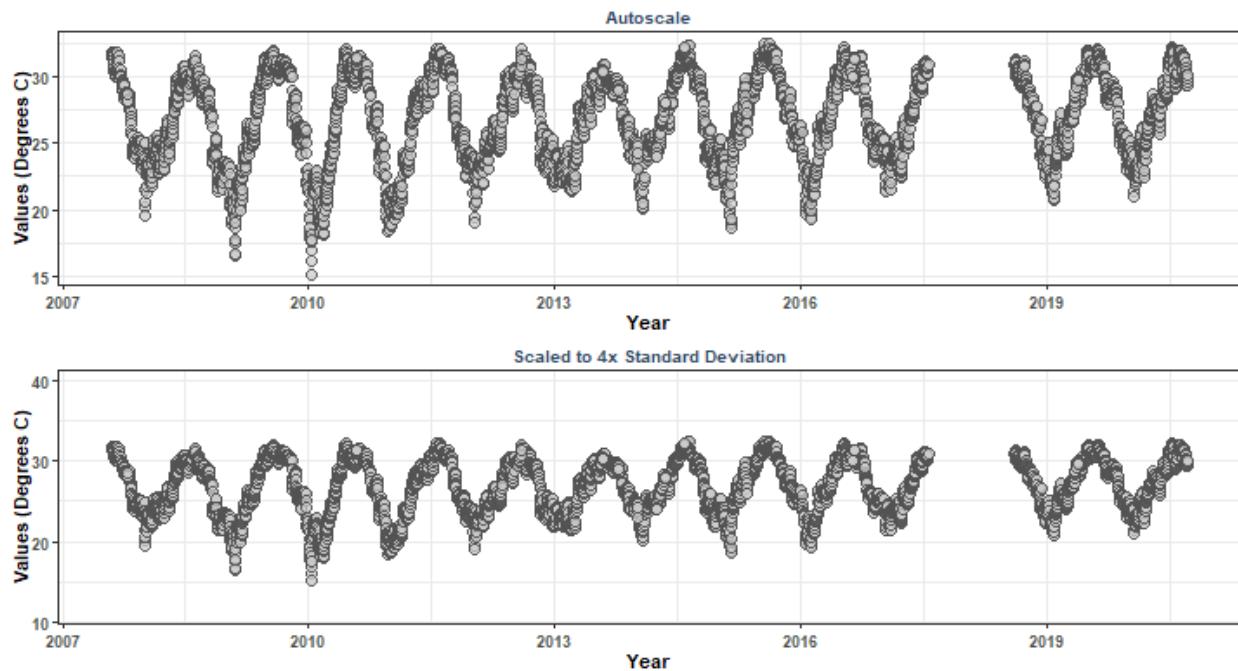
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35**

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



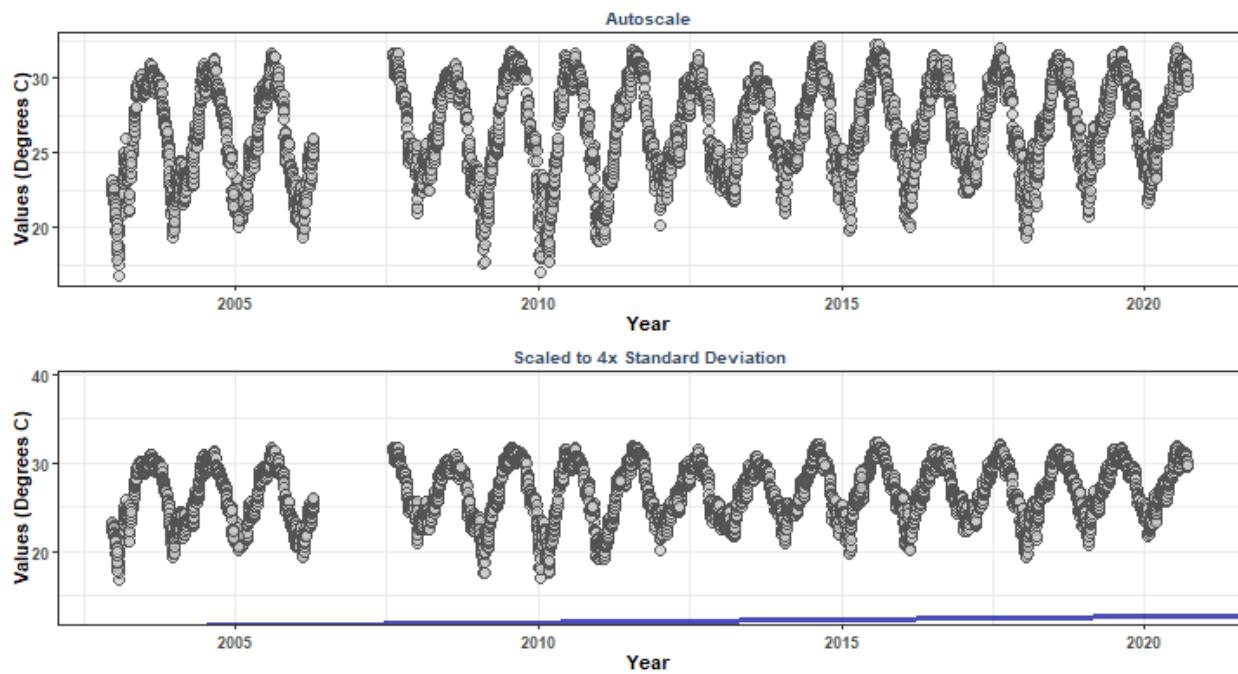
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 36**

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 | 38**

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



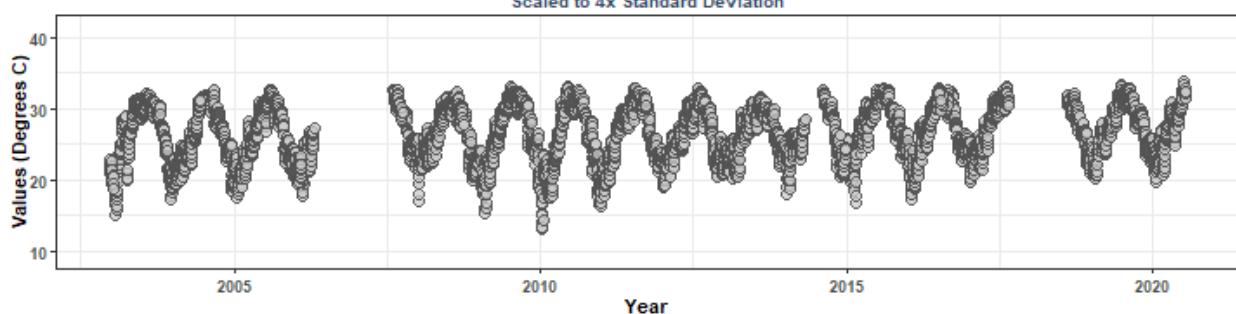
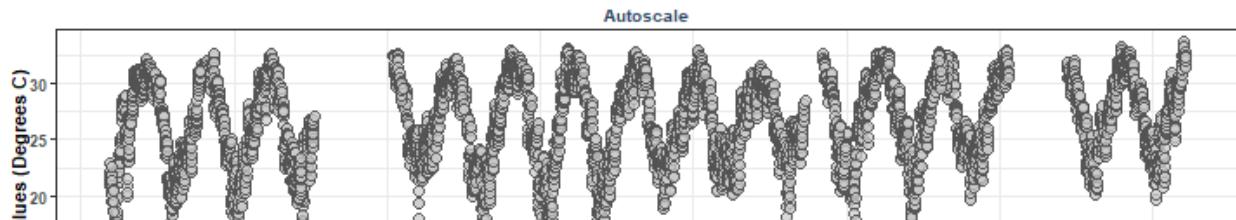
Data Points with Trendlines for Florida Keys National Marine Sanctuary

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: $y = 0.0973591701757025x + -169.197583612648$



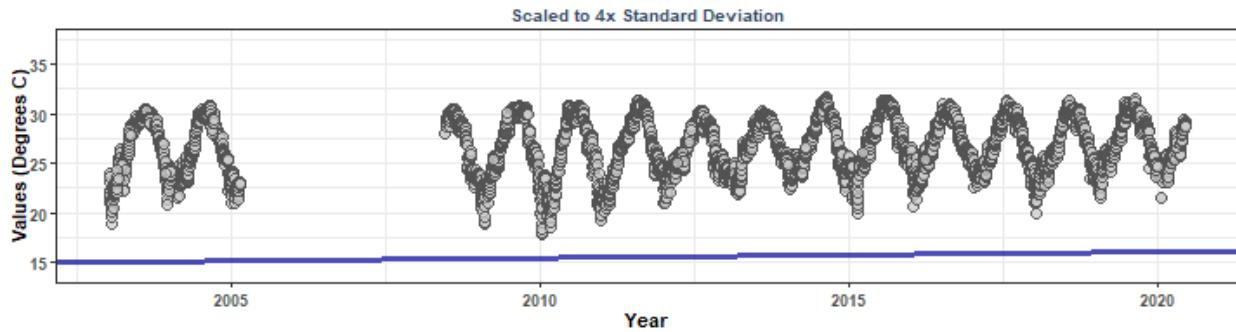
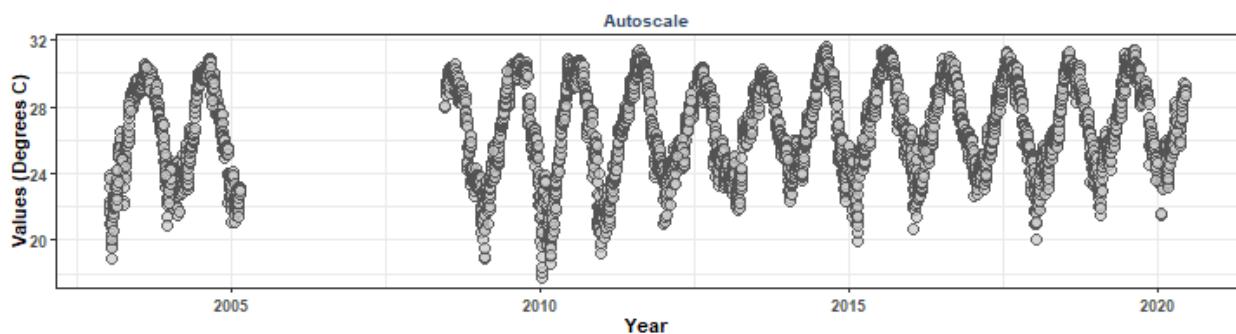
Data Points with Trendlines for Florida Keys National Marine Sanctuary

986 | Water Temperature on Coral Reefs in the Florida Keys | 51

Senn Slope = 0.0588069069069064, Senn Intercept = -102.734509585574

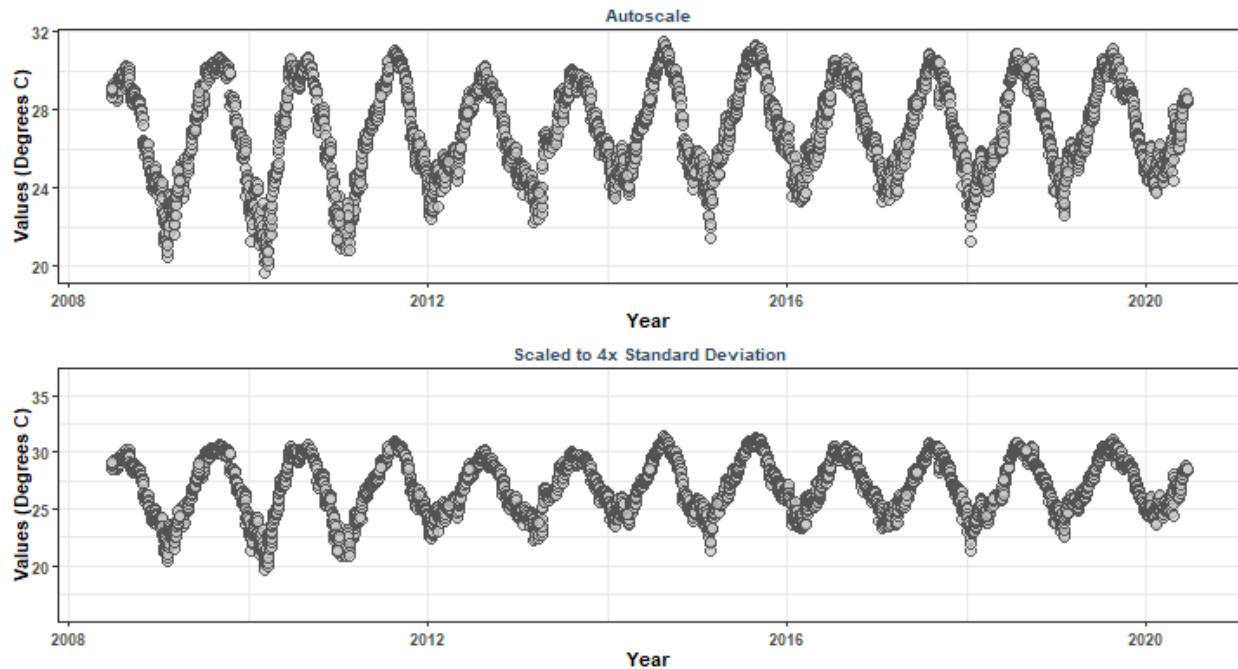
Trend = 1, tau = 0.2012, p = 0

Linear Trendline: $y = 0.0577884166951392x + -89.6158986596463$



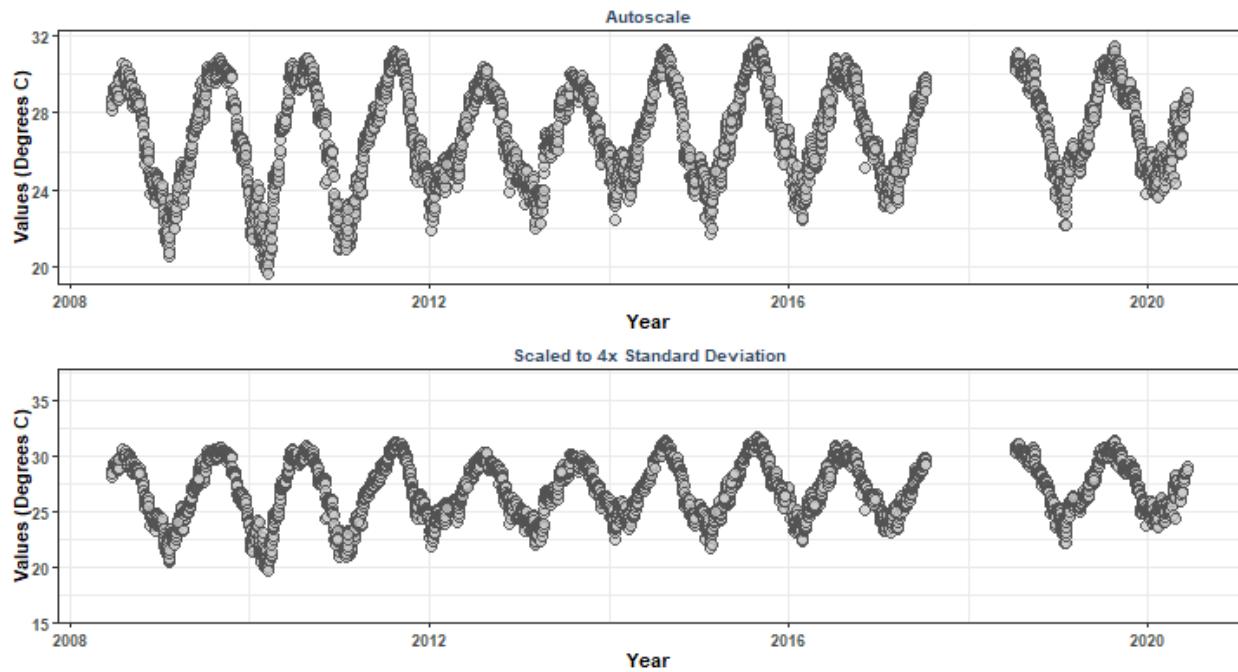
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 52**

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: $y = 0.0756847686054585x + -125.472171595292$

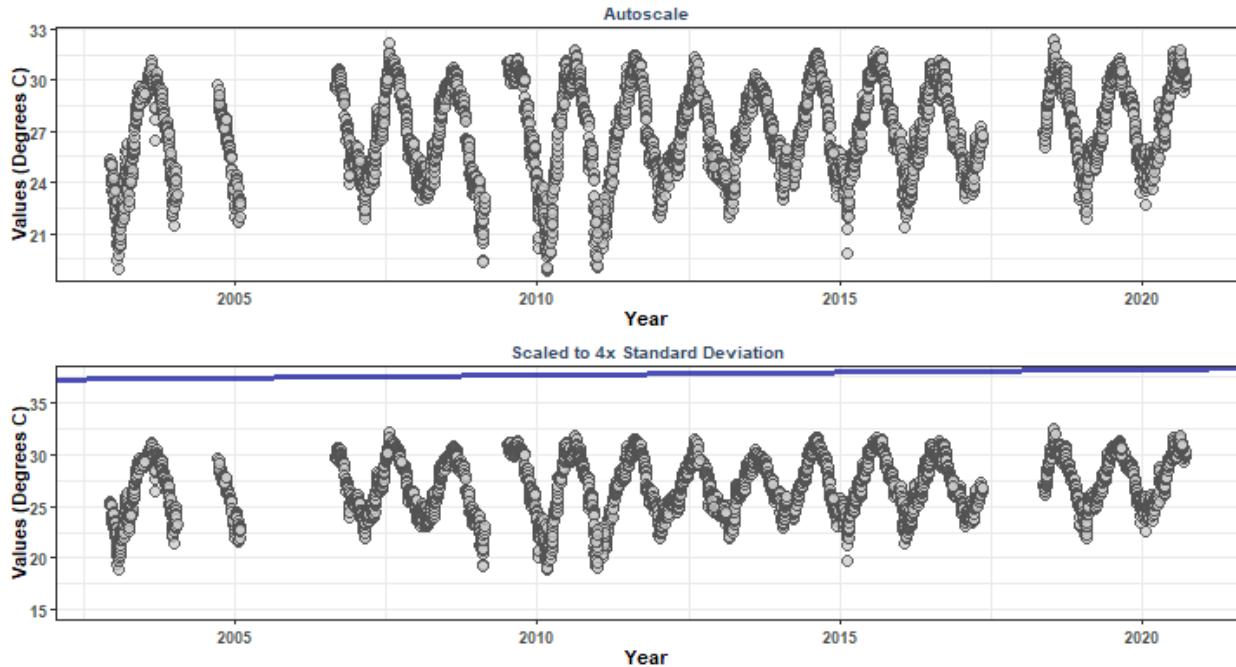


**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 55**

Senn Slope = 0.0537424242424242, Senn Intercept = -70.4432350975873

Trend = 1, tau = 0.1877, p = 0

Linear Trendline: $y = 0.0878023721678491x + -149.714121624234$

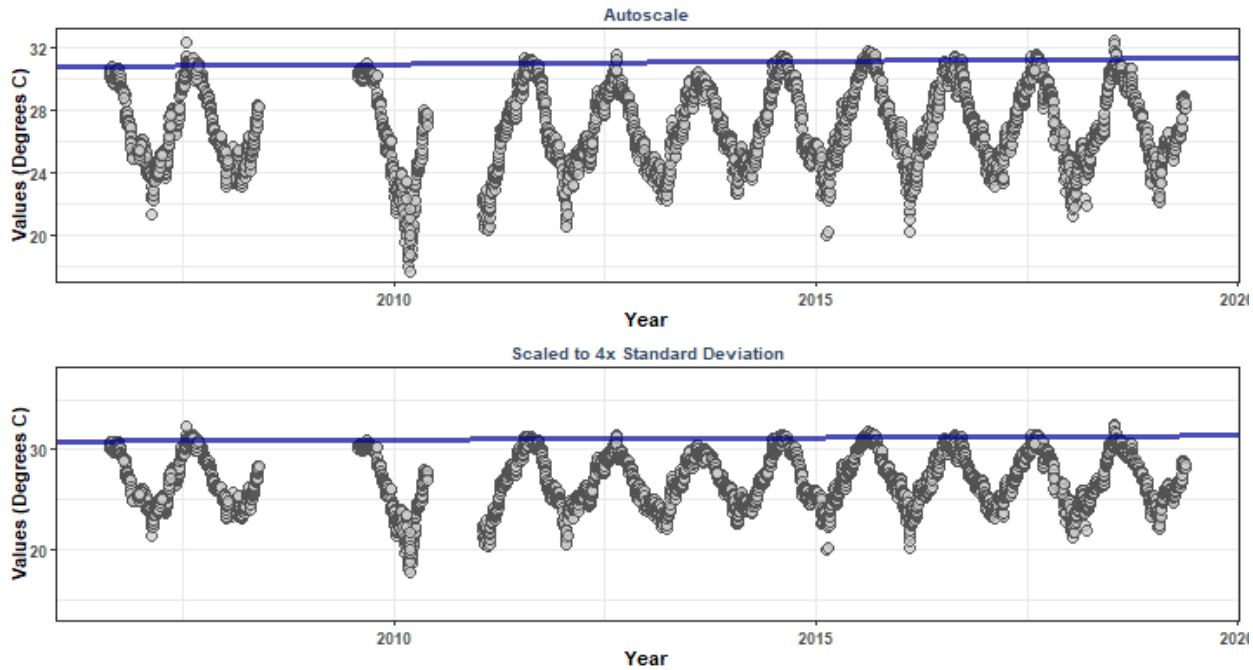


**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 56**

Senn Slope = 0.0418452380952381, Senn Intercept = -53.1868761957782

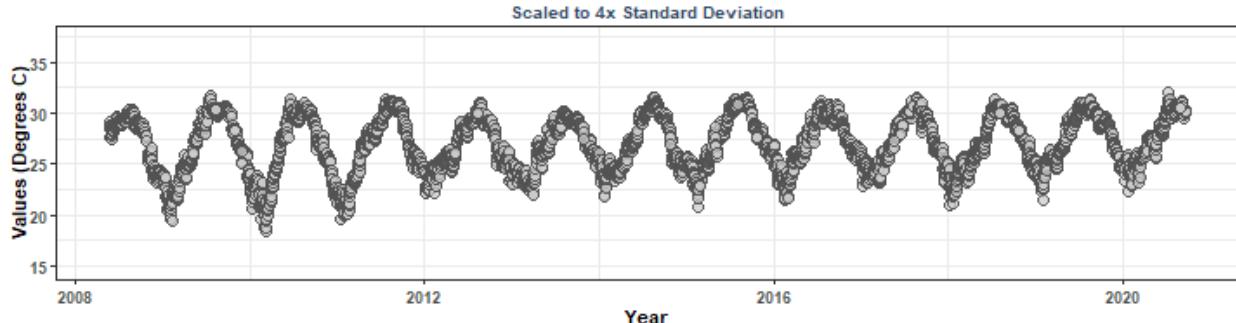
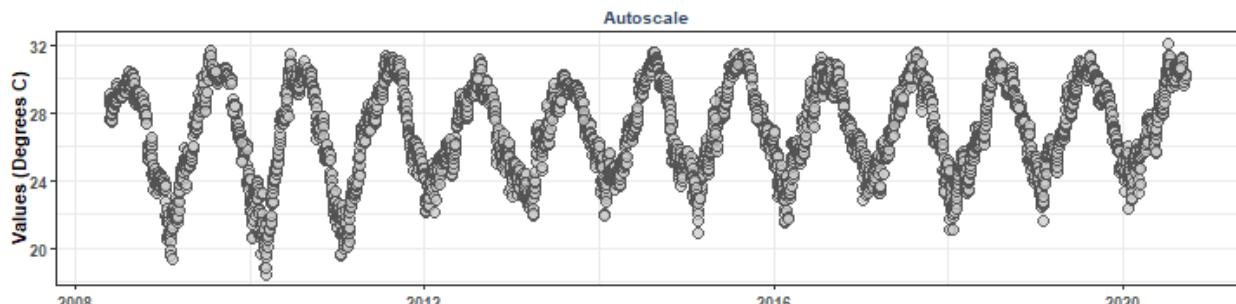
Trend = 1, tau = 0.1111, p = 0

Linear Trendline: $y = 0.0547544719857269x + -83.3223792557164$



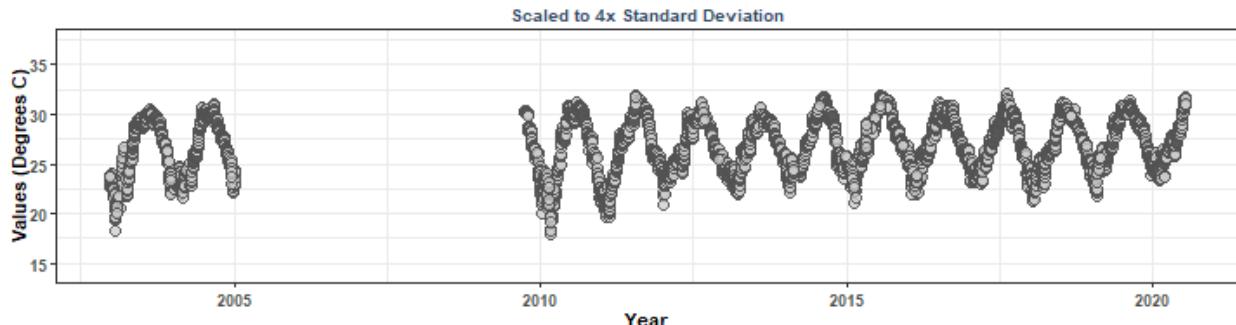
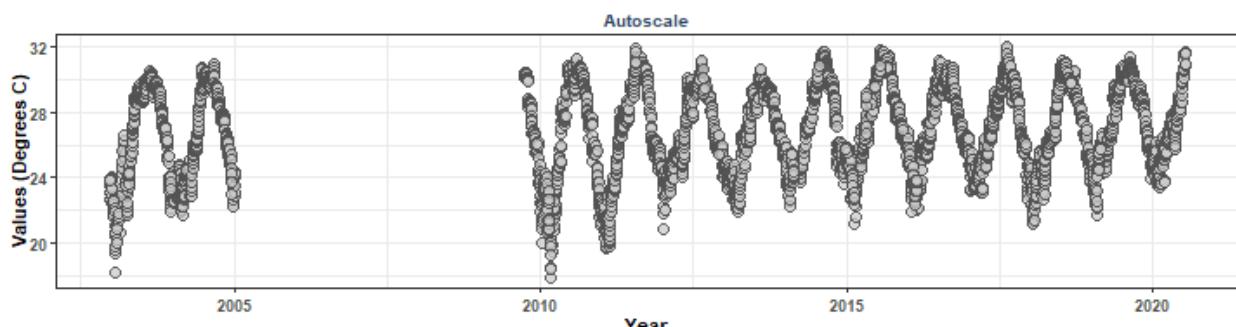
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 57**

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



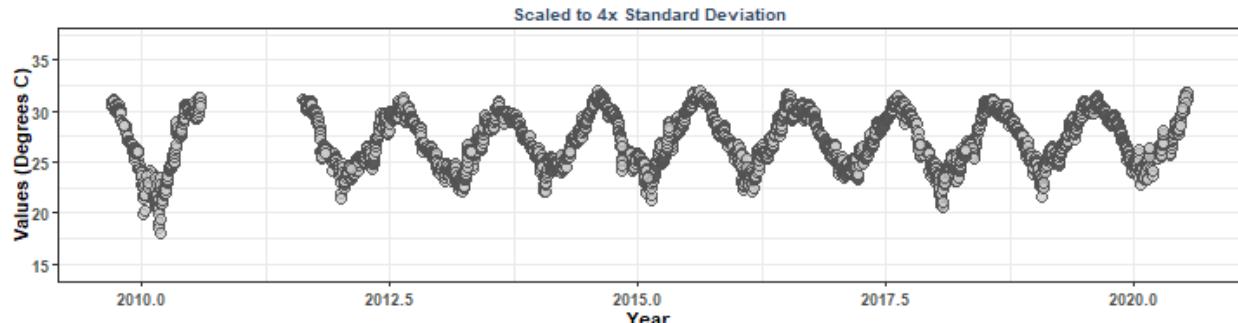
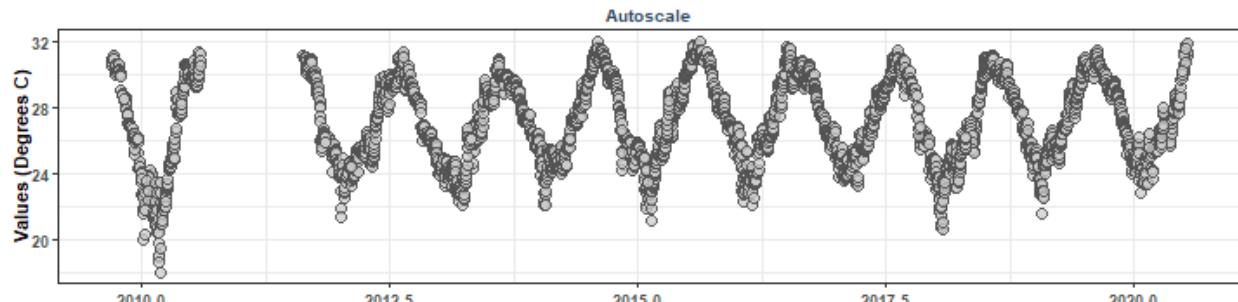
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 59**

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



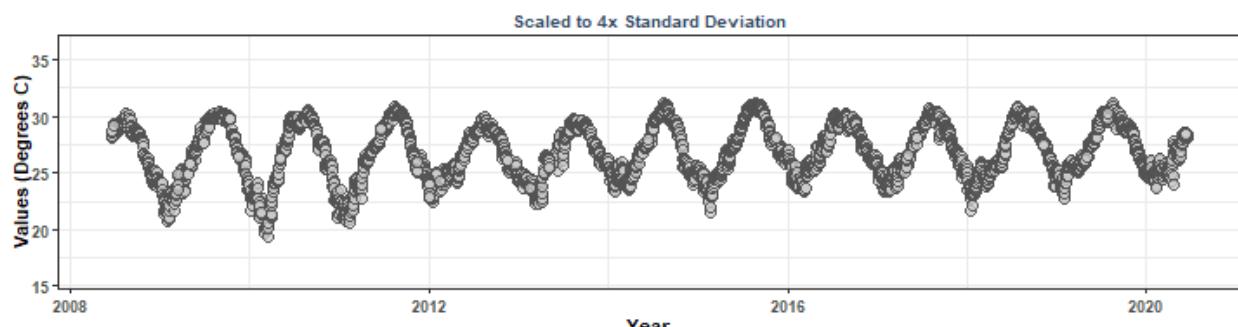
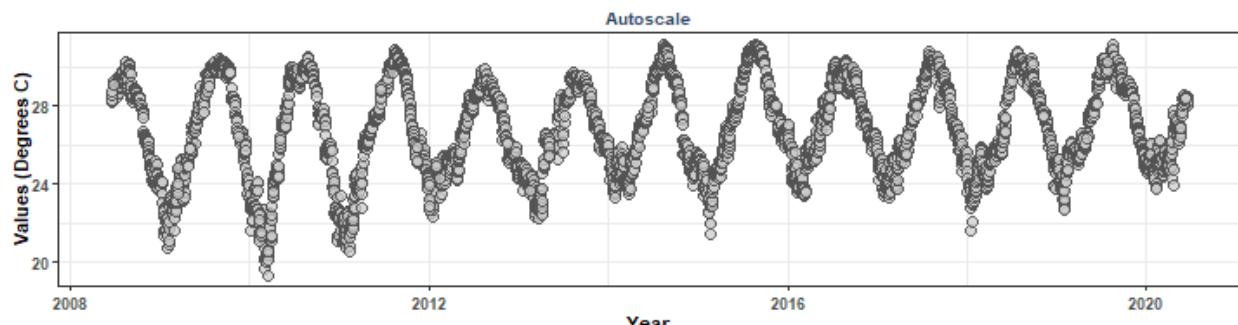
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 60**

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



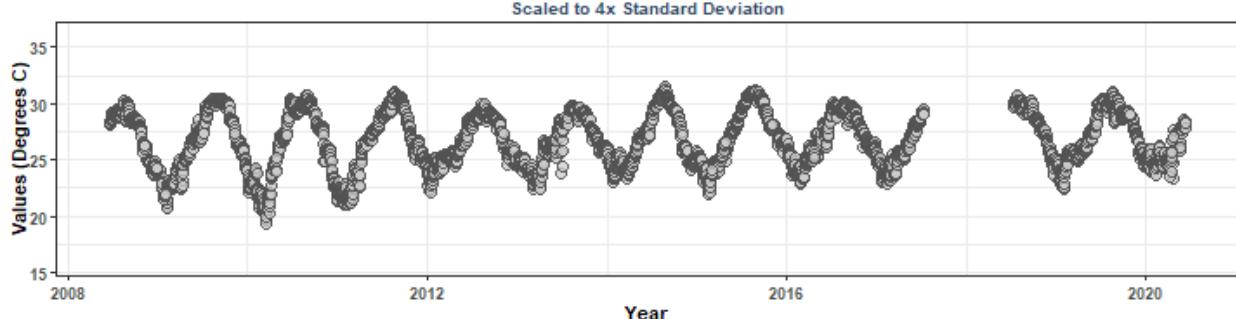
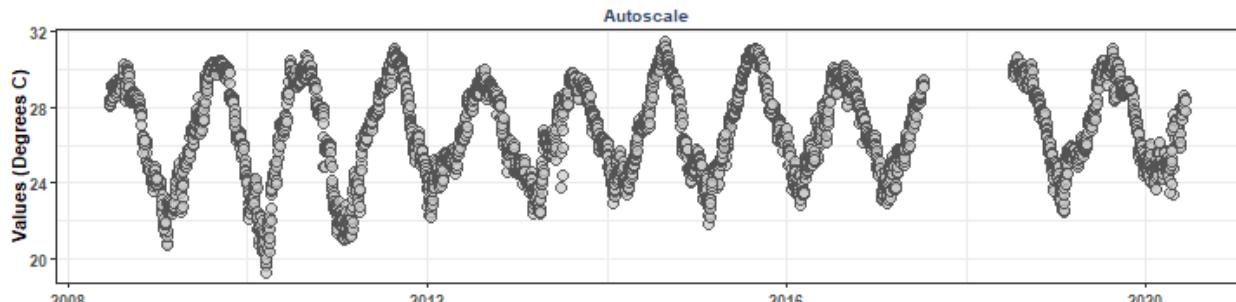
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 72**

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



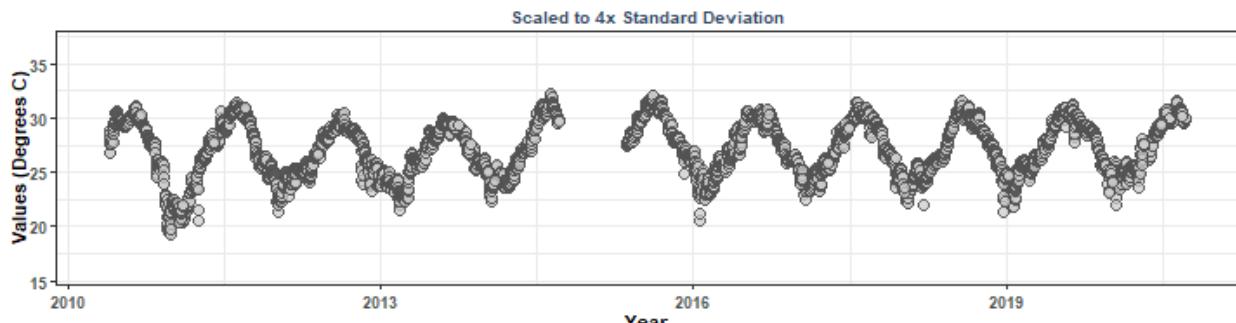
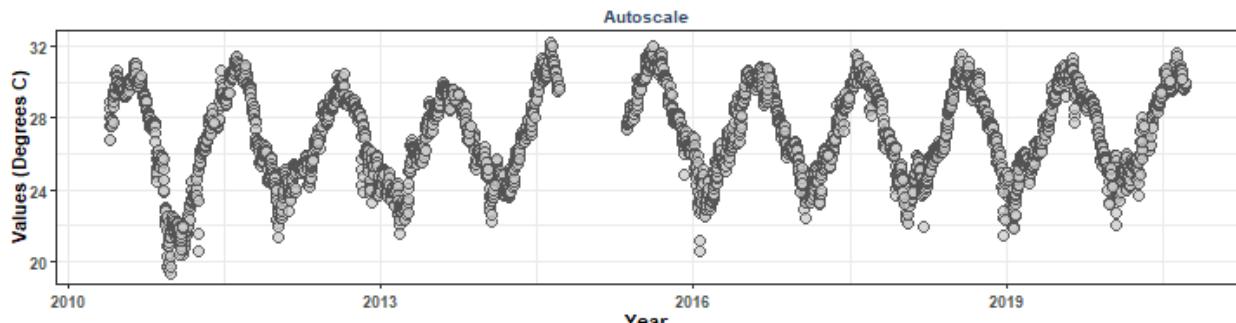
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 73**

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



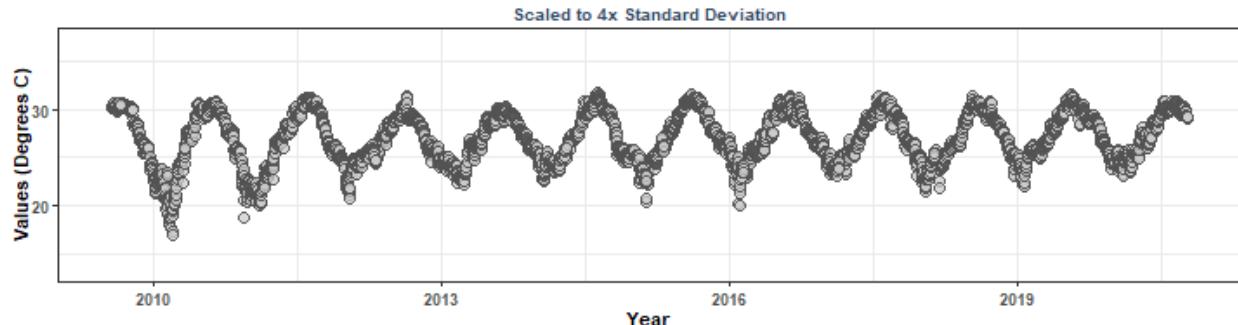
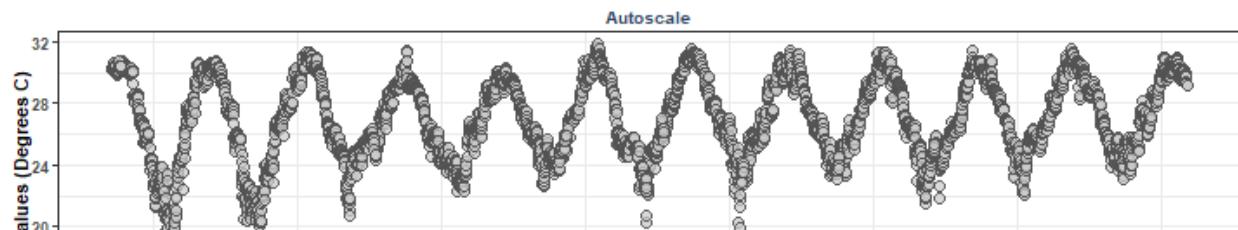
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 75**

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



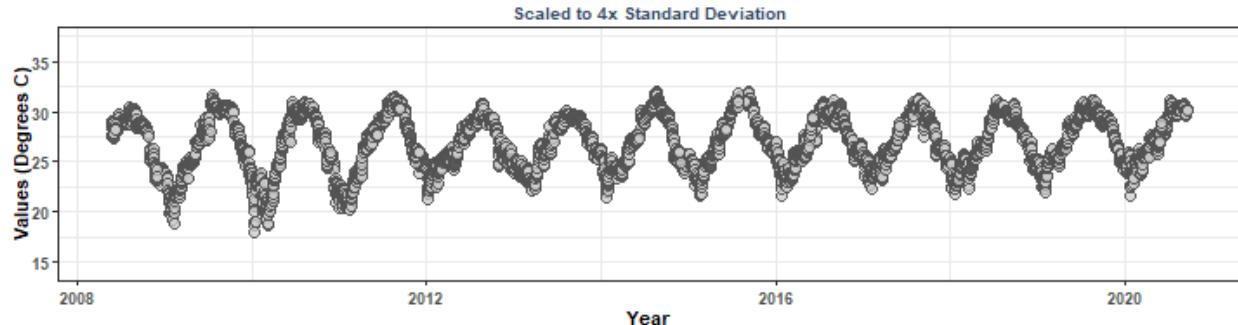
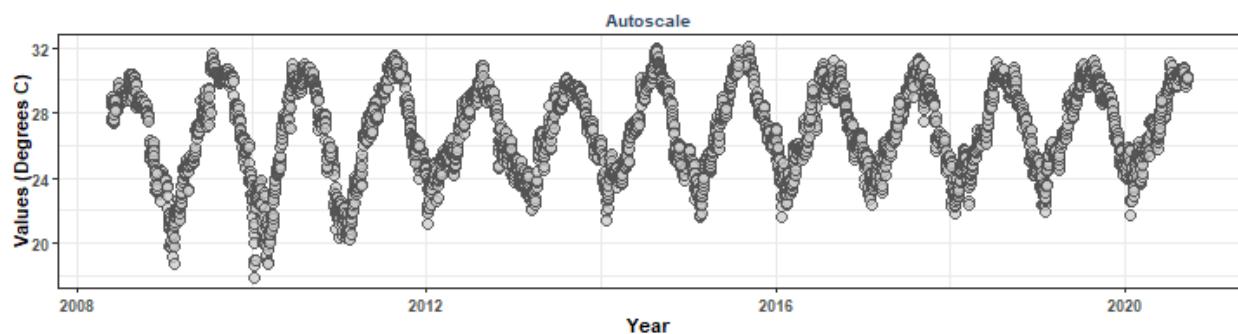
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 76**

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: $y = 0.101223511404019x + -176.957678984098$

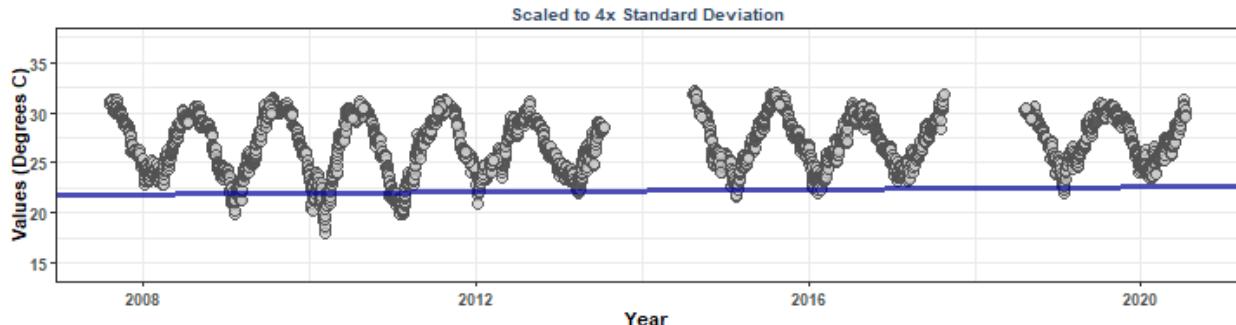
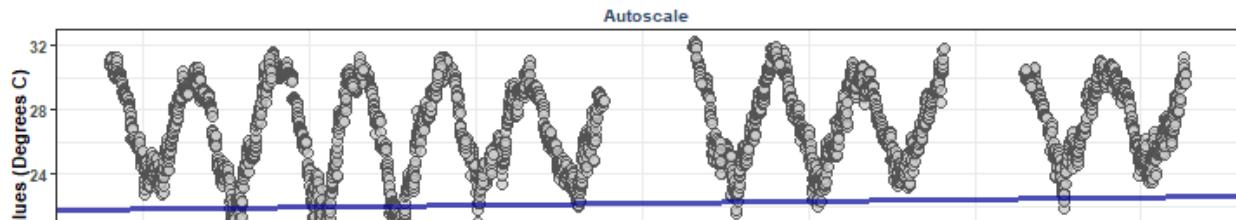


**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 79**

Senn Slope = 0.0607638888888893, Senn Intercept = -100.140754981052

Trend = 1, tau = 0.1651, p = 0

Linear Trendline: $y = 0.0710845190260051x + -116.232022934495$

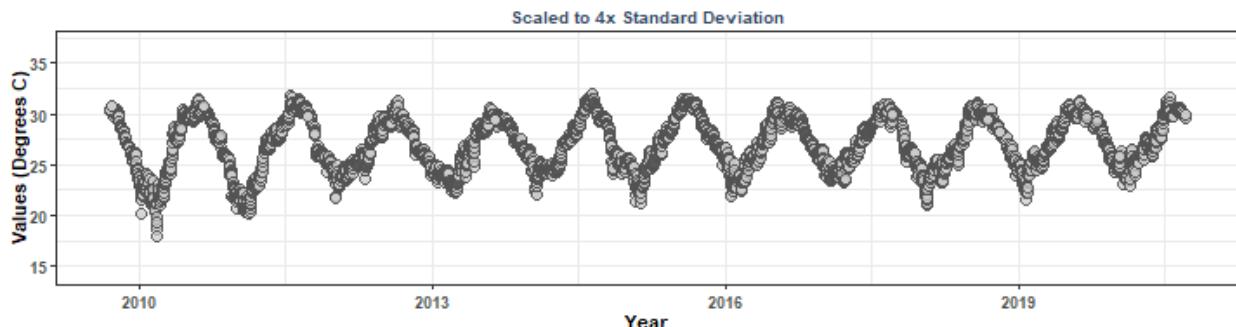
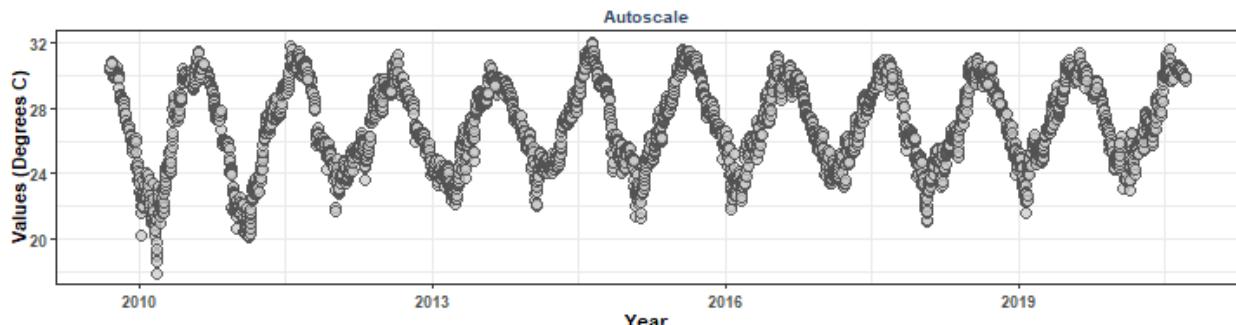


**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 80**

Senn Slope = 0.0672597099502838, Senn Intercept = -133.025089409567

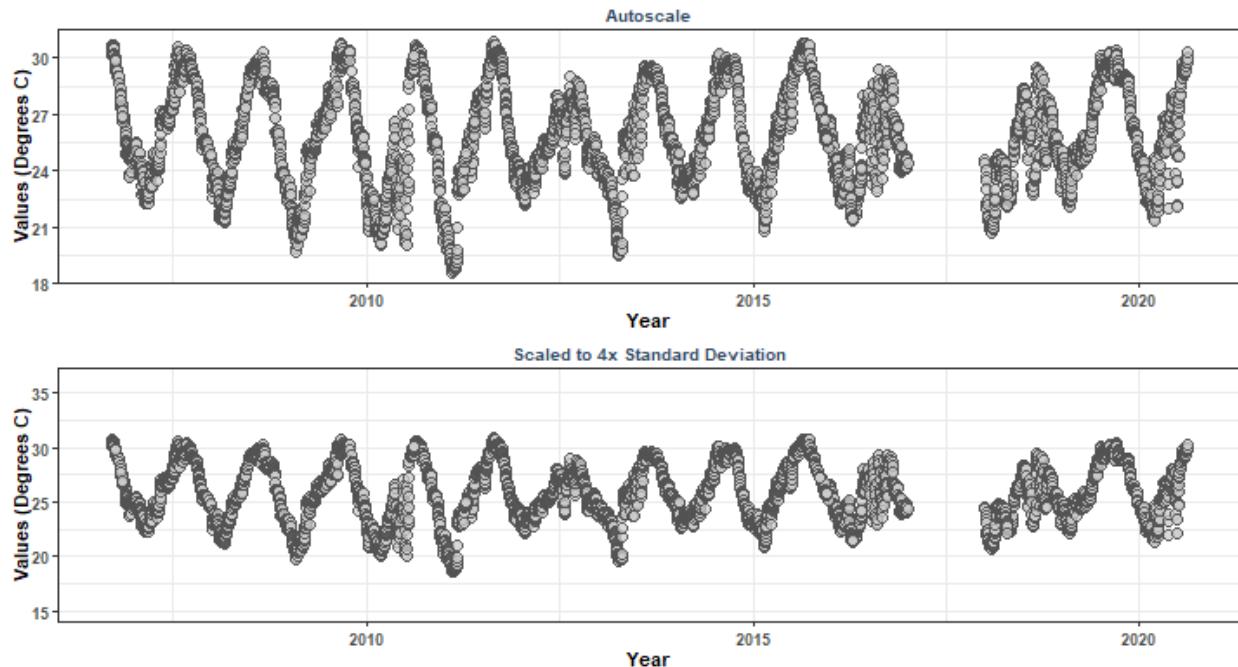
Trend = 1, tau = 0.1536, p = 0

Linear Trendline: $y = 0.113756512685588x + -202.248546006589$



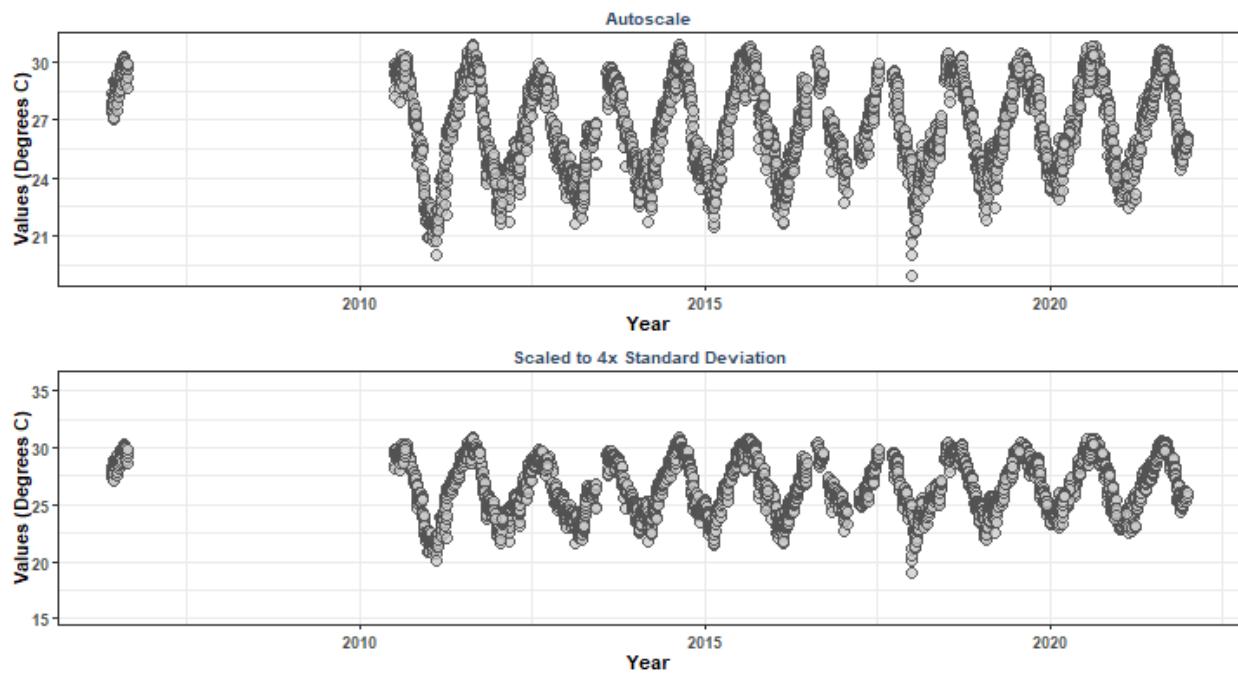
**Data Points with Trendlines for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 83**

Senn Slope = 0.014722222222219, 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: $y = 0.027491993485422x + -28.8007051376882$



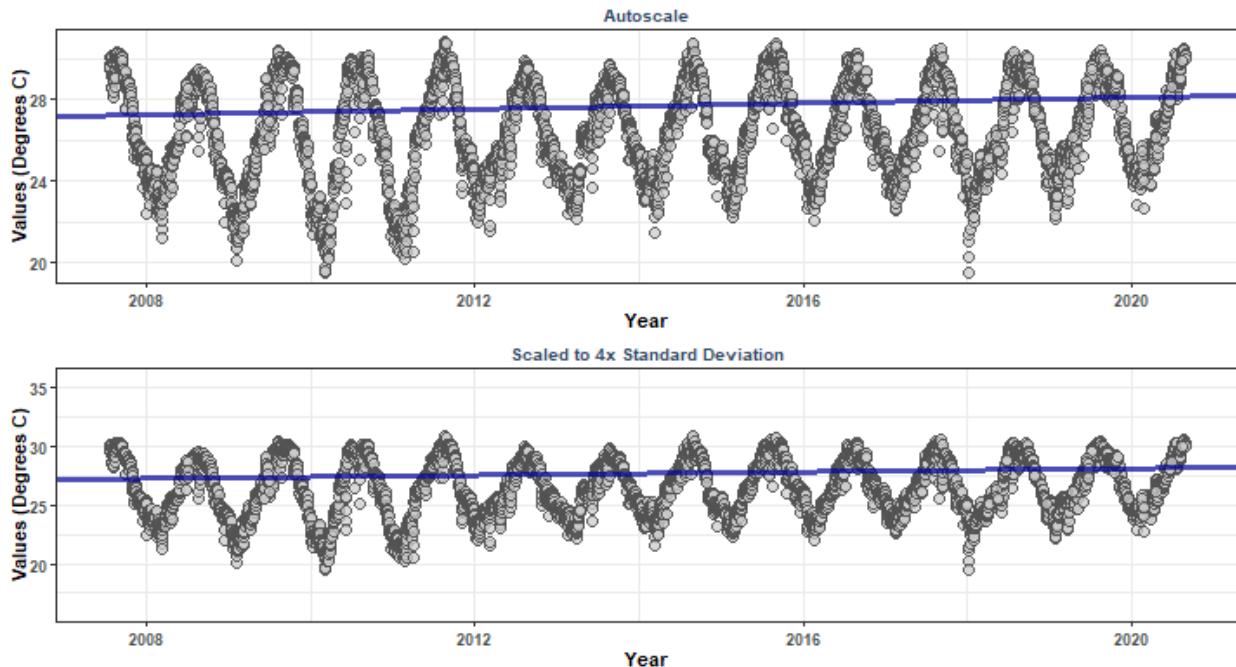
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

986 | Water Temperature on Coral Reefs in the Florida Keys | 84

Senn Slope = 0.069861111111109, Senn Intercept = -113.015892762342

Trend = 1, tau = 0.1995, p = 0

Linear Trendline: $y = 0.0752556268073296x + -125.137569159384$



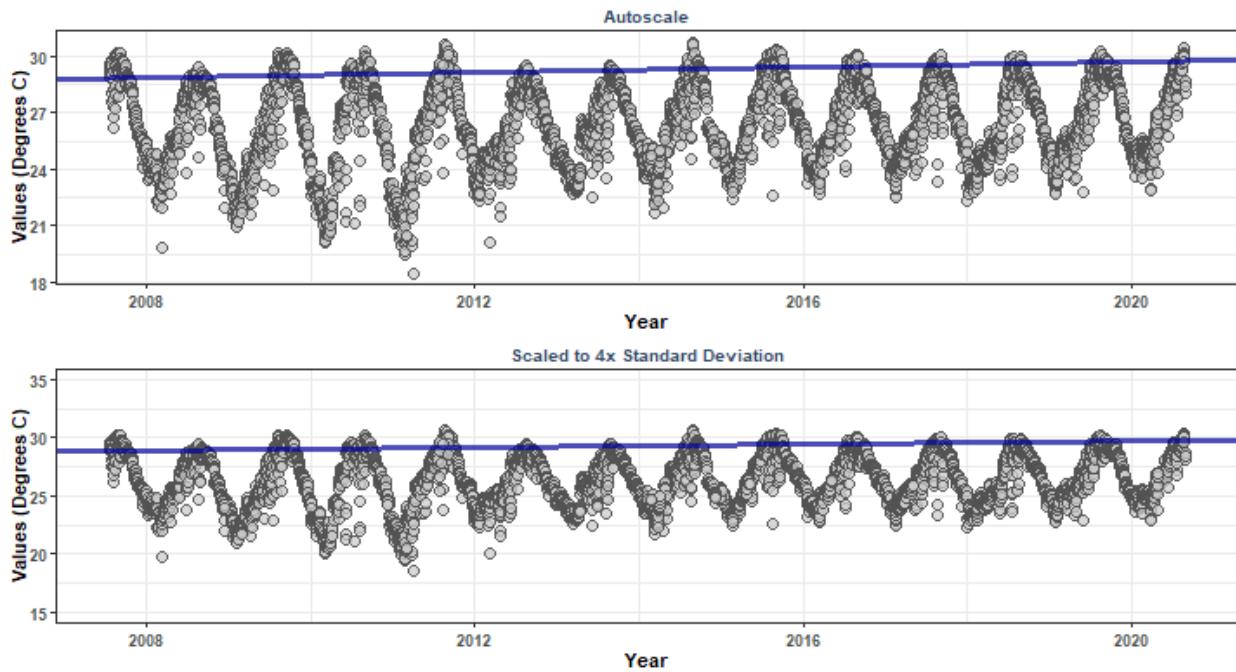
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

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: $y = 0.0738408932760551x + -122.404717163921$



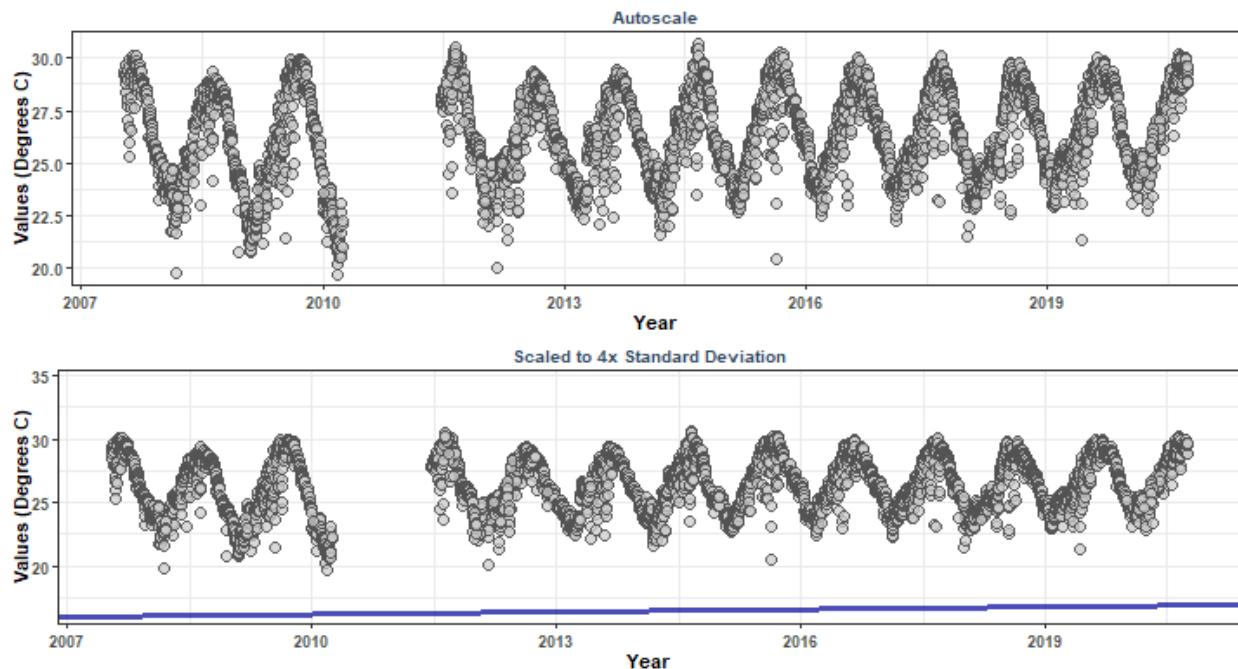
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

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: $y = 0.0701908497848003x + -115.110132887015$



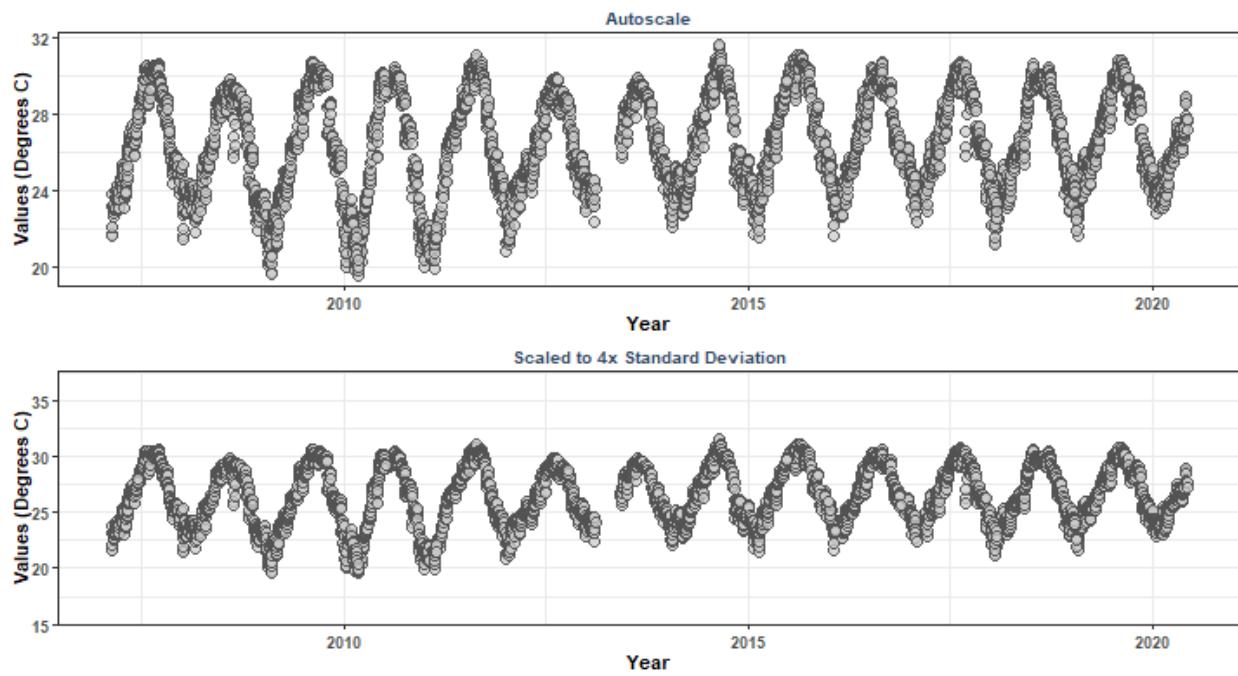
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

986 | Water Temperature on Coral Reefs in the Florida Keys | 87

Senn Slope = 0.0751413043478262, Senn Intercept = -154.05234375

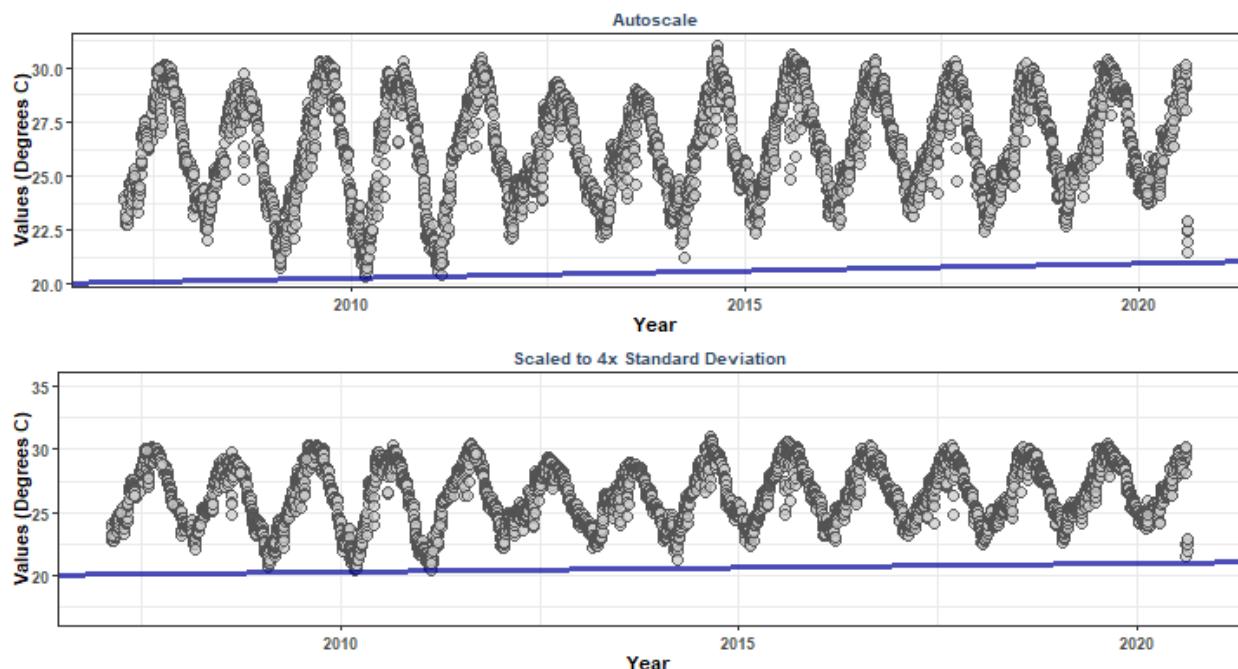
Trend = 1, tau = 0.2106, p = 0

Linear Trendline: $y = 0.0713616123954723x + -117.17982546088$



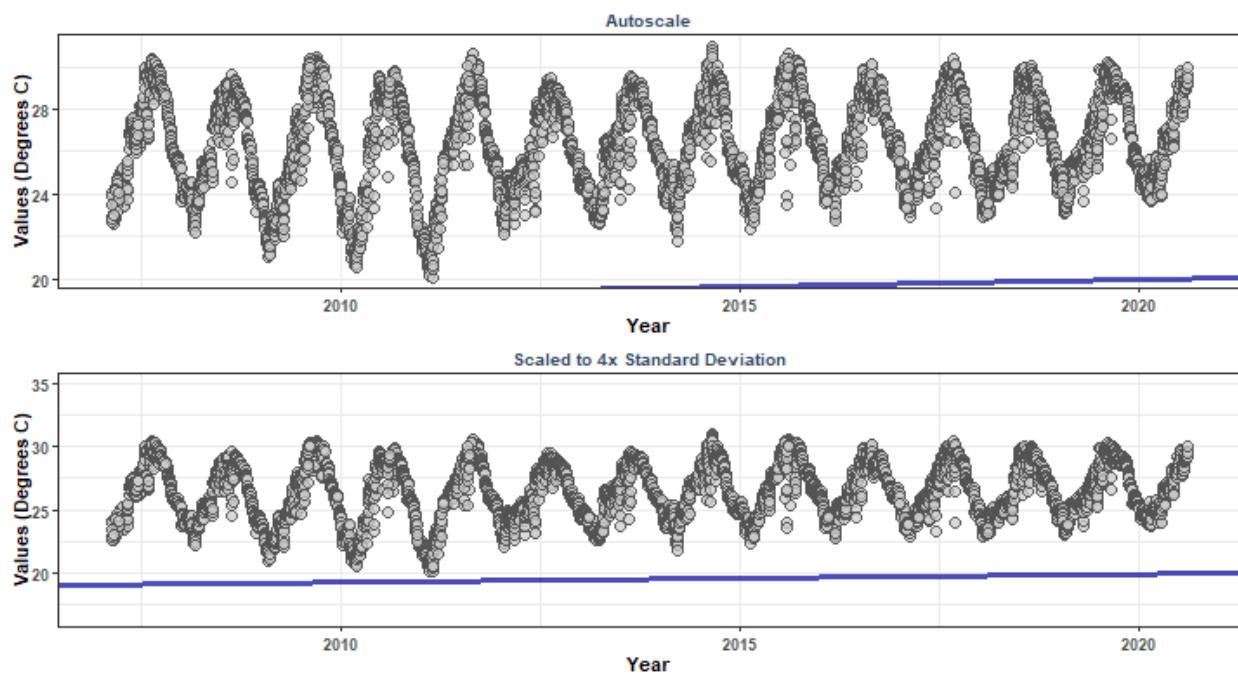
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 88**

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



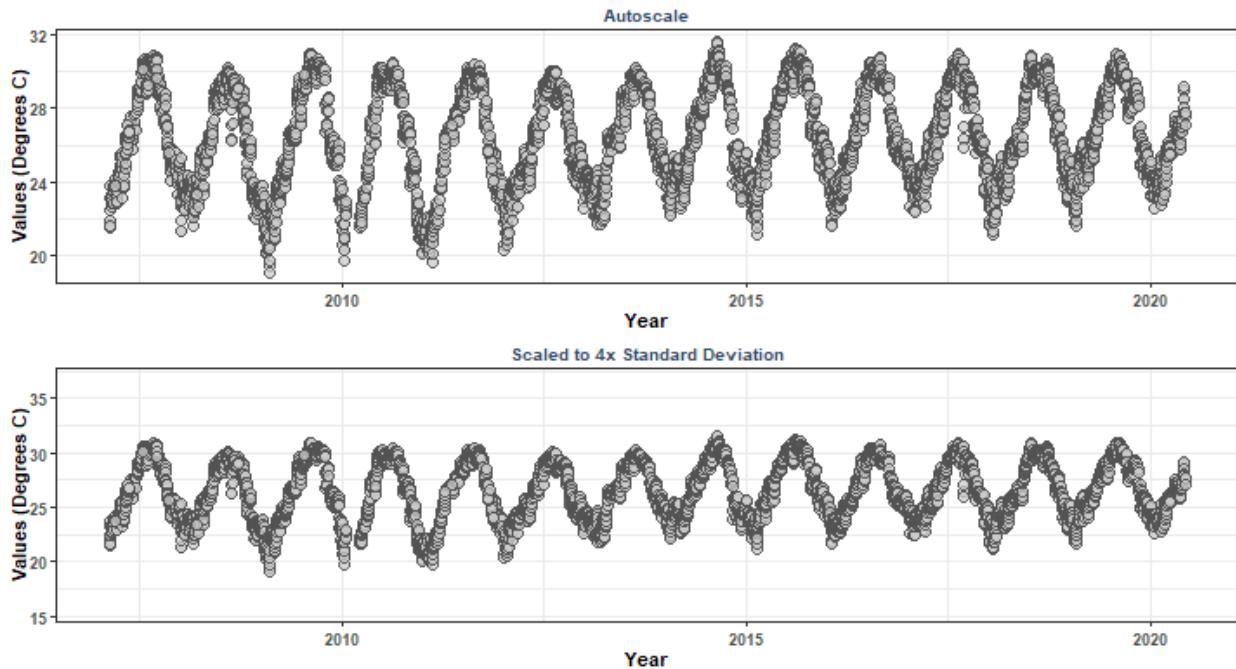
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 89**

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



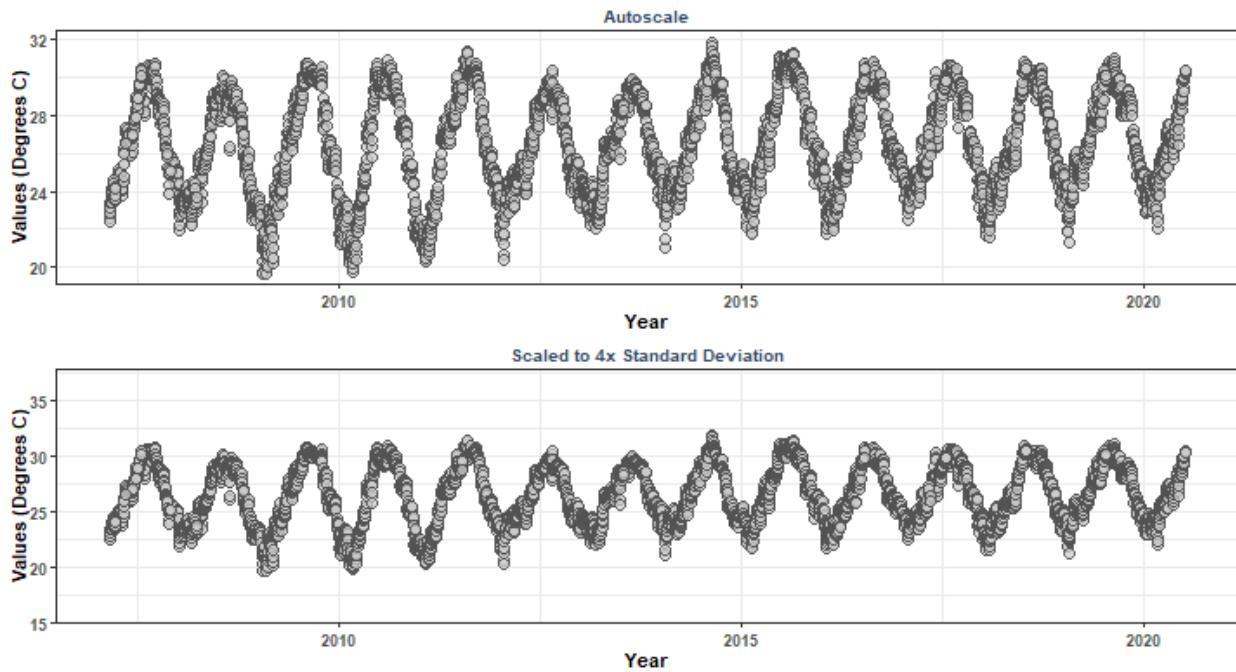
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 90**

Senn Slope = 0.075249999999998, 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: $y = 0.0675511404339929x + -109.483020223426$



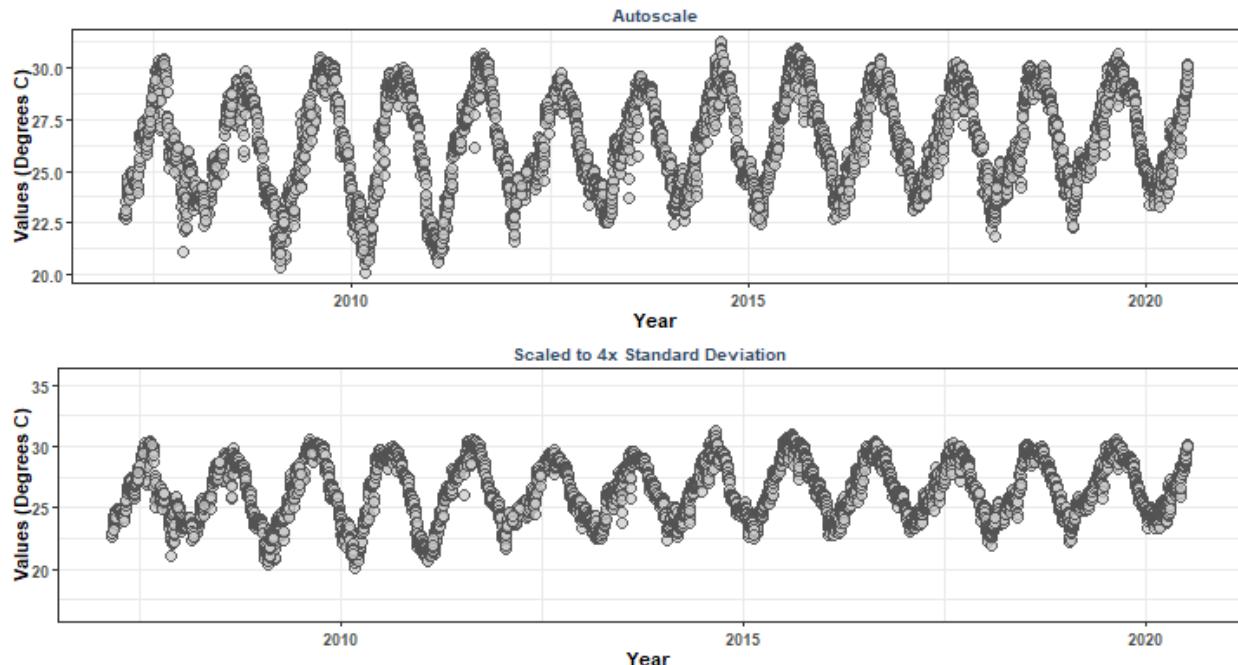
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

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: $y = 0.0817134630326932x + -138.14408842809$



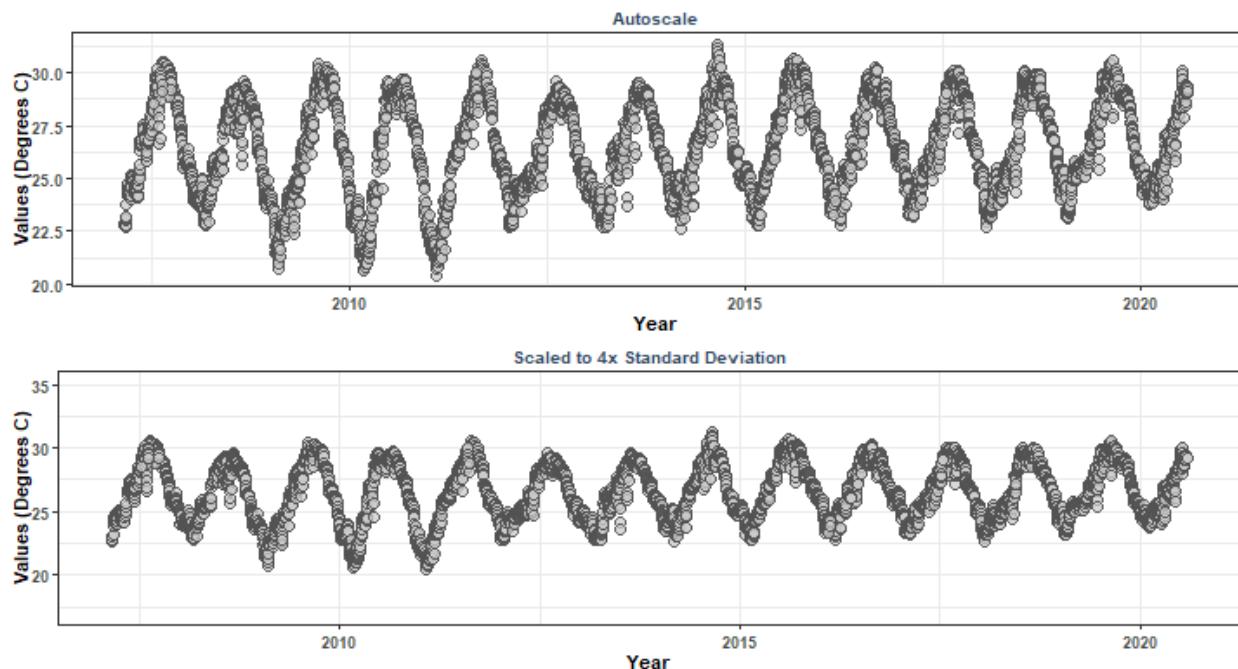
Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area

986 | Water Temperature on Coral Reefs in the Florida Keys | 93

Senn Slope = 0.0584999999999995, Senn Intercept = -108.031704312866

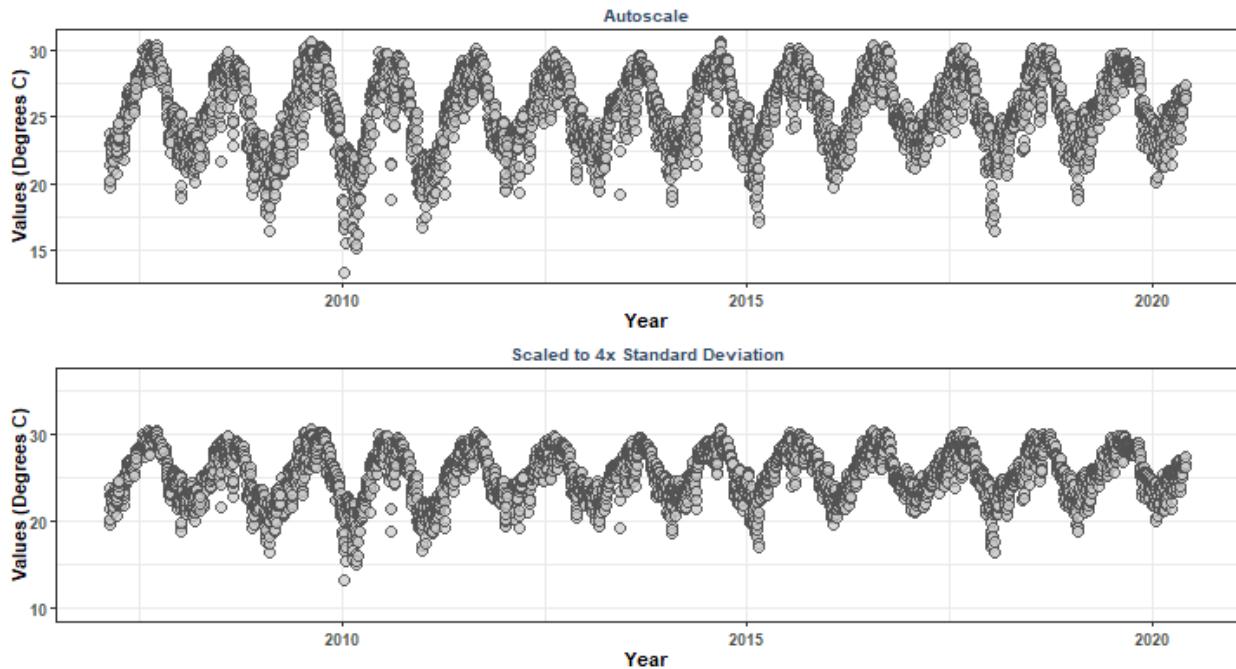
Trend = 1, tau = 0.184, p = 0

Linear Trendline: $y = 0.0633856800046505x + -101.148325427102$



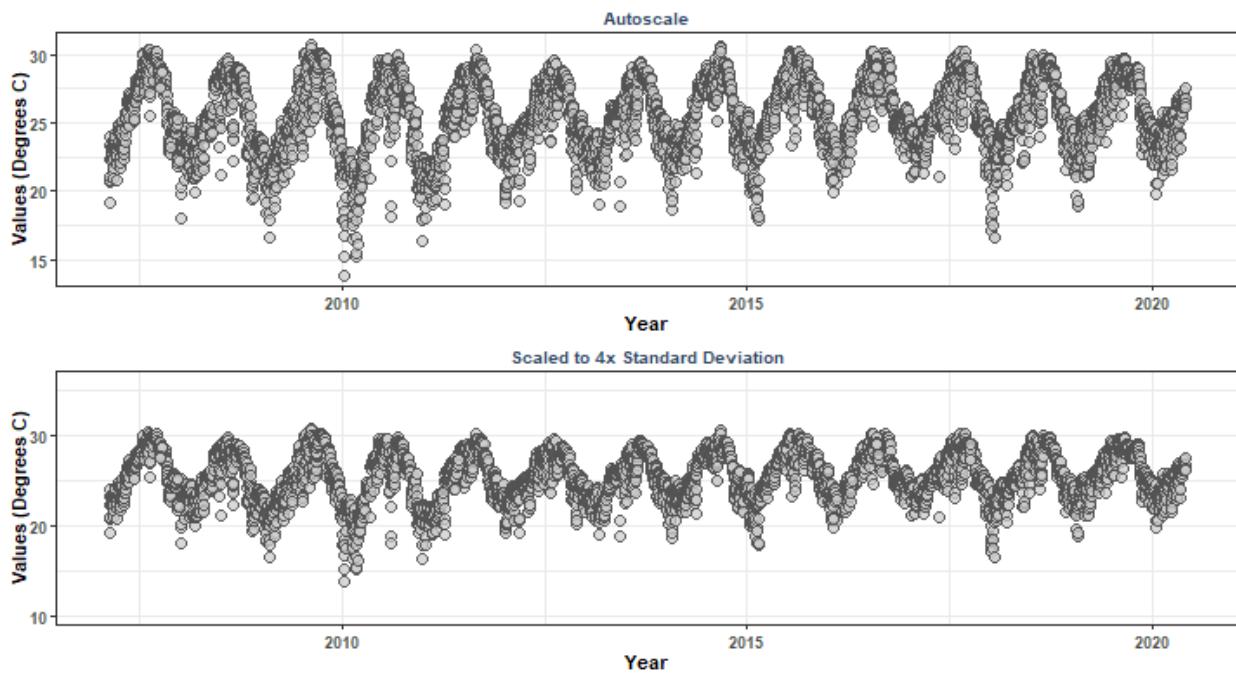
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 94**

Senn Slope = 0.06878787878789, Senn Intercept = -136.398074426329
 Trend = 1, tau = 0.133, p = 0
 Linear Trendline: $y = 0.0629320879243104x + -101.280803397563$



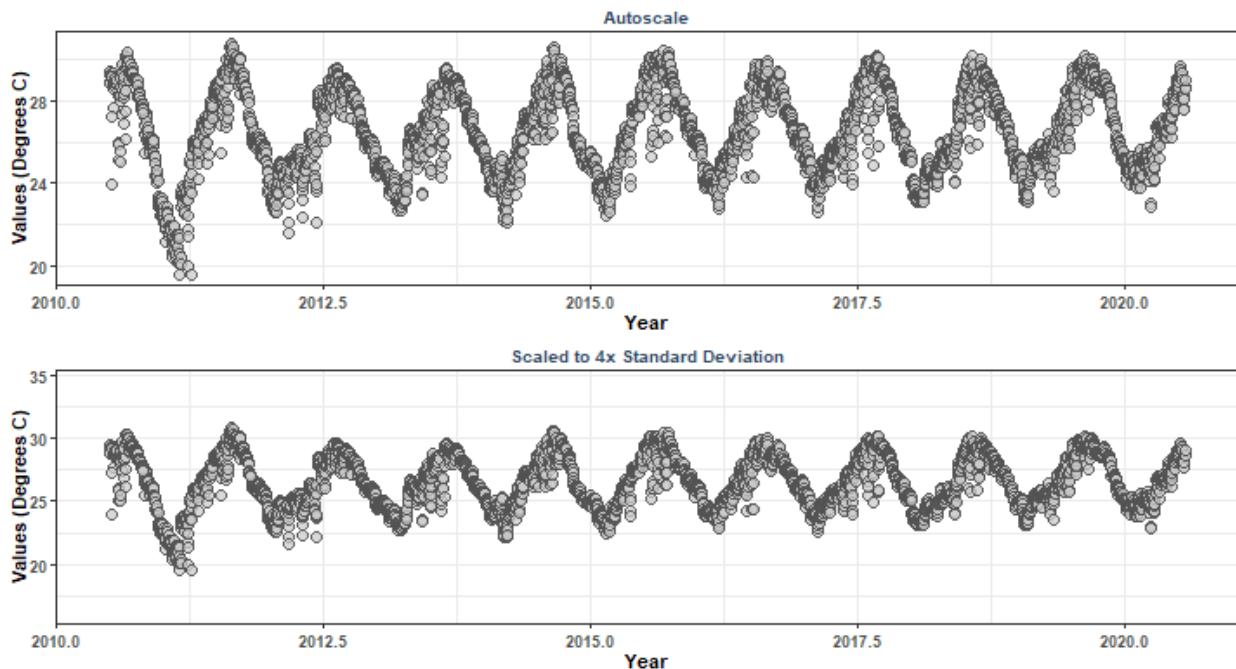
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 95**

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



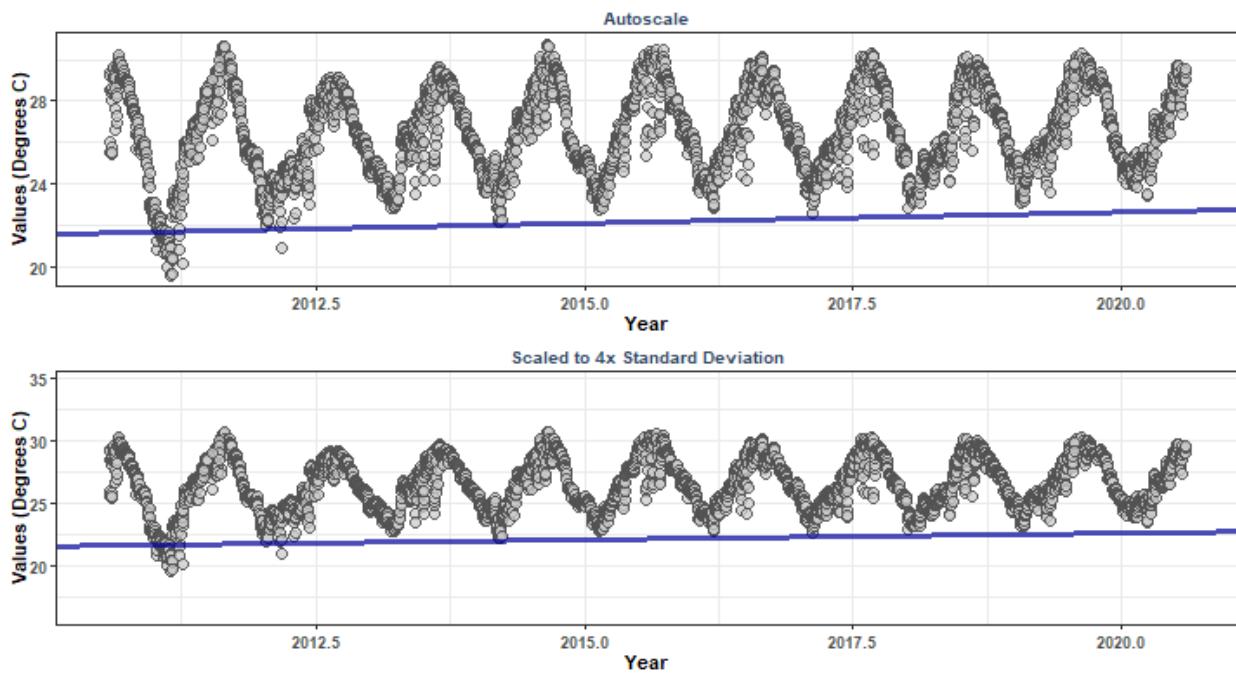
**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 97**

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



**Data Points with Trendlines for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 98**

Senn Slope = 0.1072916666666667, Senn Intercept = -194.115825892857
 Trend = 1, tau = 0.2318, p = 0
 Linear Trendline: $y = 0.105544453985412x + -186.243121128126$



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$MonitoringID == Mon_IDs[i]]  
    Mon_name <- paste(KT.Stats$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(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("Summary Box Plots for ",
                                       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("Summary Box Plots for ",
                                         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("Summary Box Plots for ",
                                         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)))

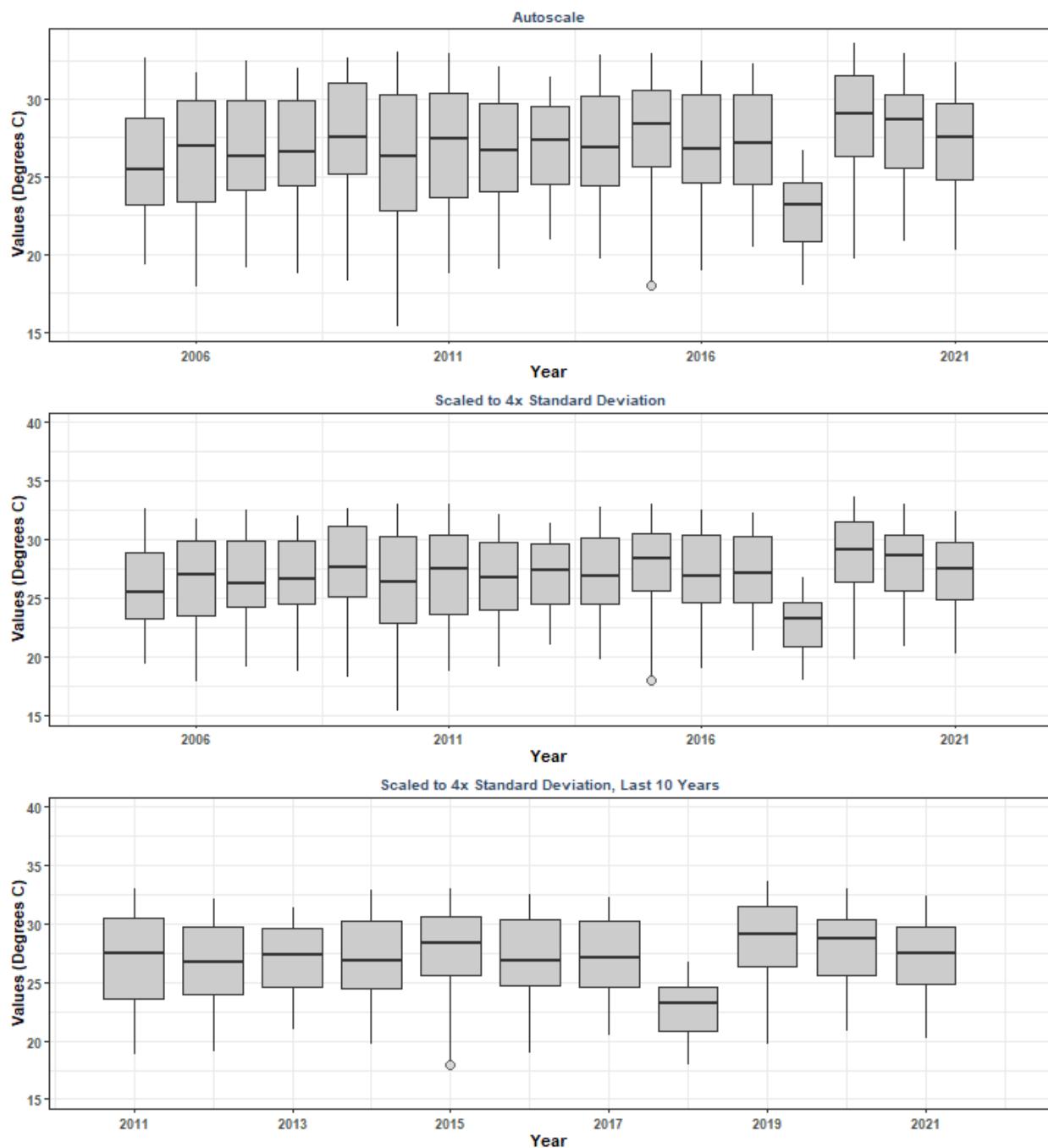
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```

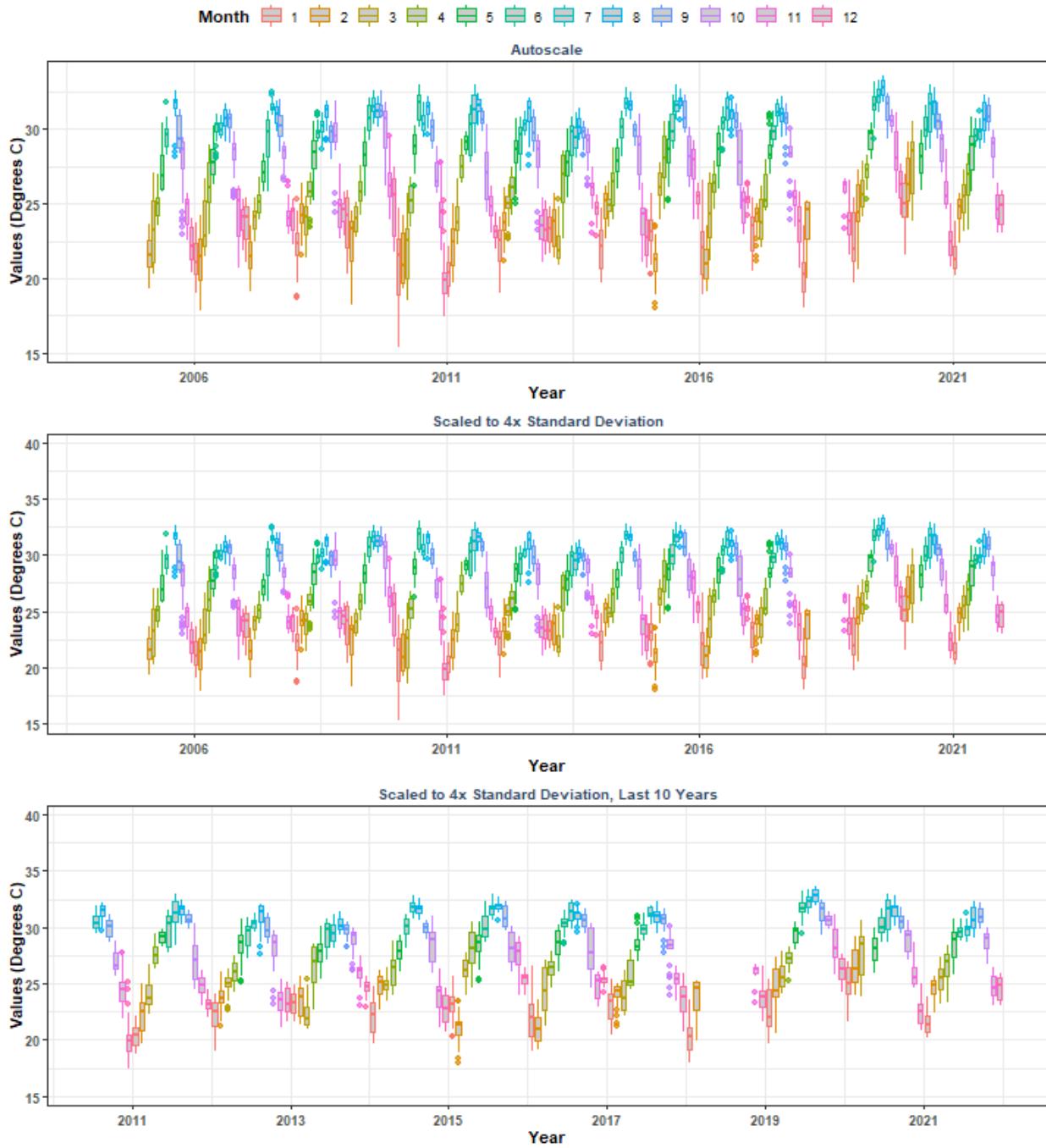
rm(plot_data)
rm(p1, p2, p3, p4, p5, p6, p7, p8, p9, p0, p00, p000, leg1, leg2,
  Yset, YMset, Mset)
}
}

```

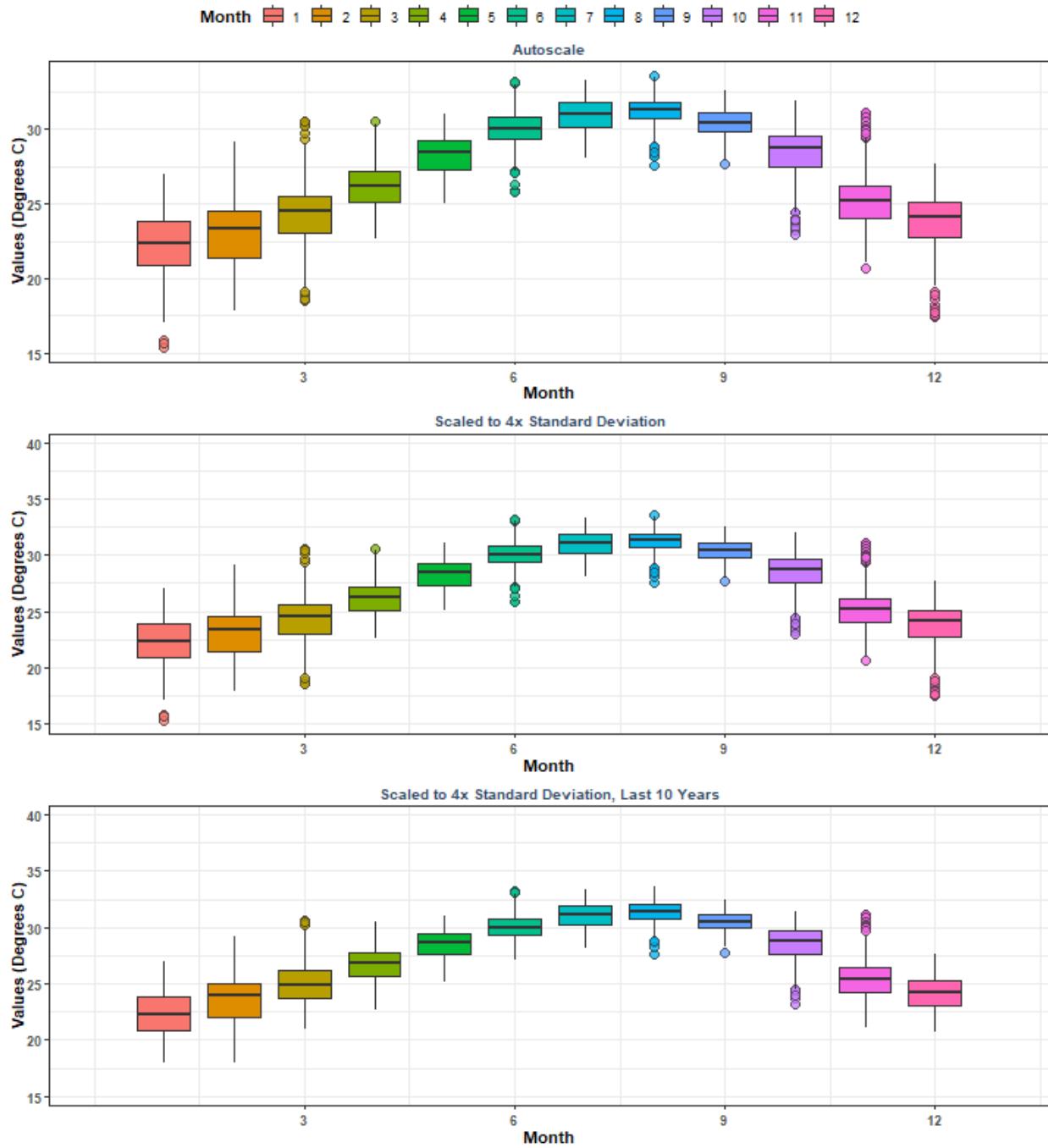
**Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1**
By Year



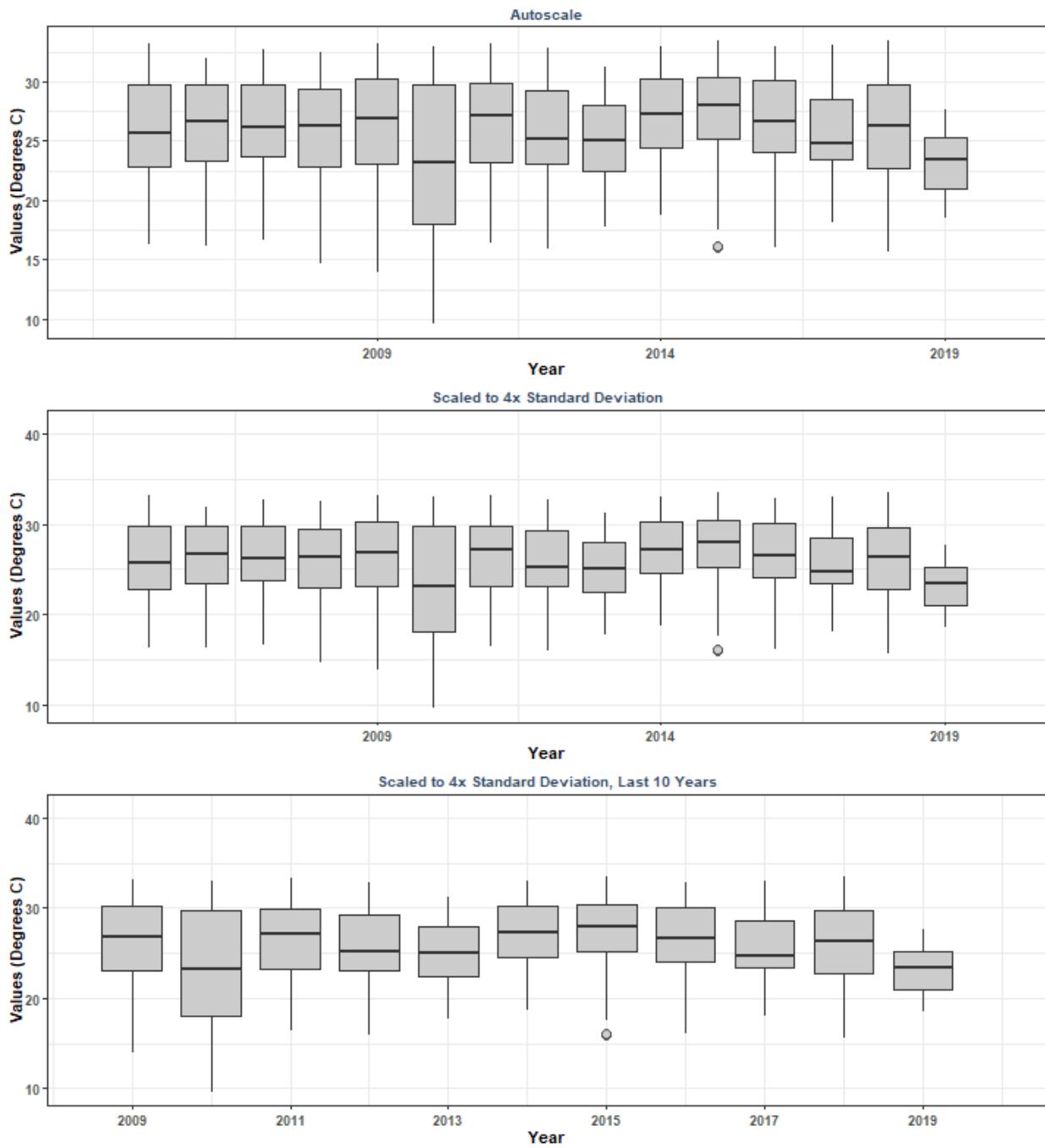
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1
 By Year & Month



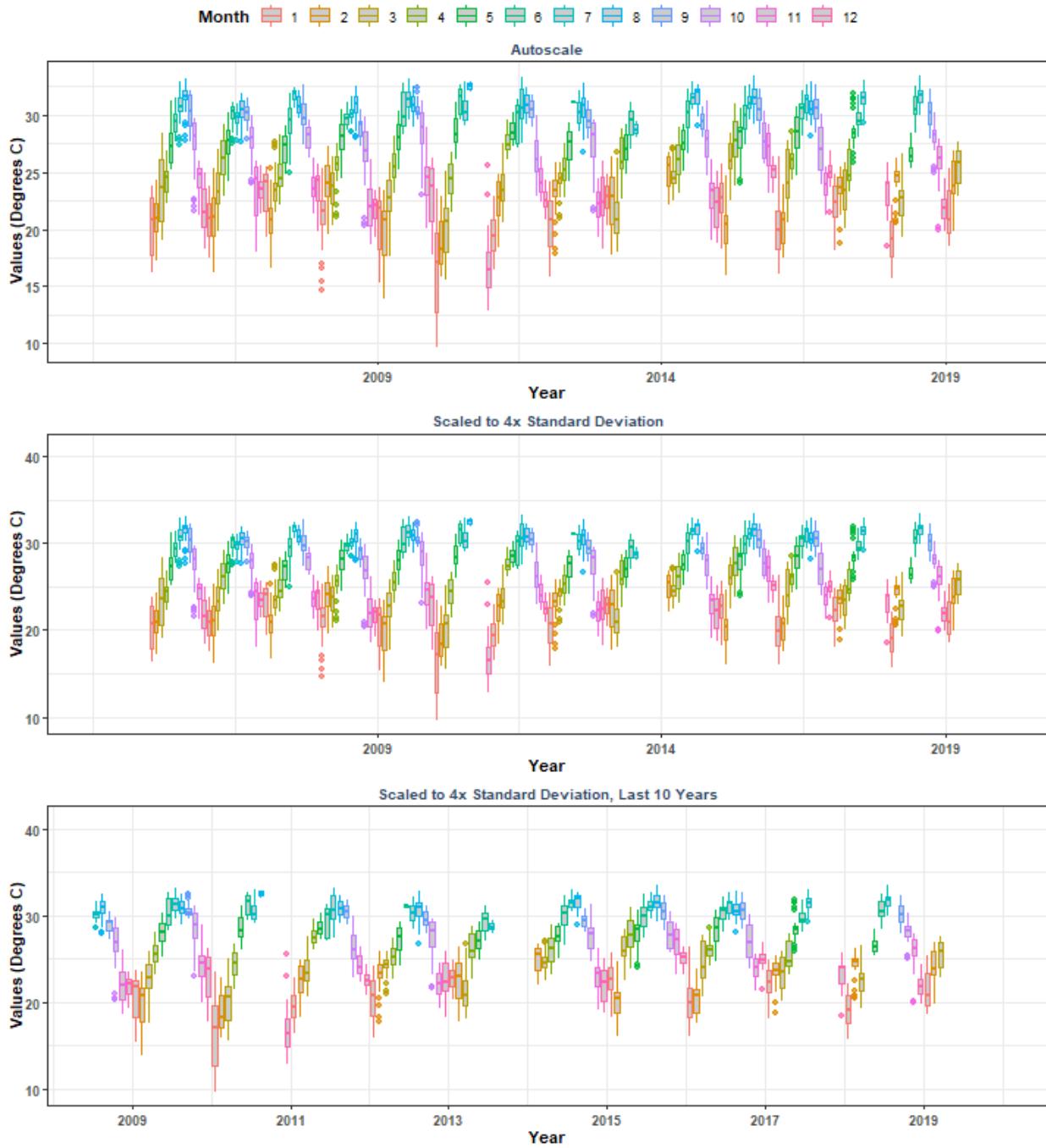
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | KYWF1
 By Month



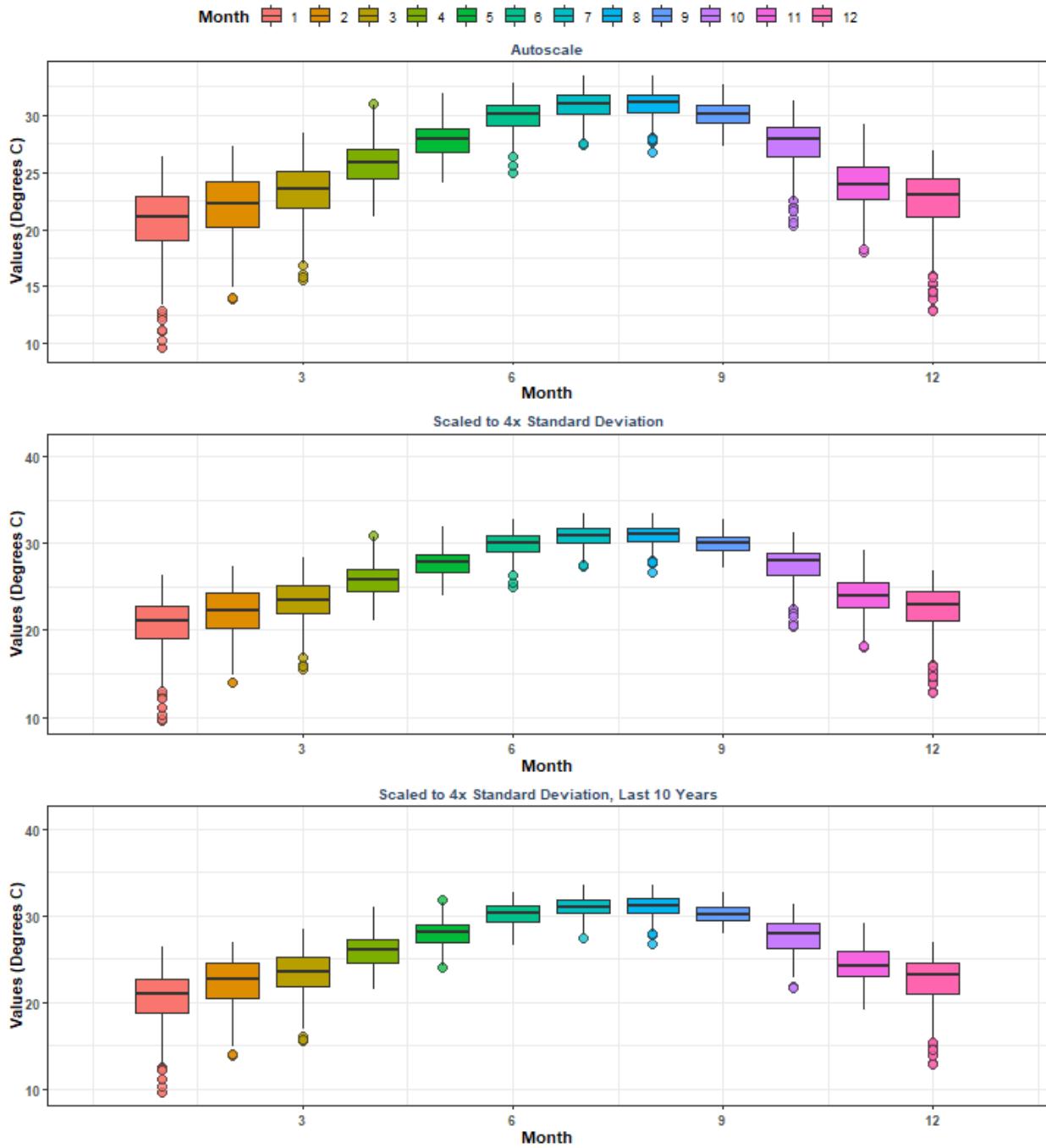
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1
By Year



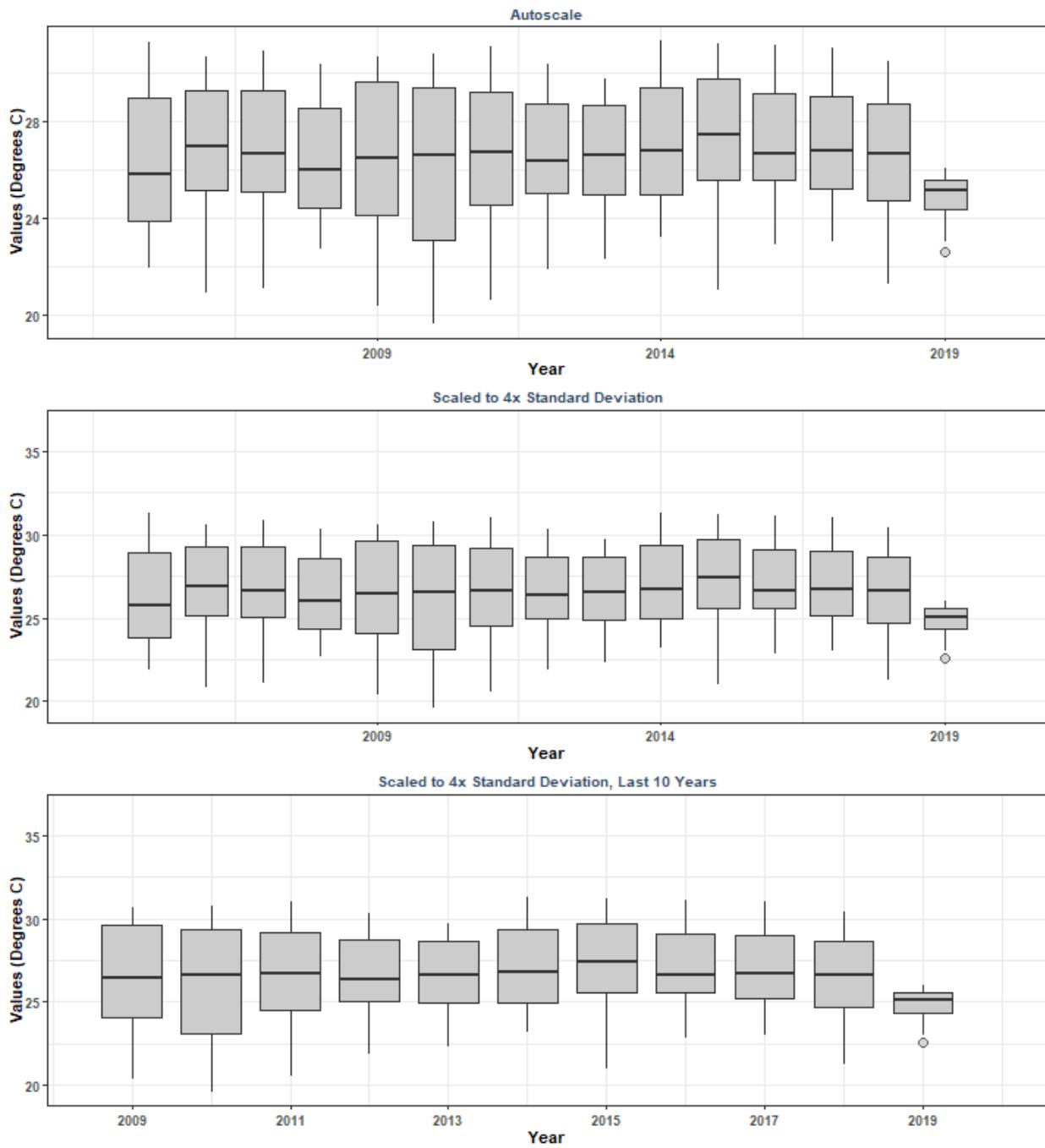
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1
 By Year & Month



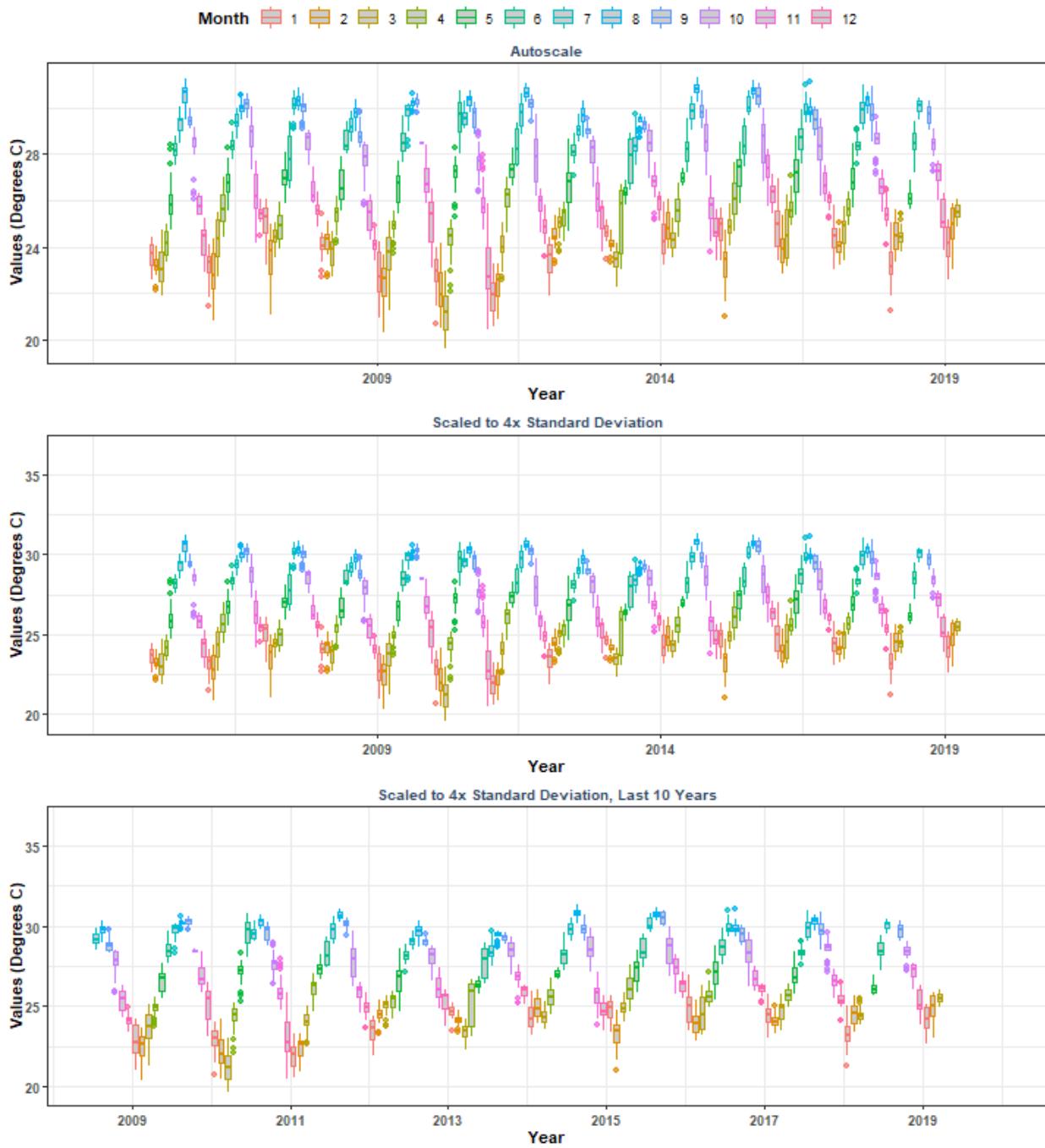
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | LONF1
 By Month



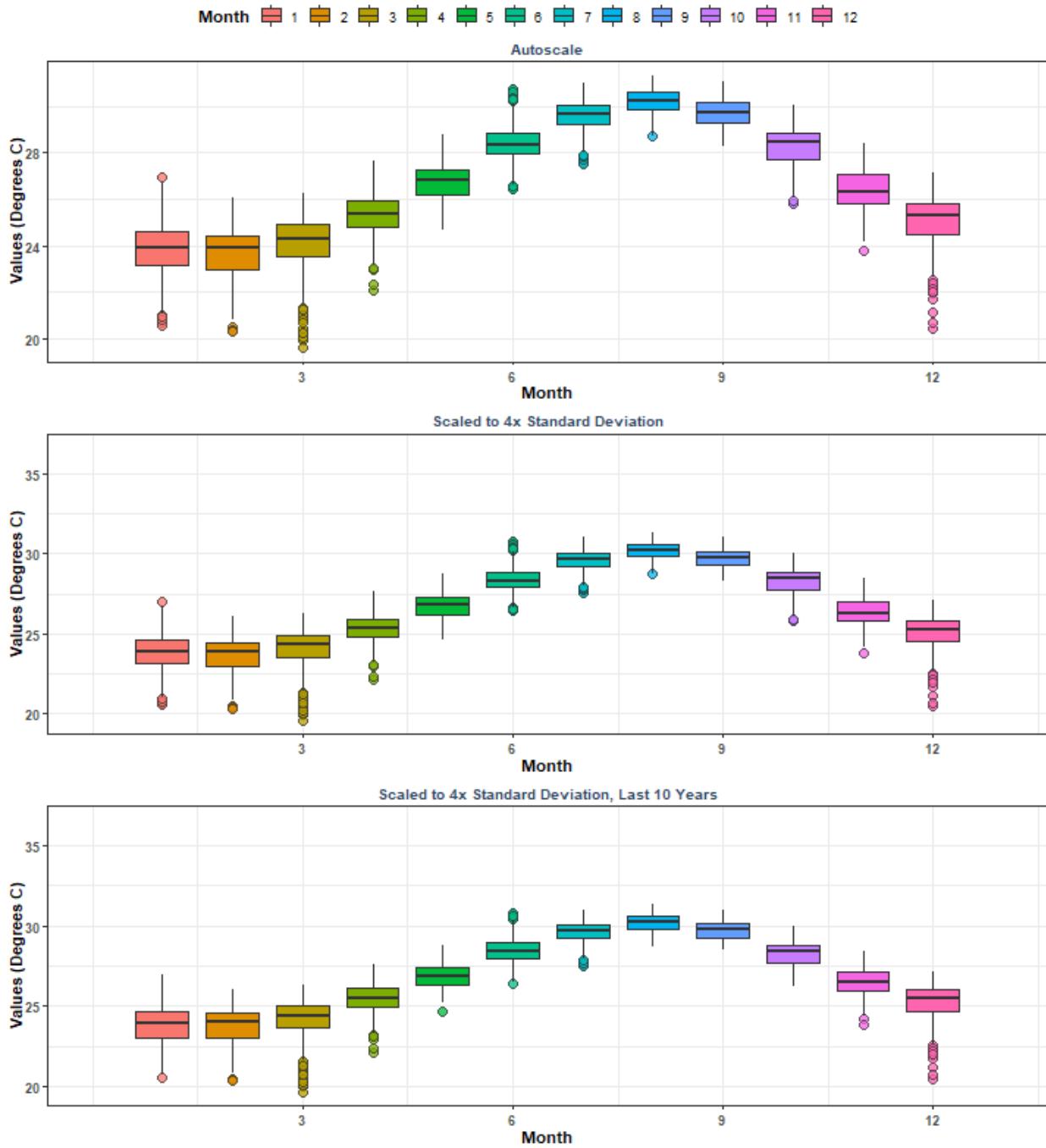
Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1
 By Year & Month

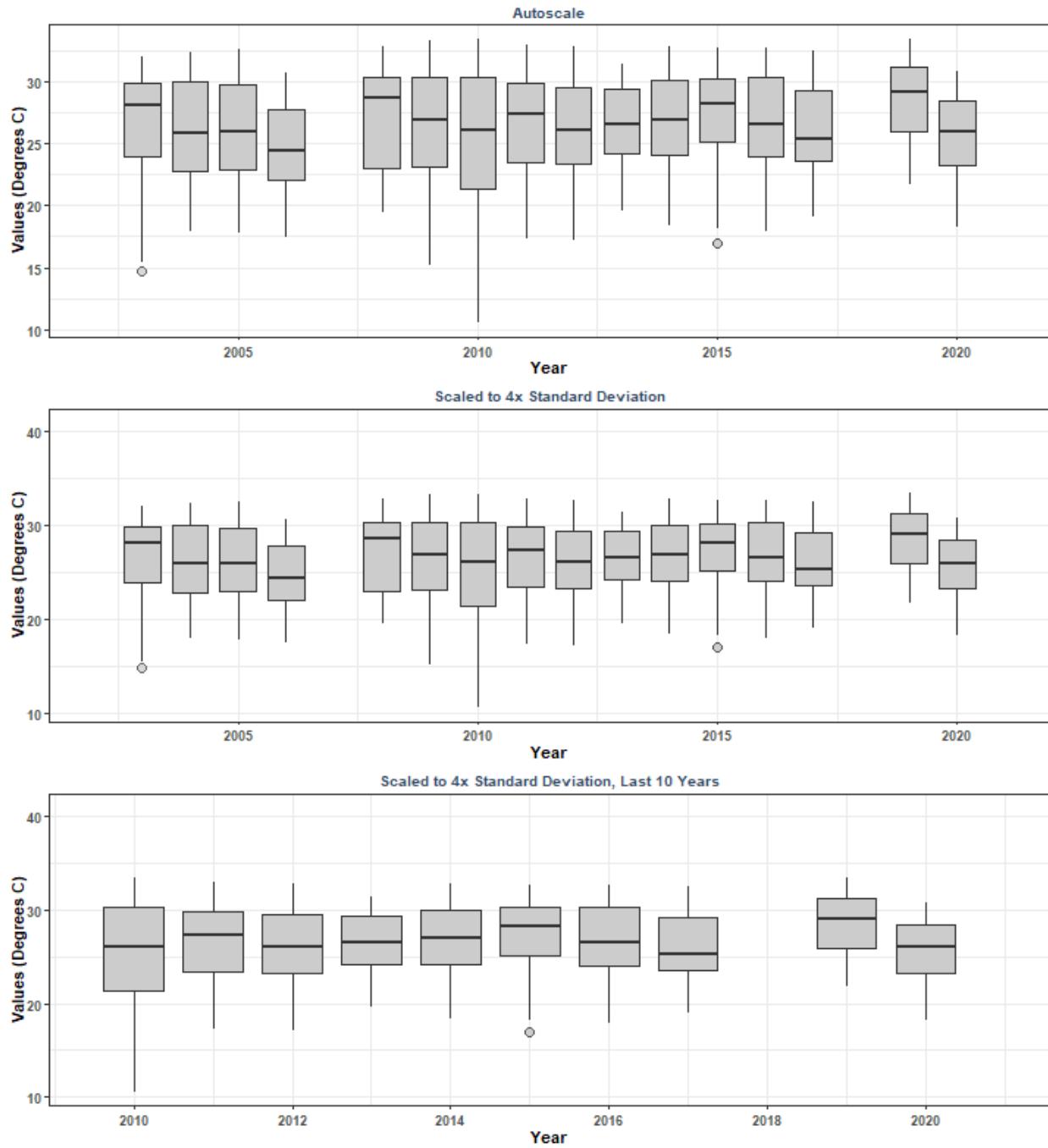


Summary Box Plots for Florida Keys National Marine Sanctuary
5 | National Data Buoy Center | MLRF1
 By Month

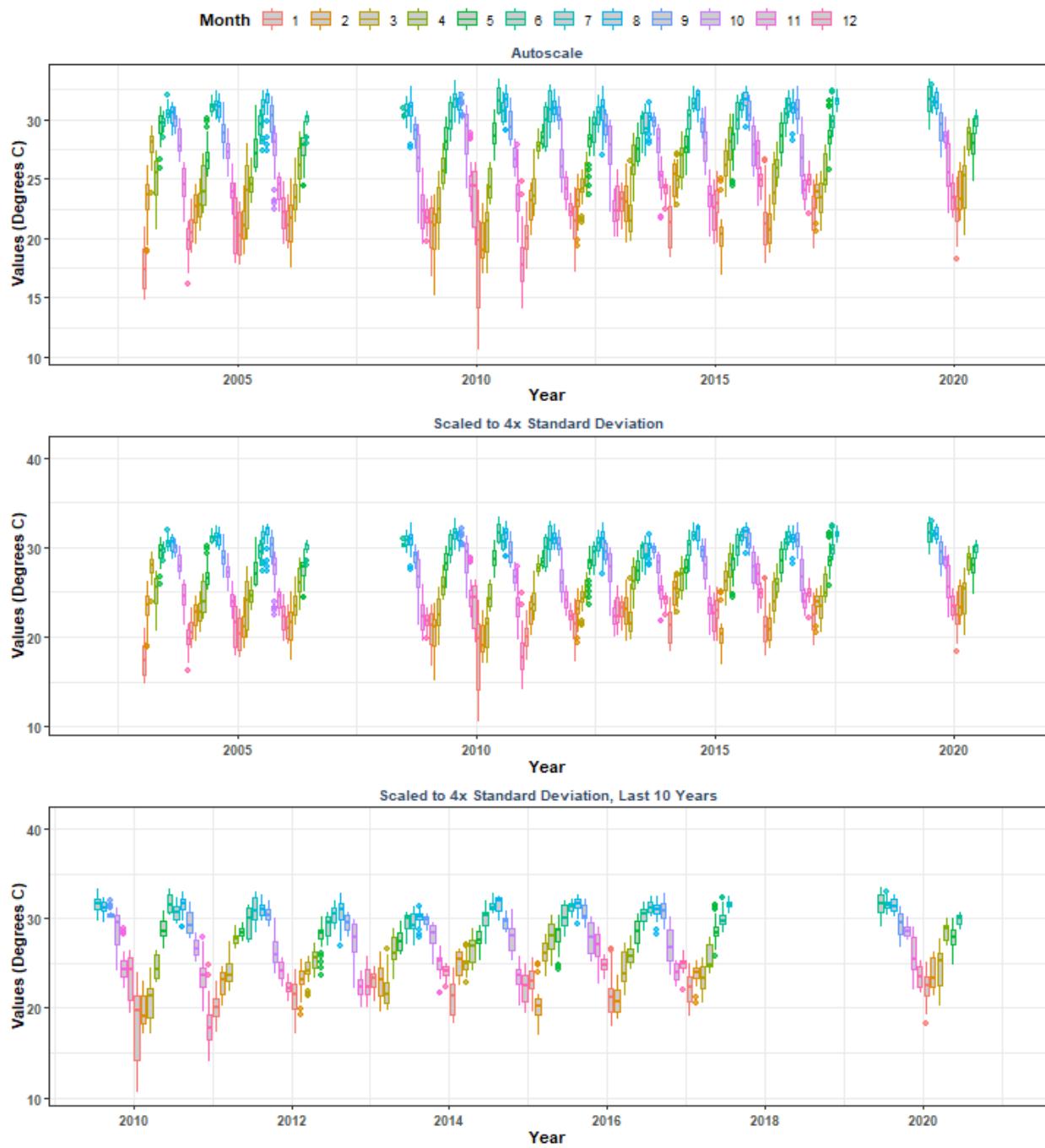


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11**

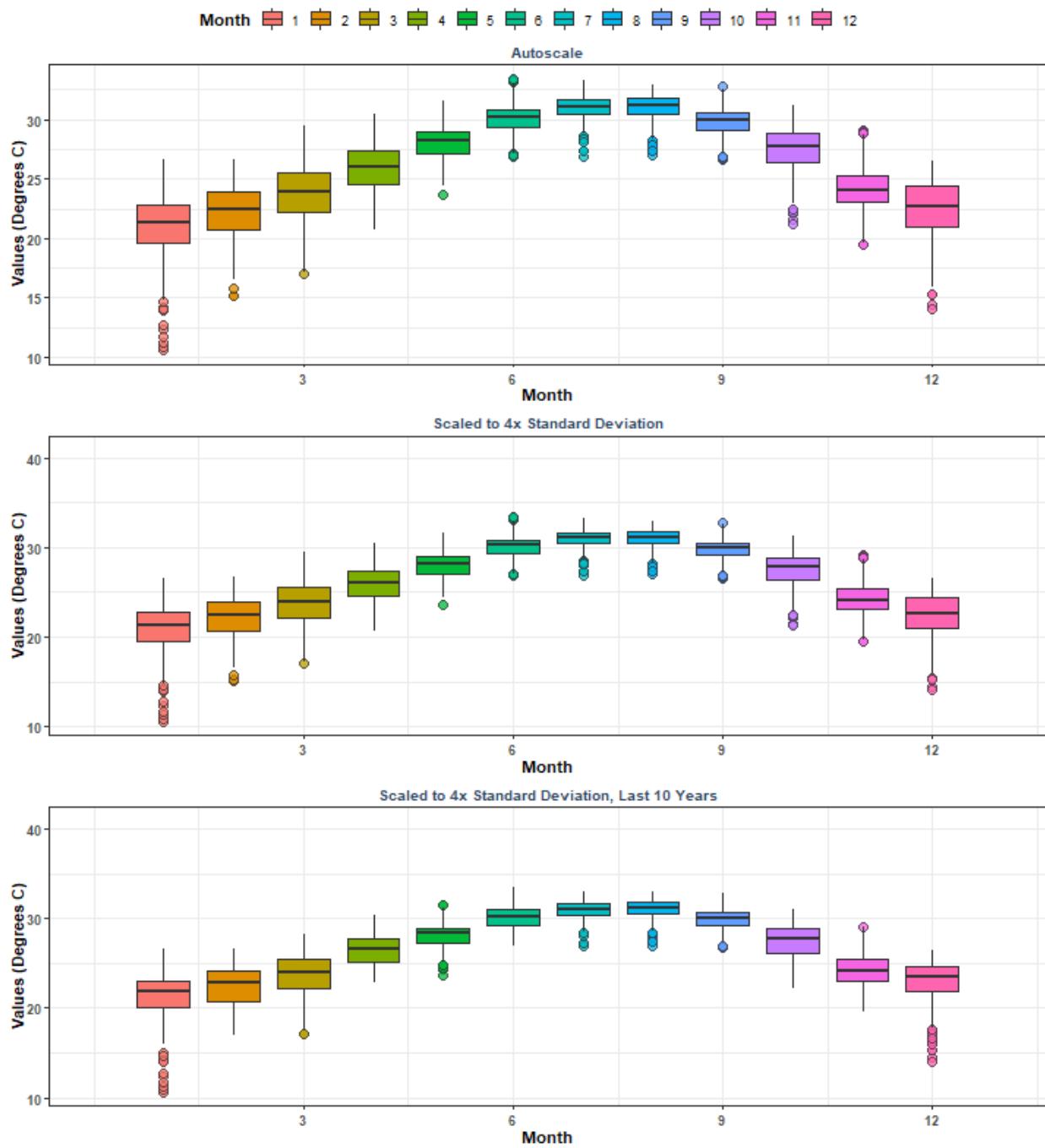
By Year



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

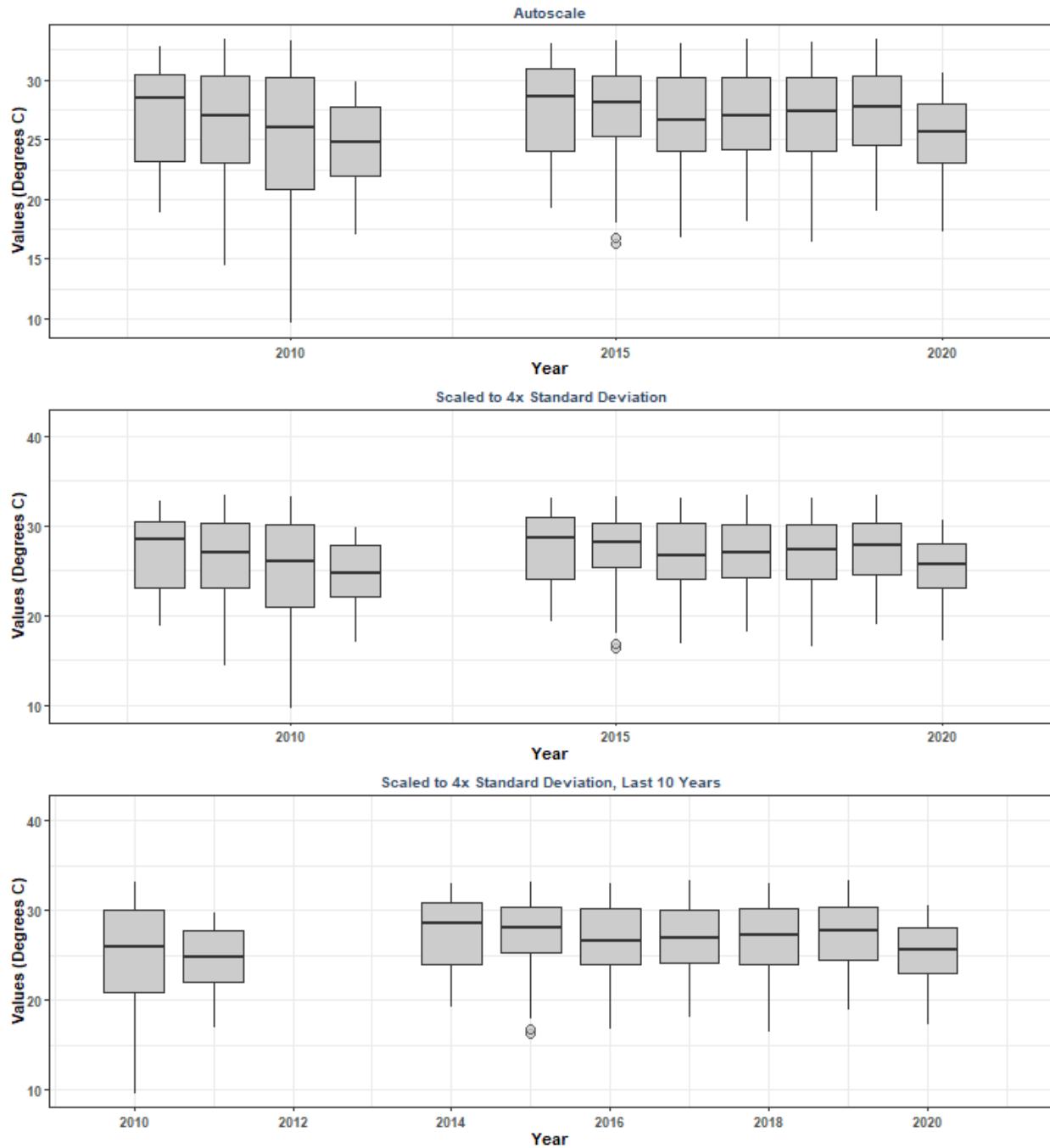


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 11
 By Month

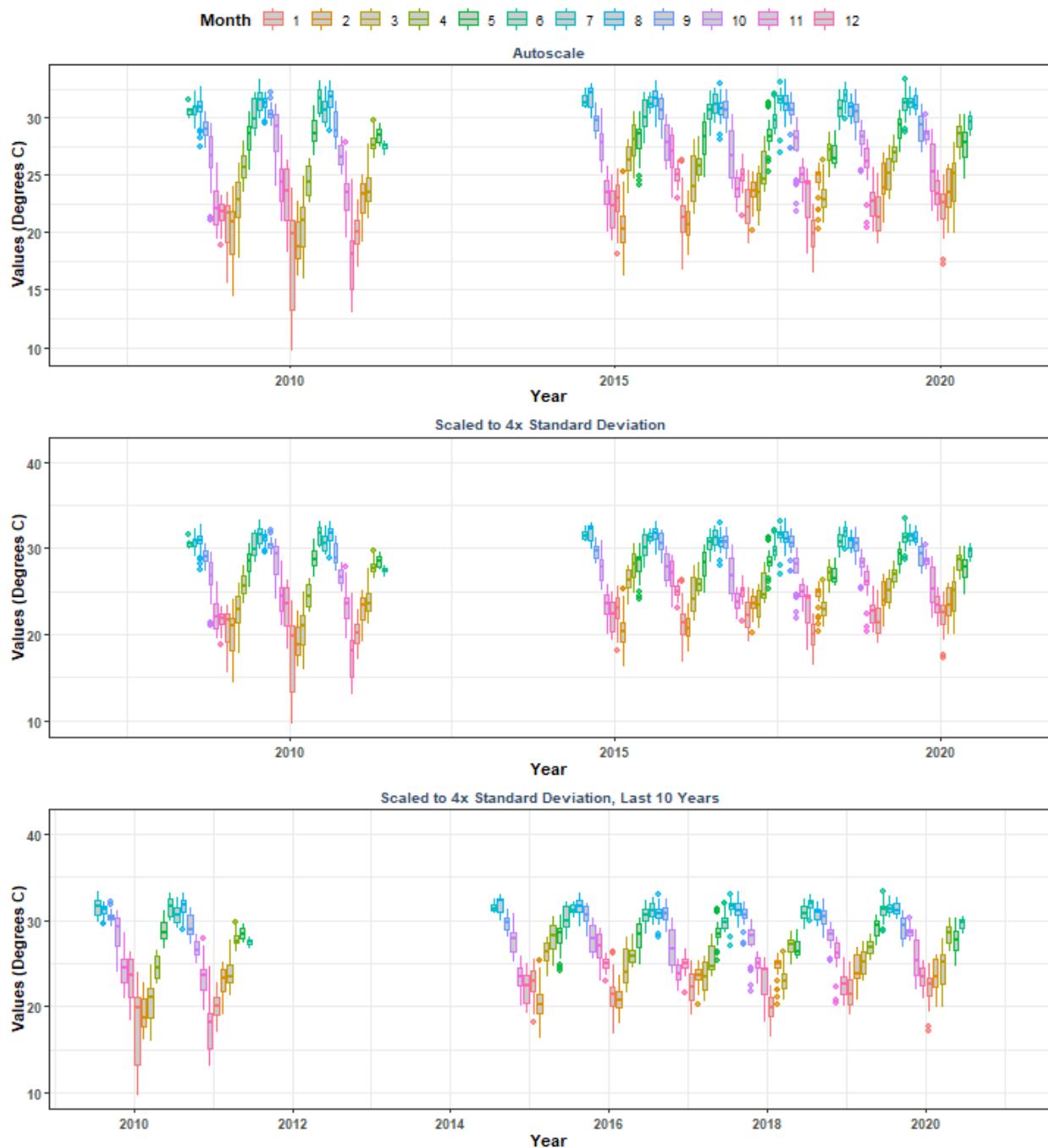


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12**

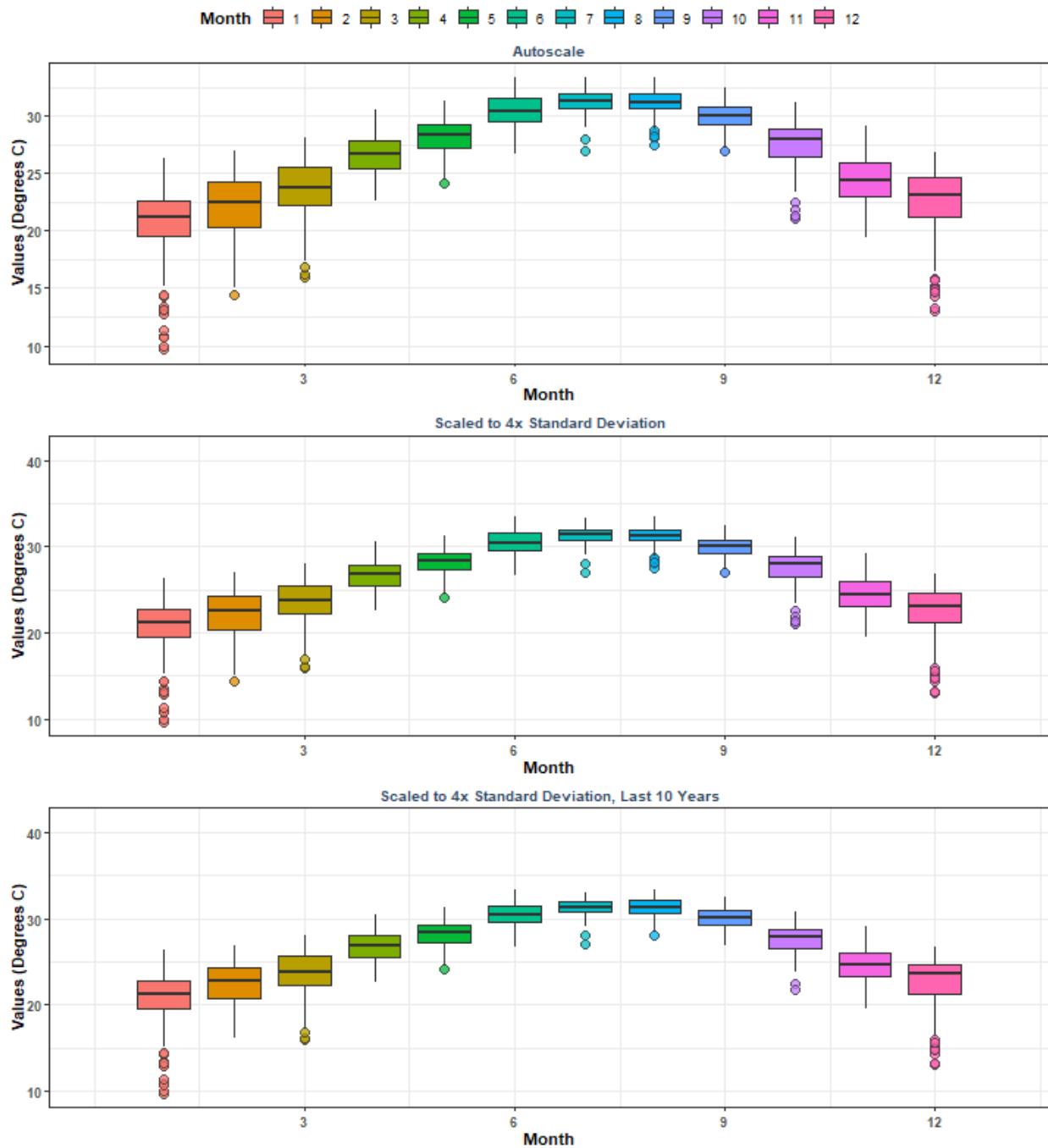
By Year



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

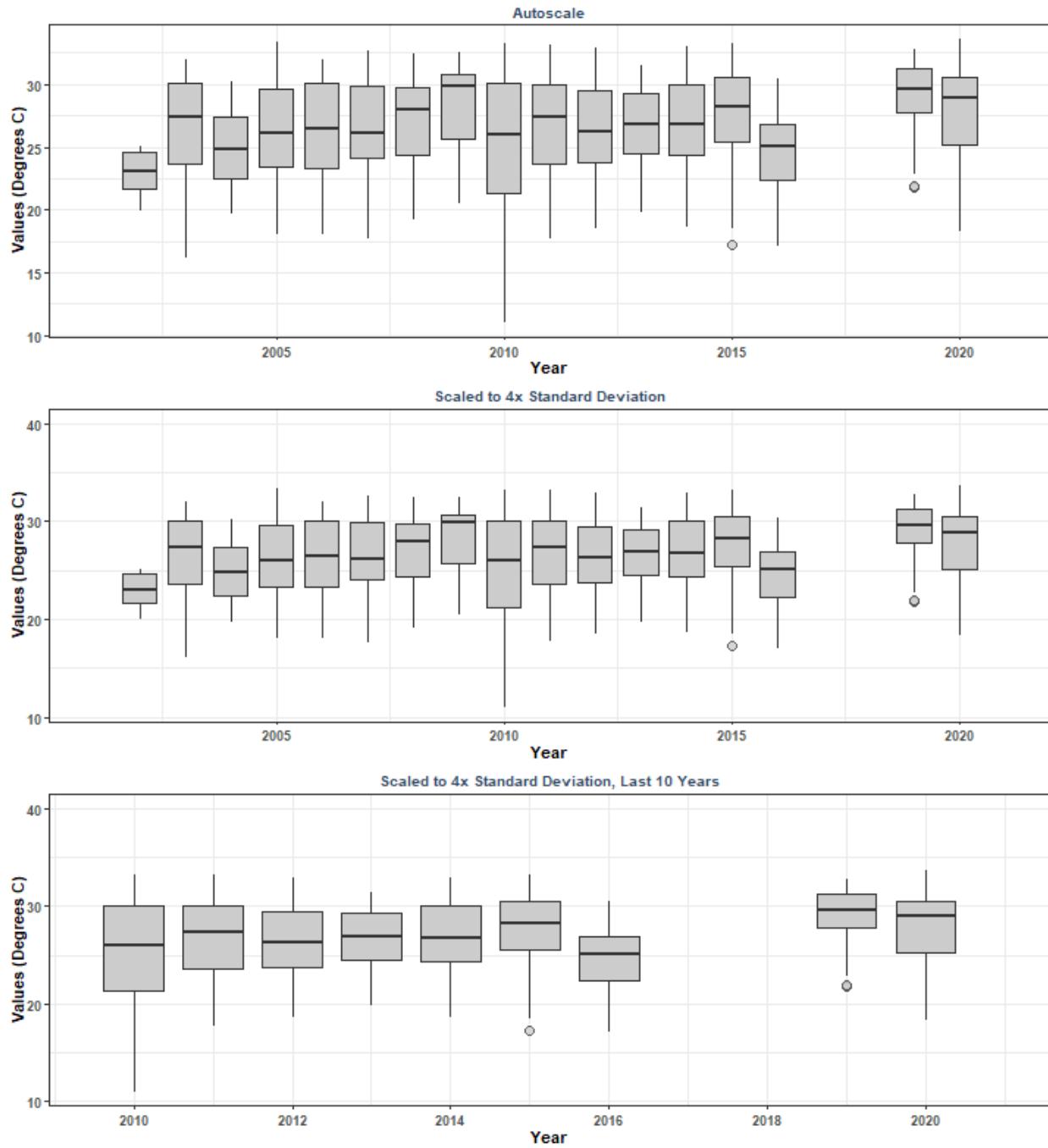


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 12**
By Month

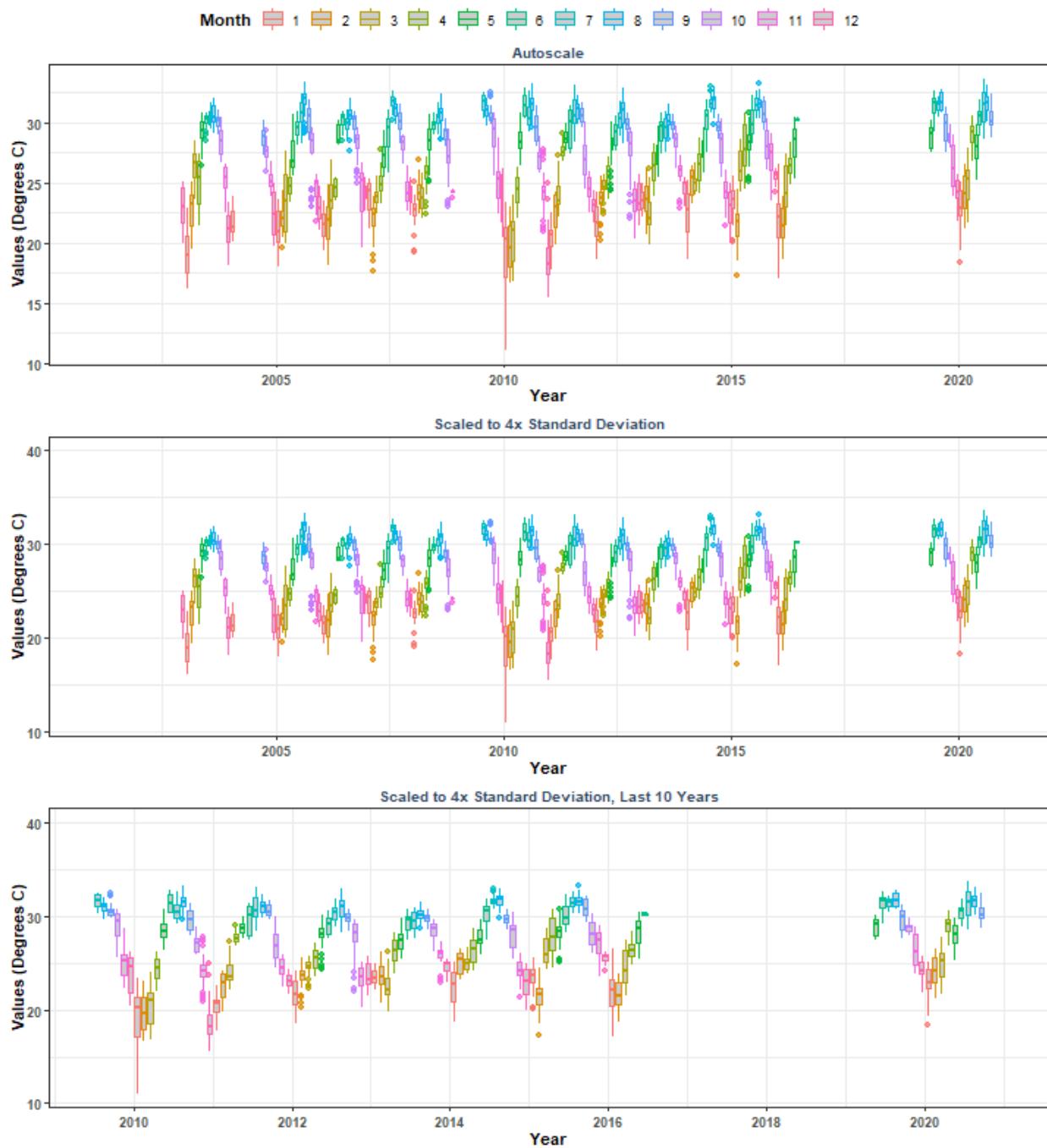


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14**

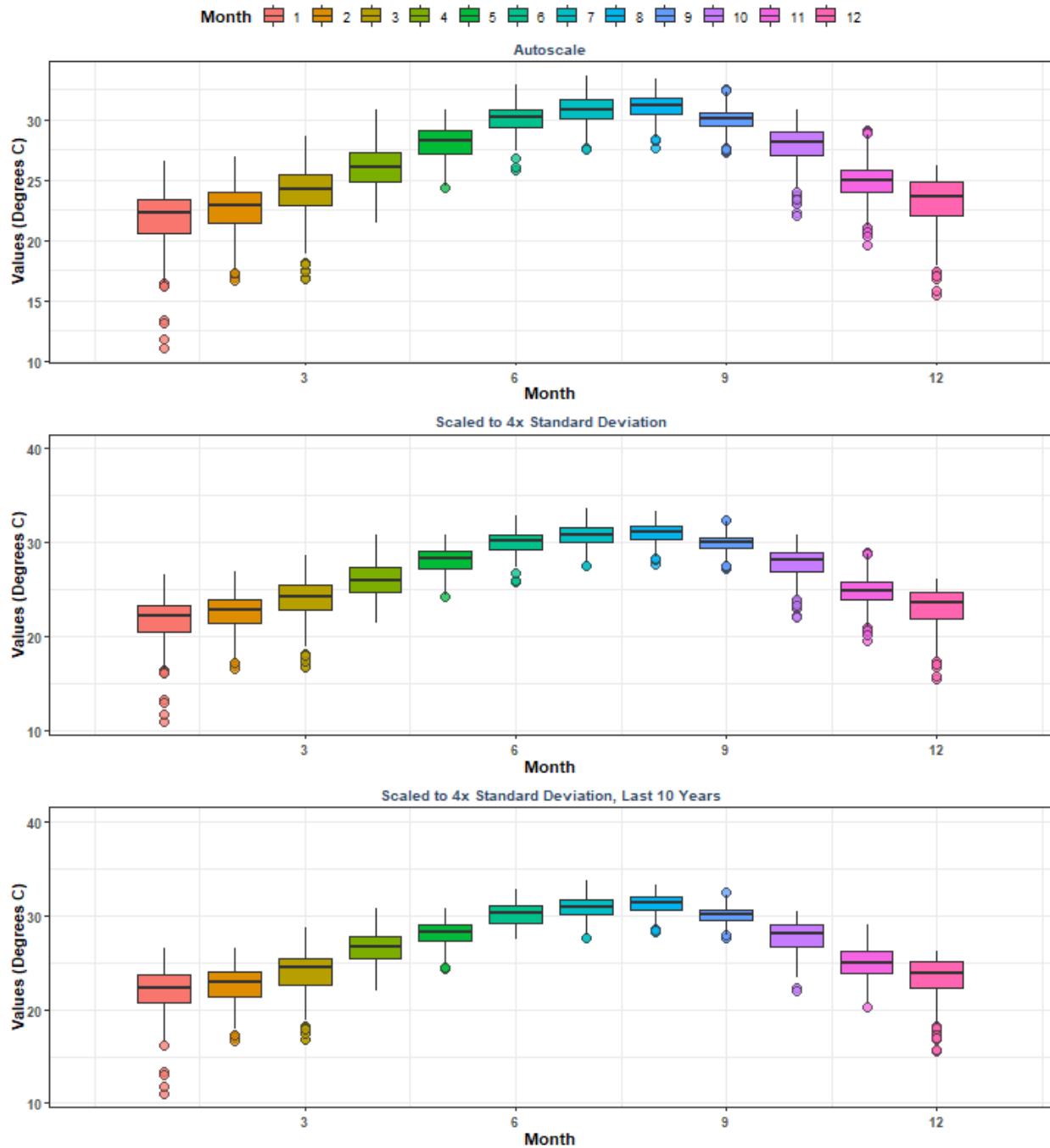
By Year



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

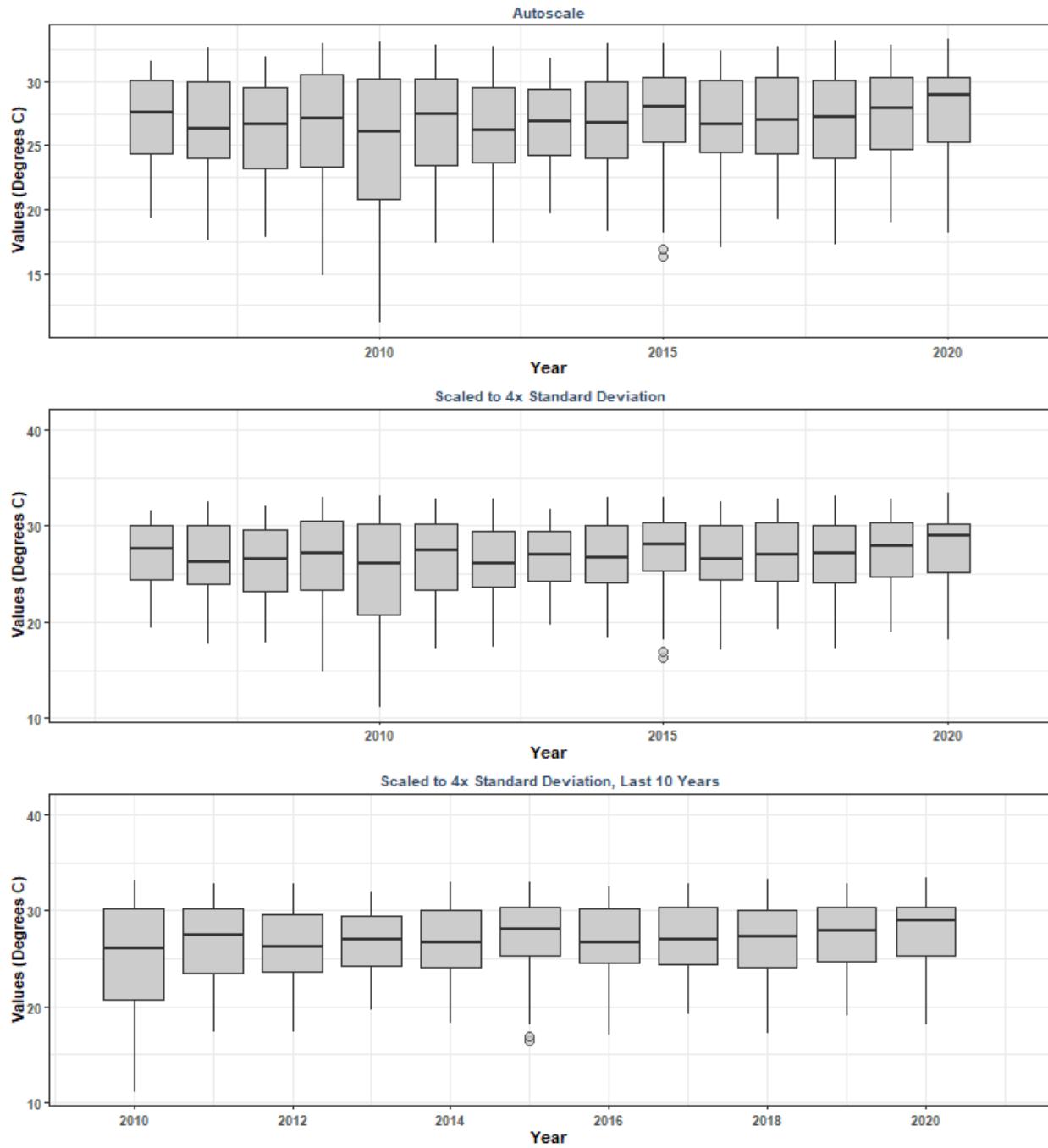


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 14
 By Month

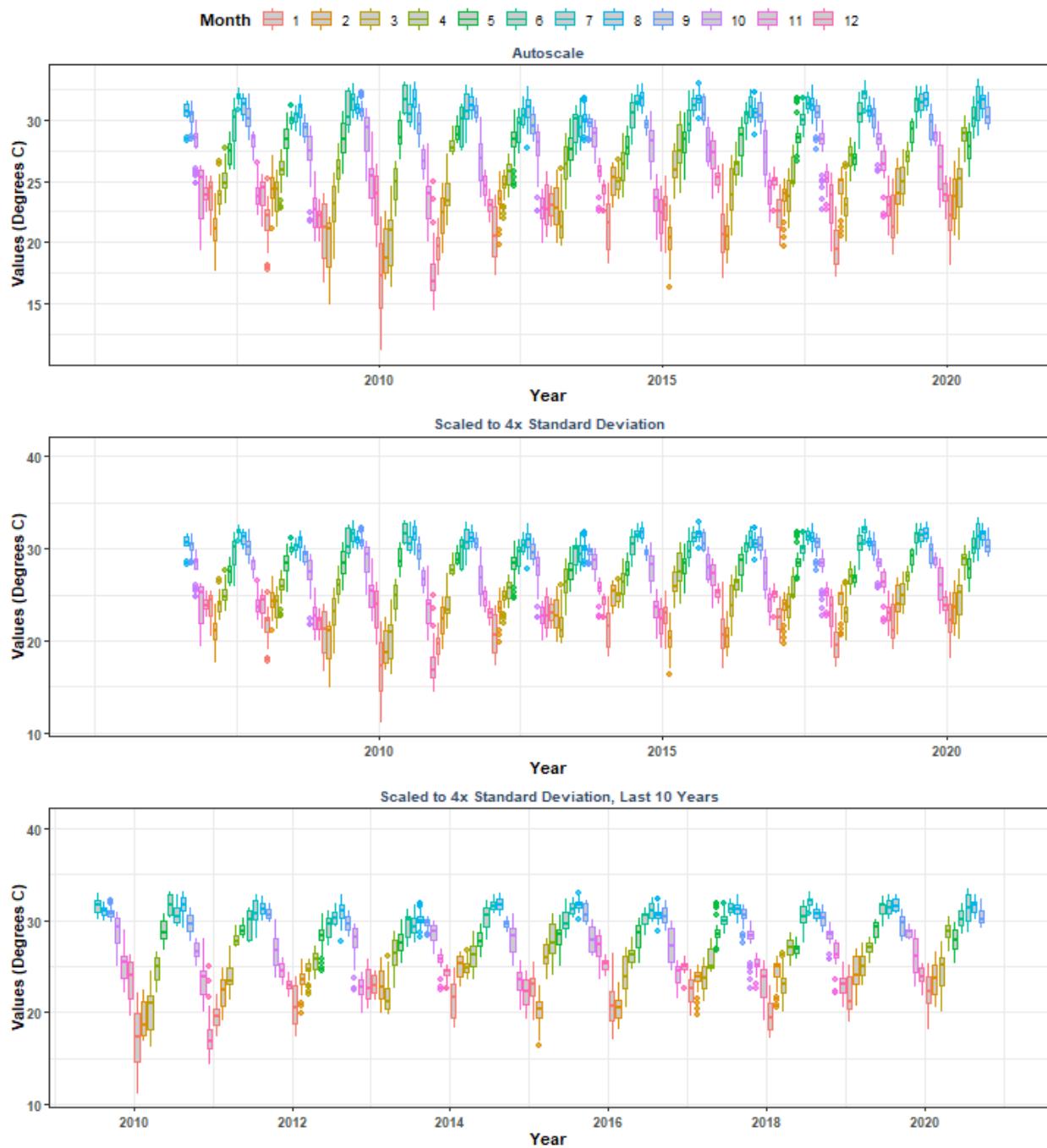


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15**

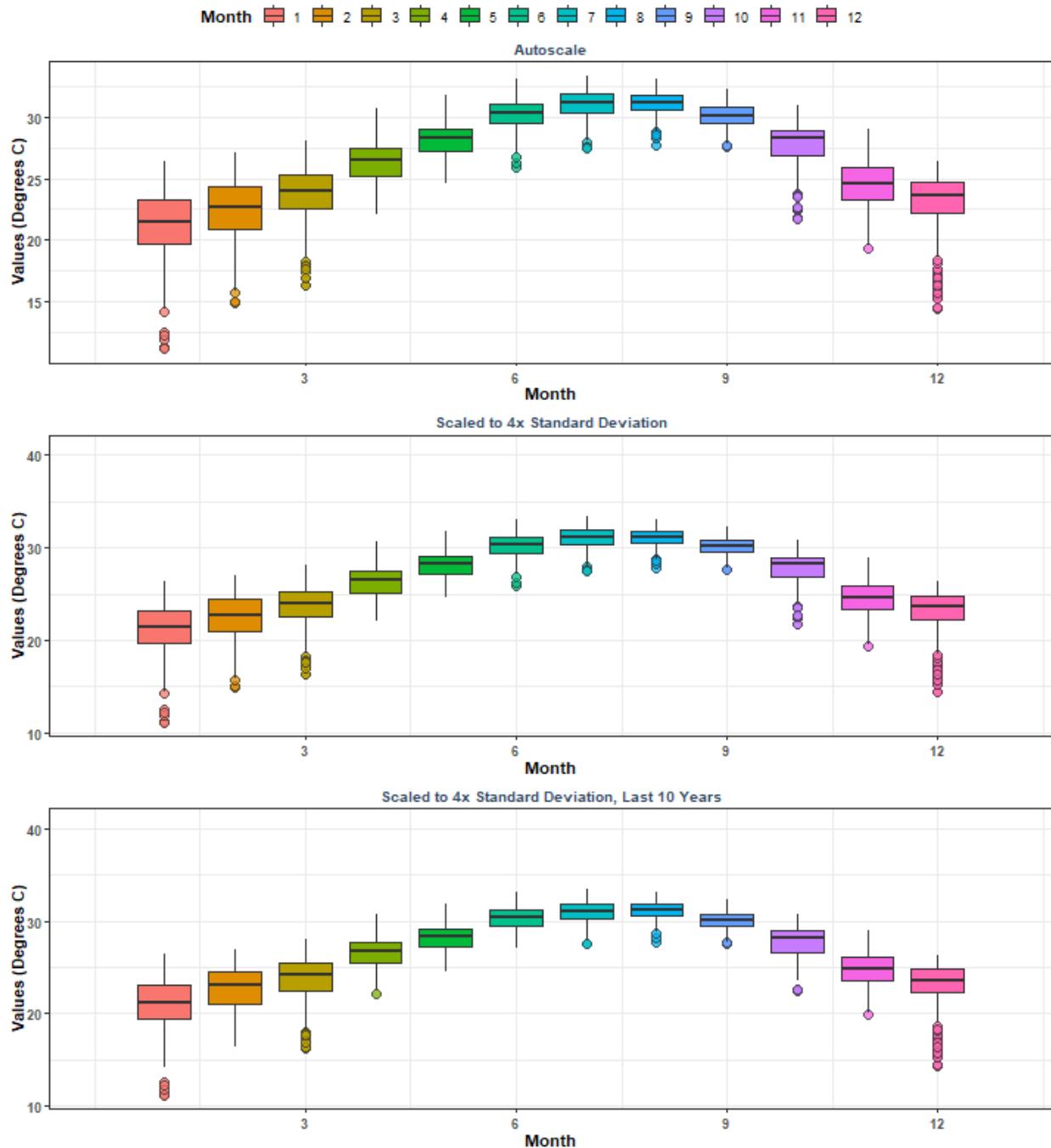
By Year



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

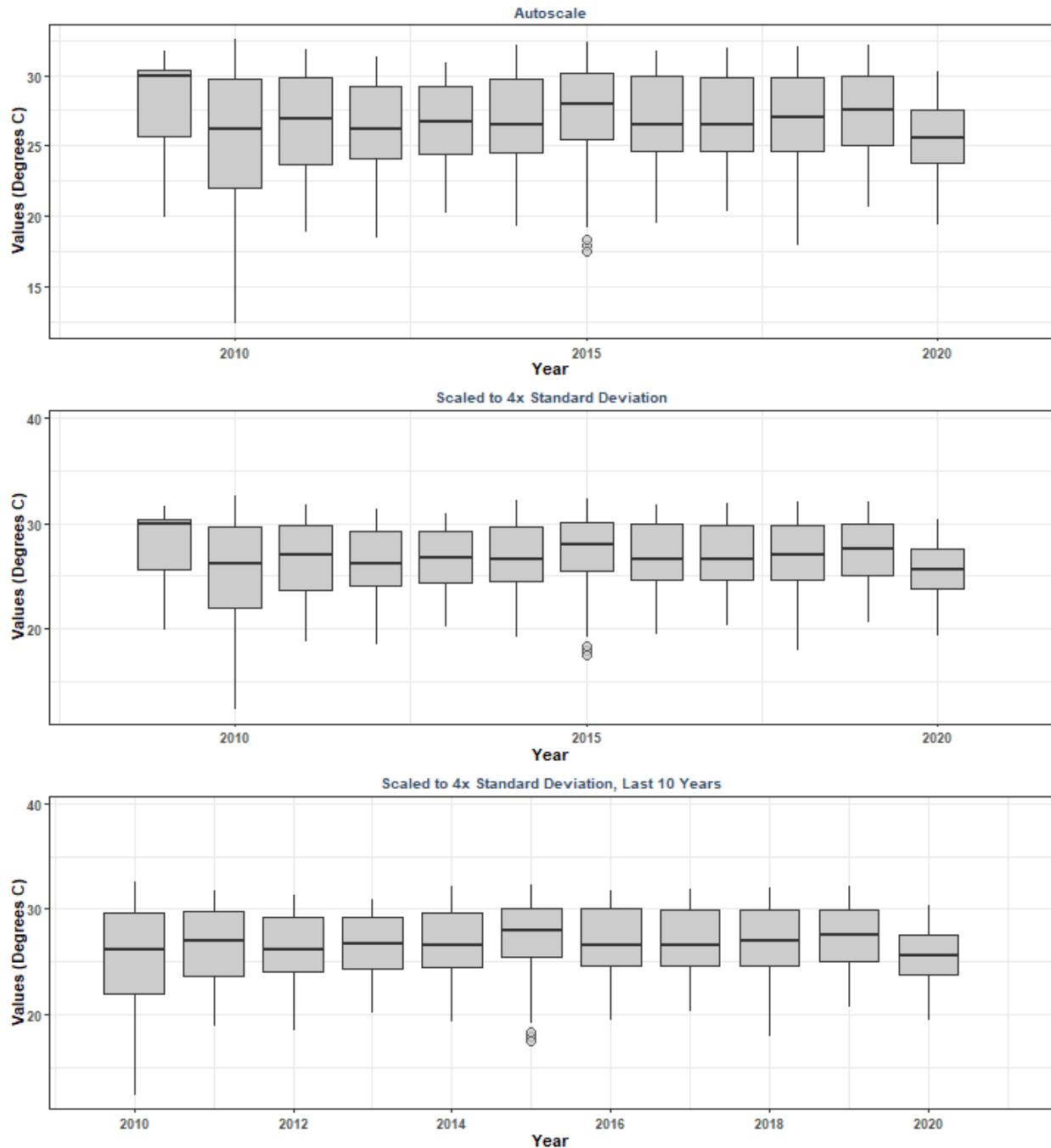


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 15
 By Month



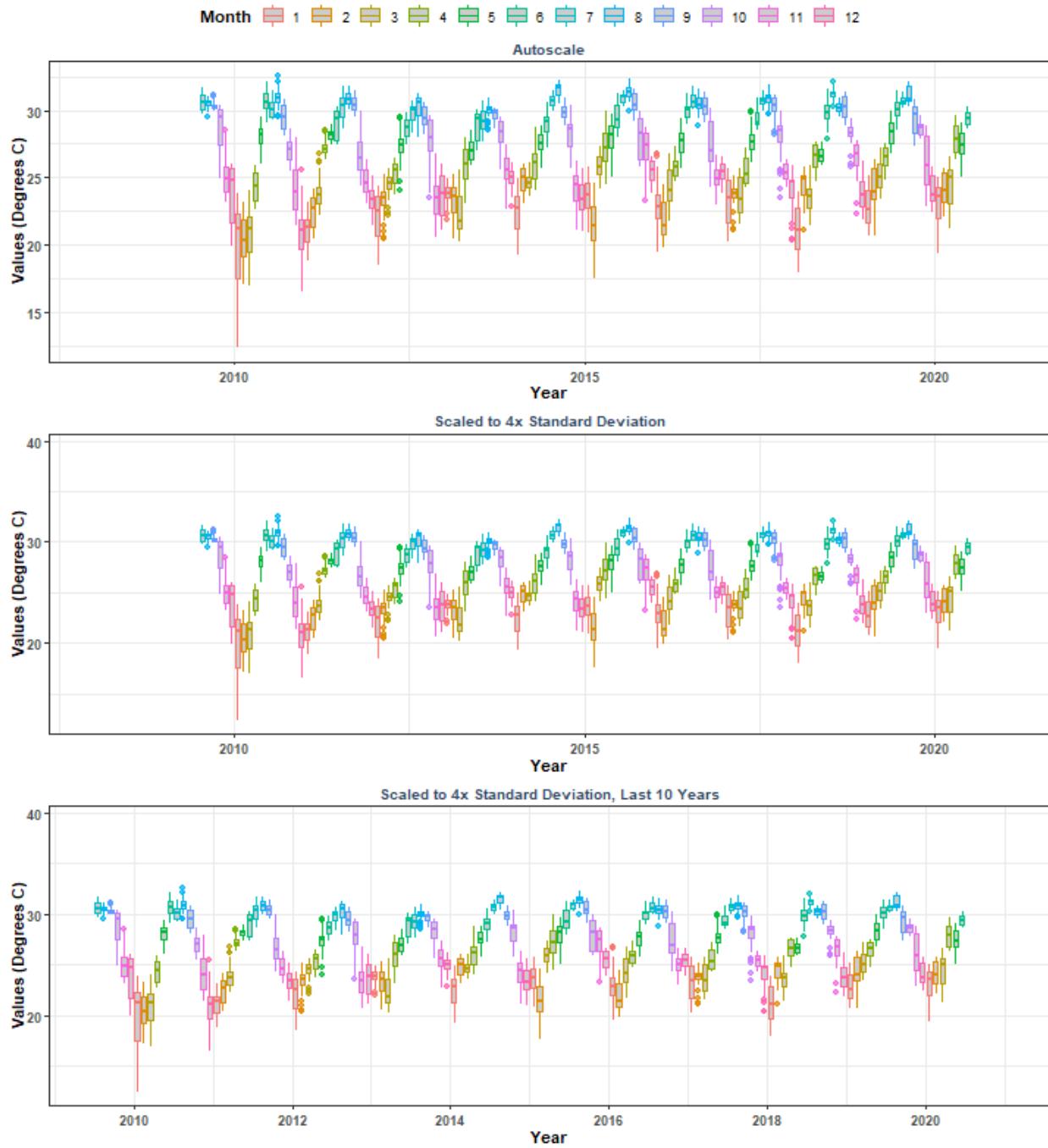
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22**

By Year

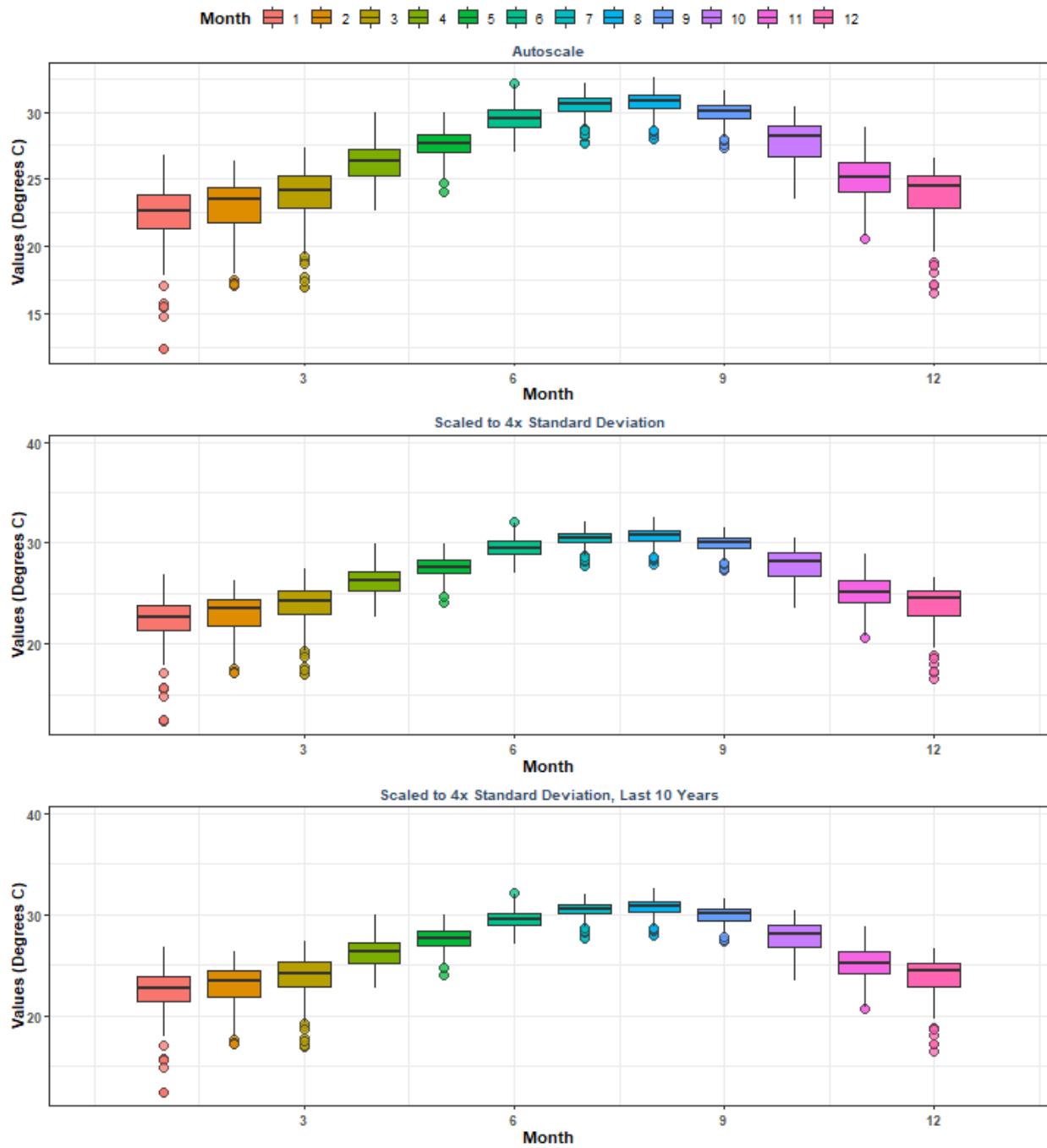


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22**

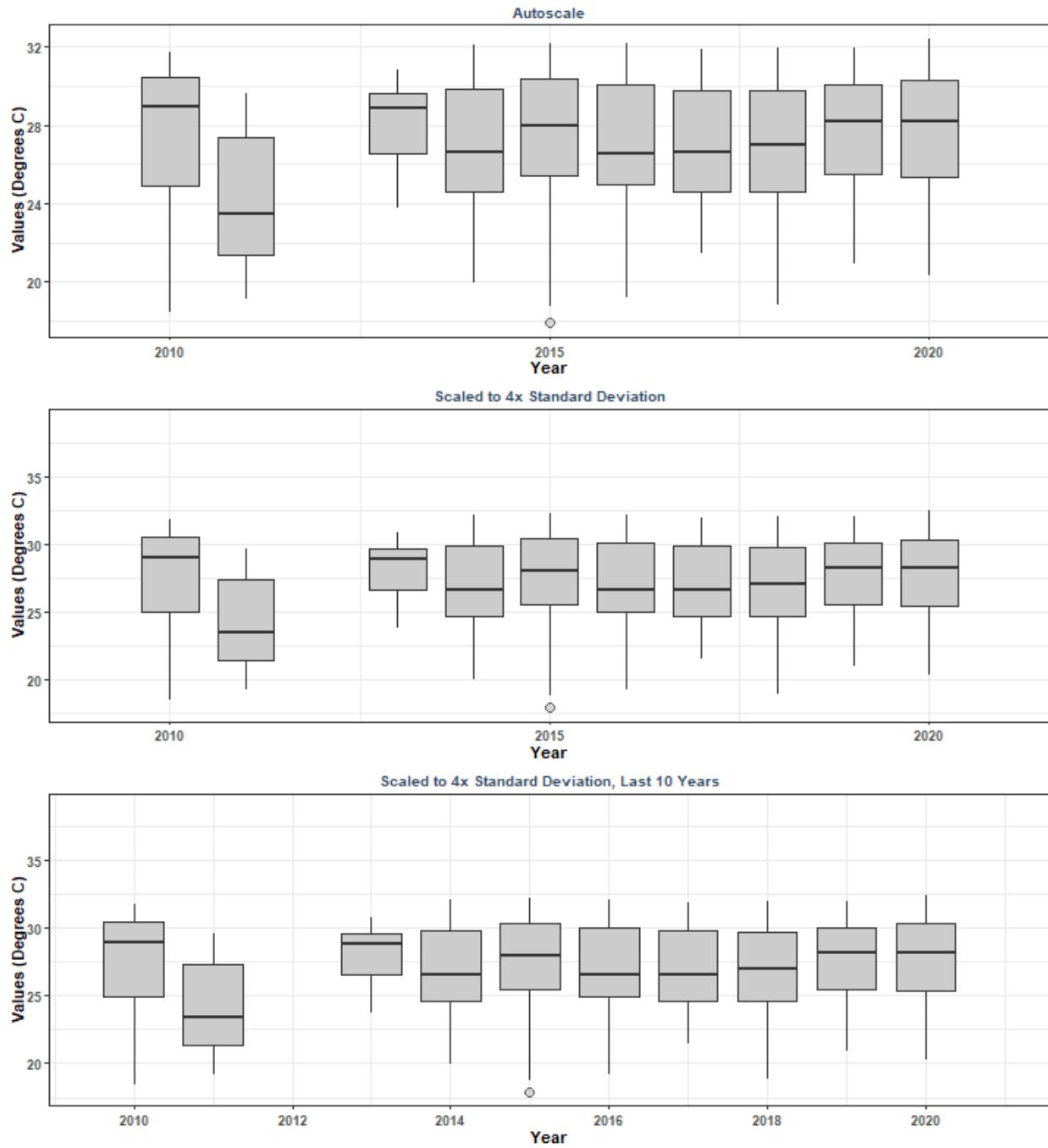
By Year & Month



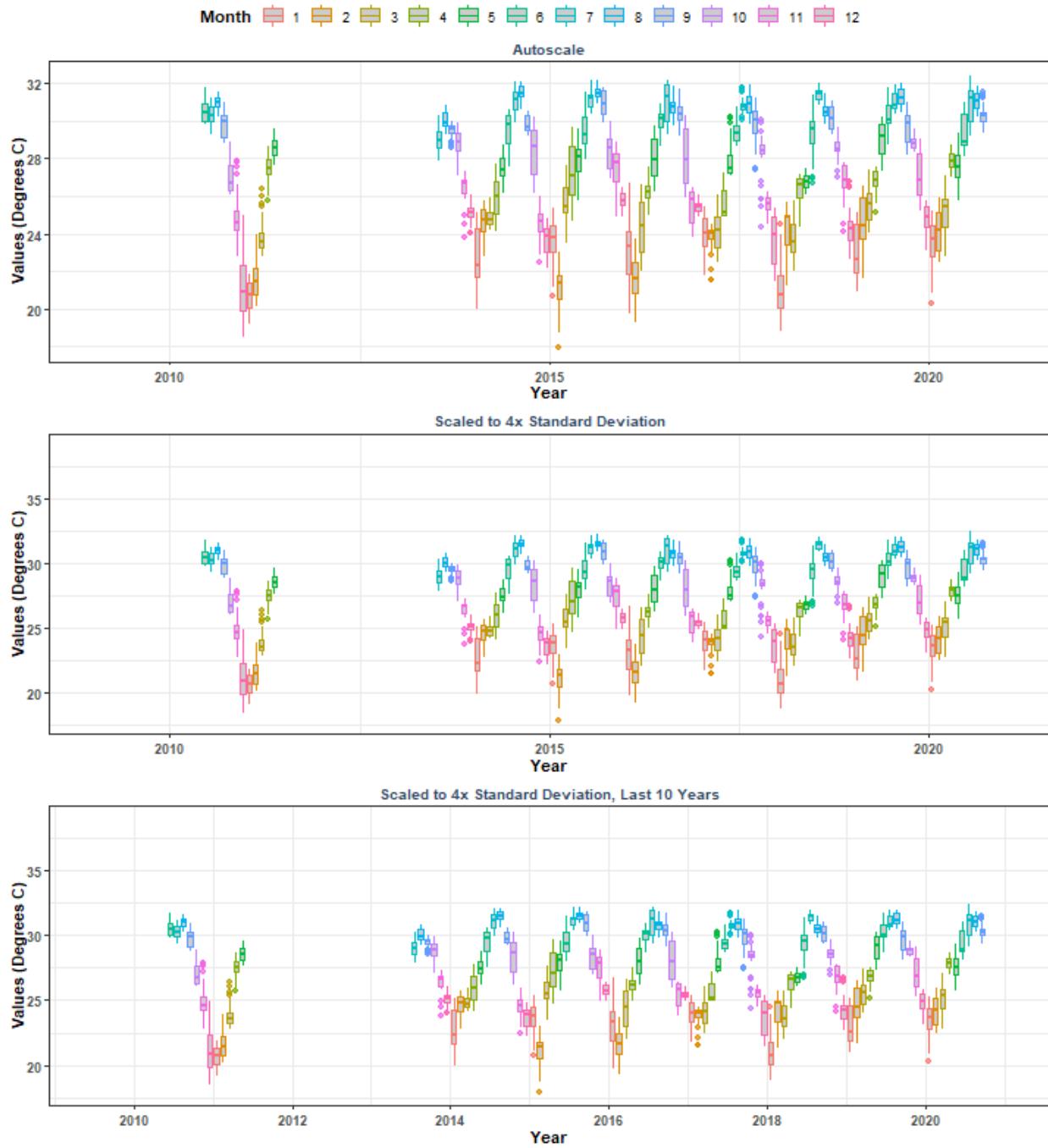
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 22
 By Month



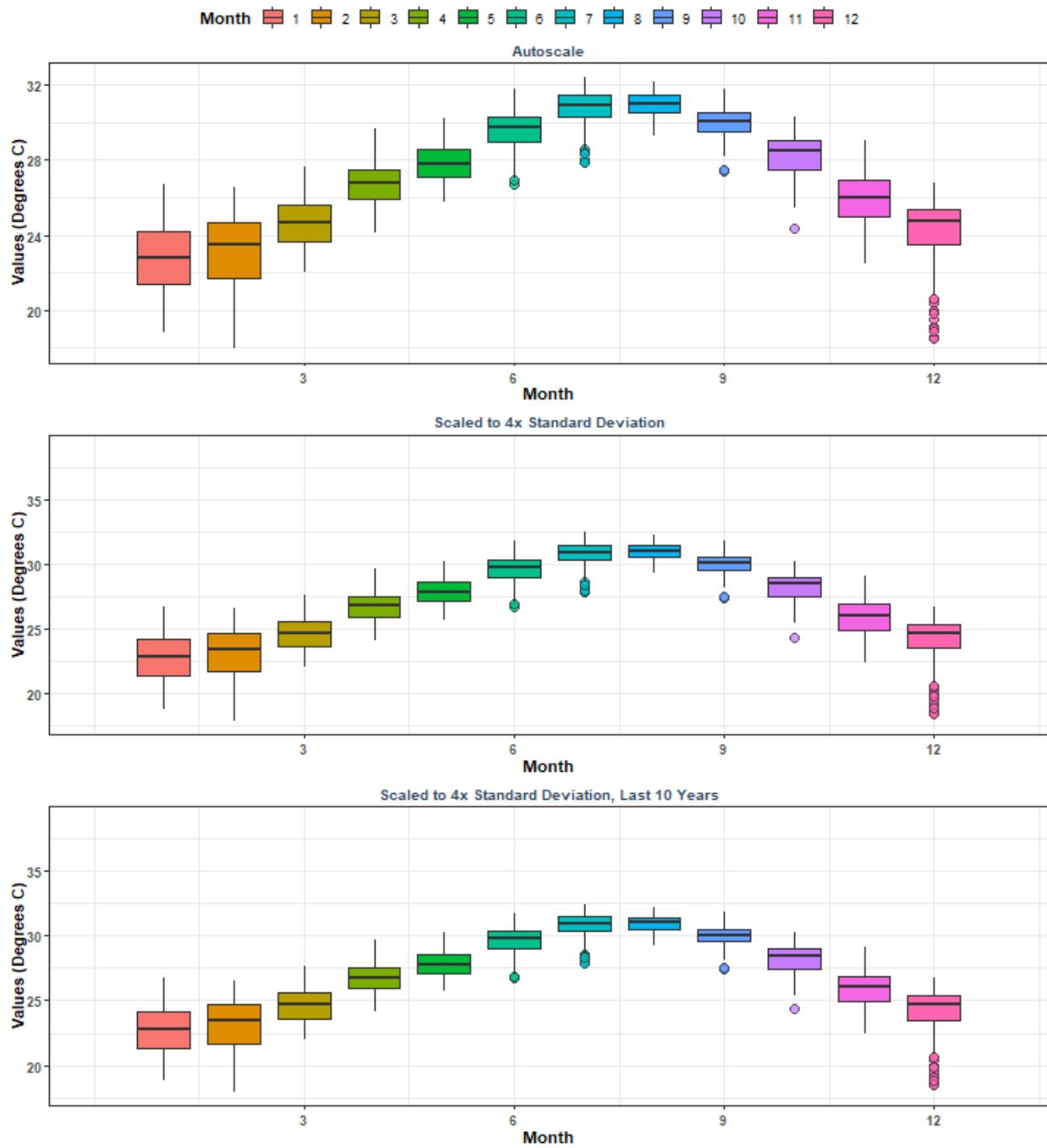
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25**
By Year



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

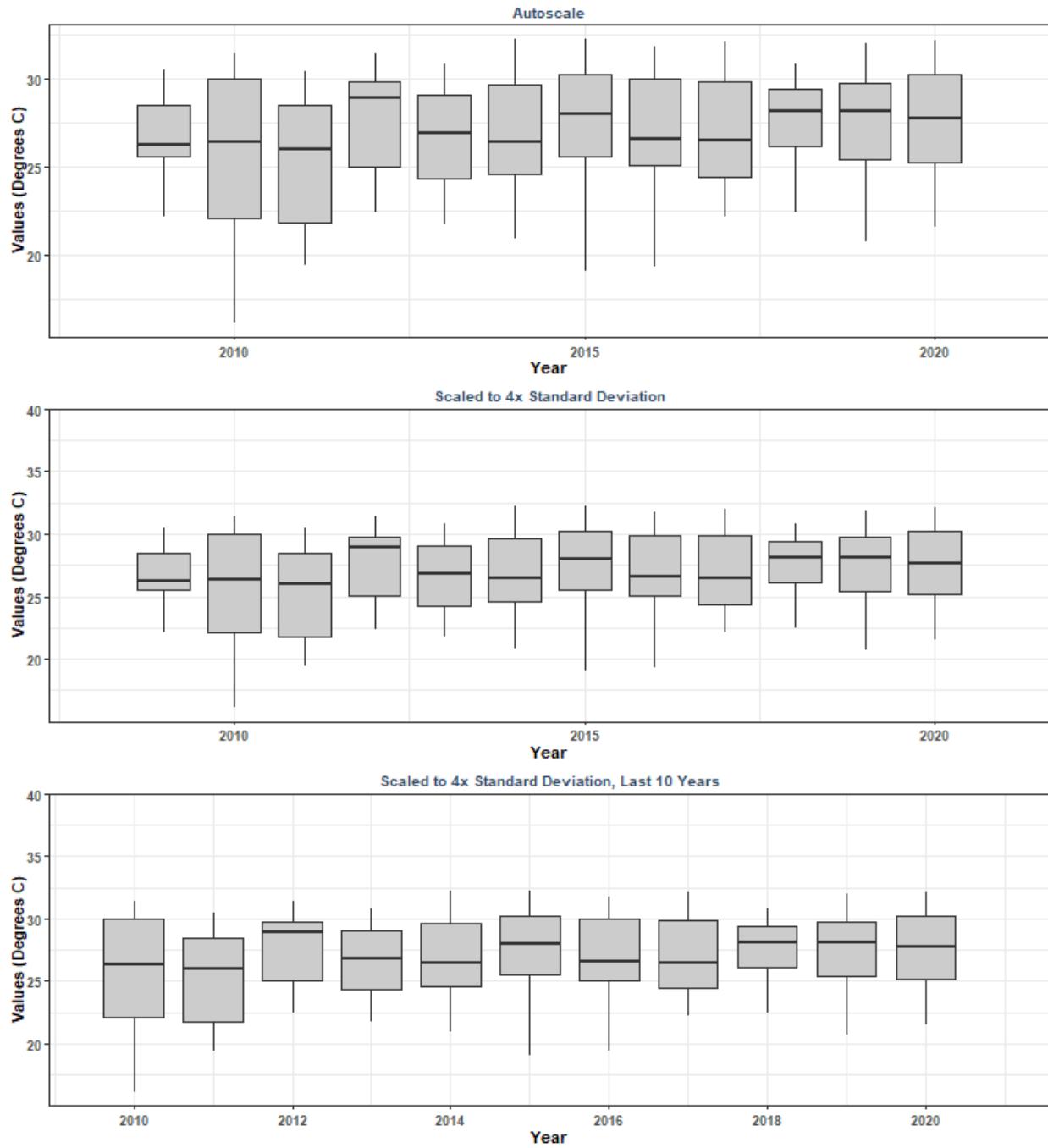


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 25
 By Month

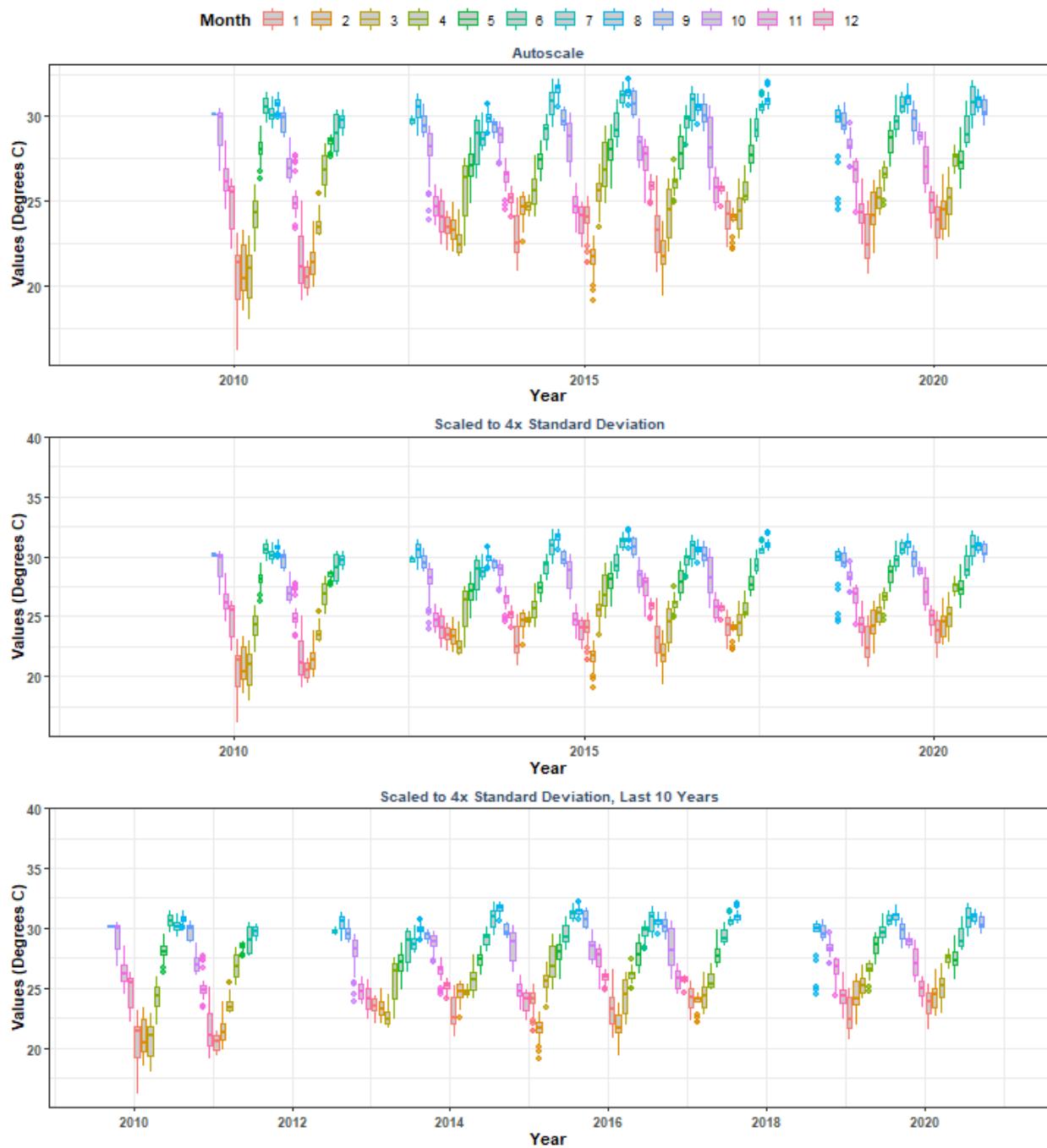


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26**

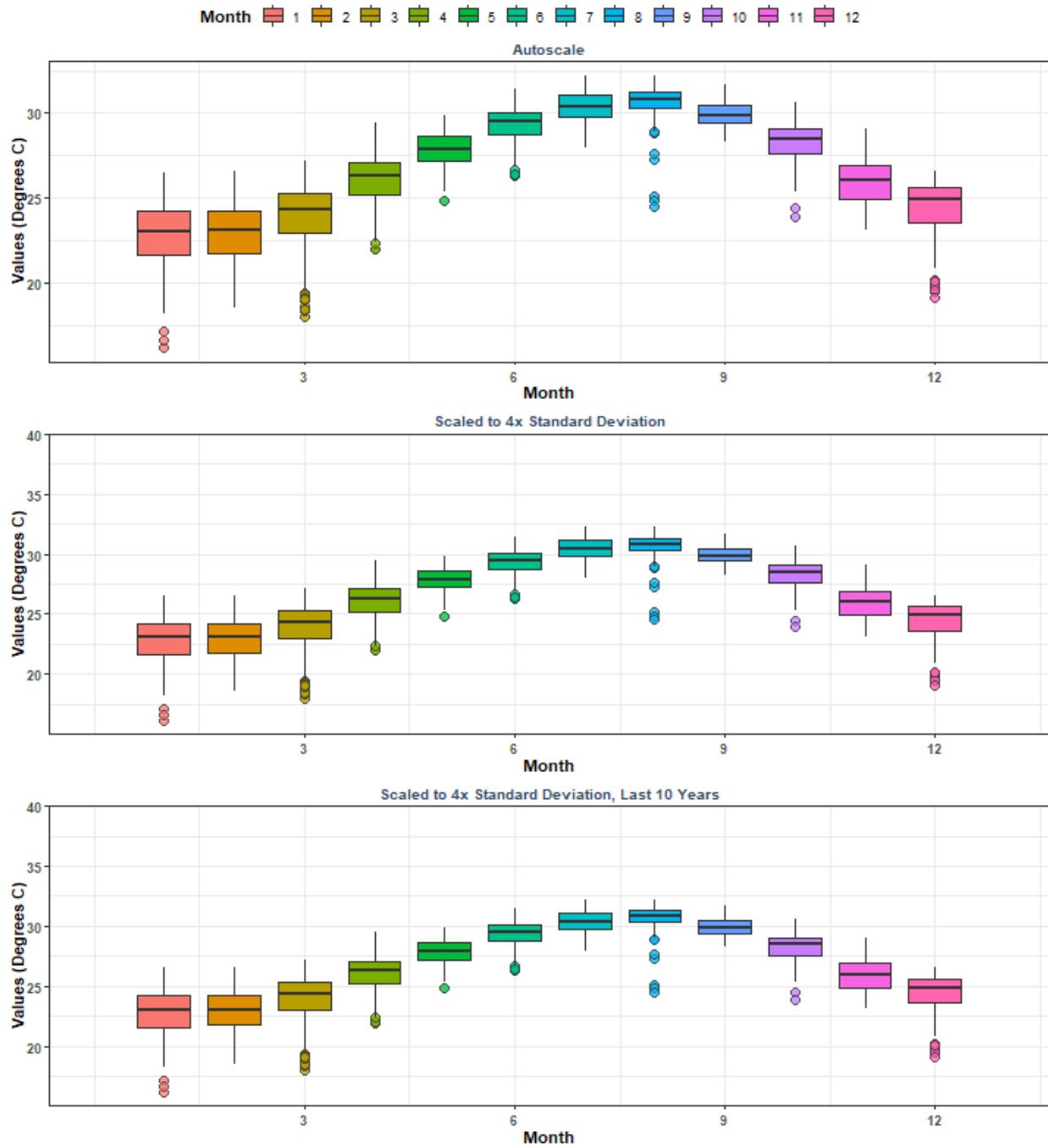
By Year



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

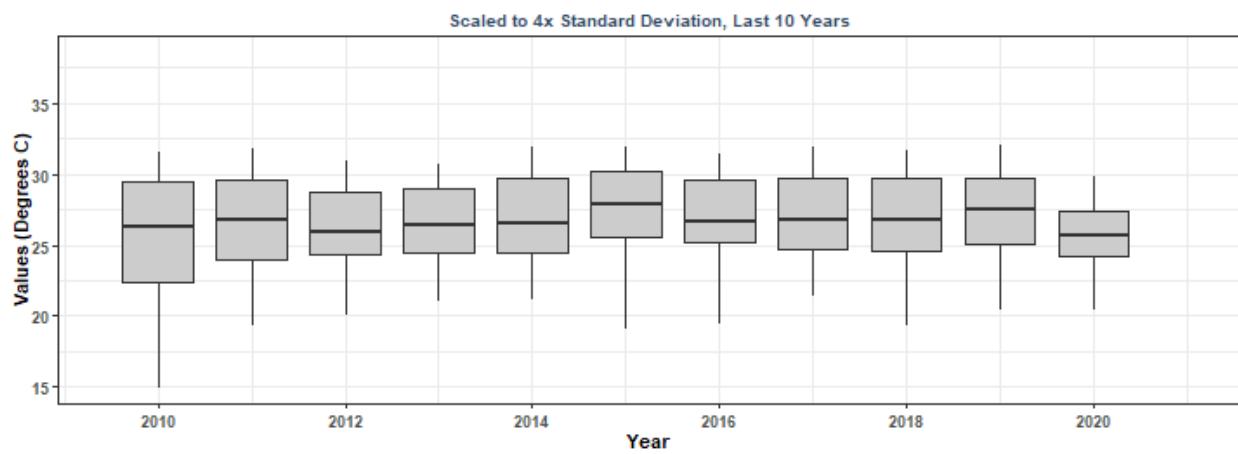
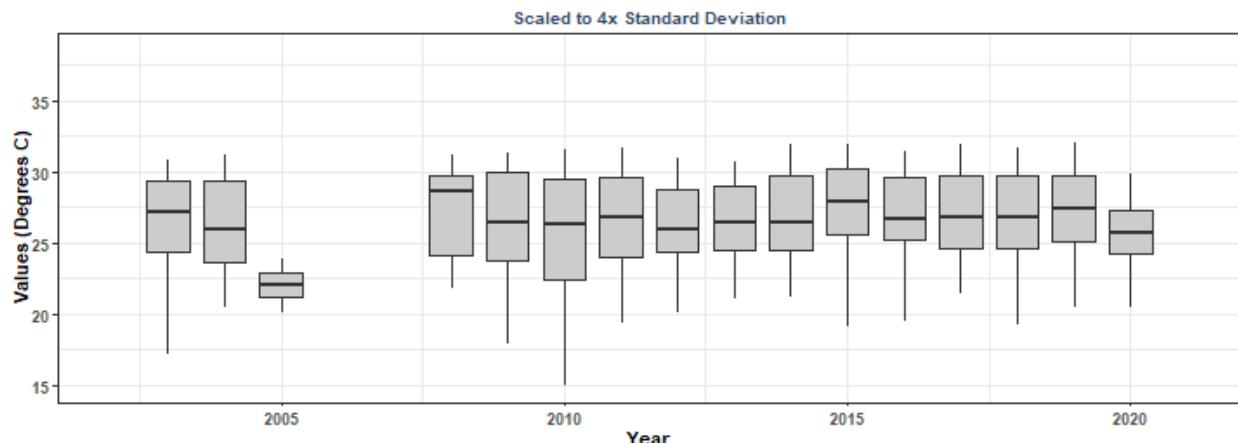
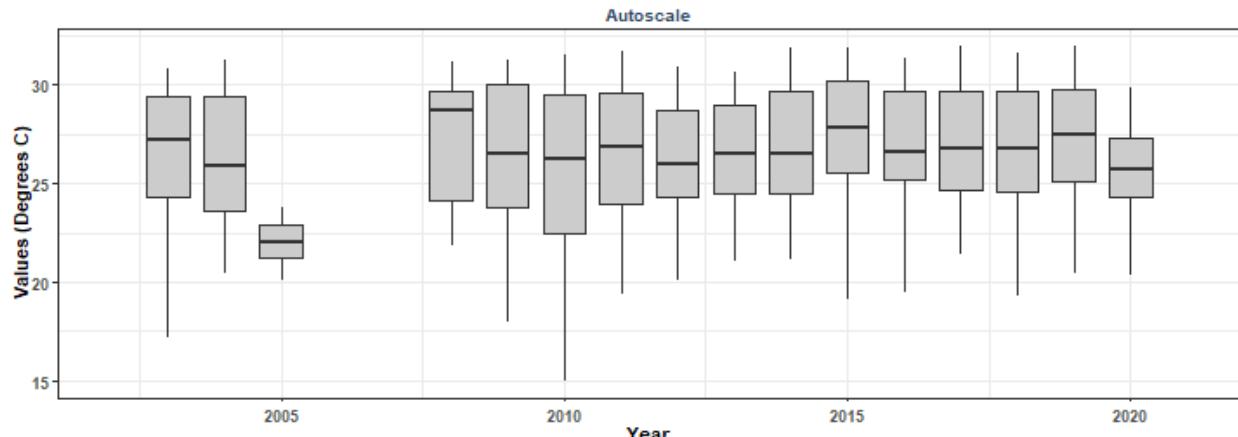


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 26
 By Month

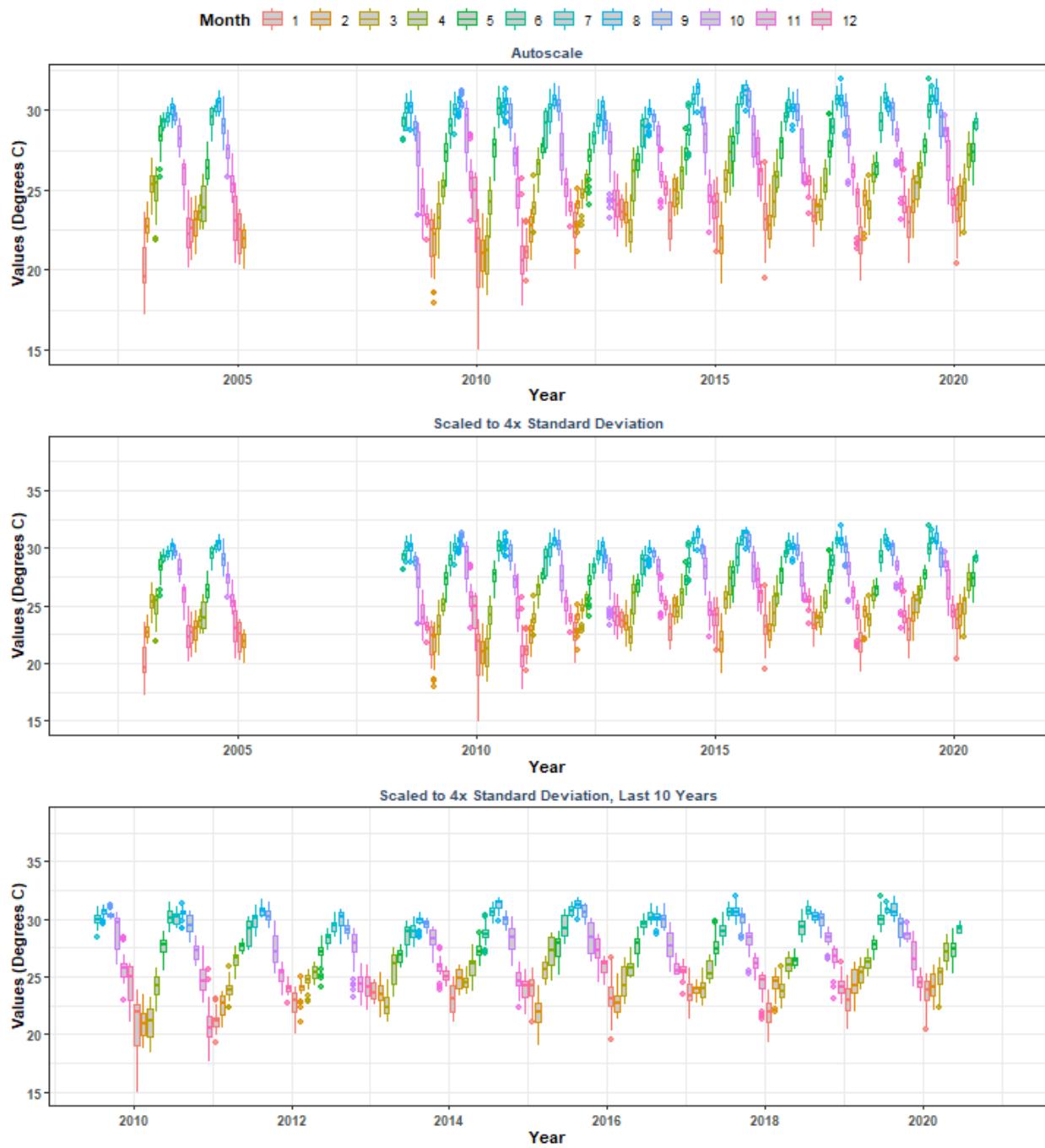


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32**

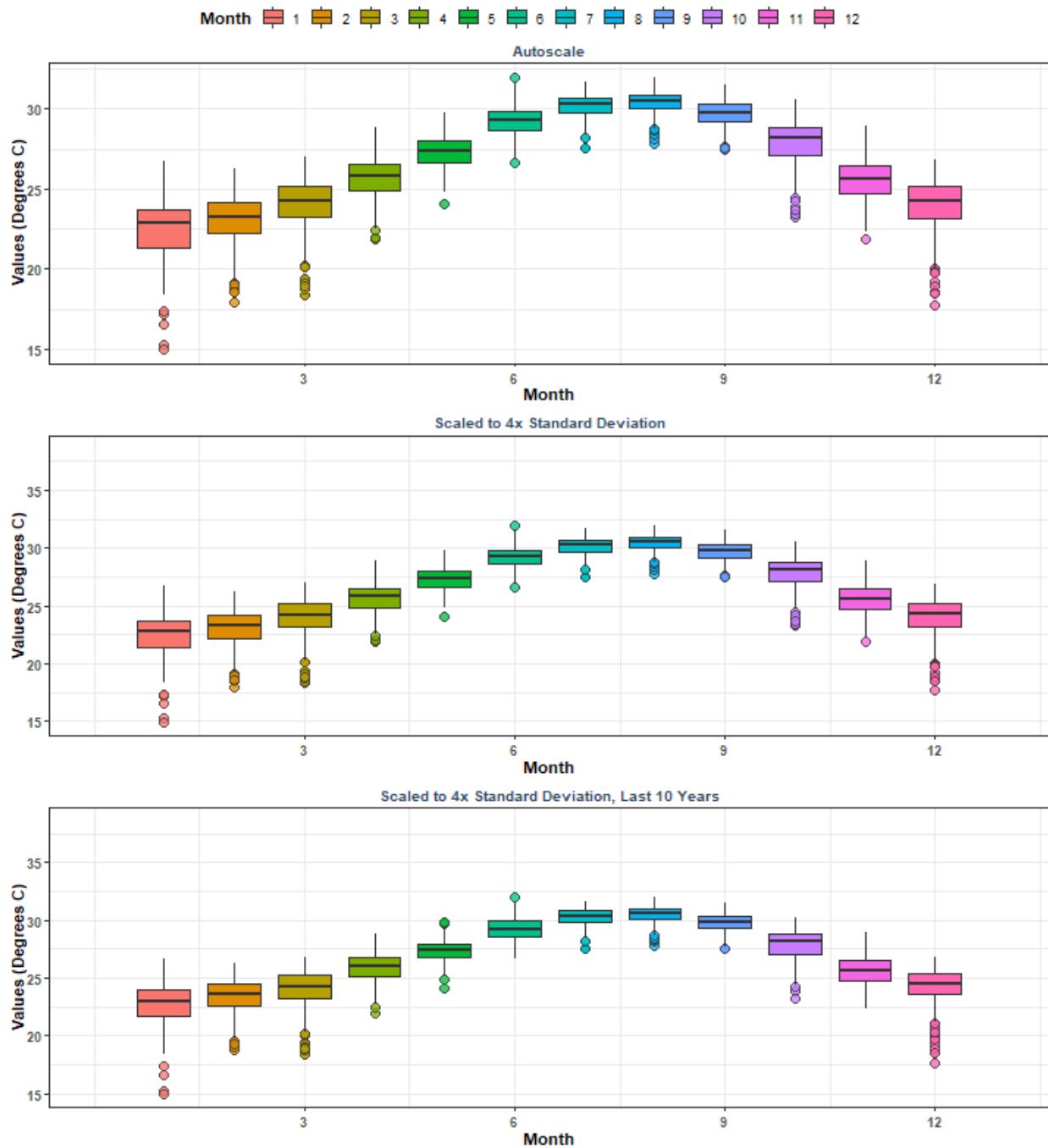
By Year



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

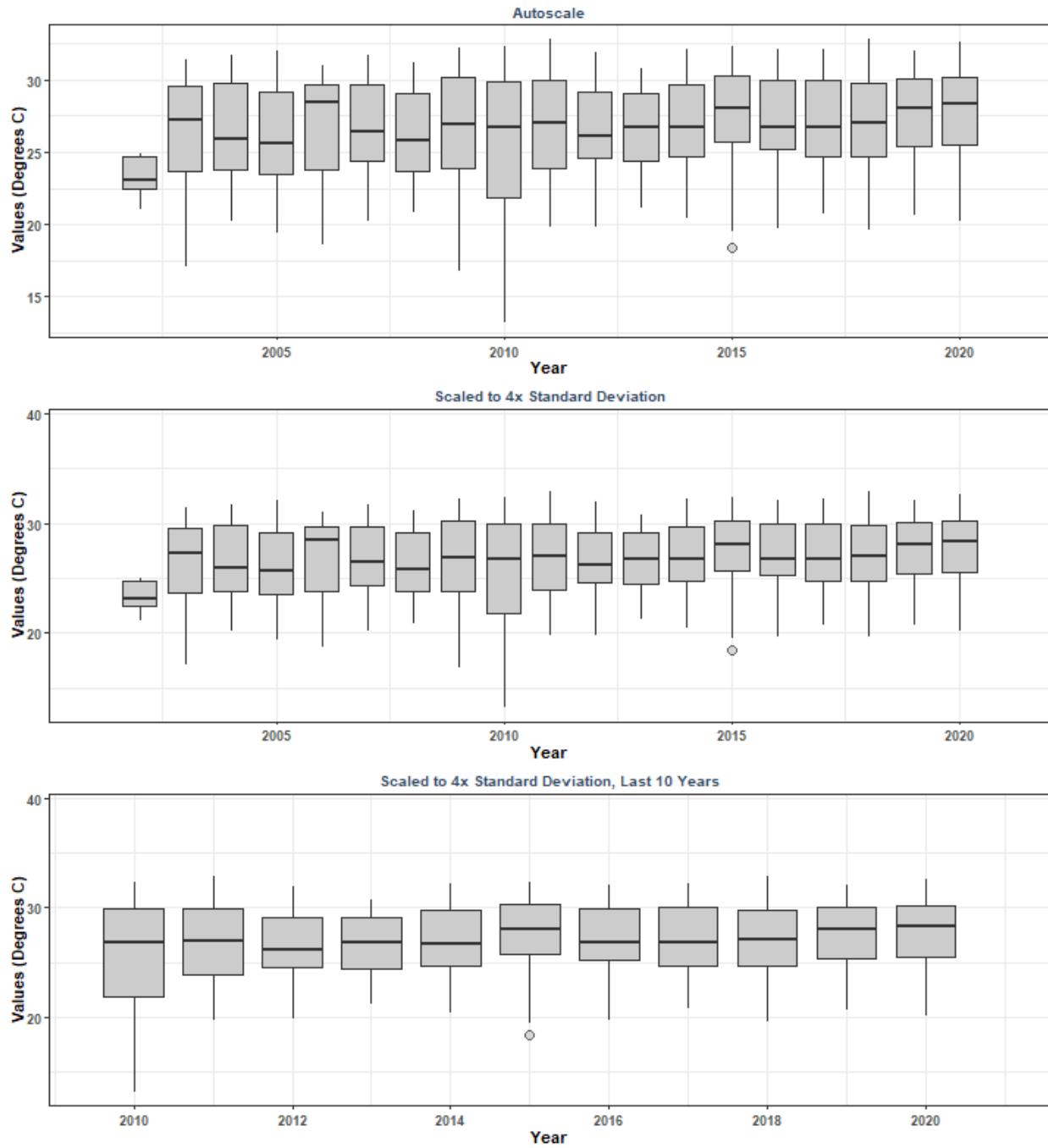


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 32
 By Month

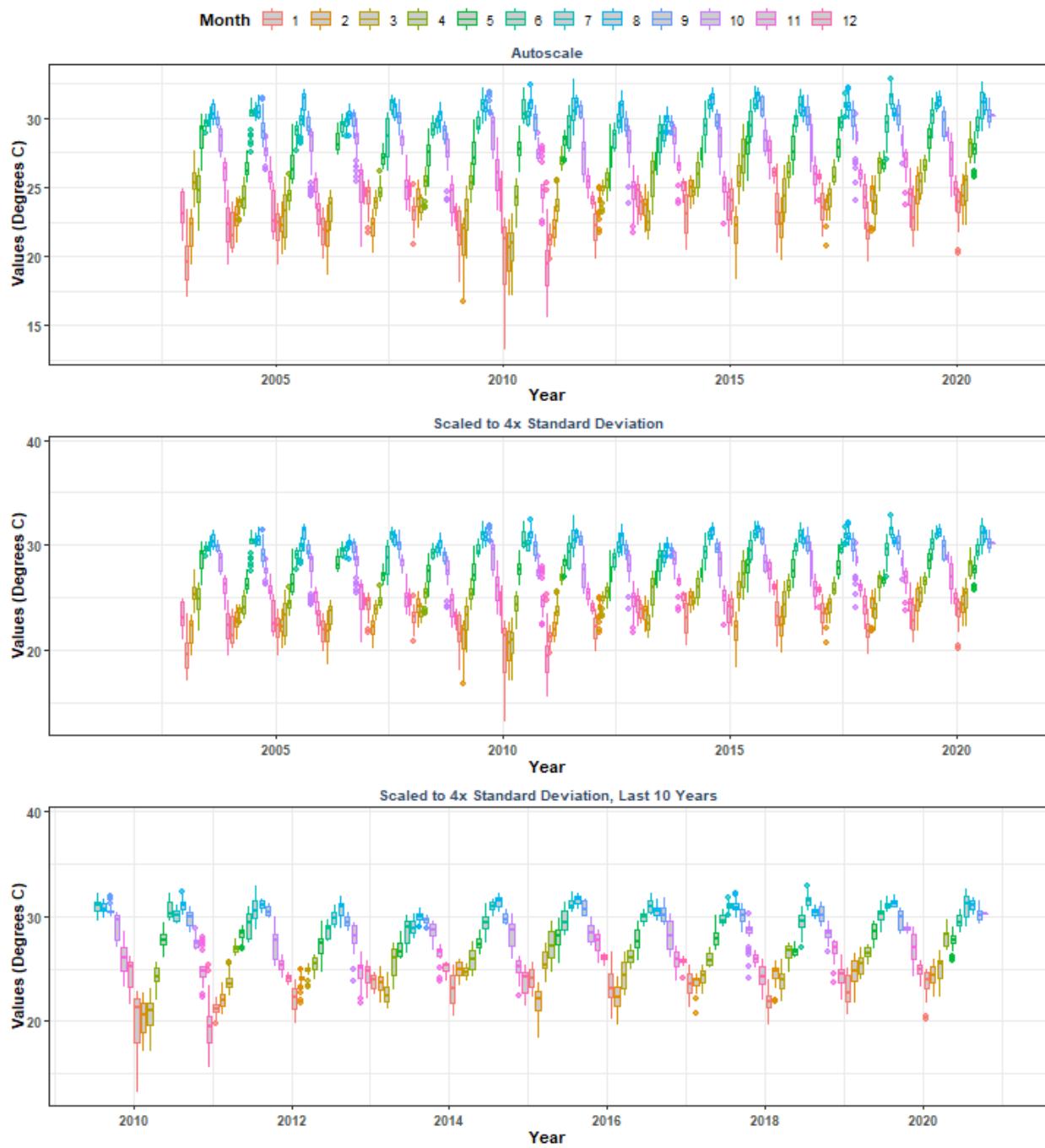


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34**

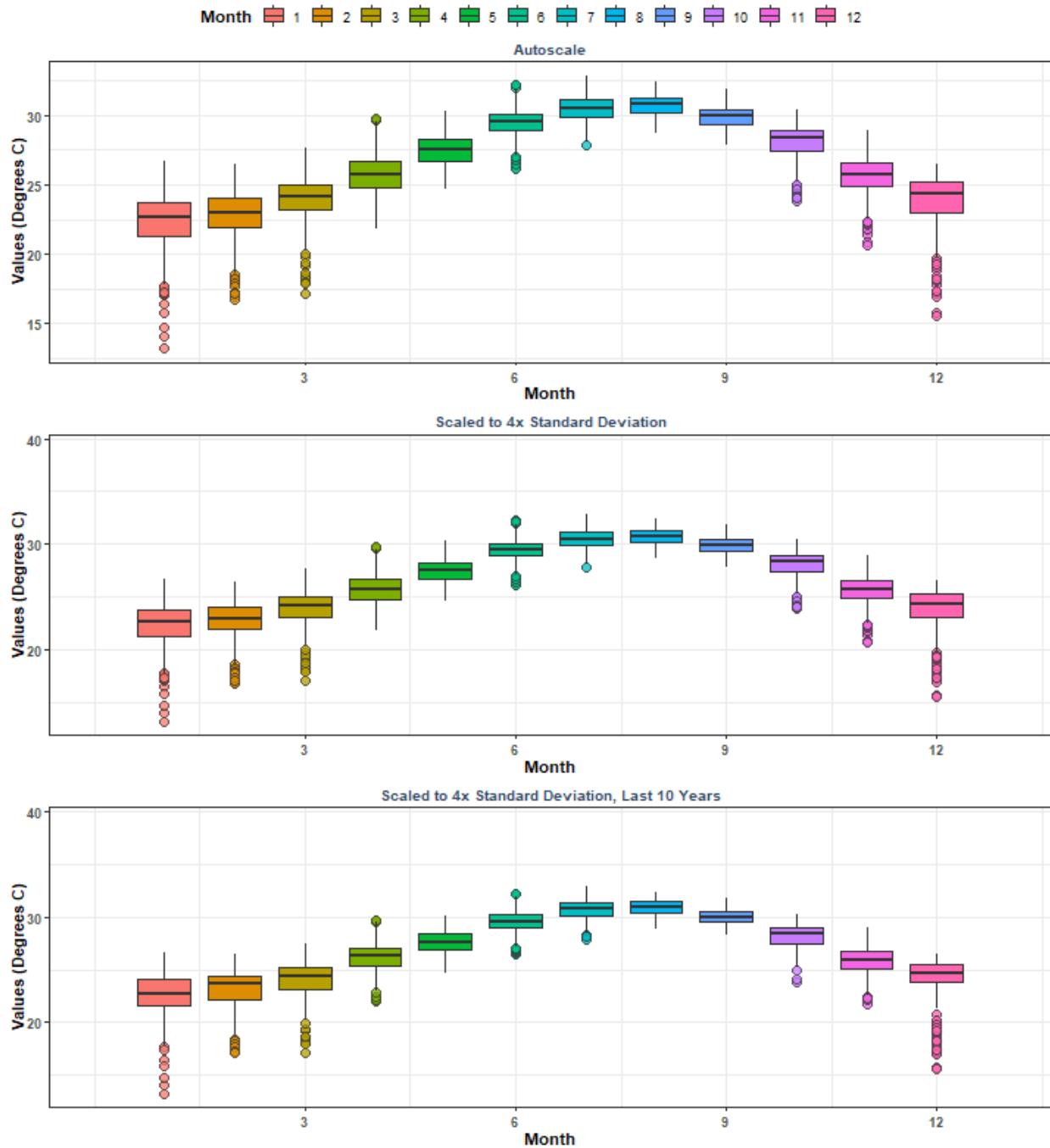
By Year



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

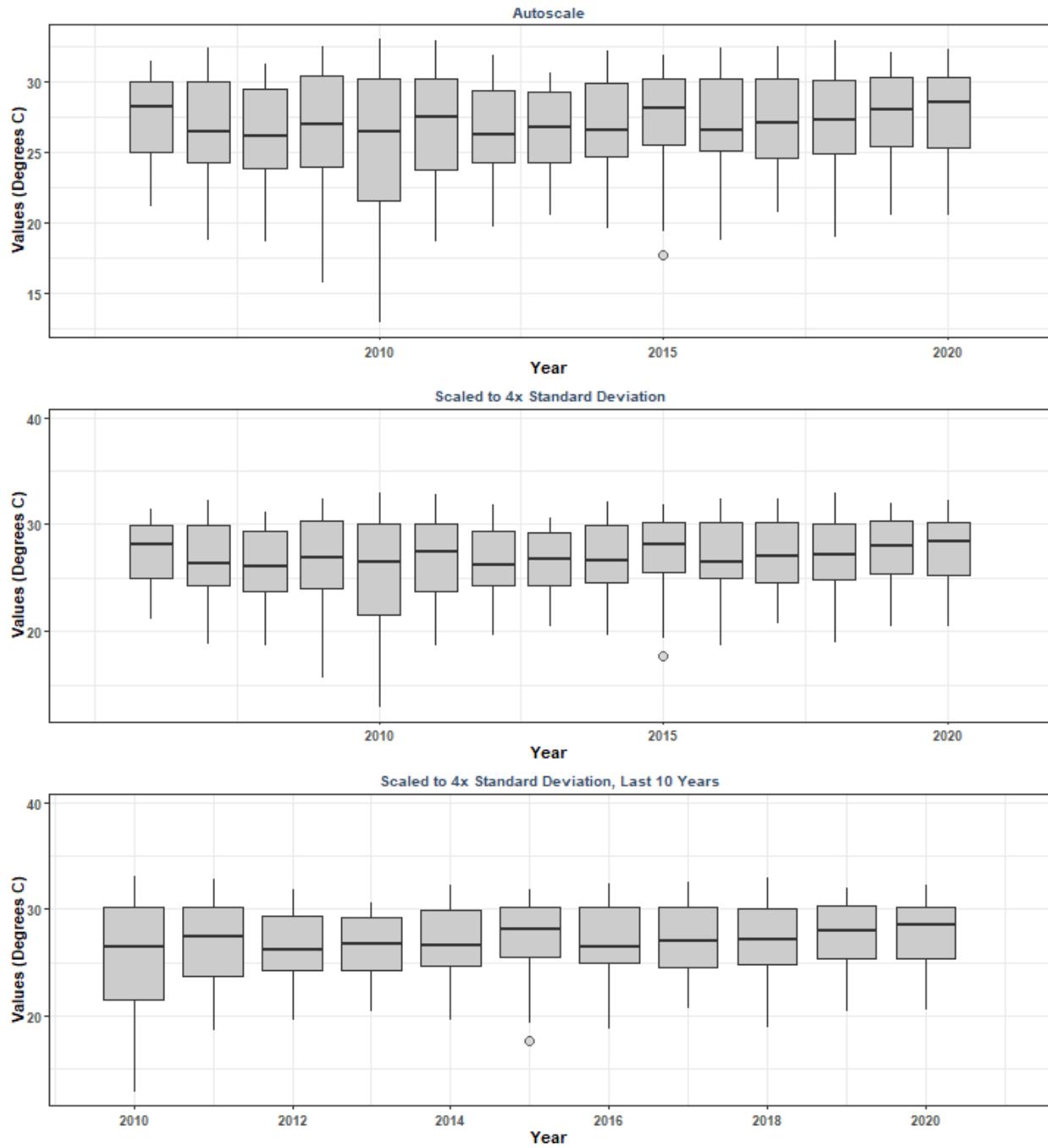


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 34
 By Month

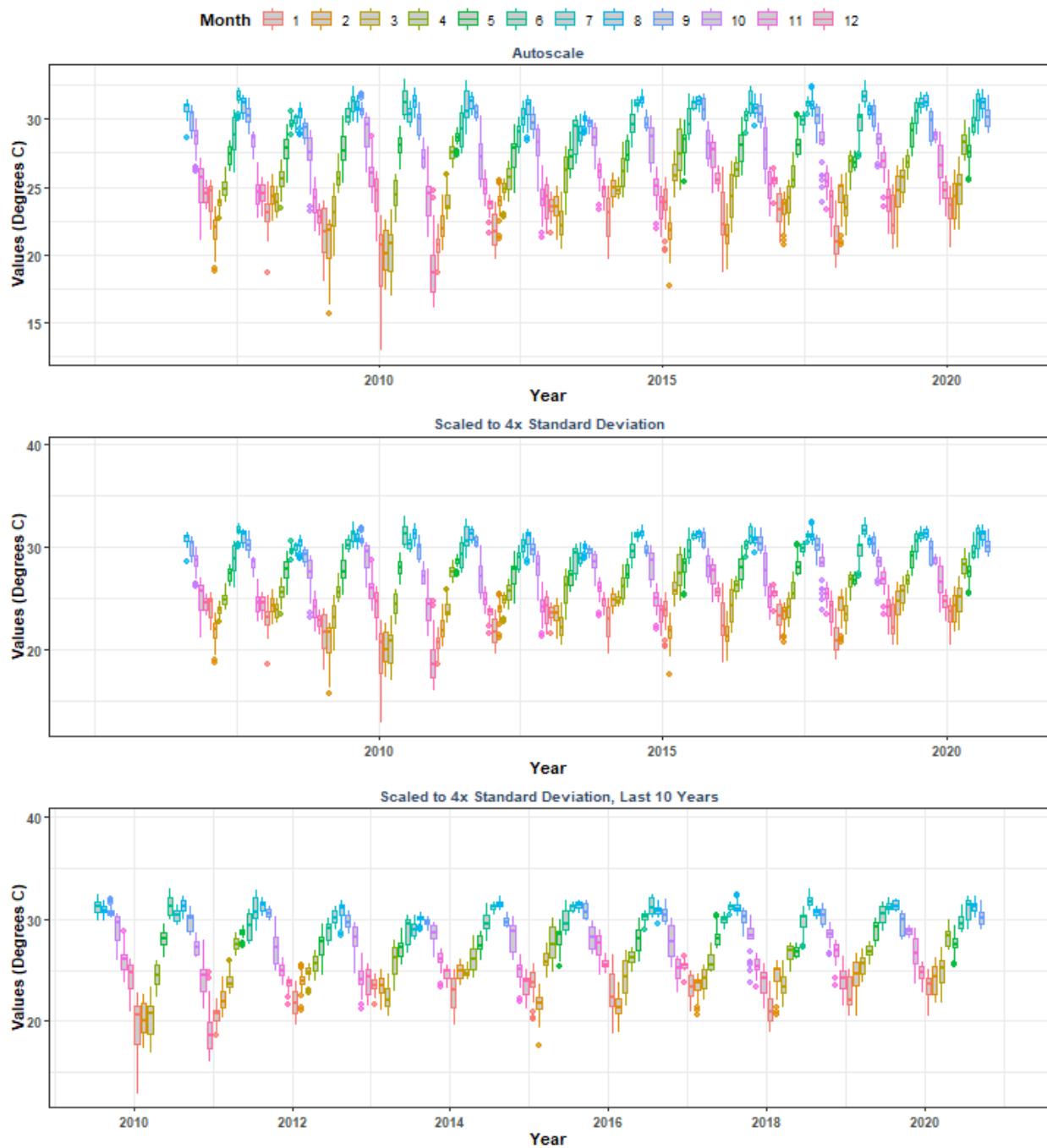


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35**

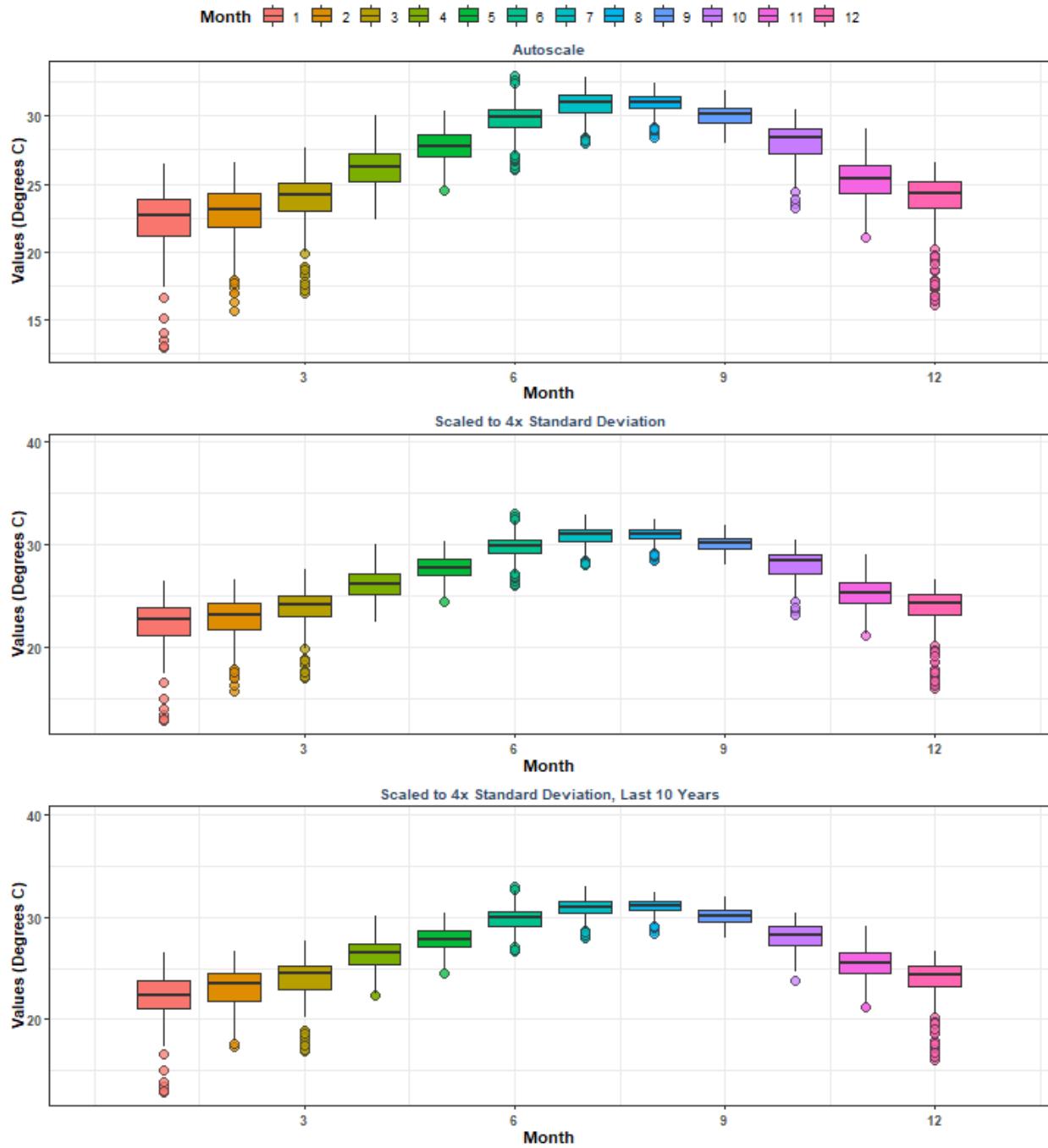
By Year



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

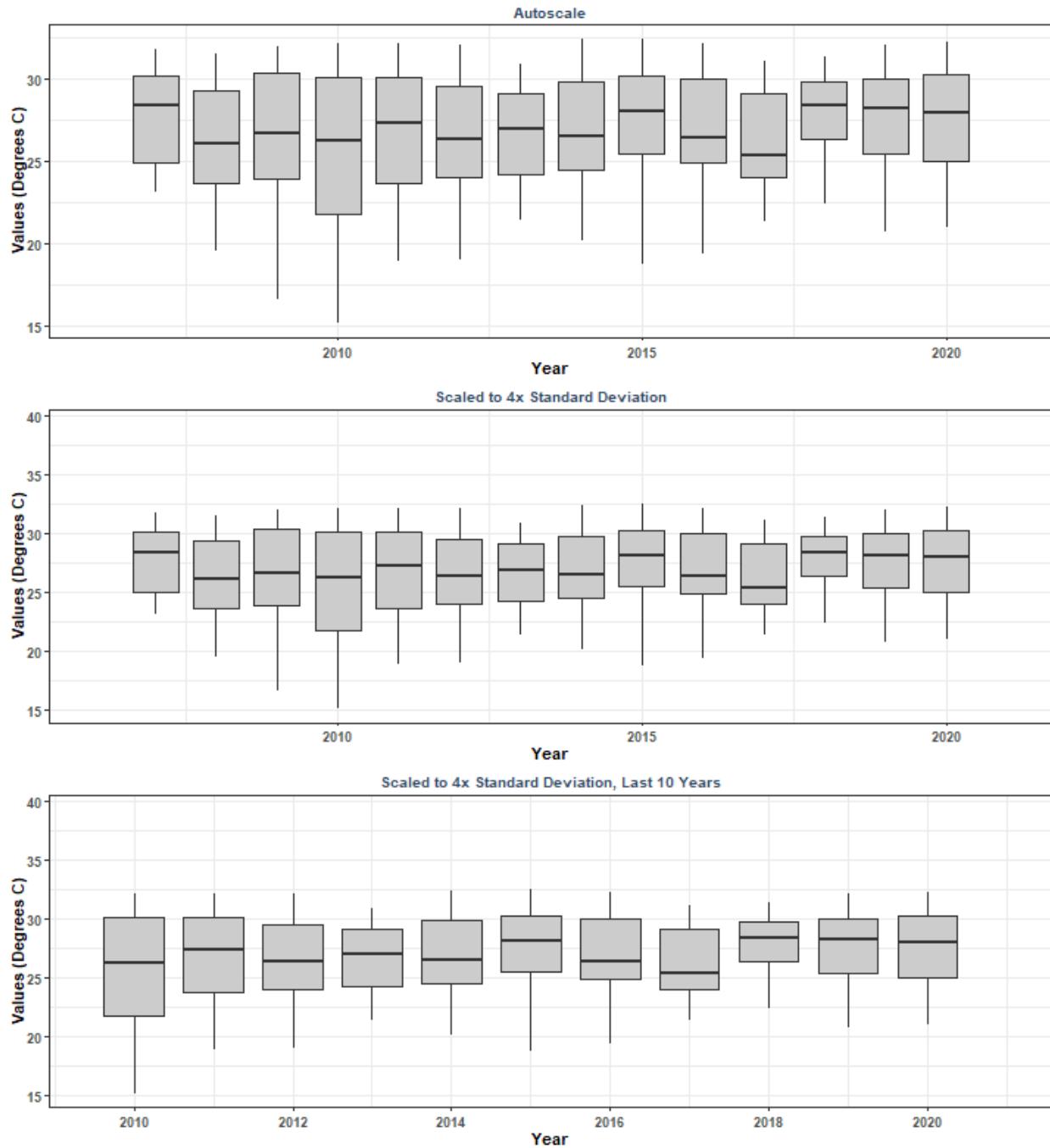


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 35
 By Month

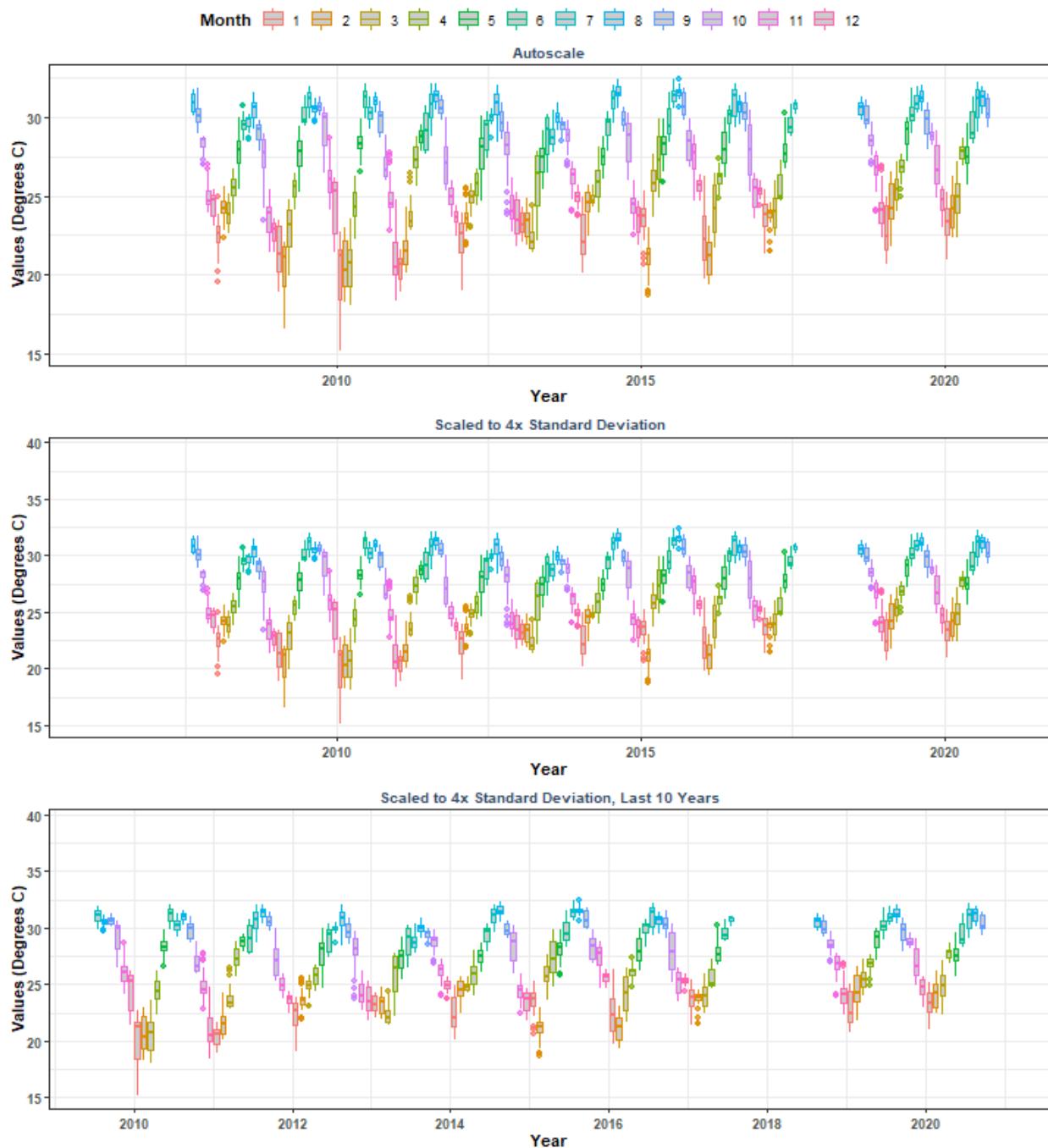


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 36**

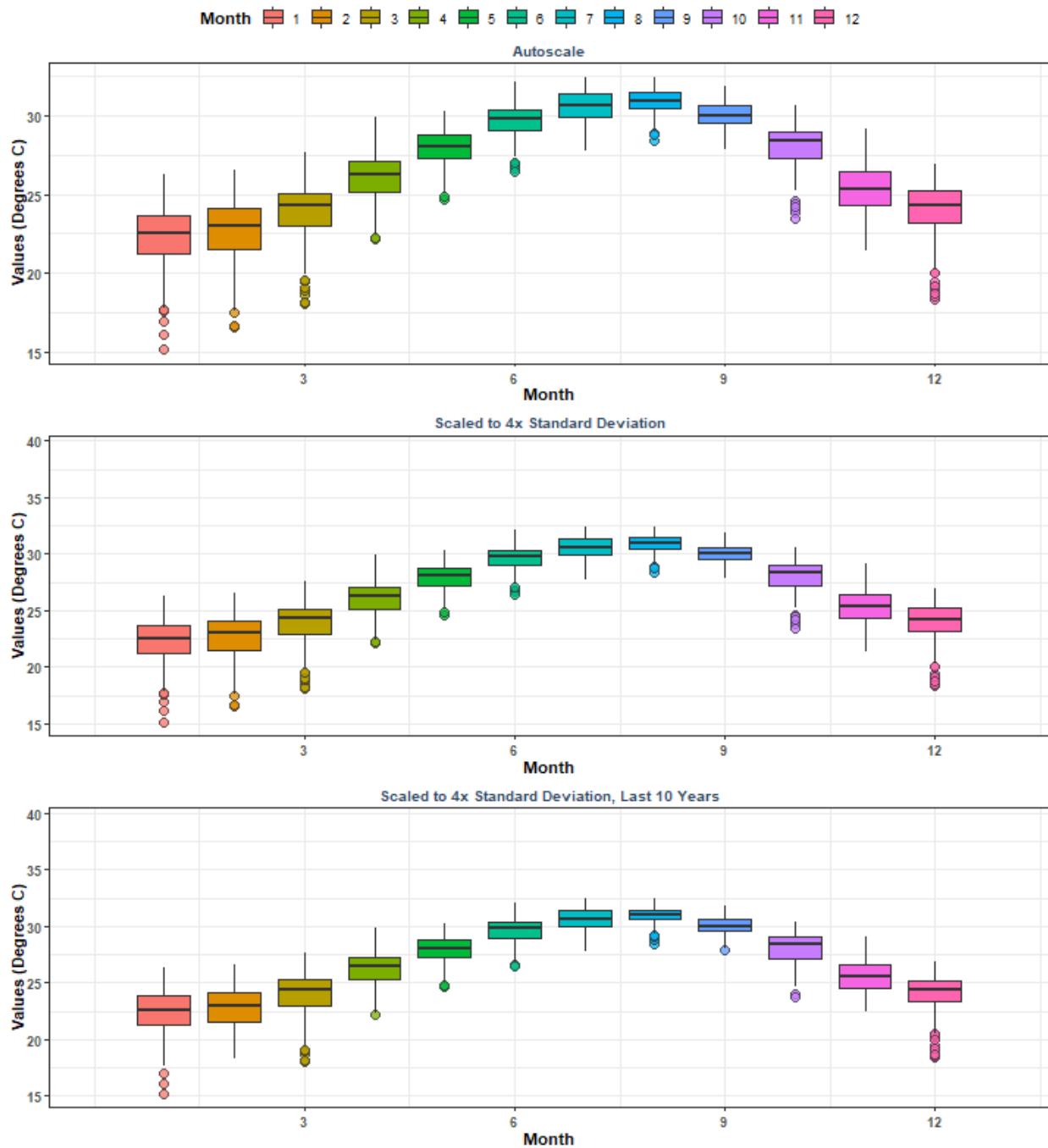
By Year



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

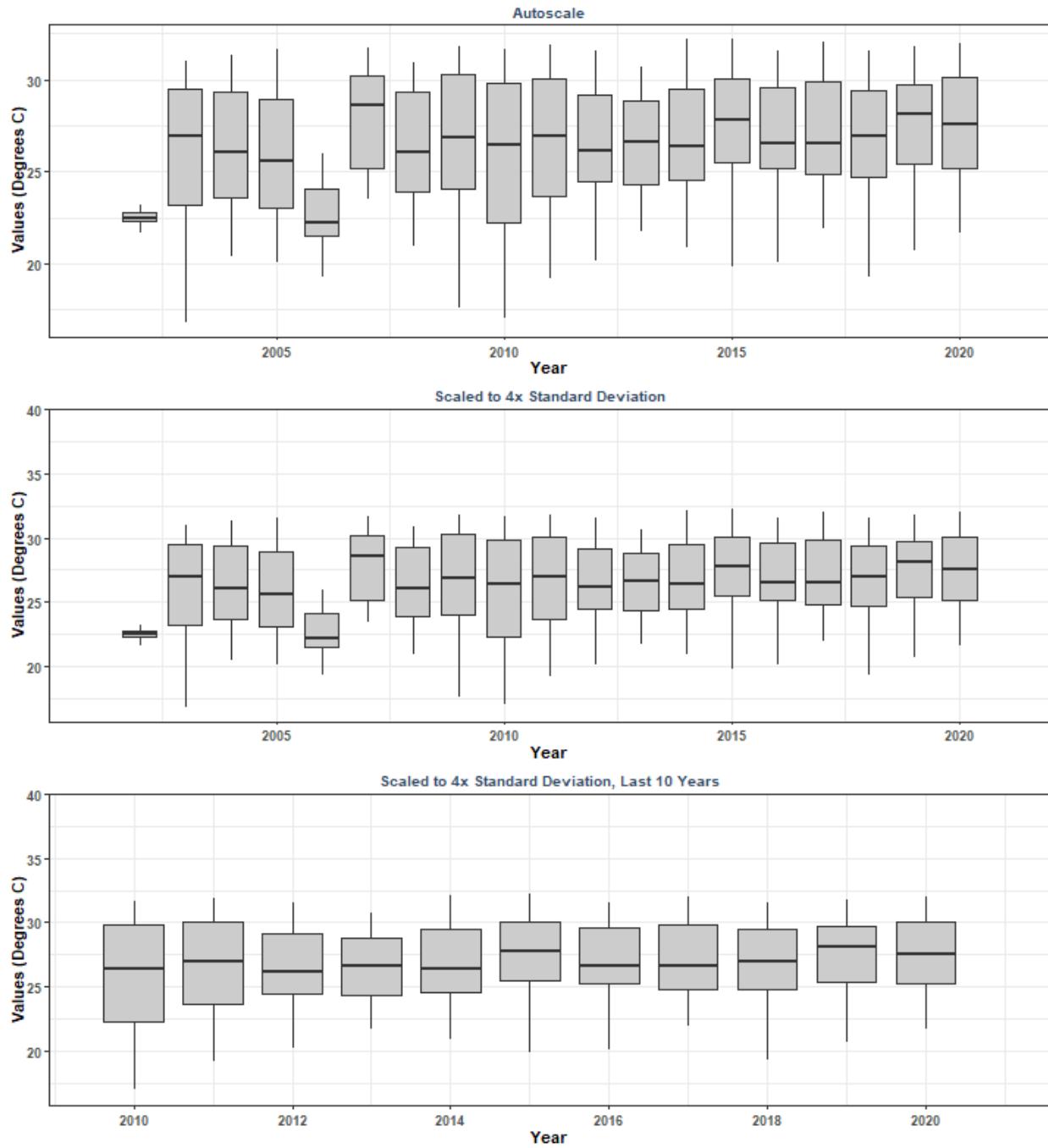


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 36
 By Month

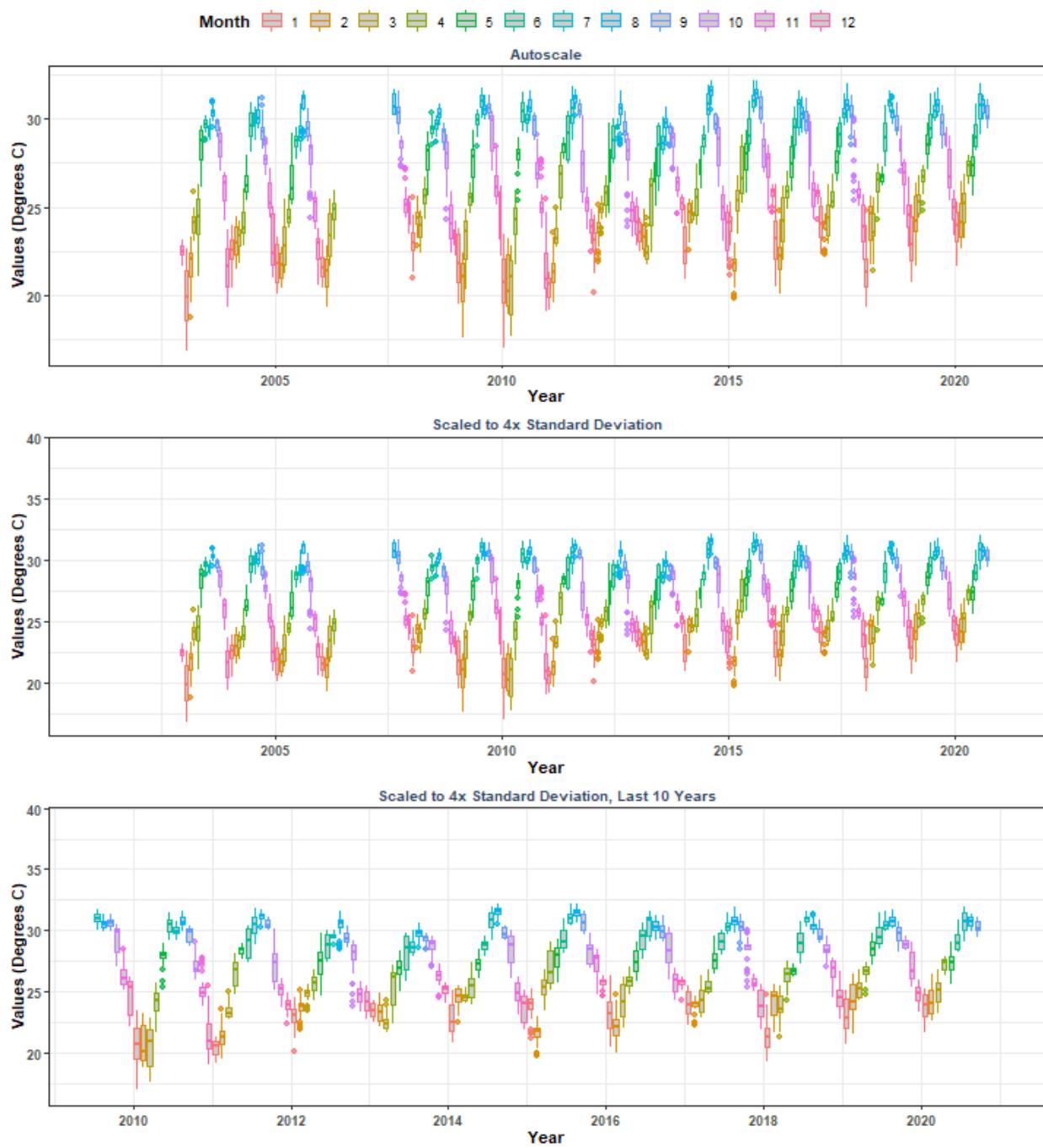


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 38**

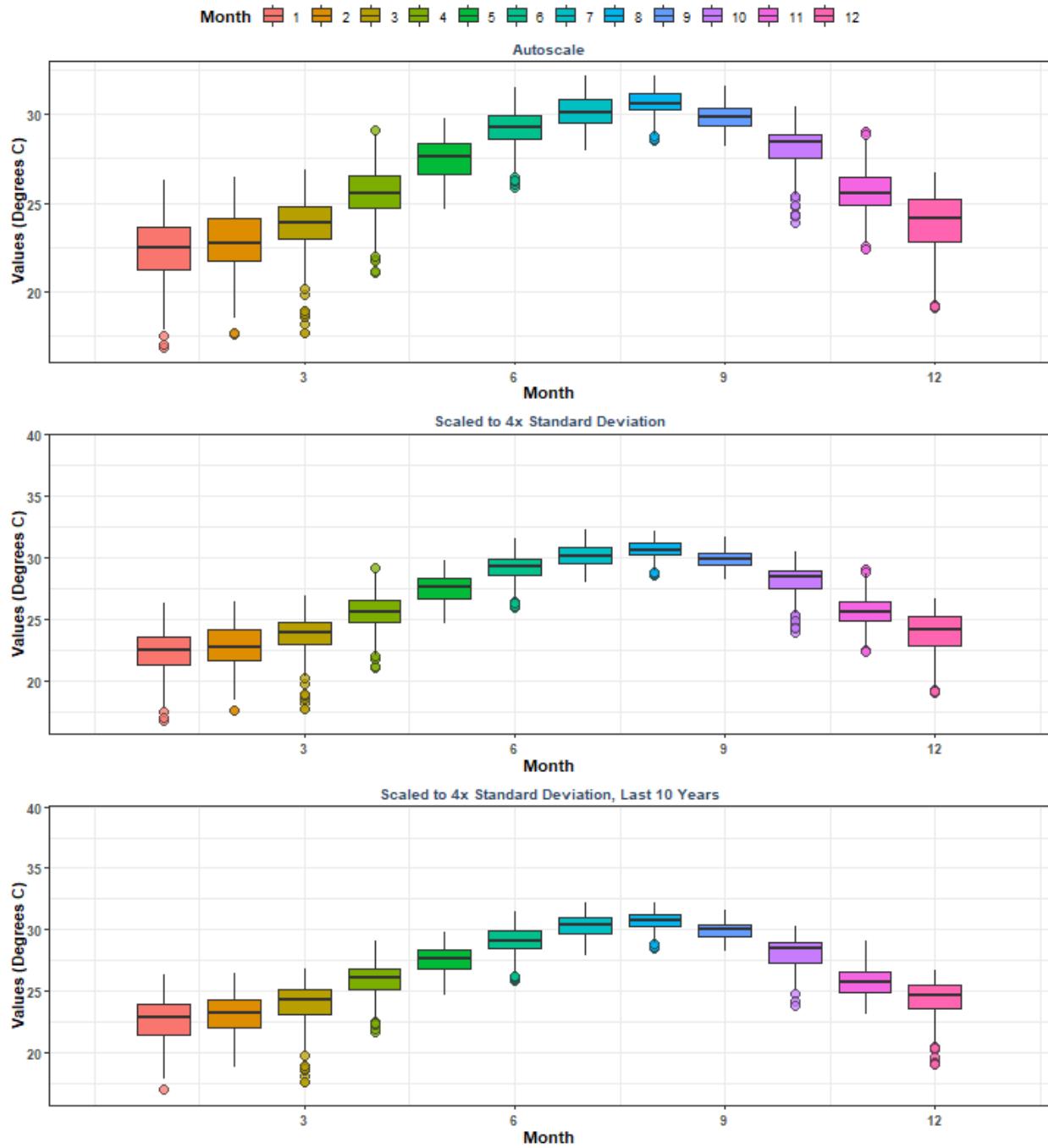
By Year



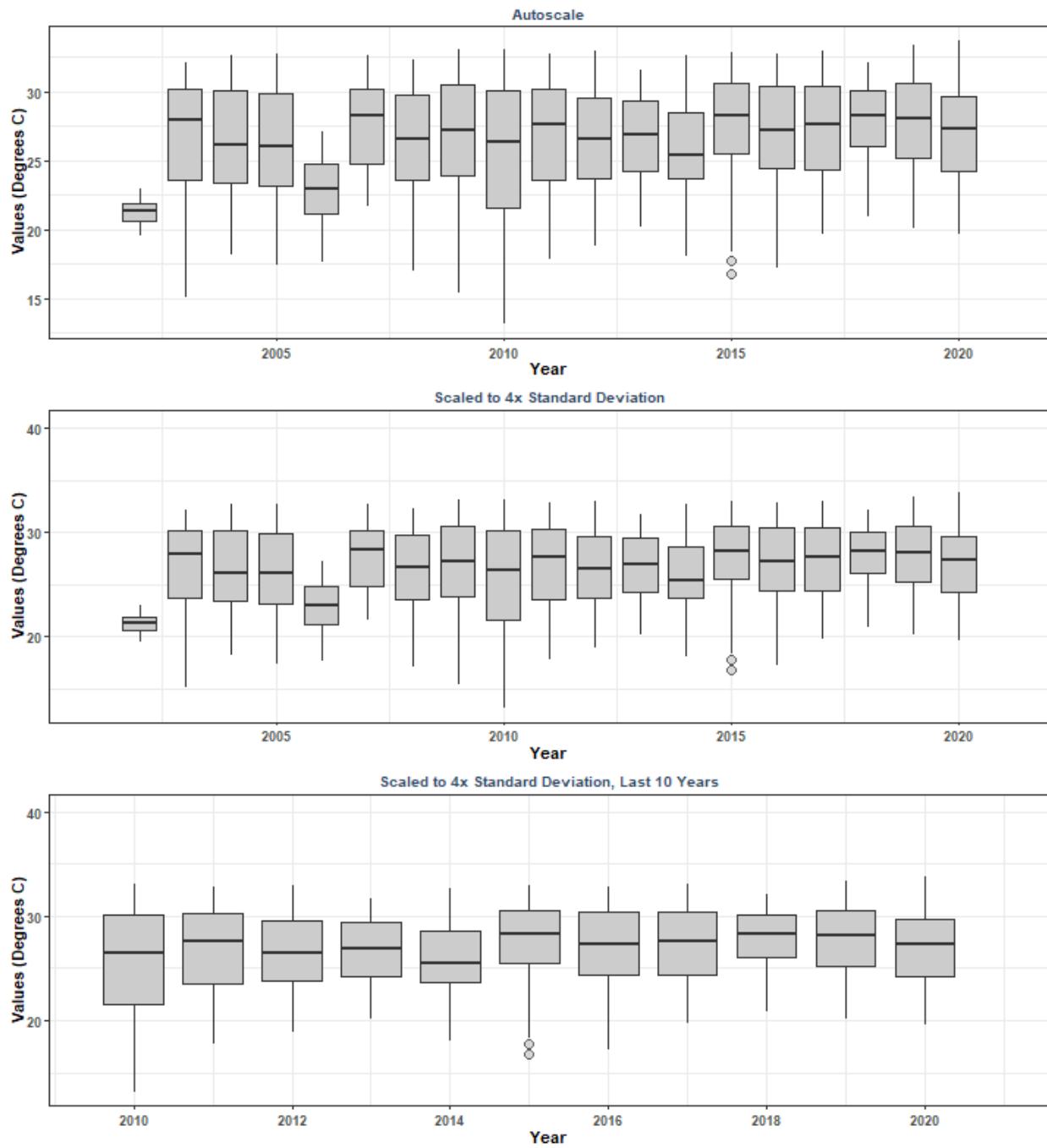
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 38
By Year & Month



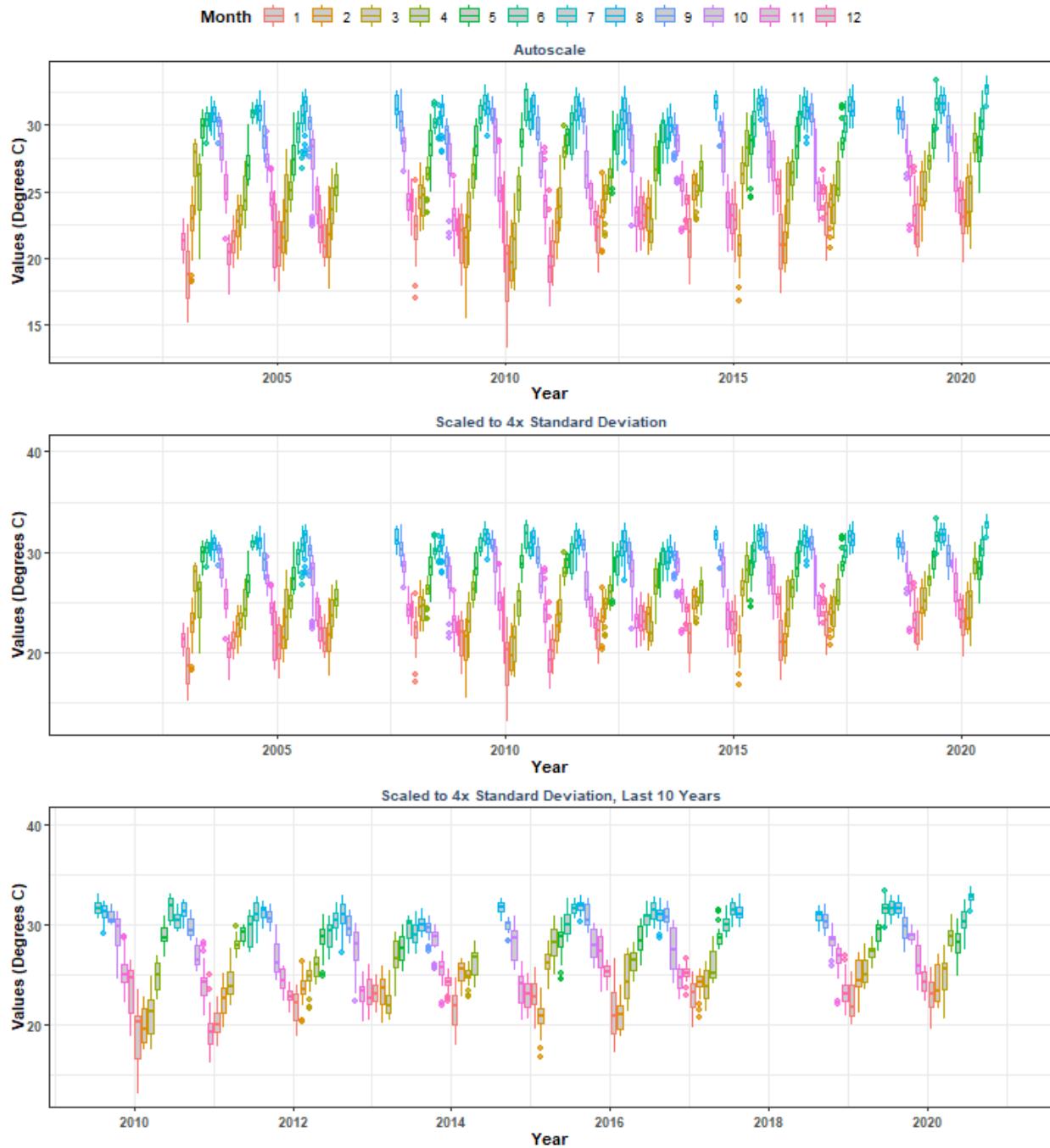
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 38
 By Month



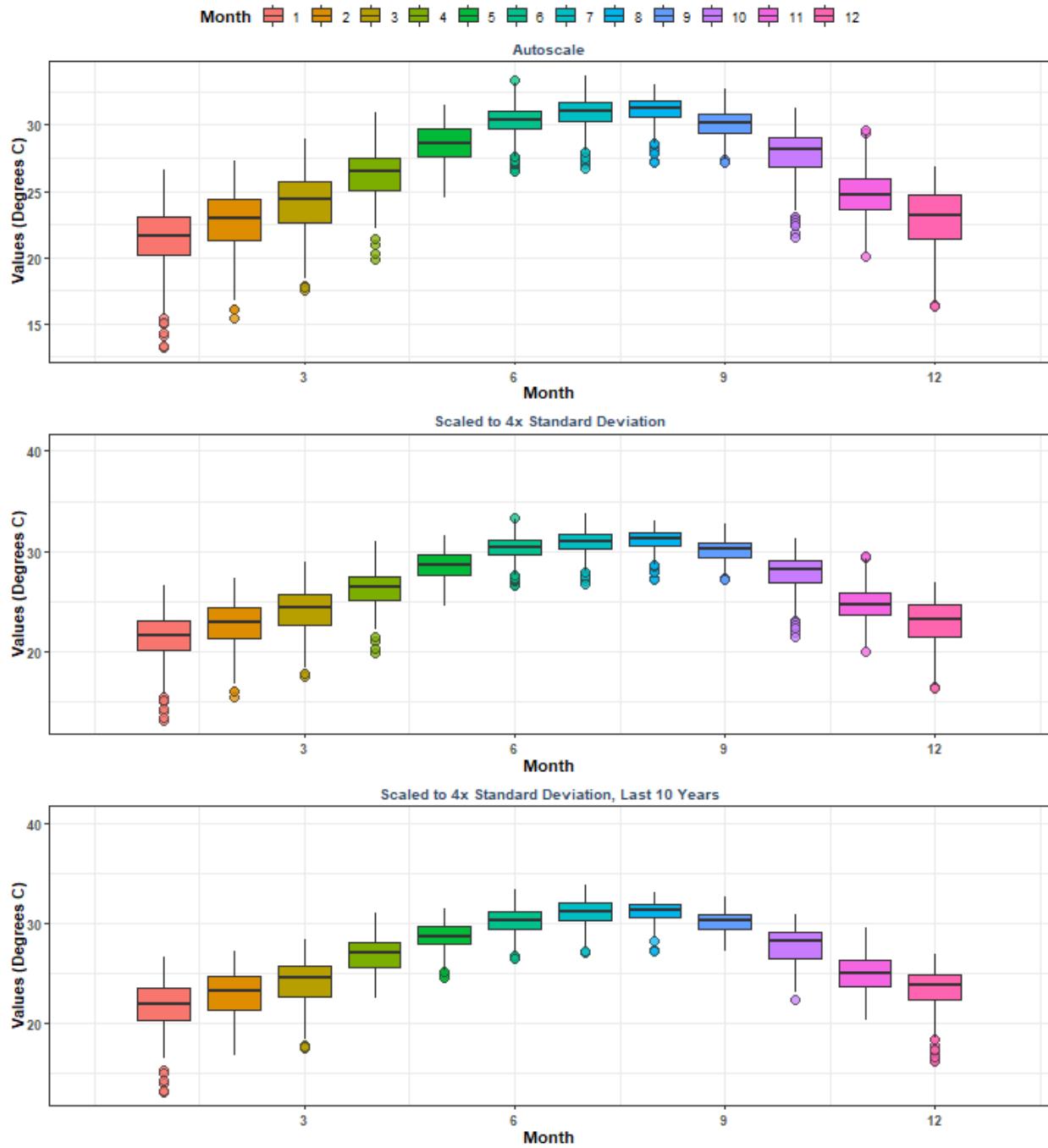
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 40**
By Year



**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 40**
By Year & Month

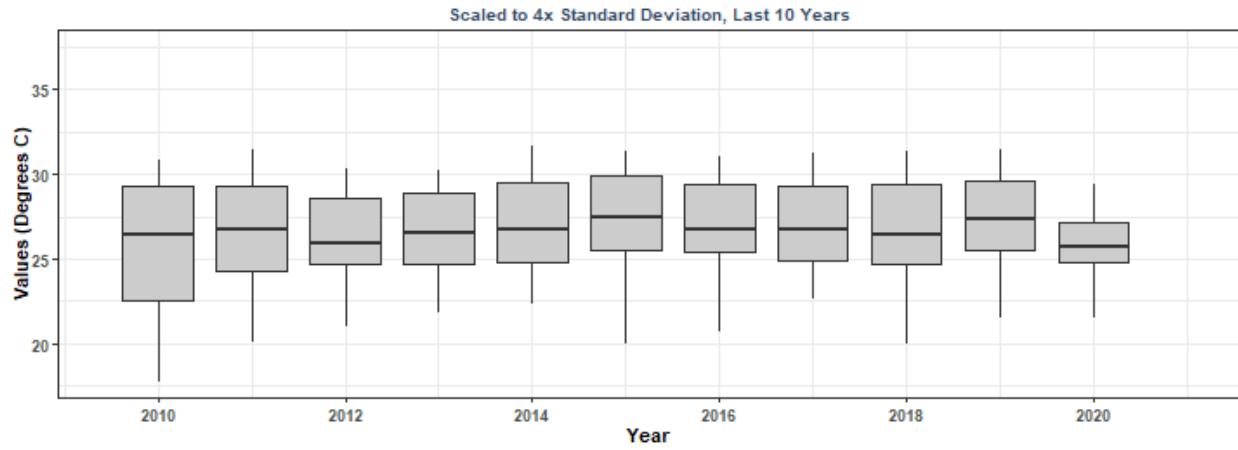
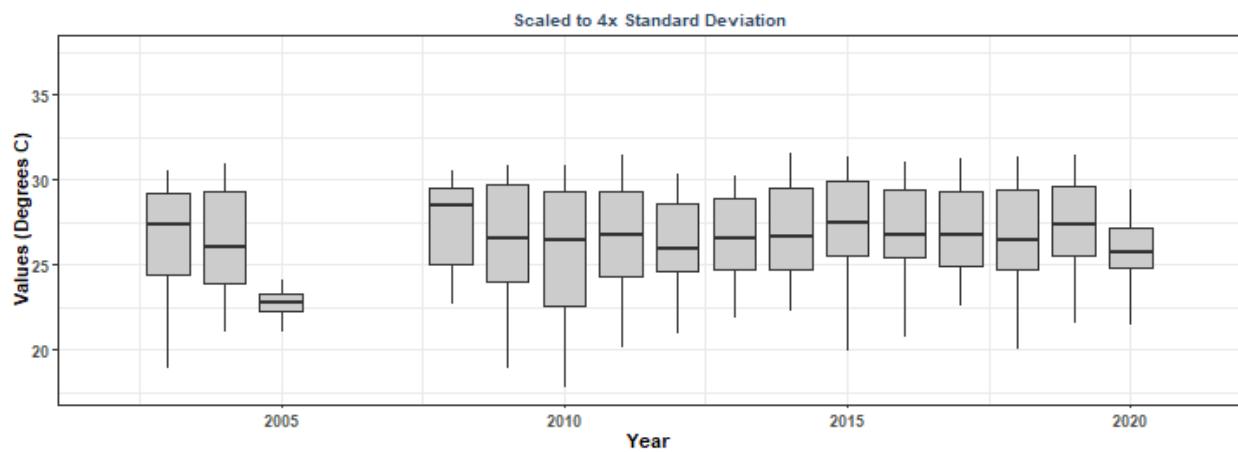
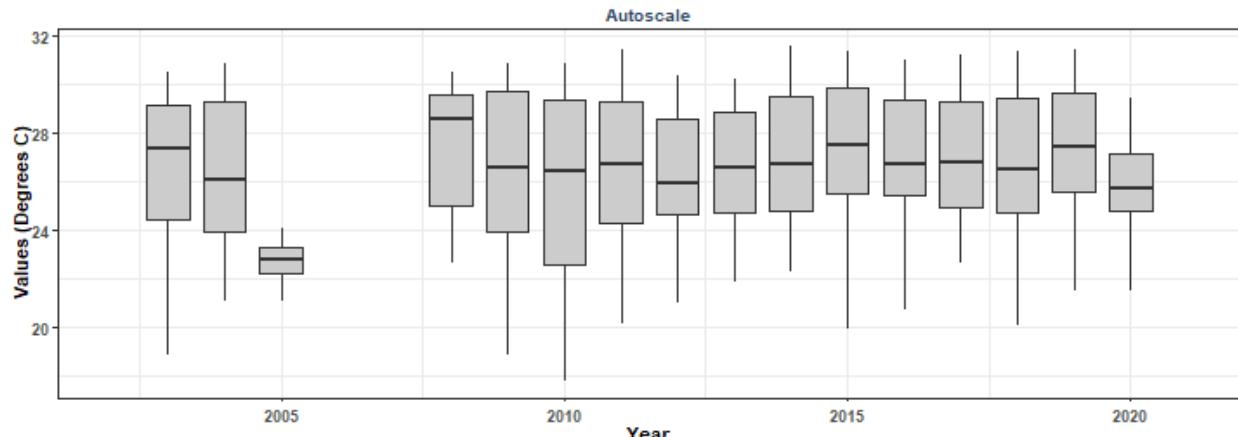


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 40
 By Month

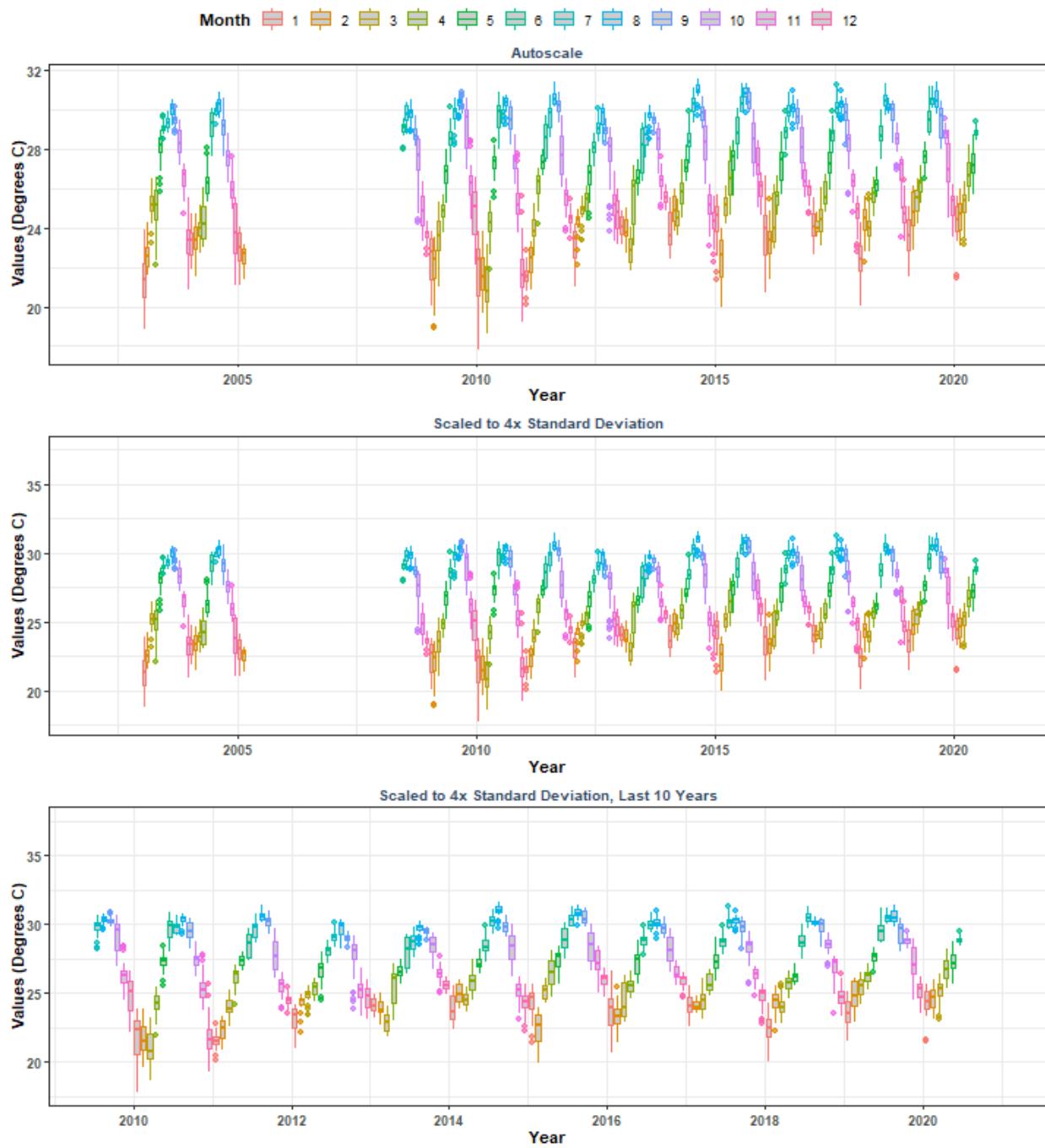


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 51**

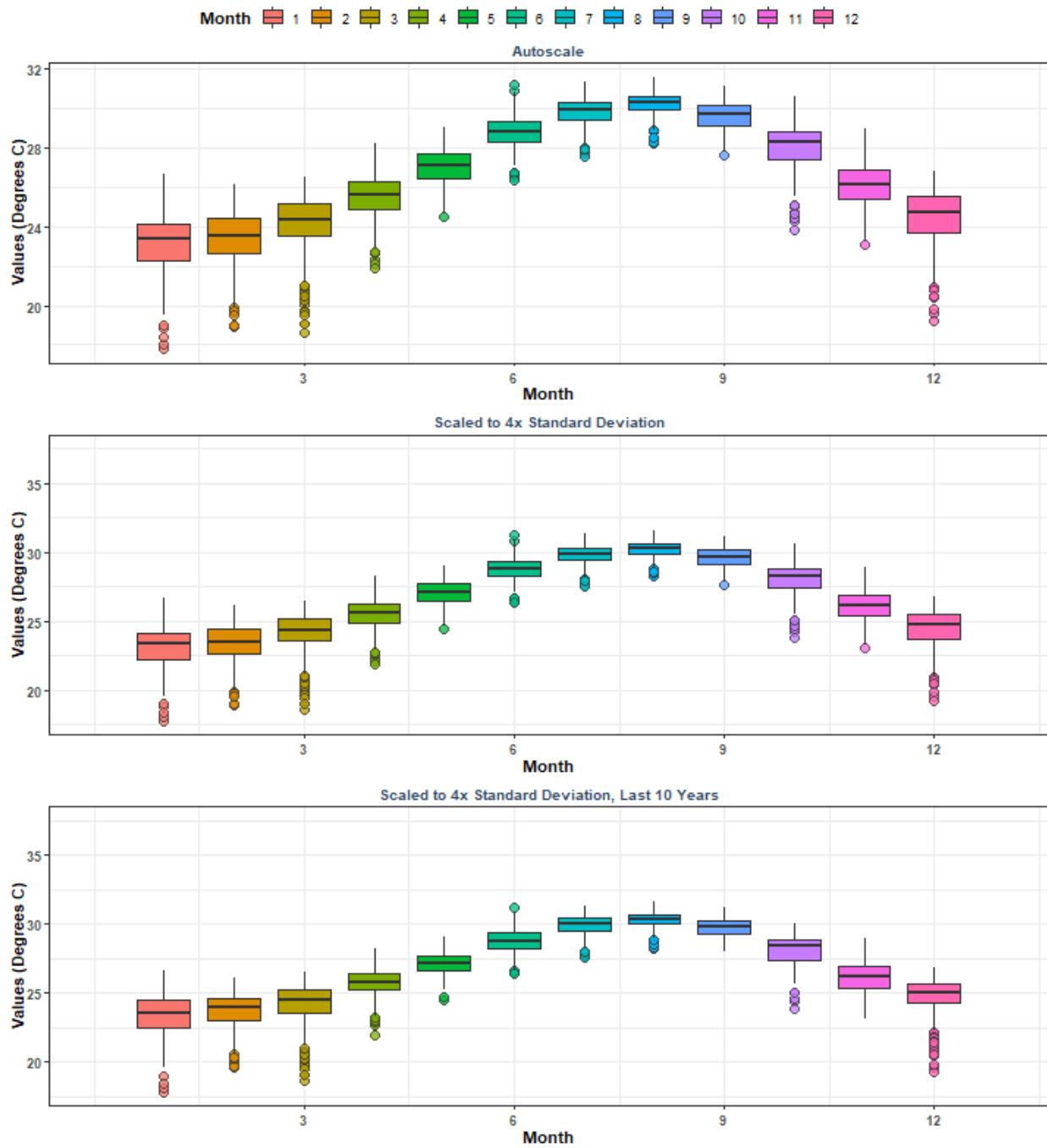
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 51
By Year & Month

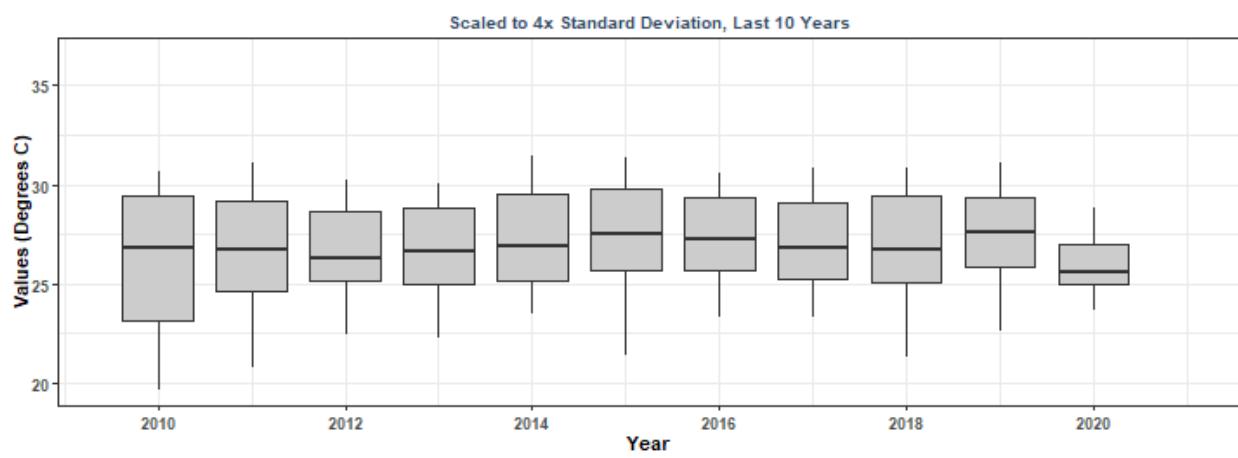
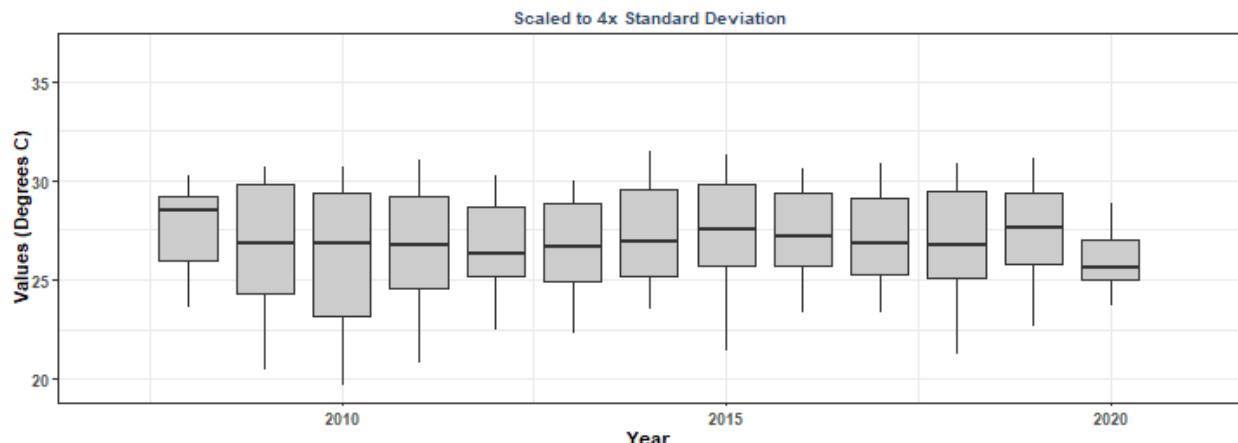
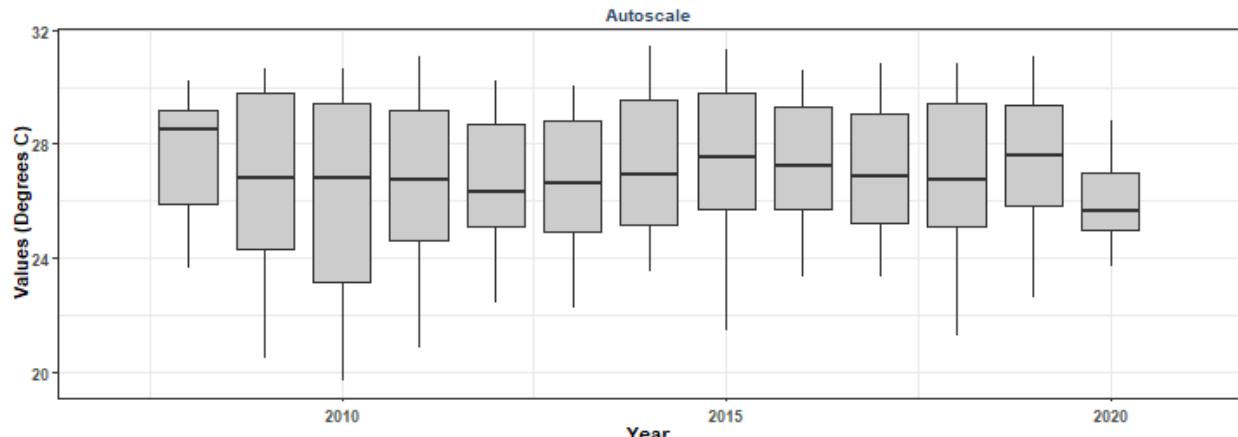


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 51
 By Month

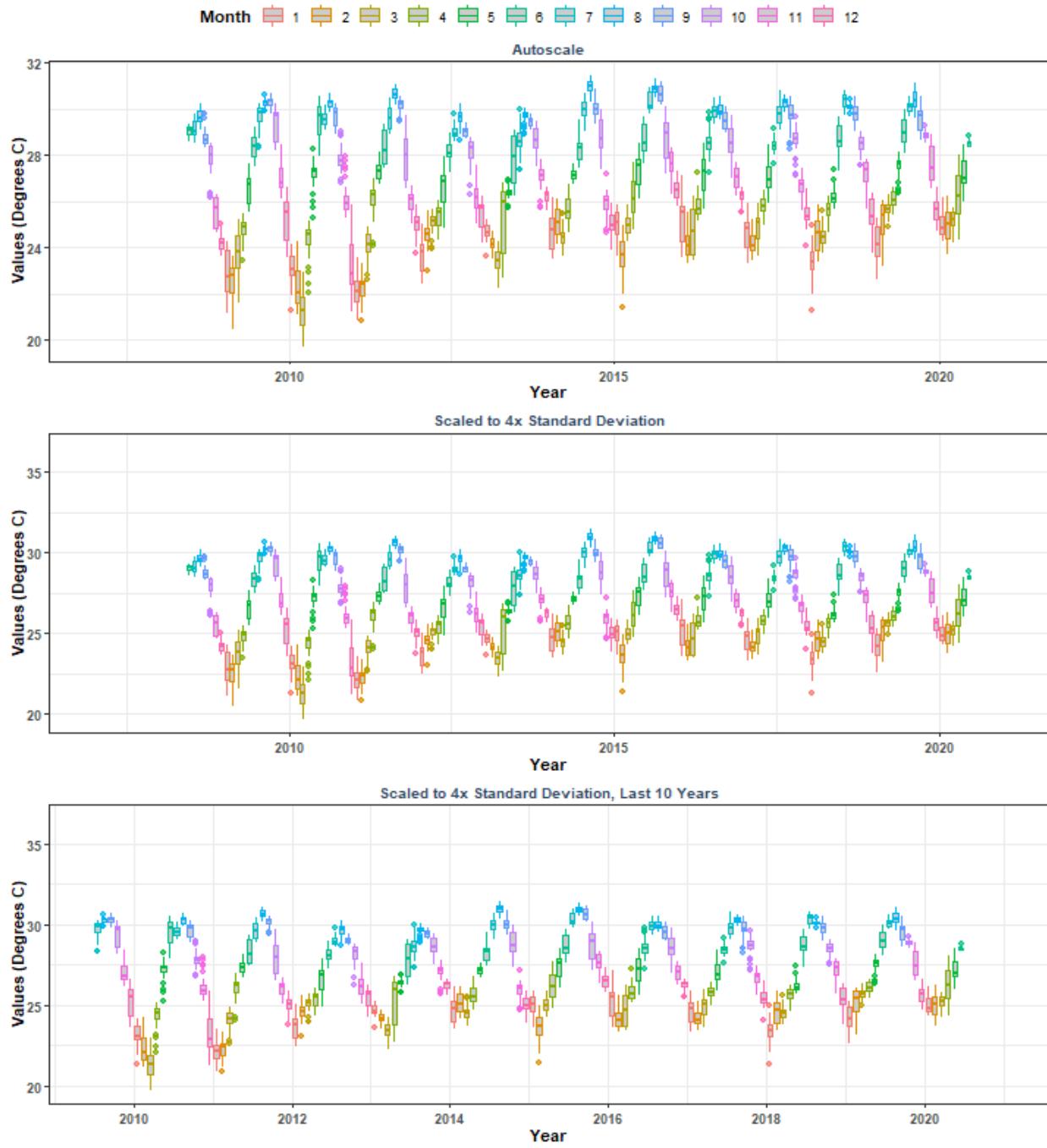


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 52**

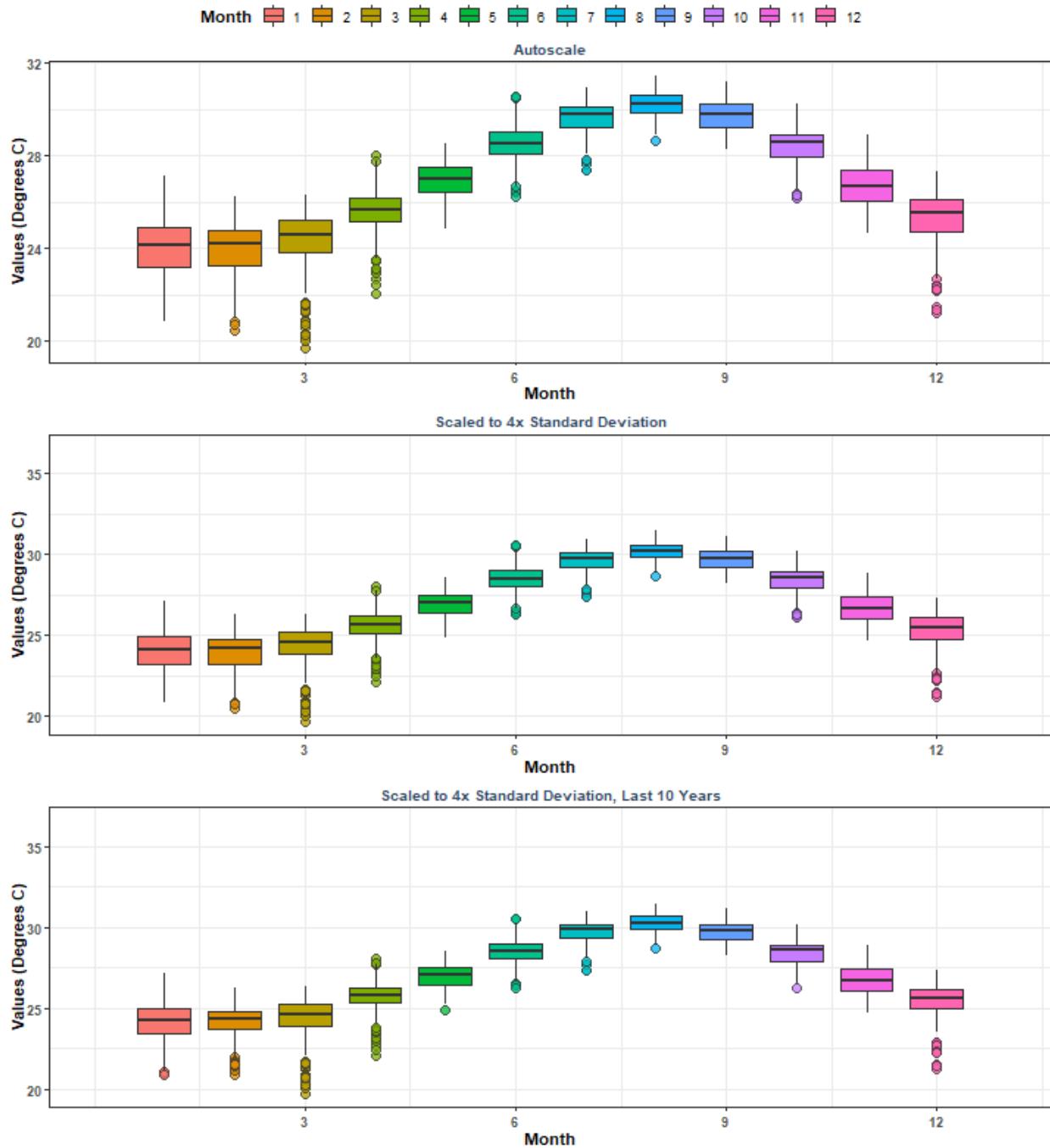
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 52
By Year & Month

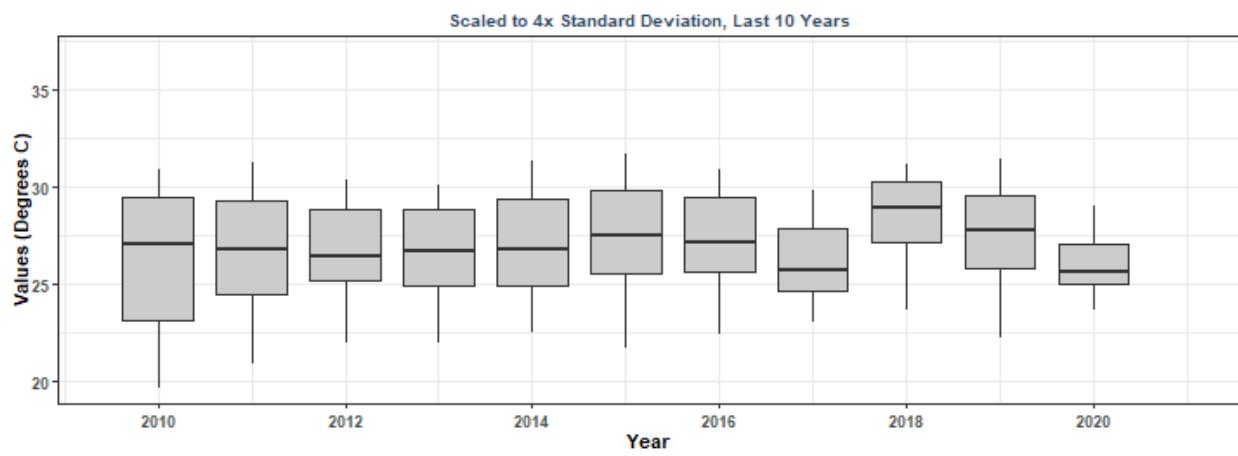
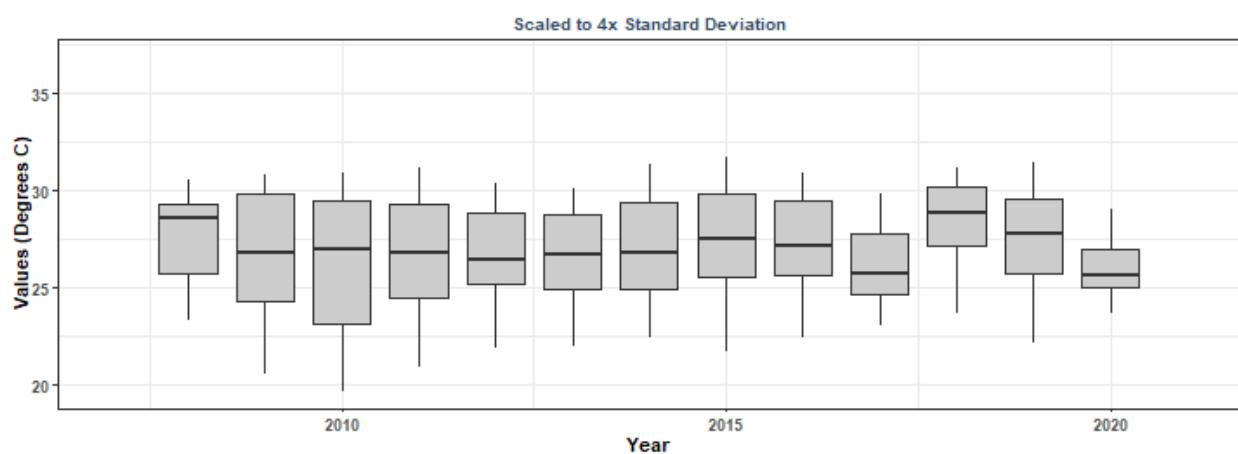
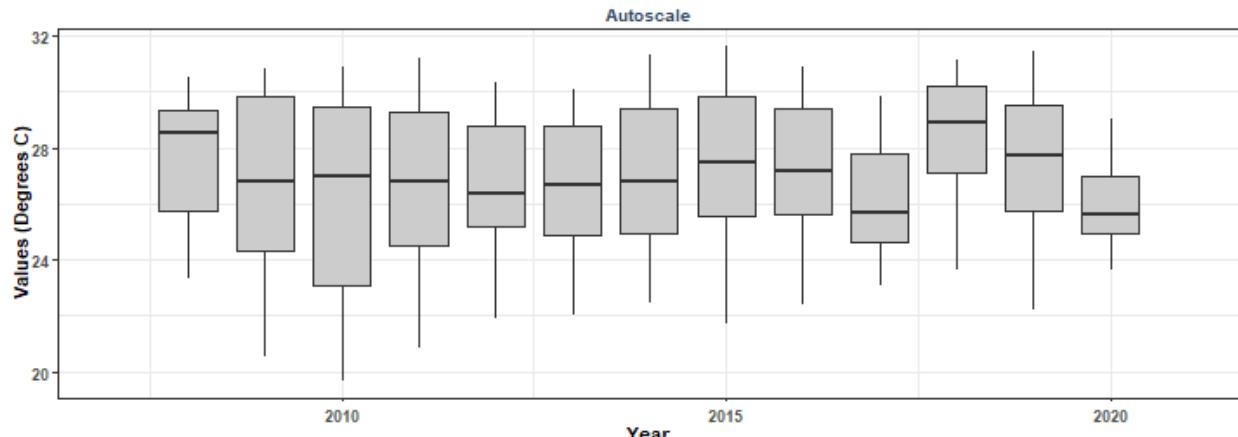


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 52
 By Month

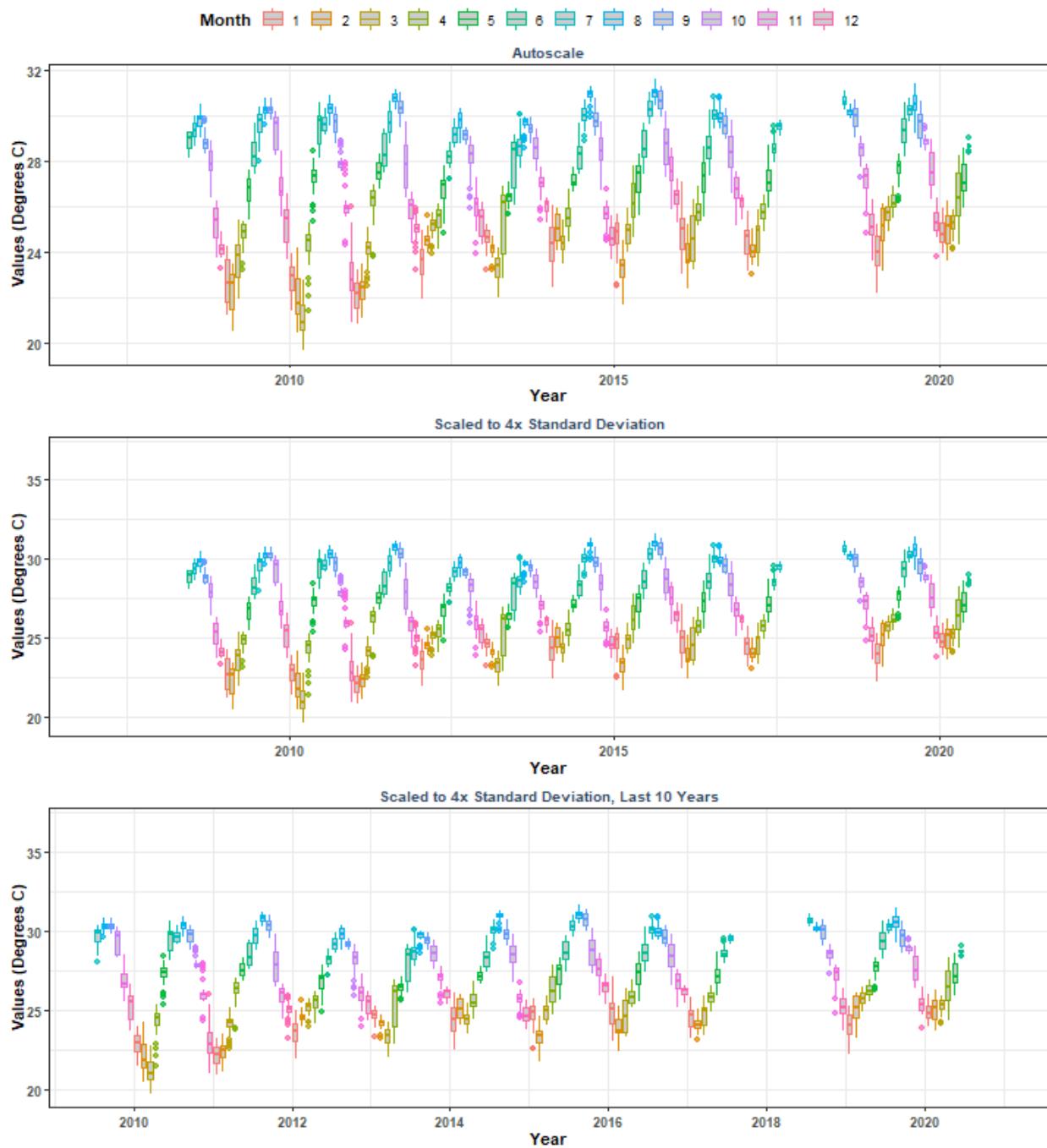


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 53**

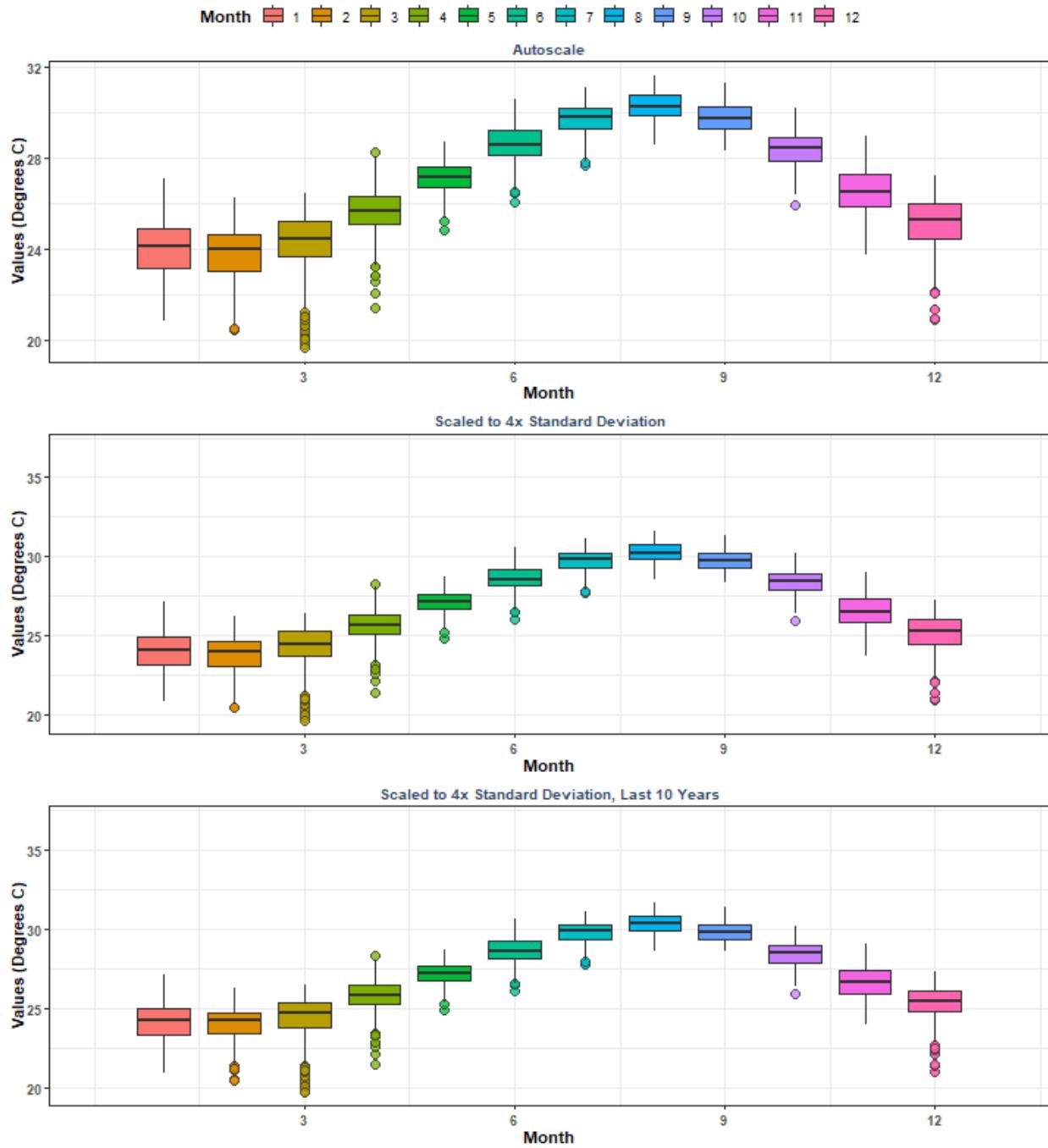
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 53
 By Year & Month

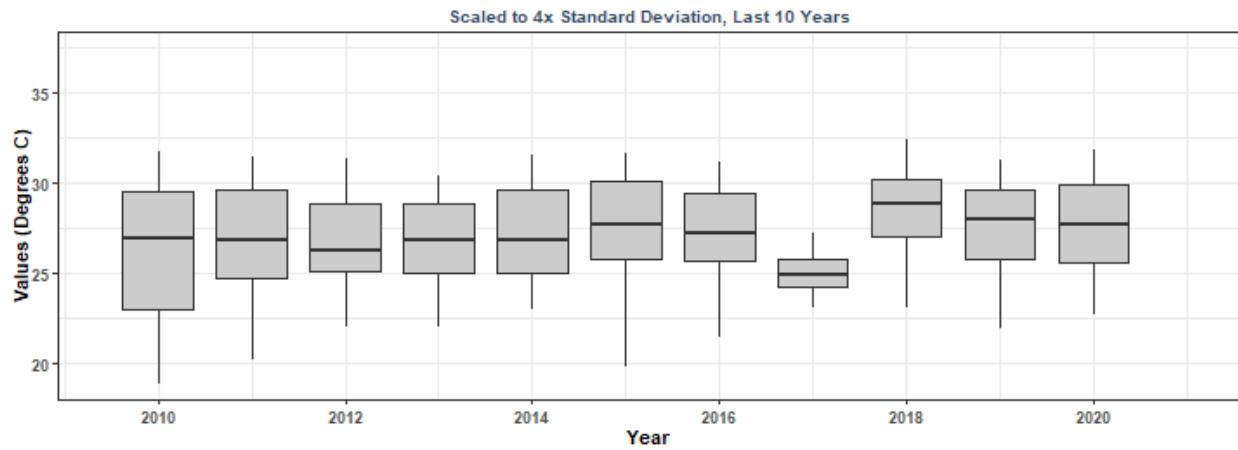
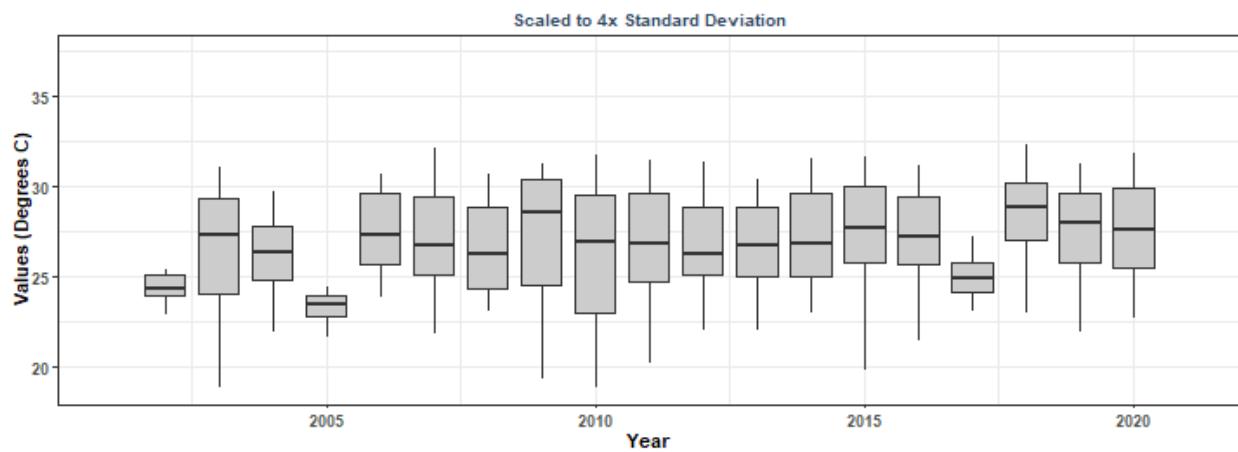
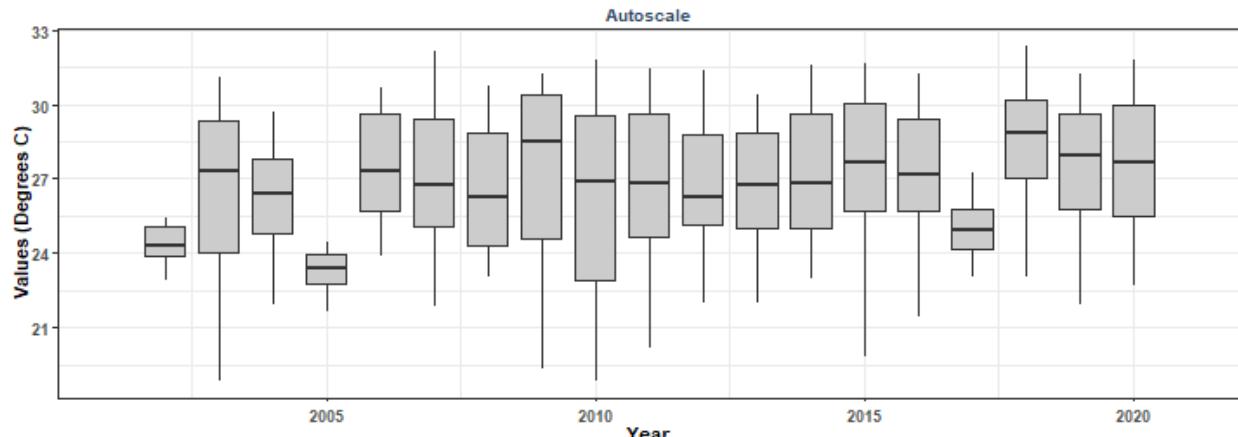


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 53
 By Month

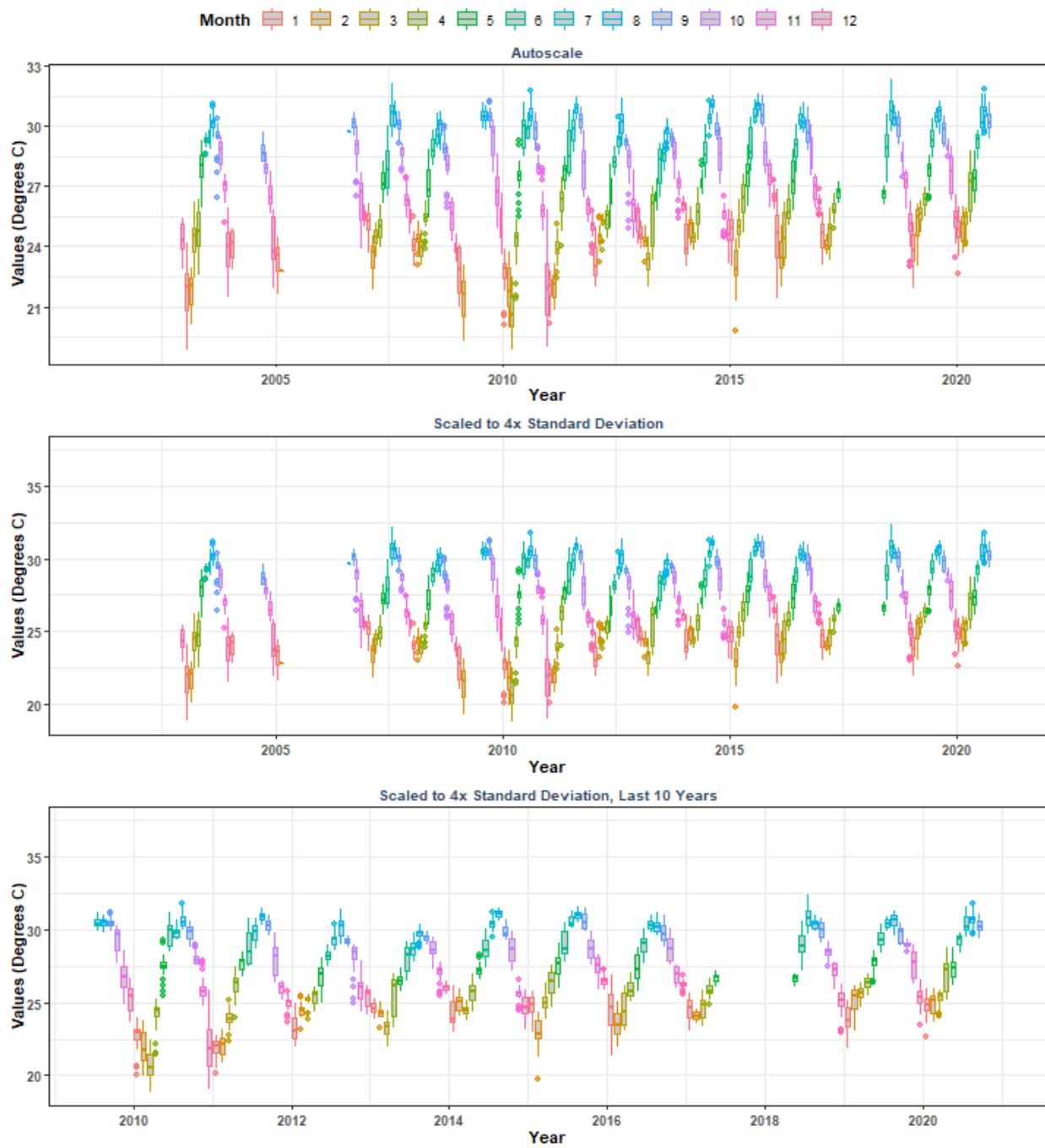


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 55**

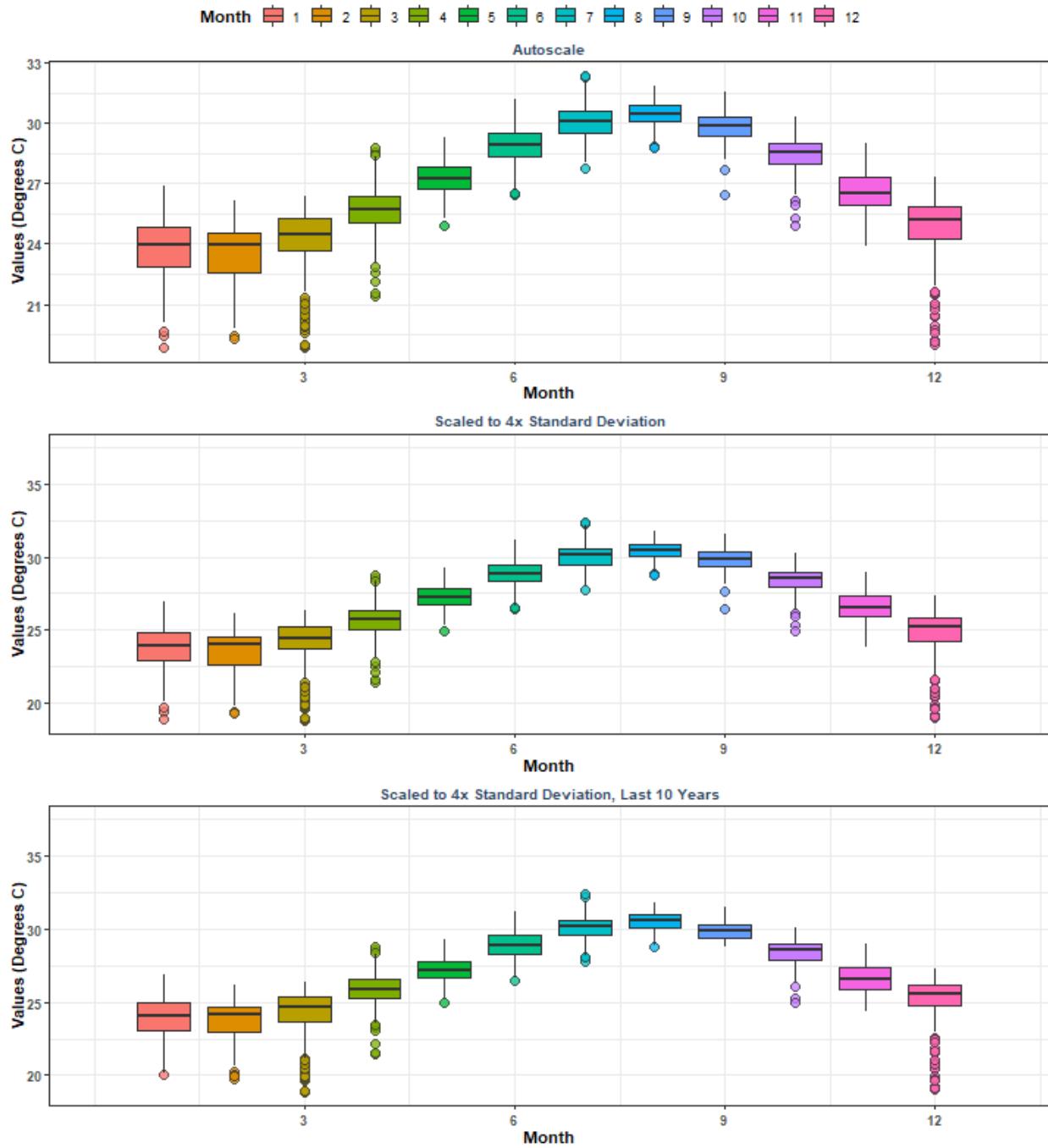
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 55
 By Year & Month

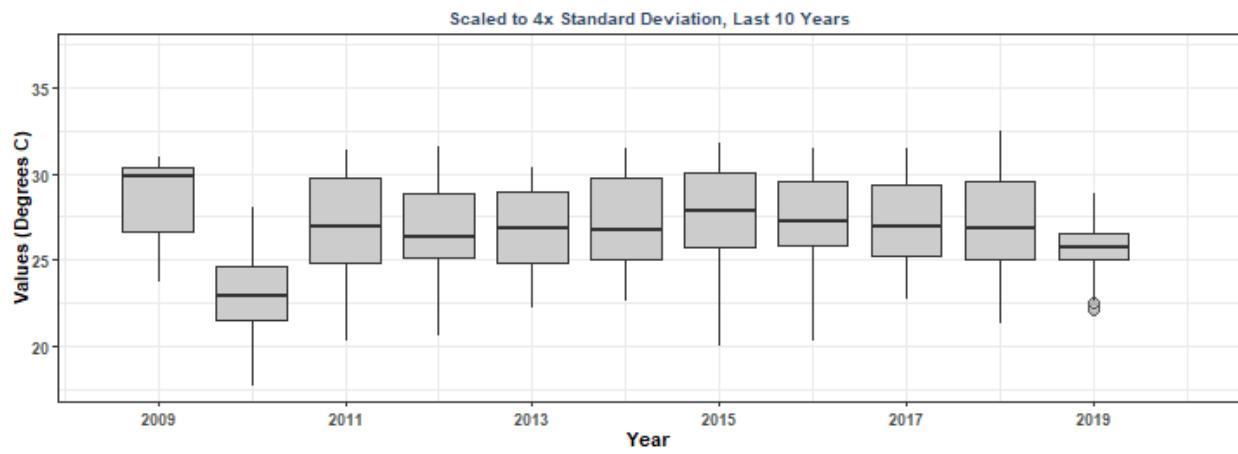
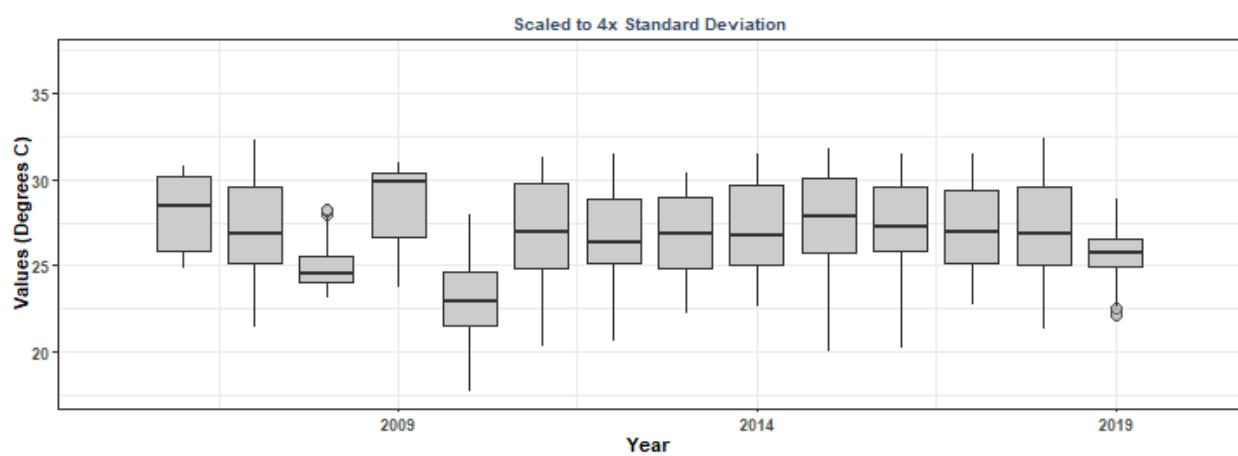
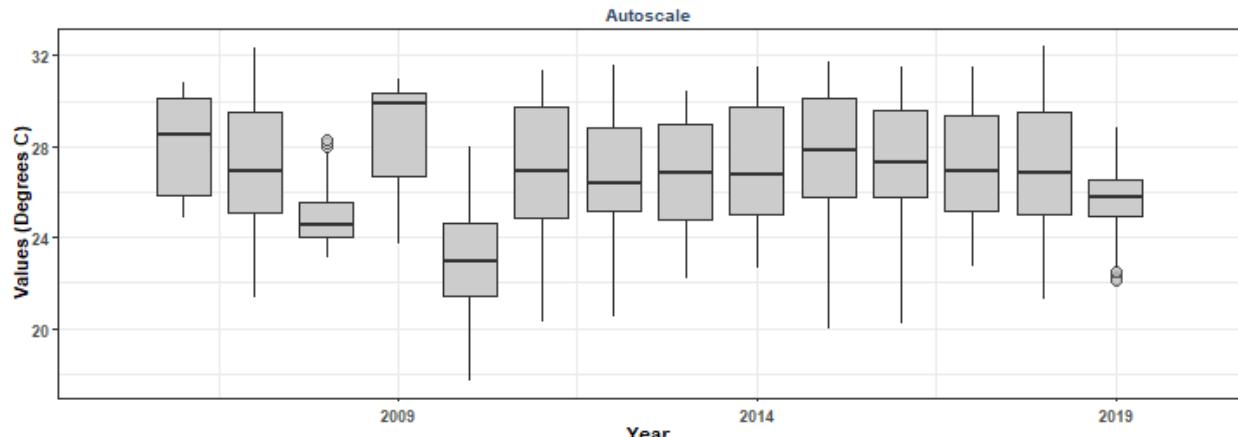


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 55
 By Month

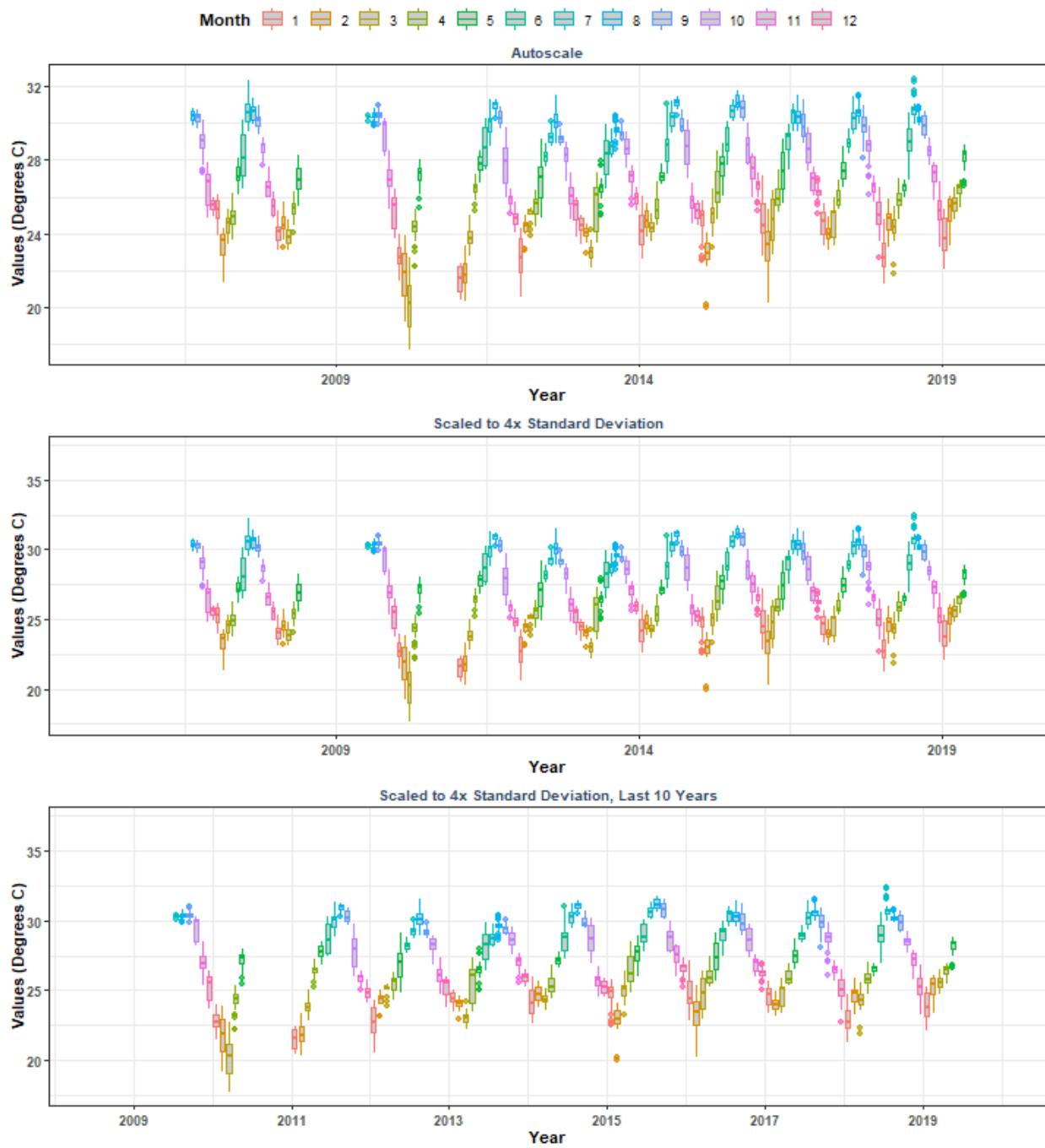


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 56**

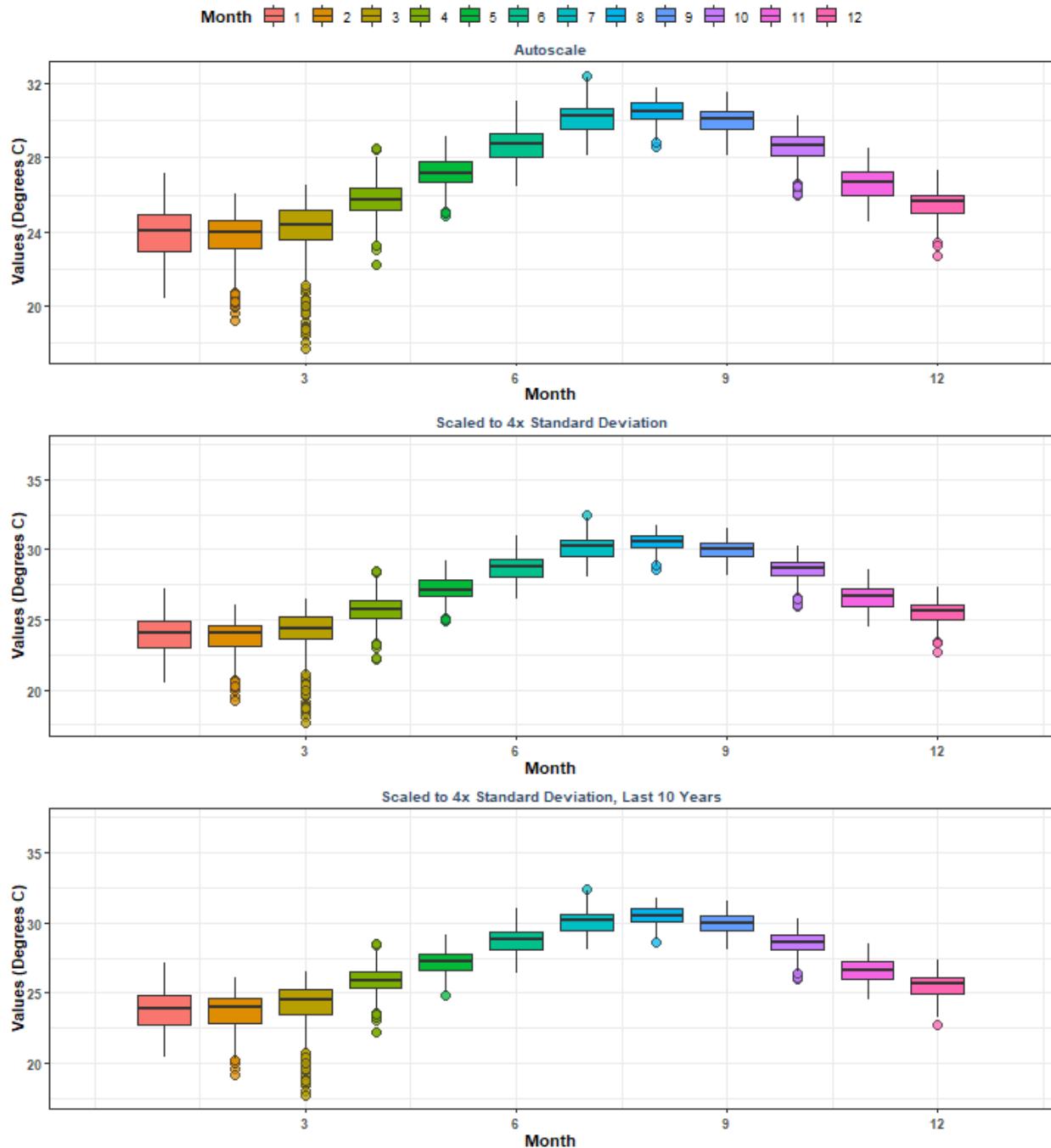
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 56
 By Year & Month

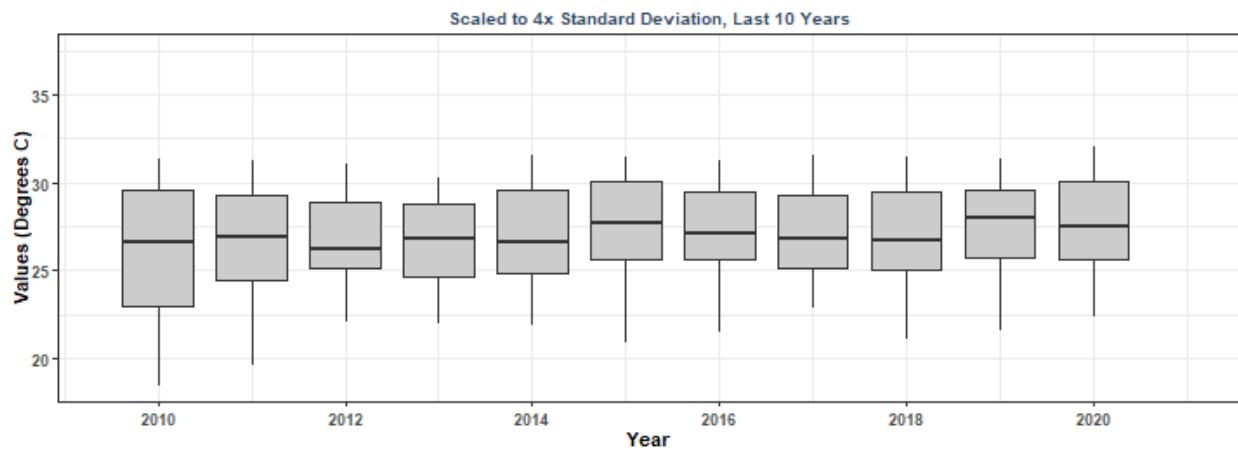
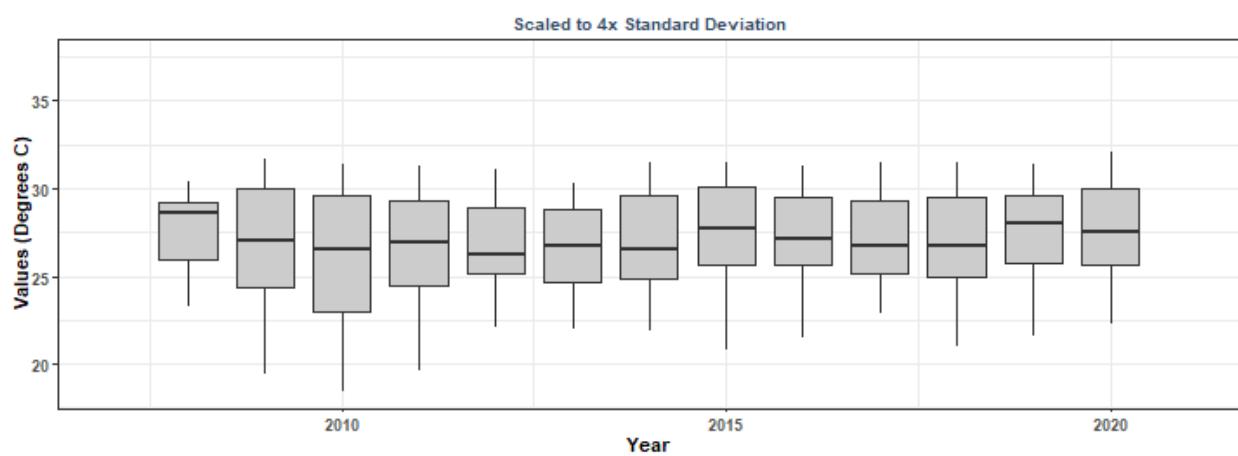
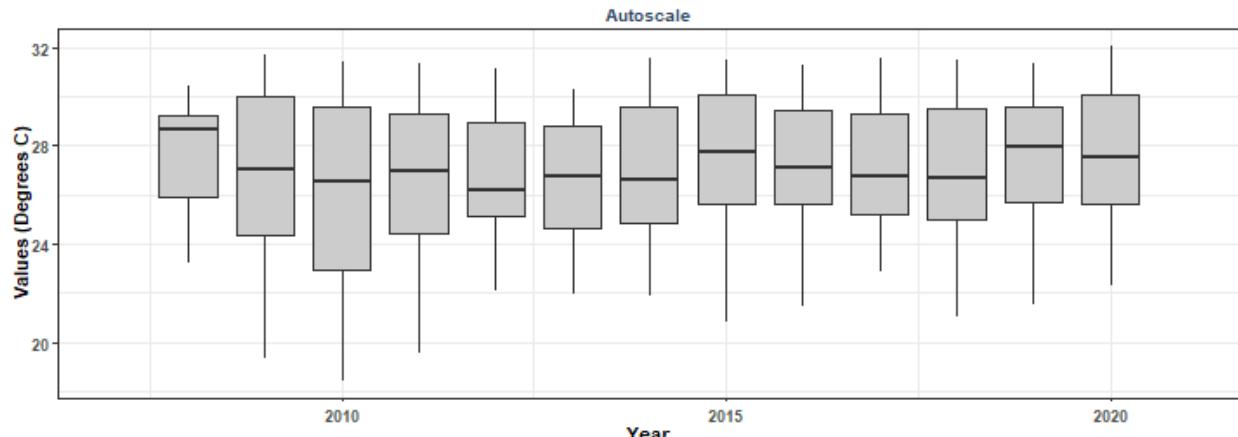


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 56
 By Month

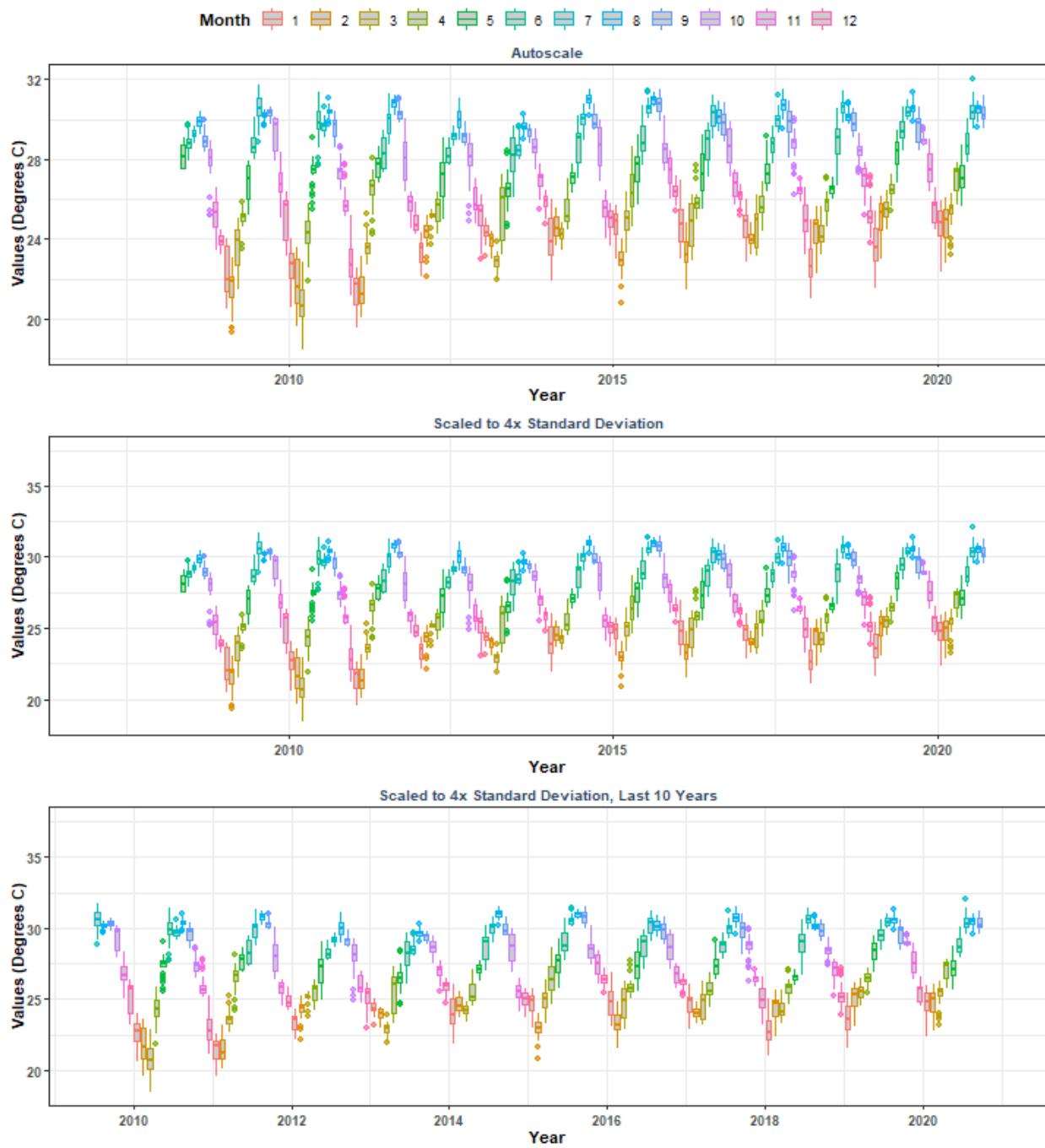


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 57**

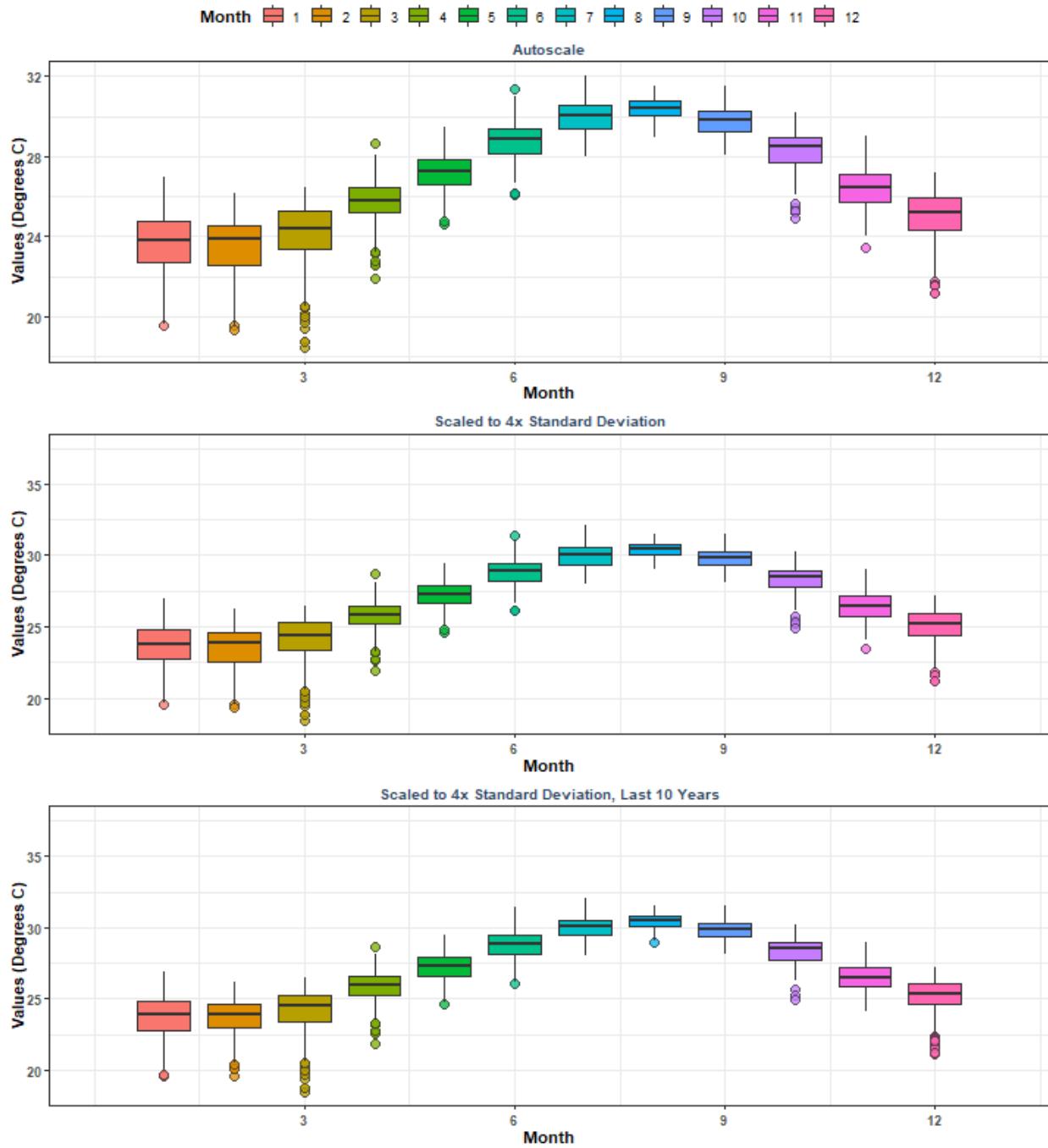
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 57
 By Year & Month

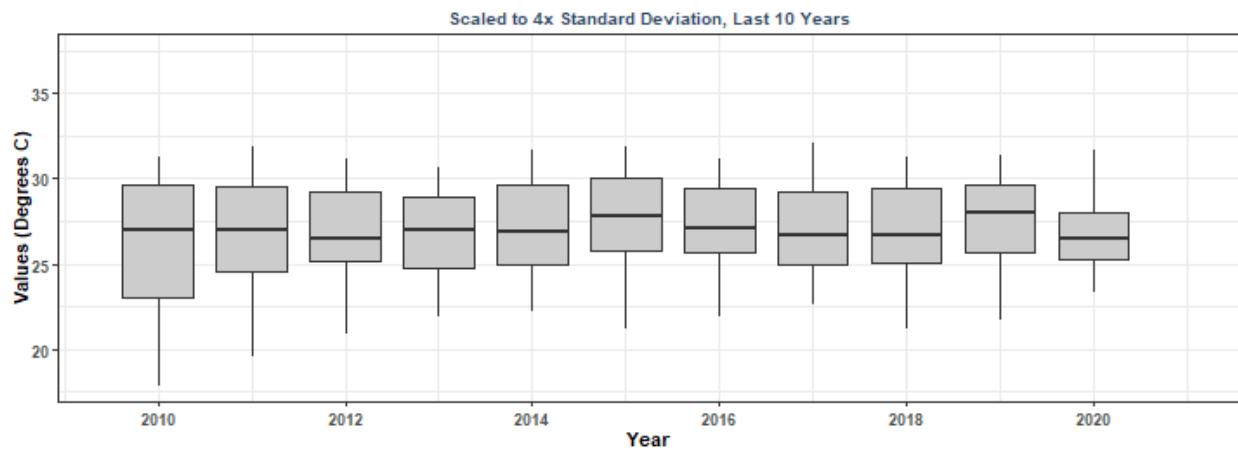
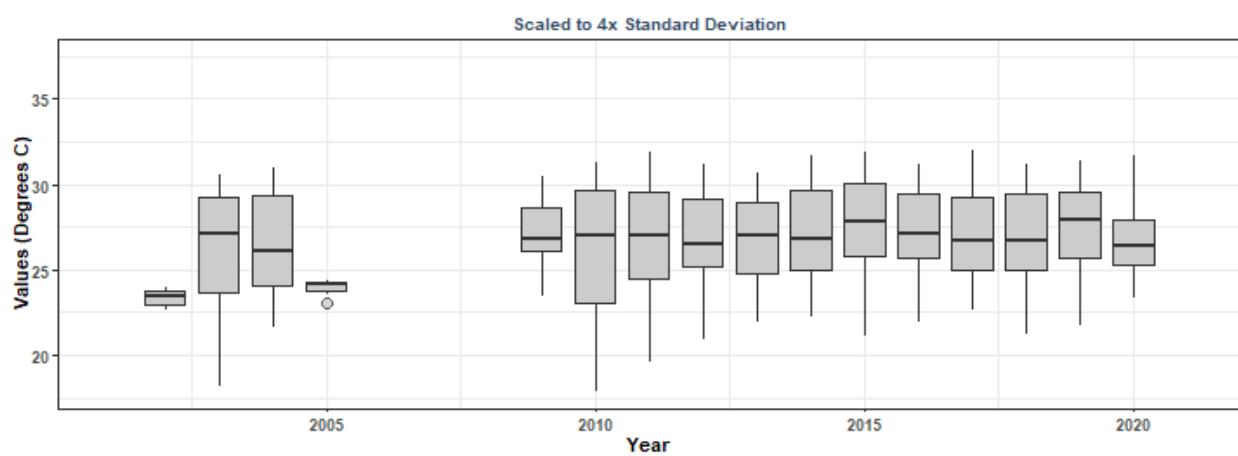
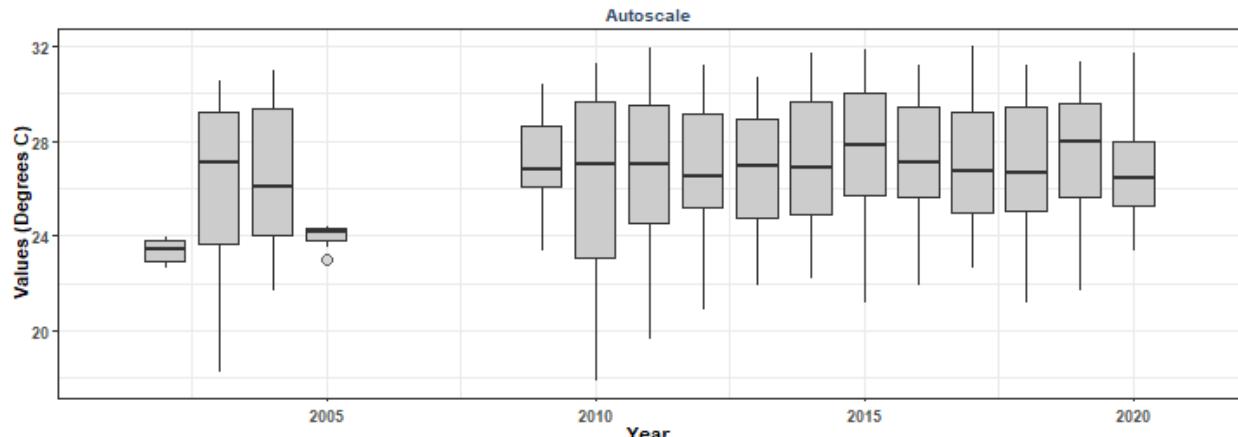


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 57
 By Month

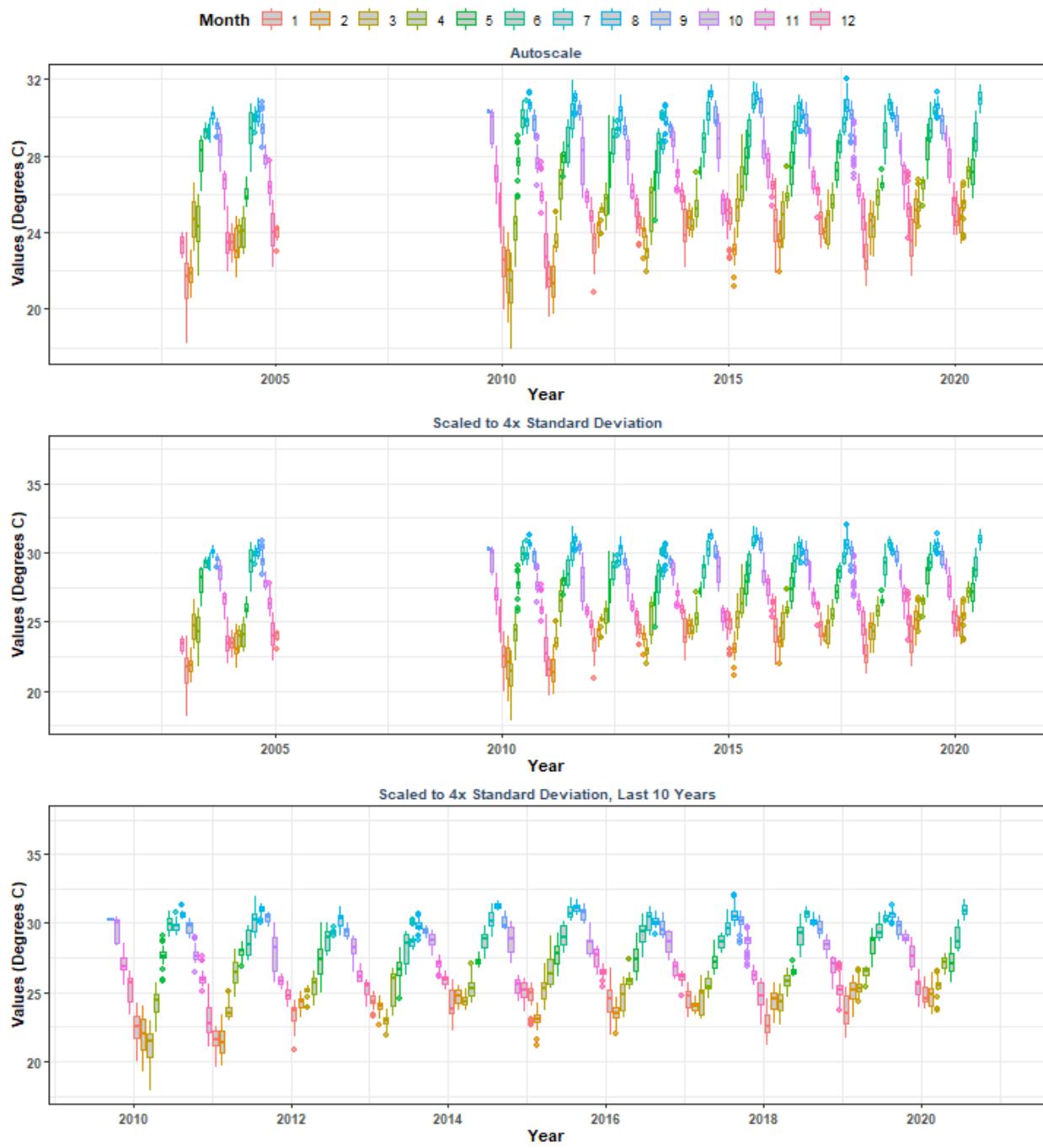


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 59**

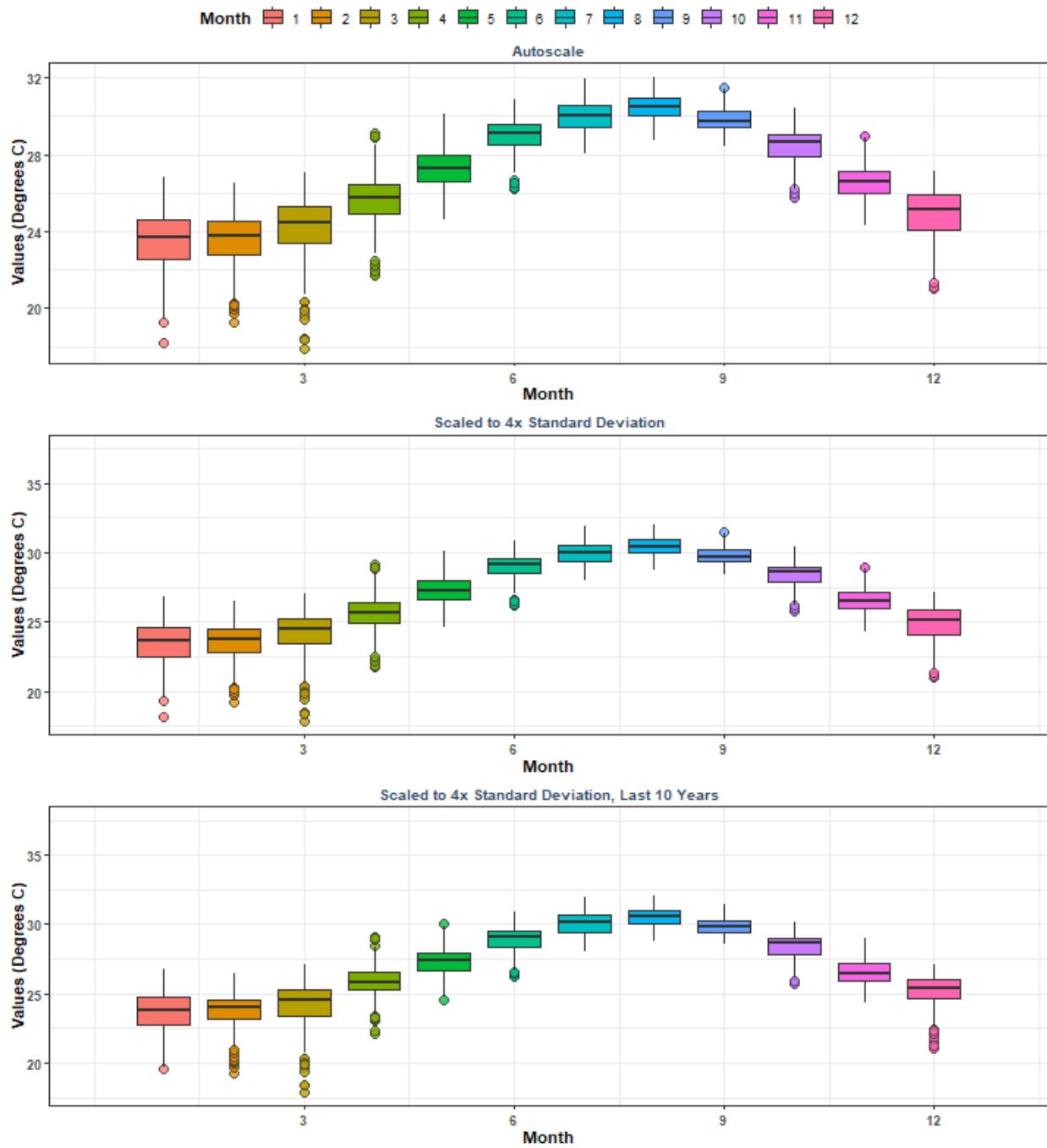
By Year



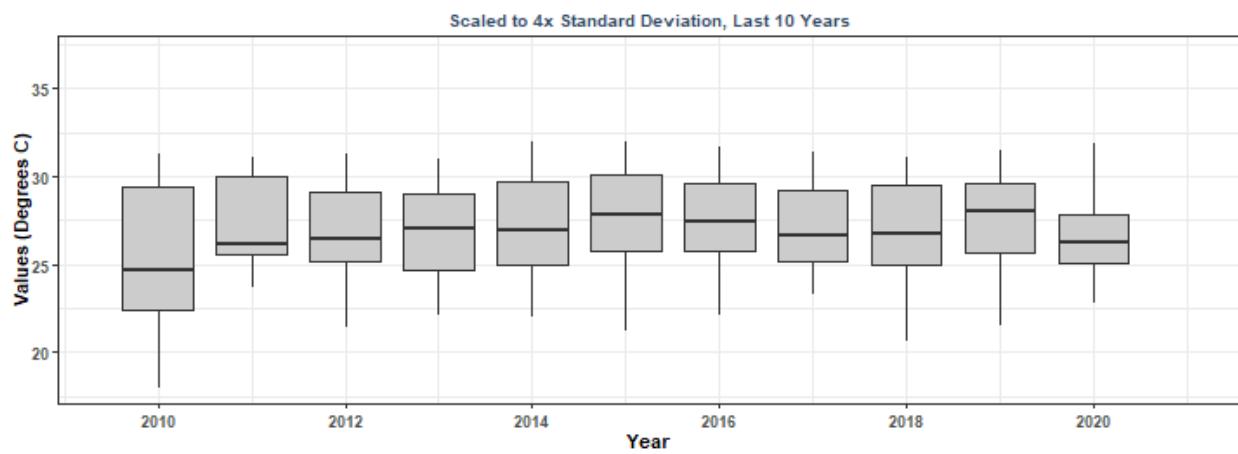
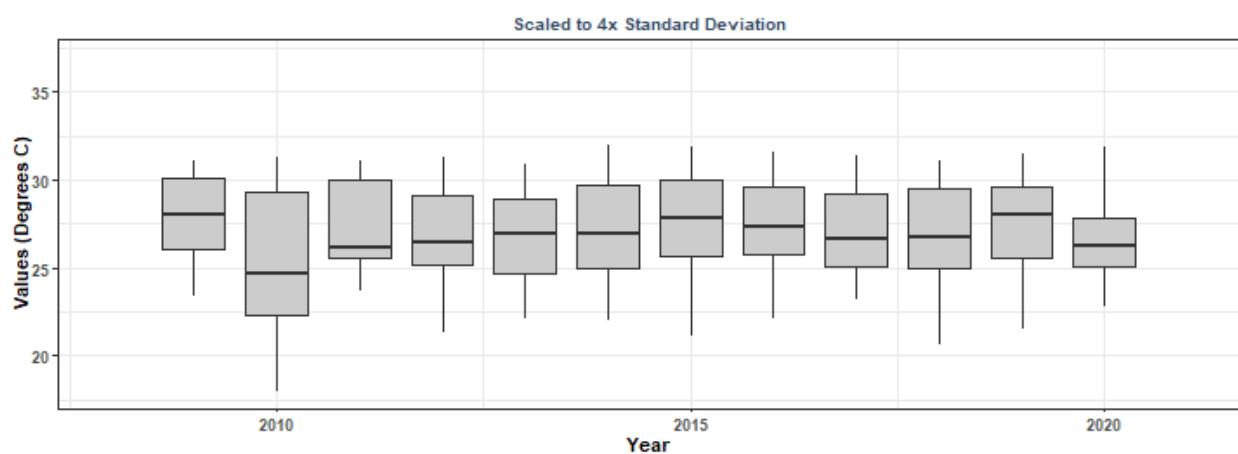
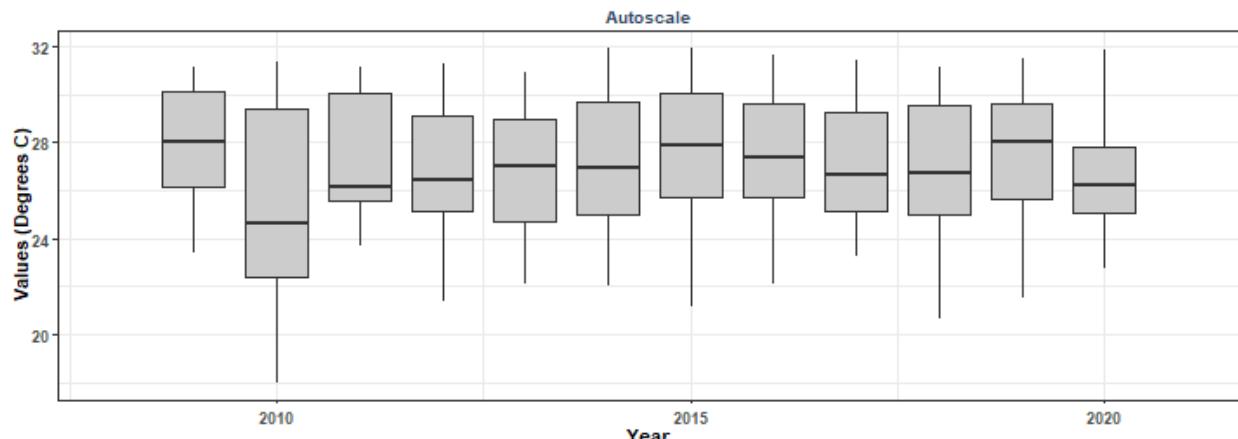
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 59
By Year & Month



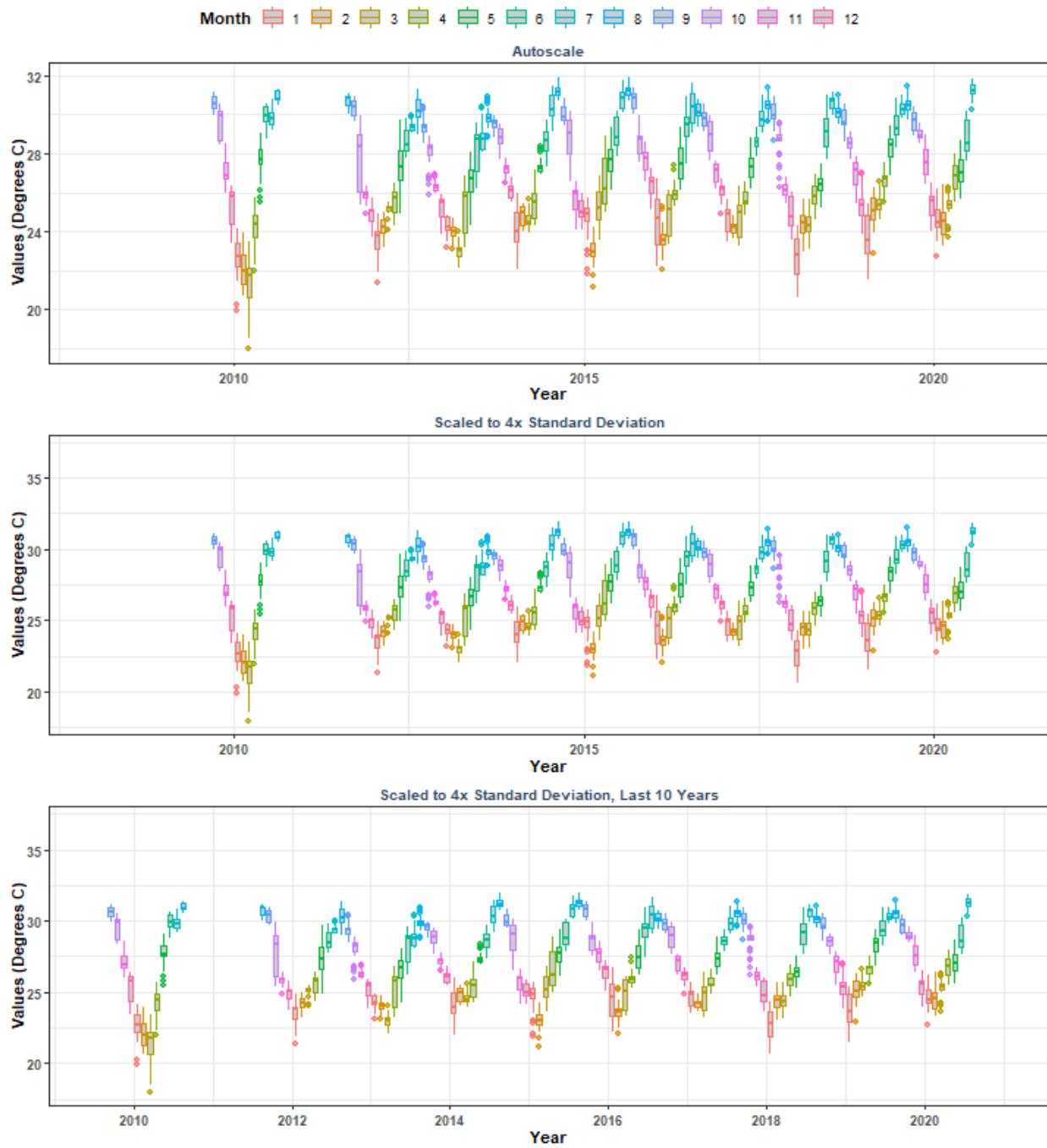
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 59
 By Month



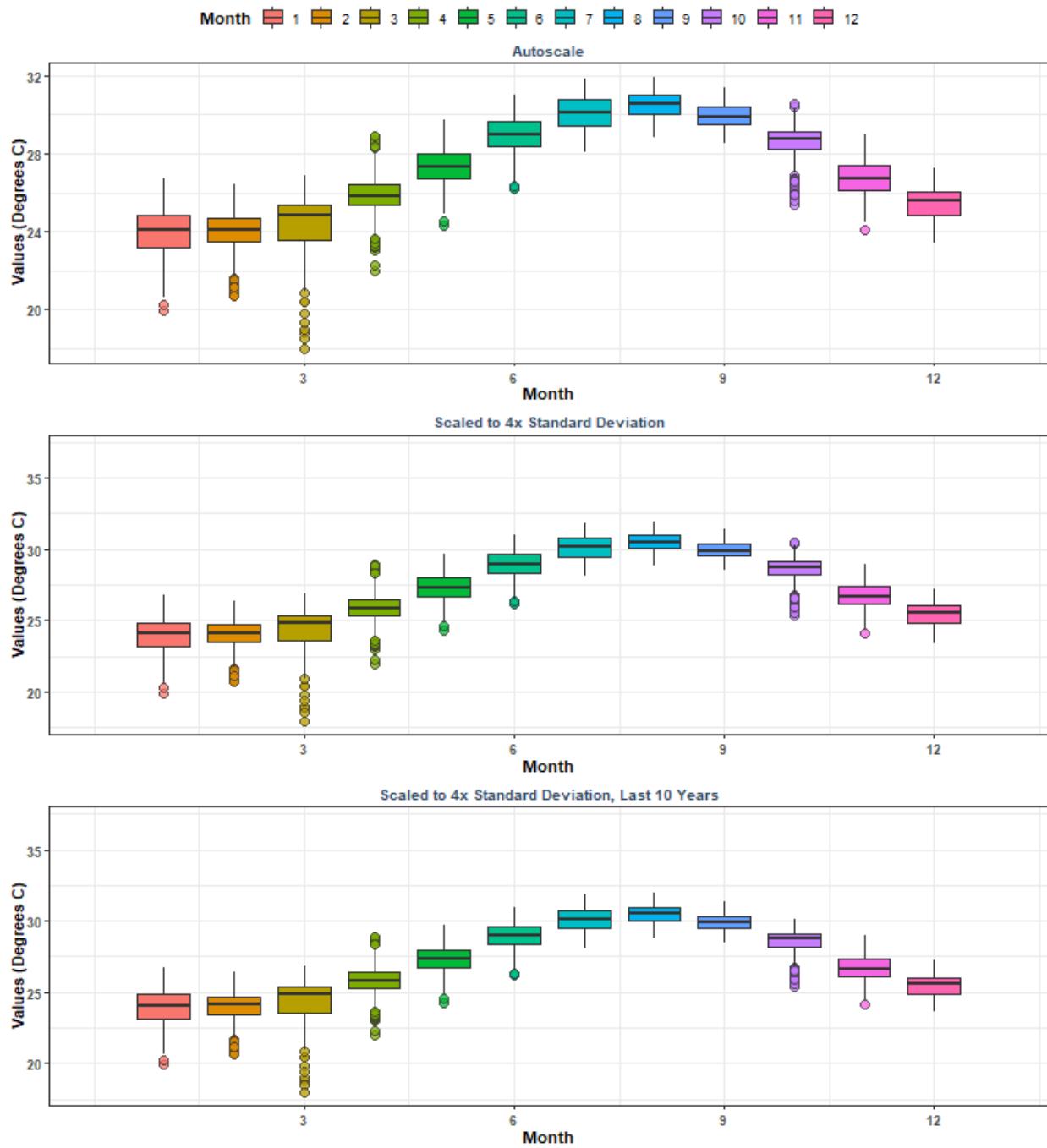
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 60**
By Year



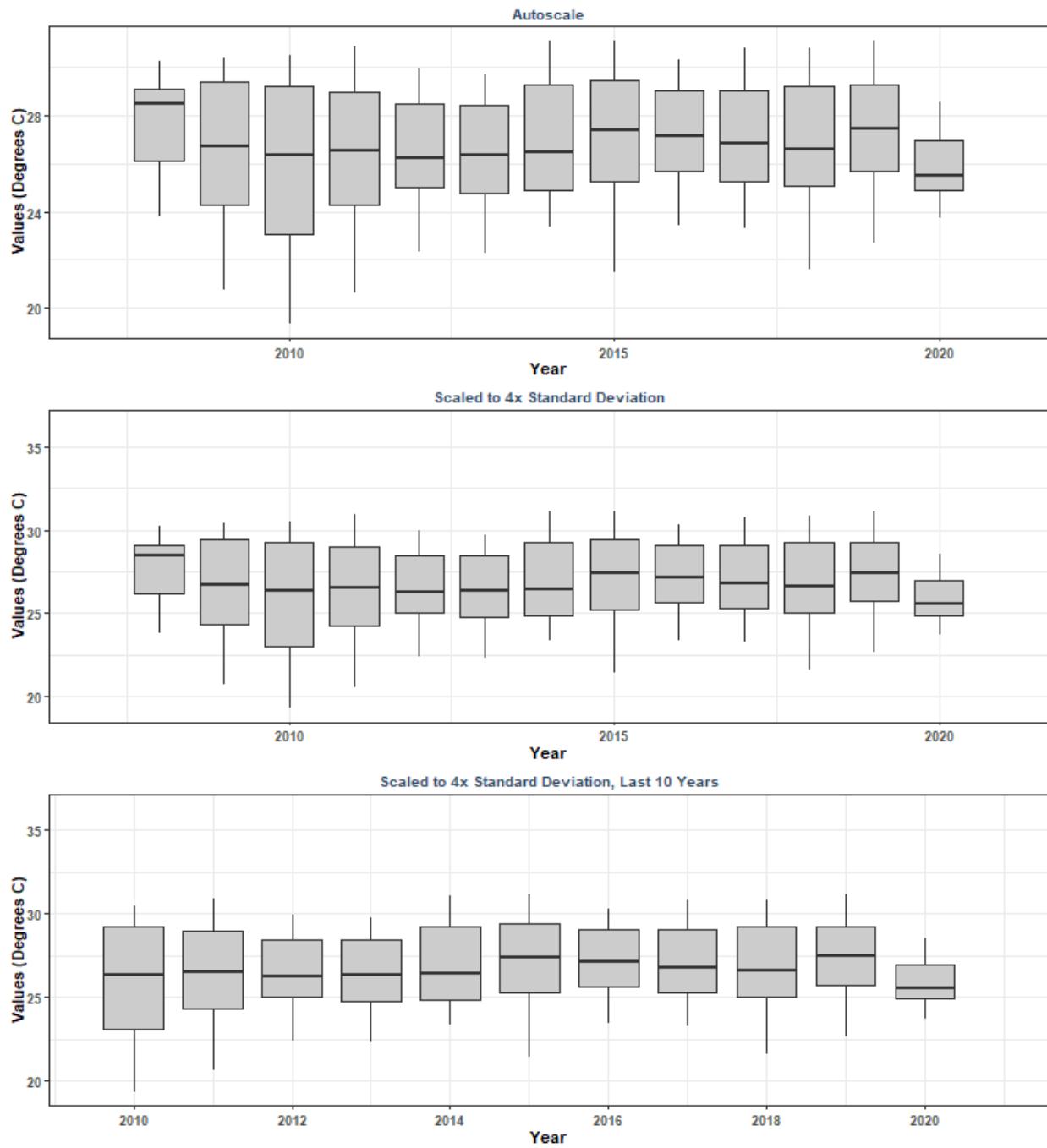
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 60
 By Year & Month



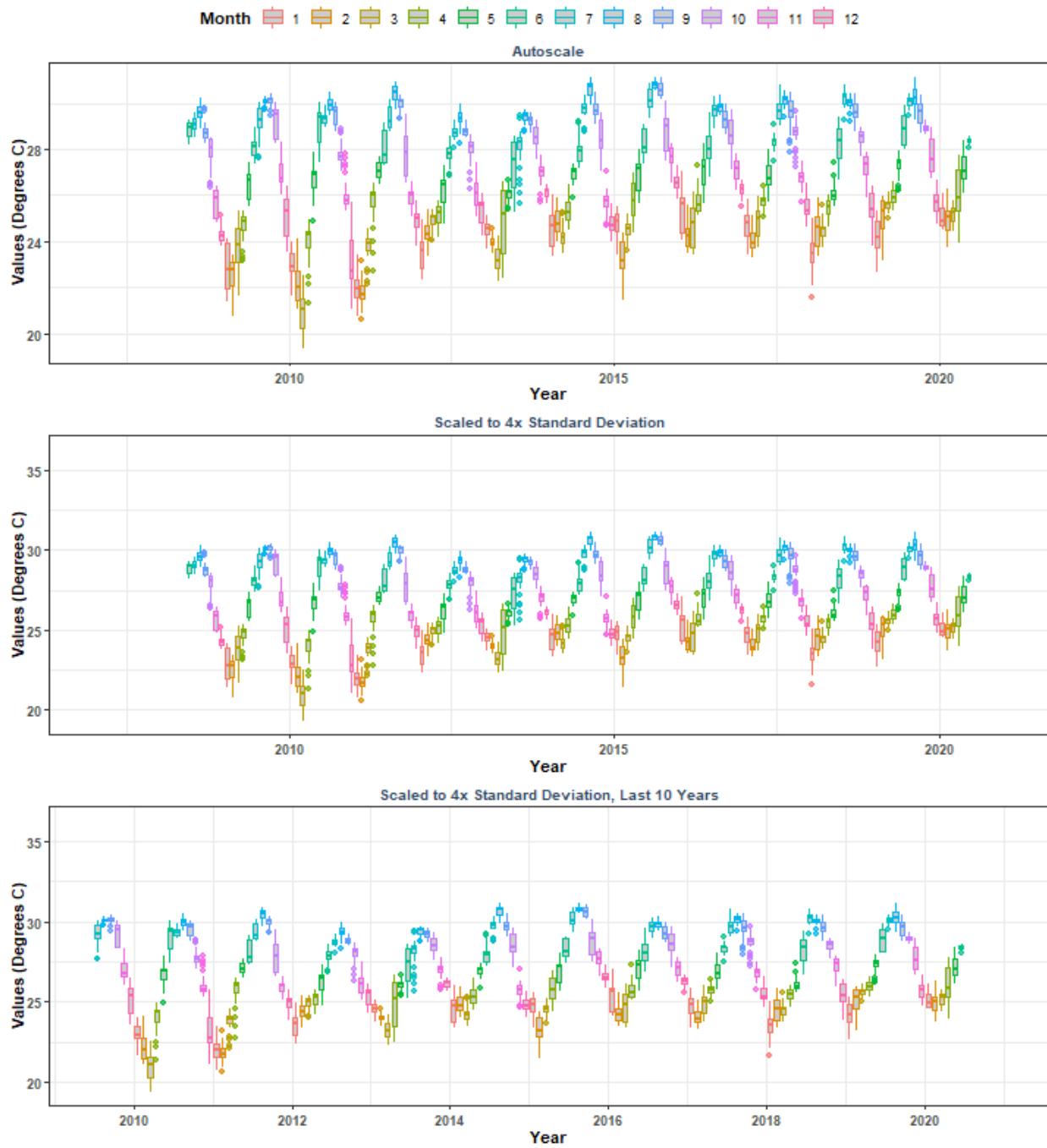
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 60
 By Month



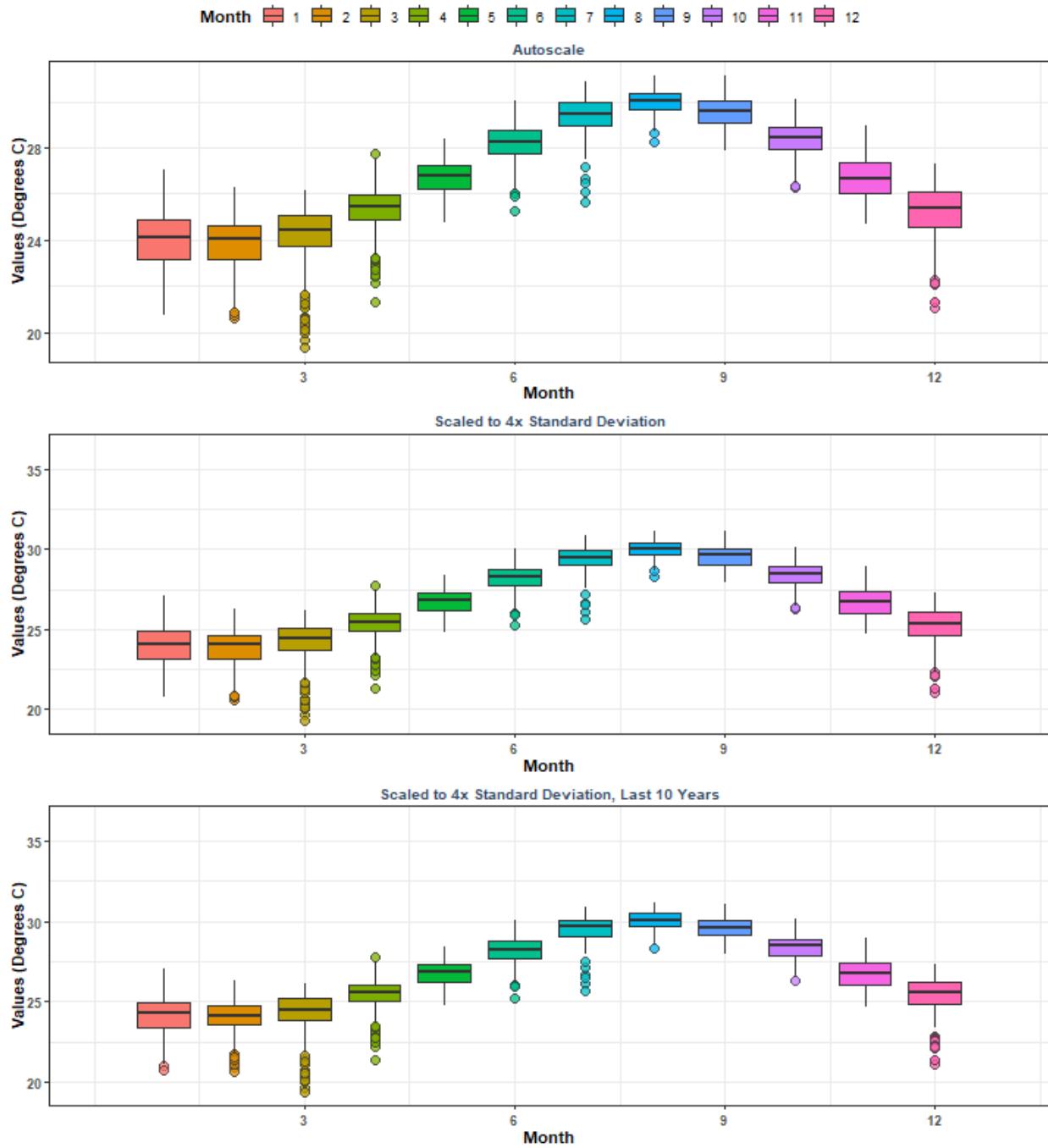
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 72**
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 72
 By Year & Month

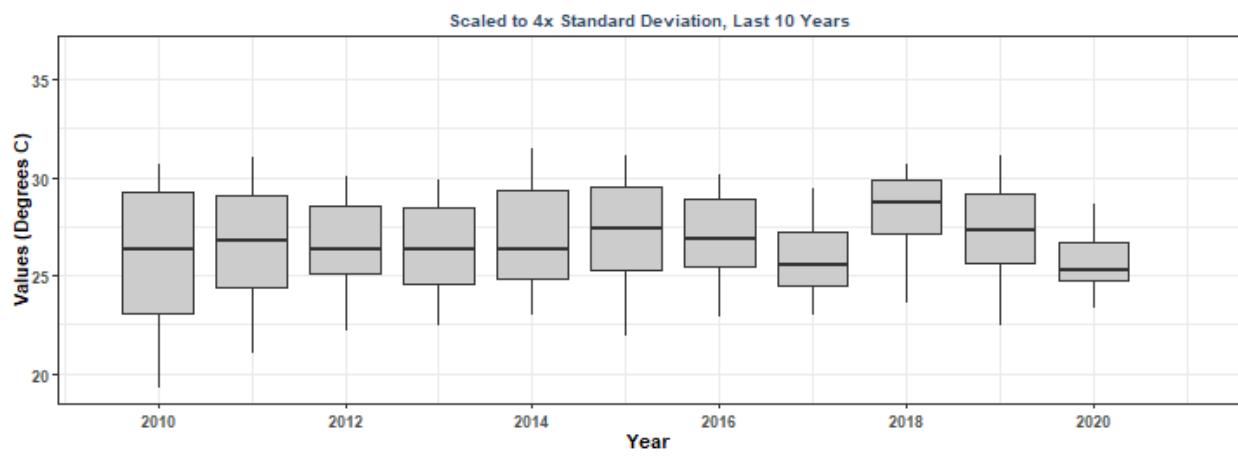
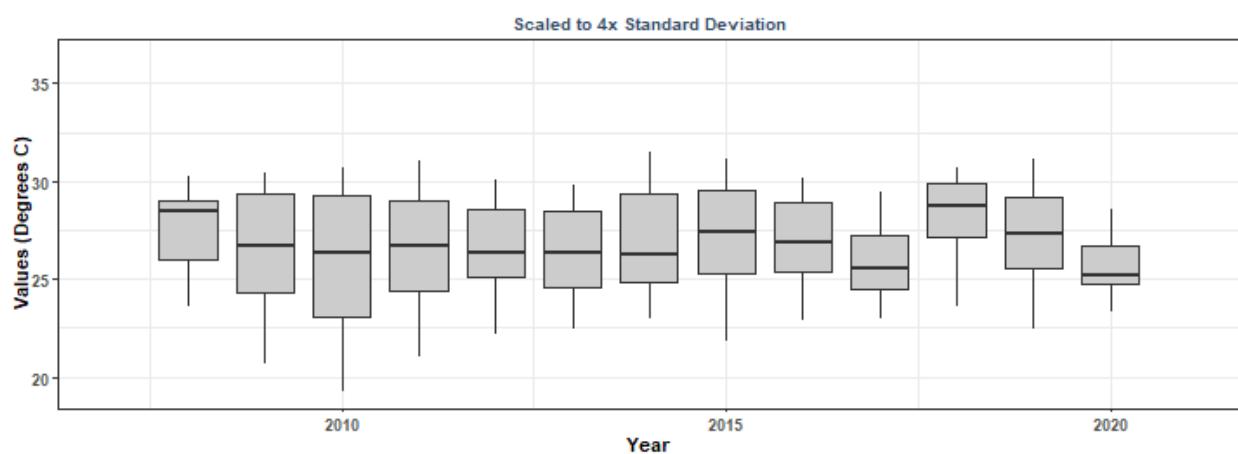
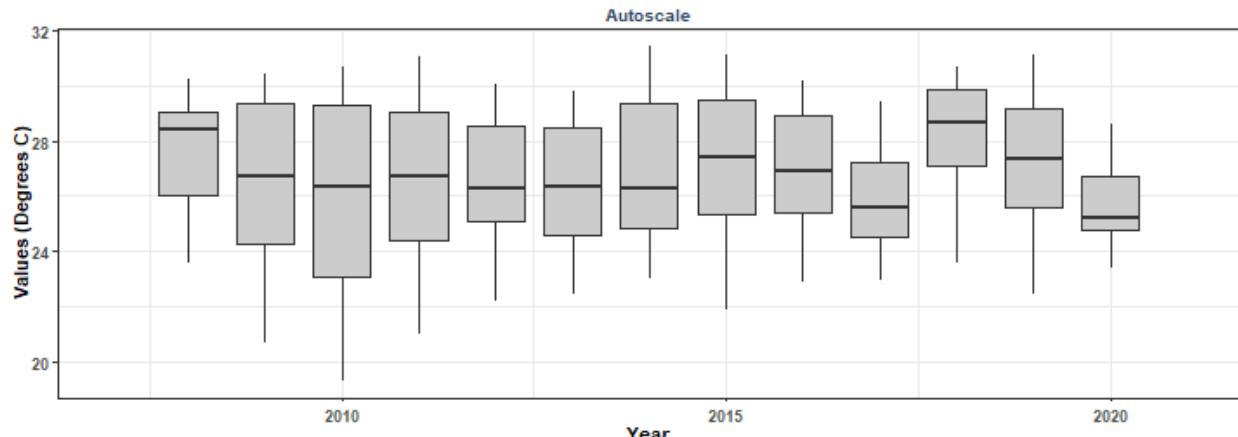


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 72
 By Month

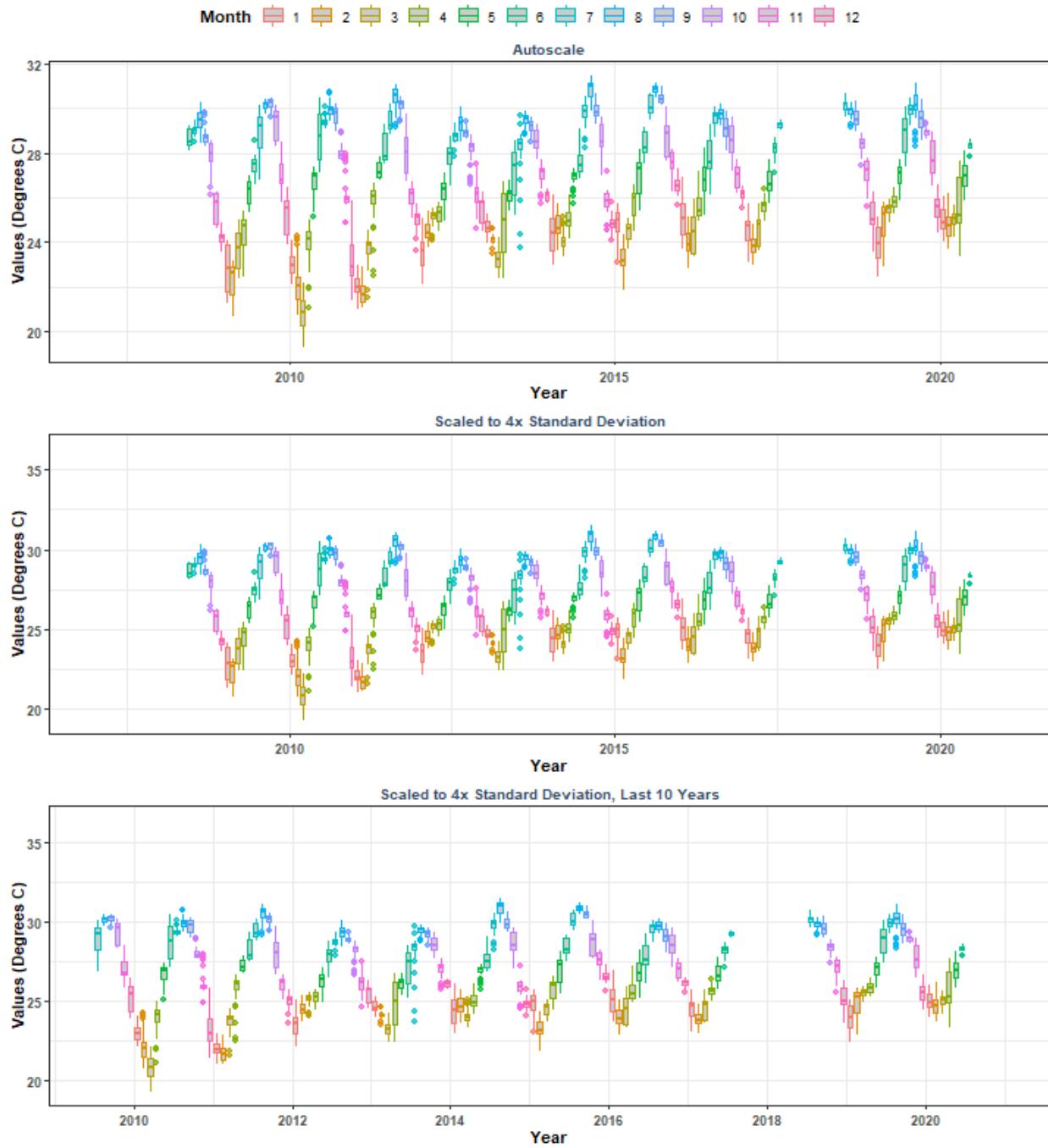


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 73**

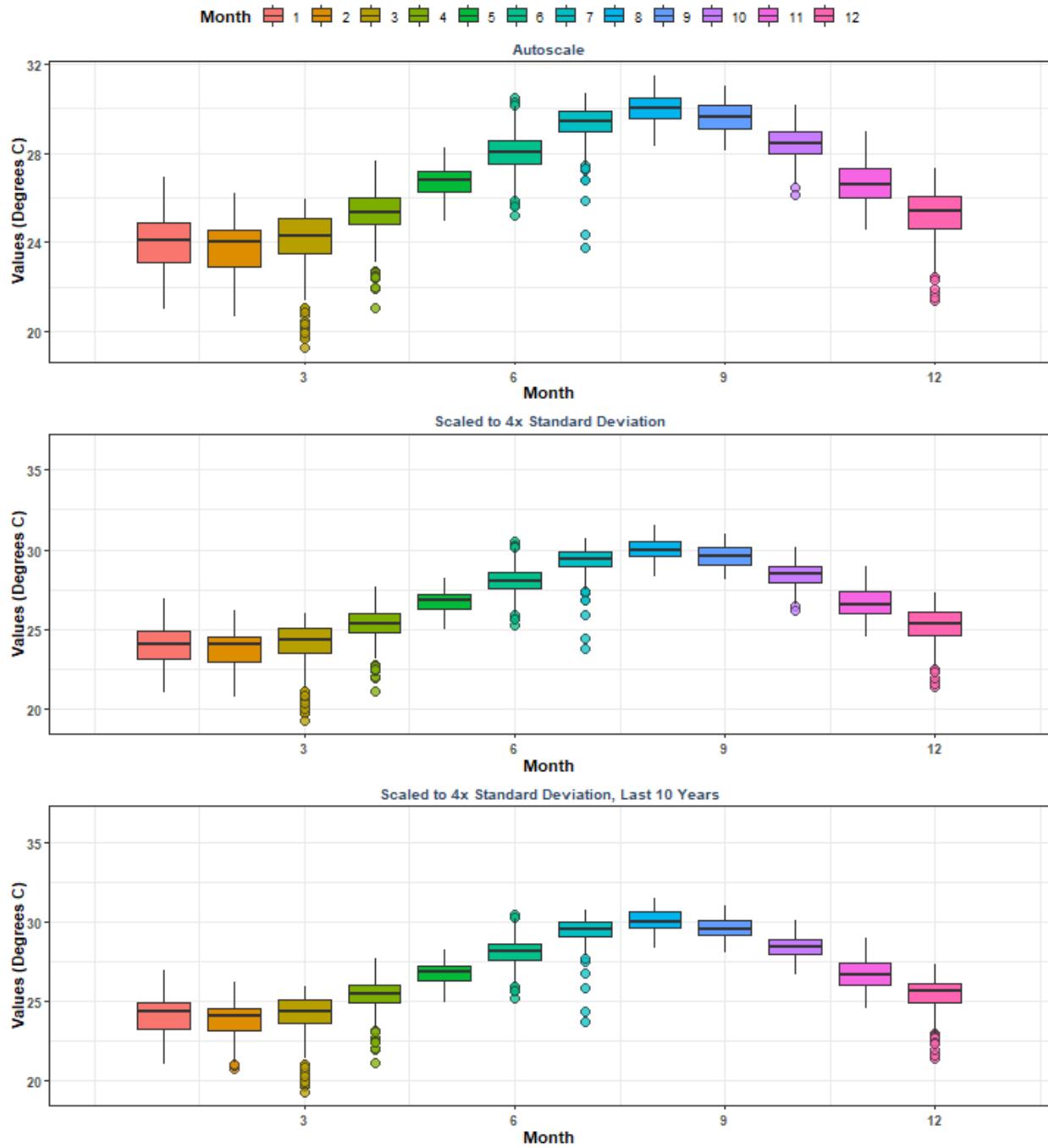
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 73
By Year & Month

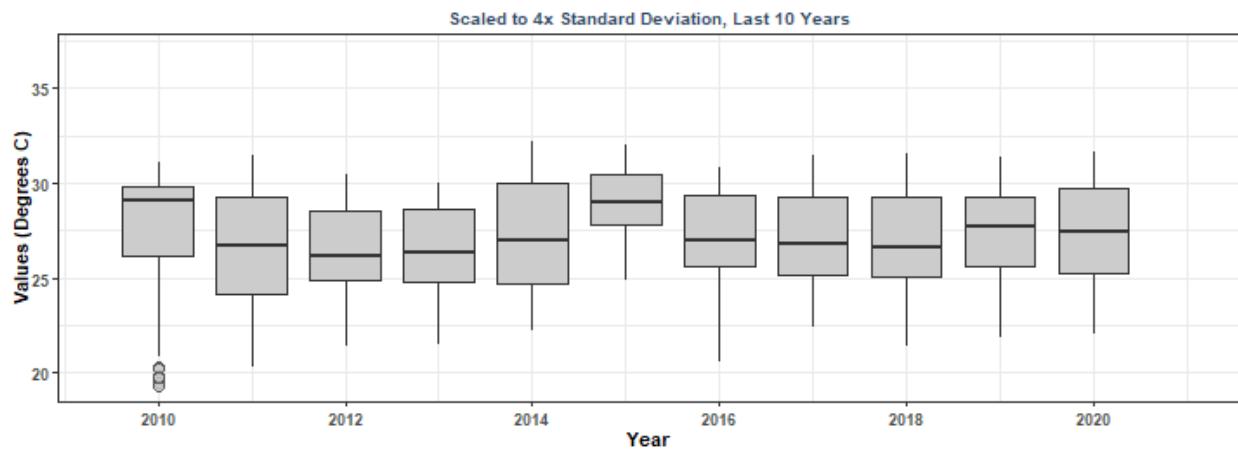
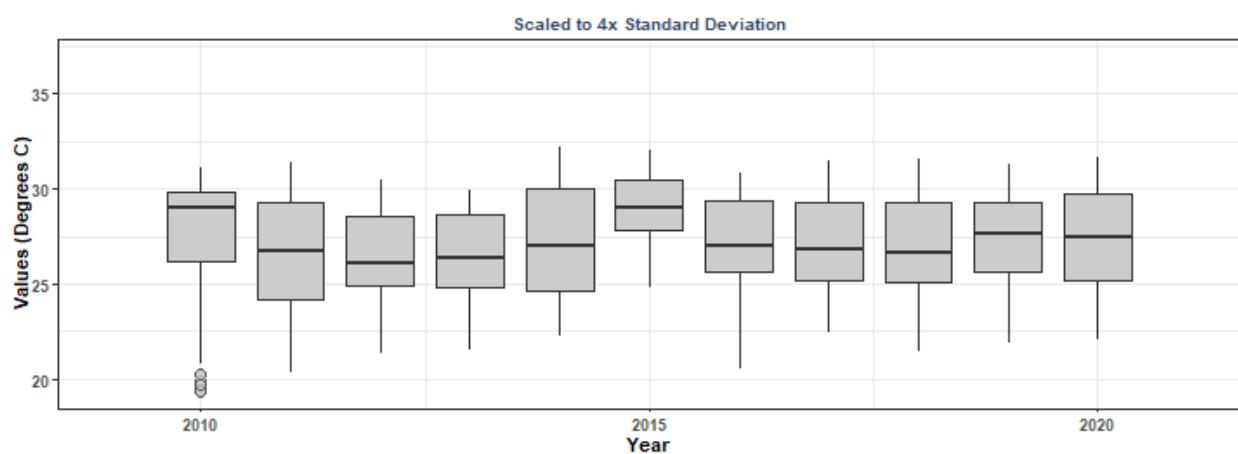
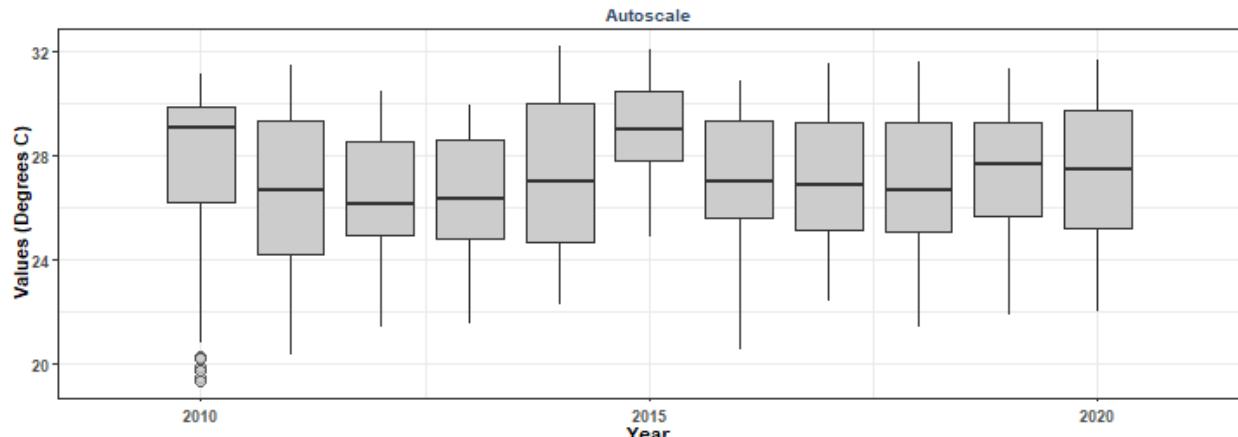


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 73
 By Month

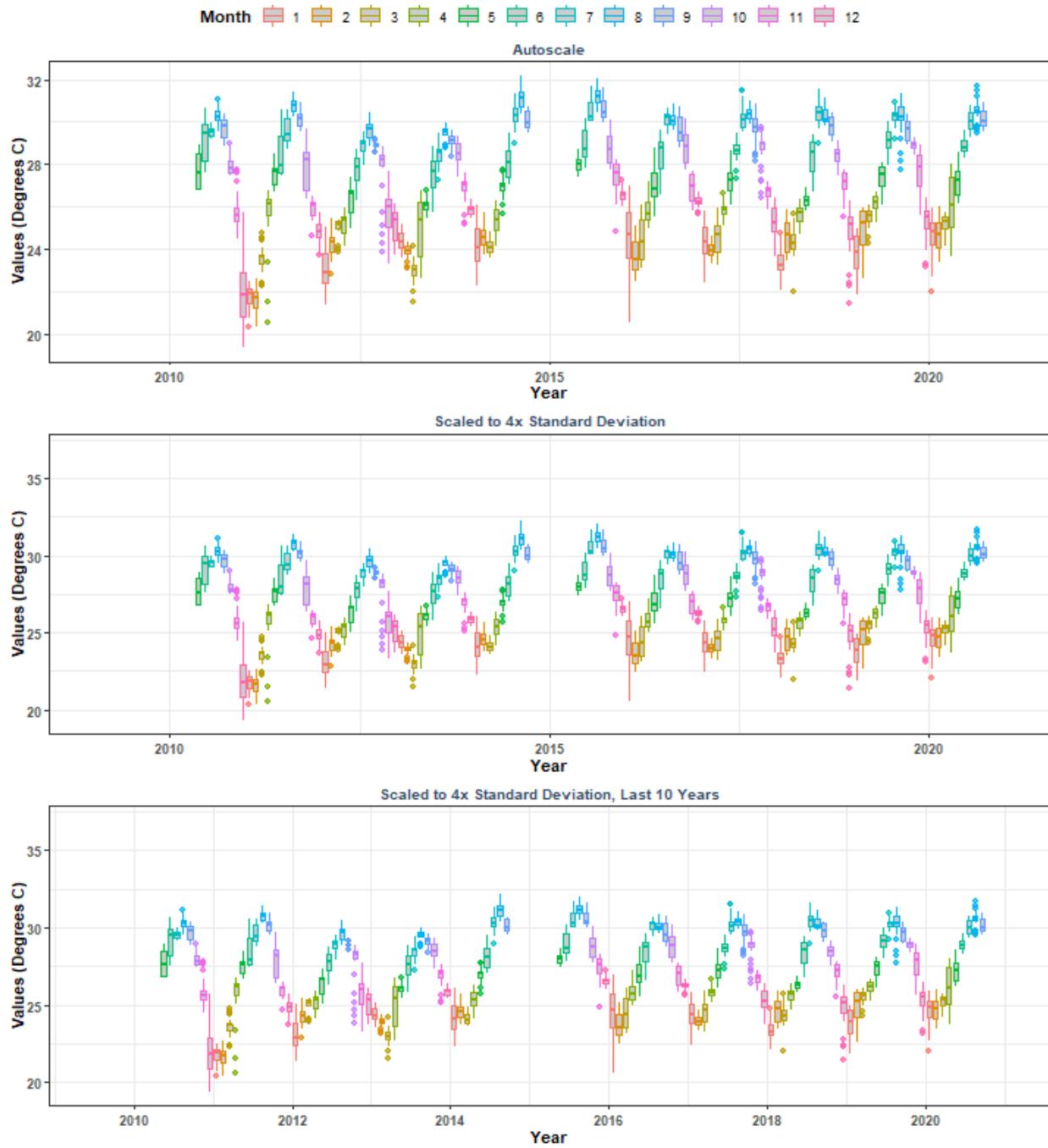


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 75**

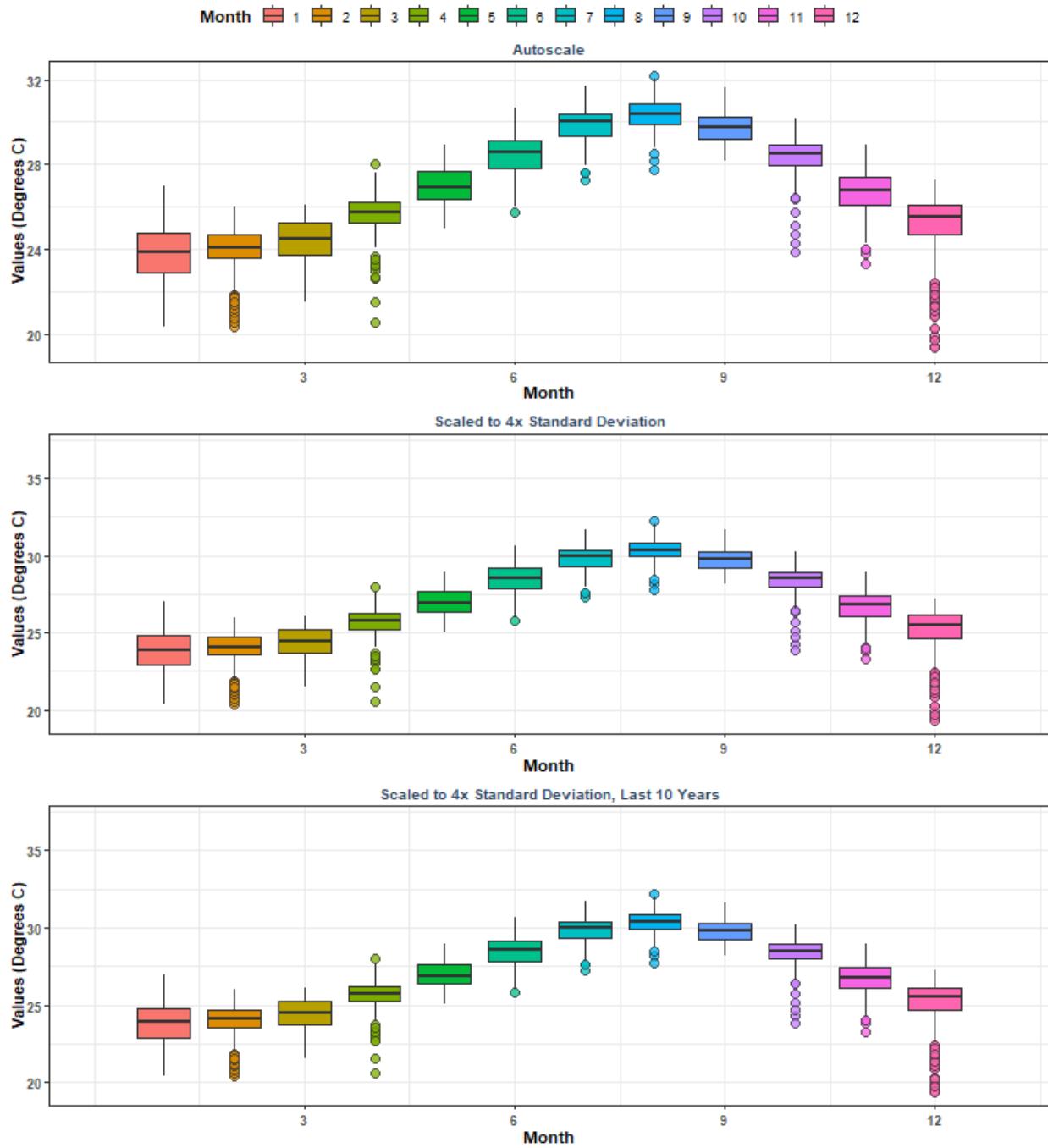
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 75
 By Year & Month

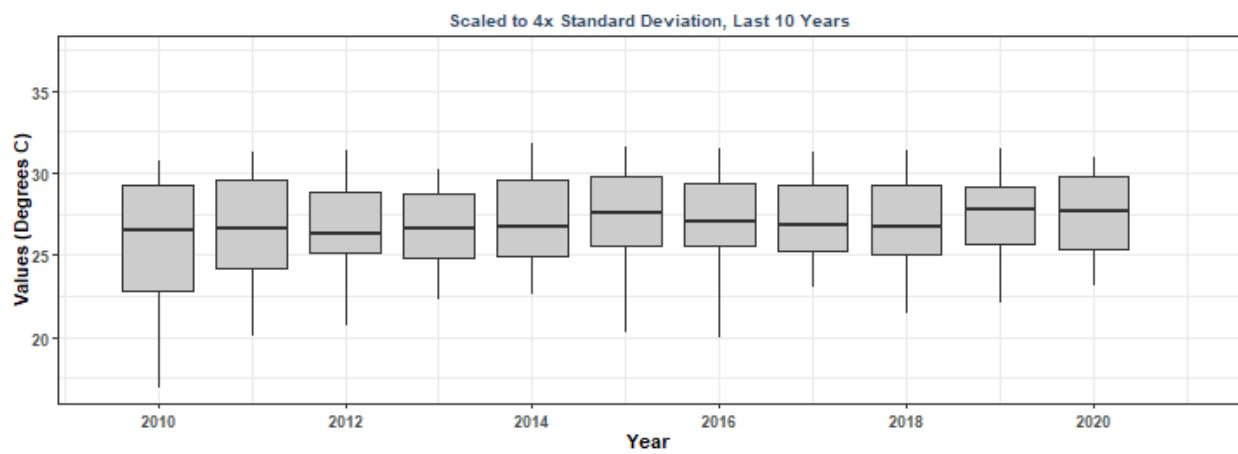
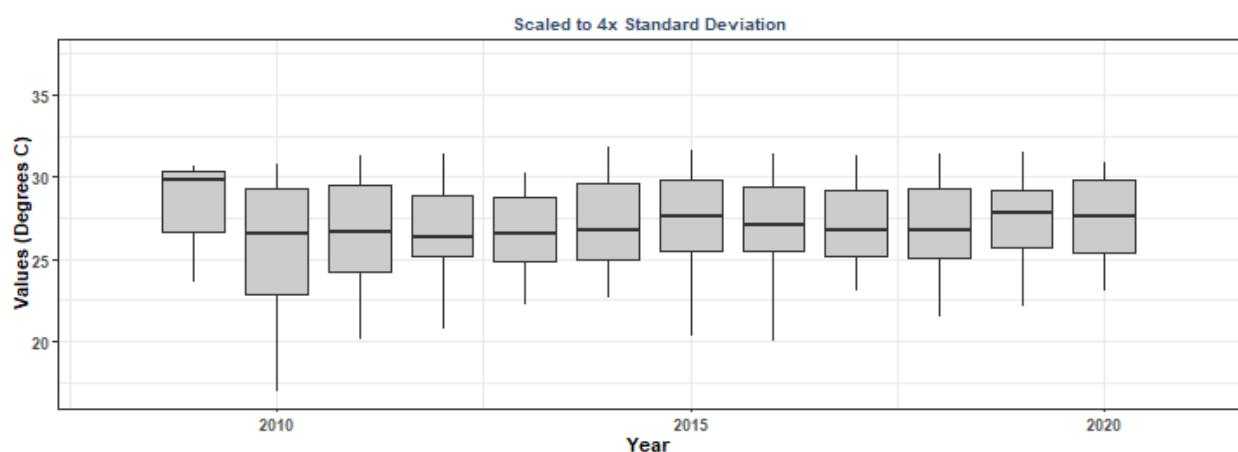
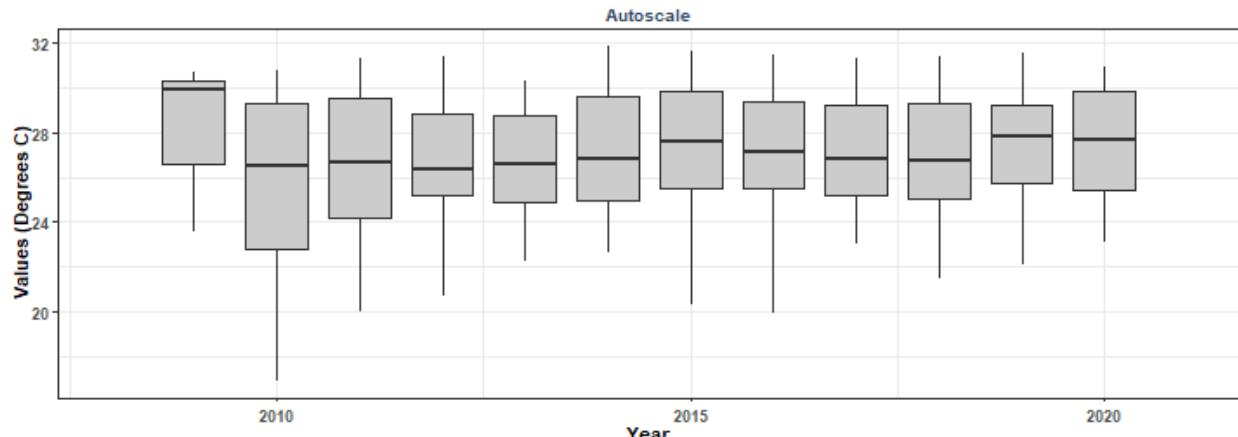


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 75
 By Month

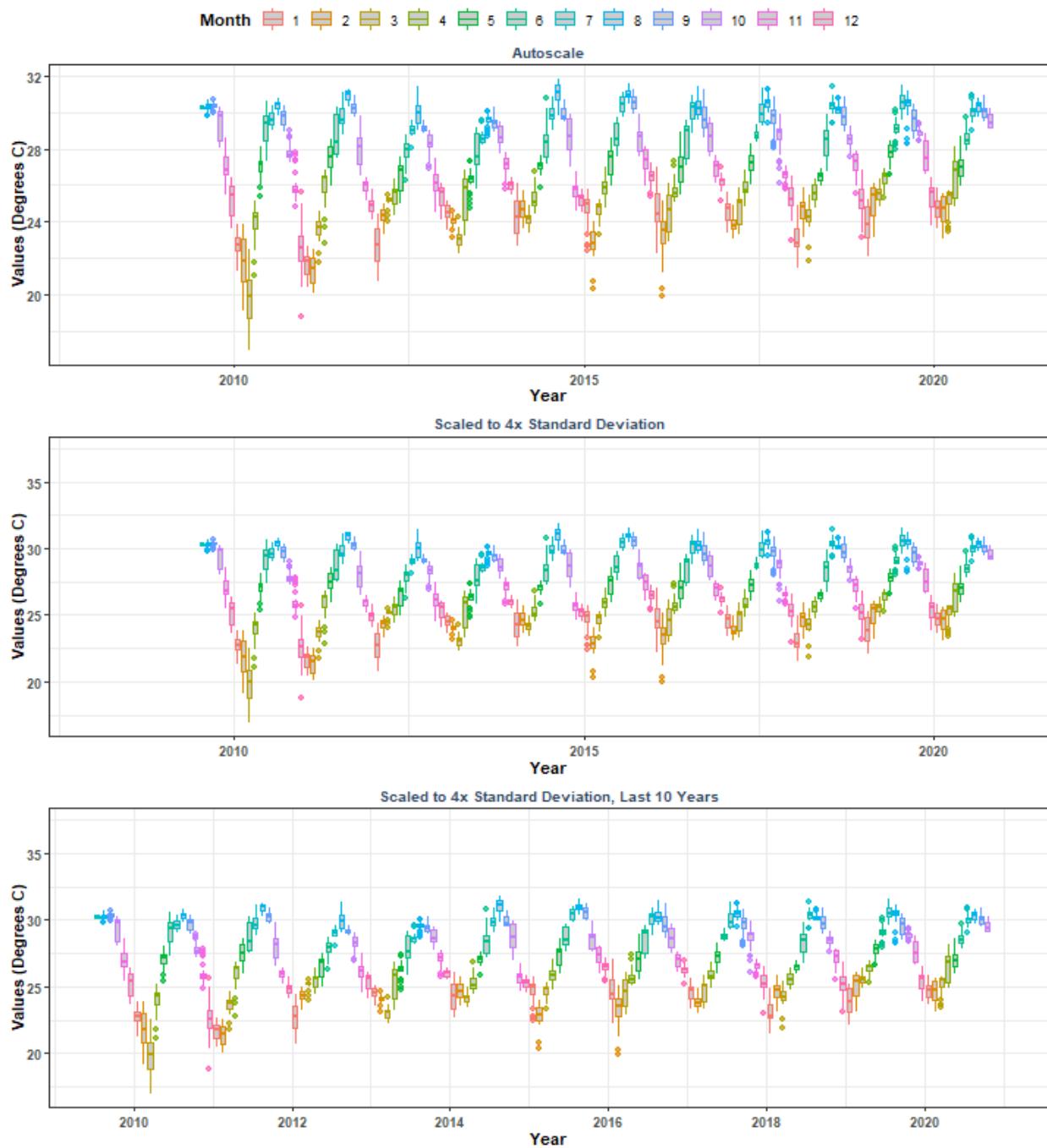


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 76**

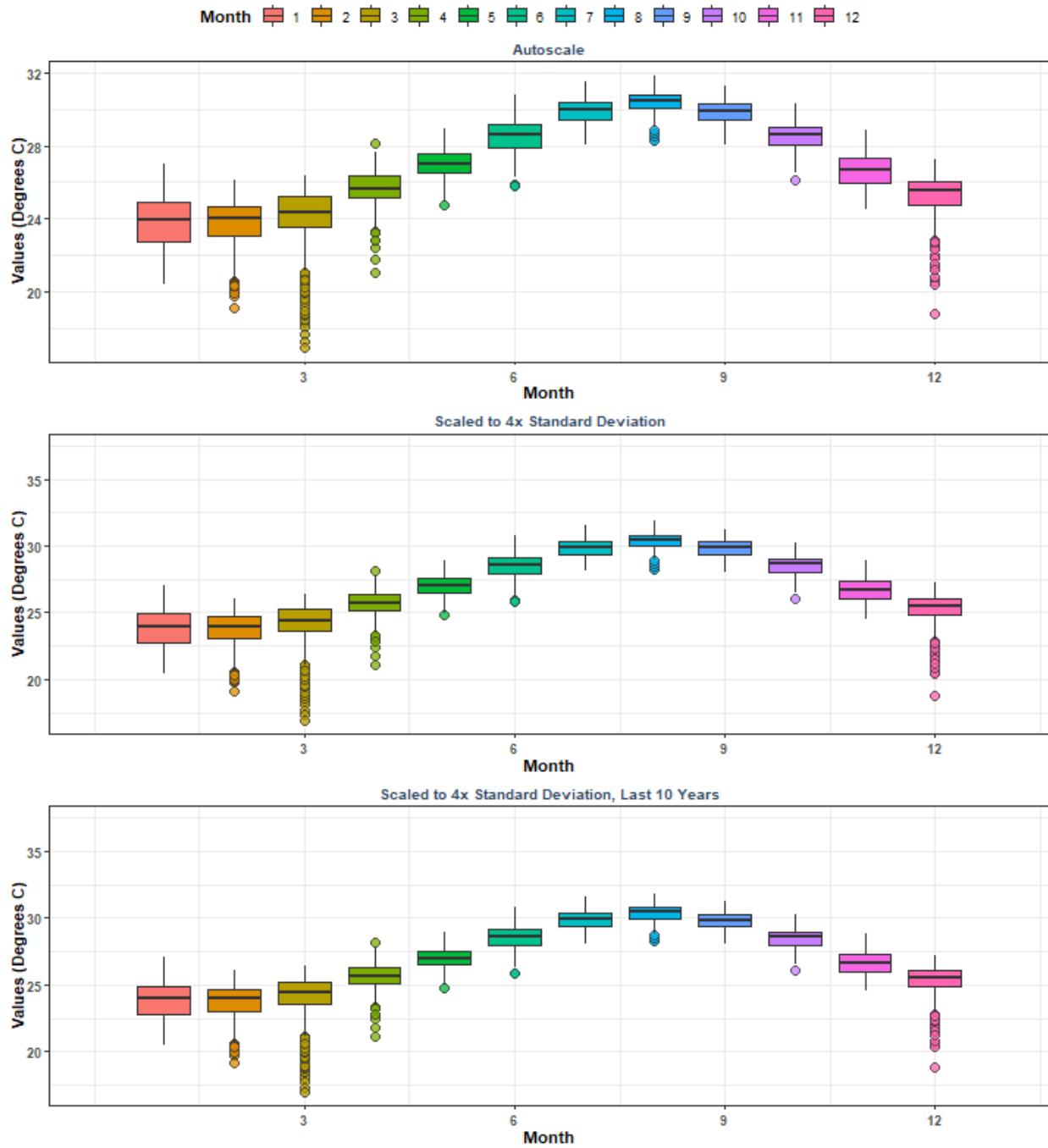
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 76
By Year & Month

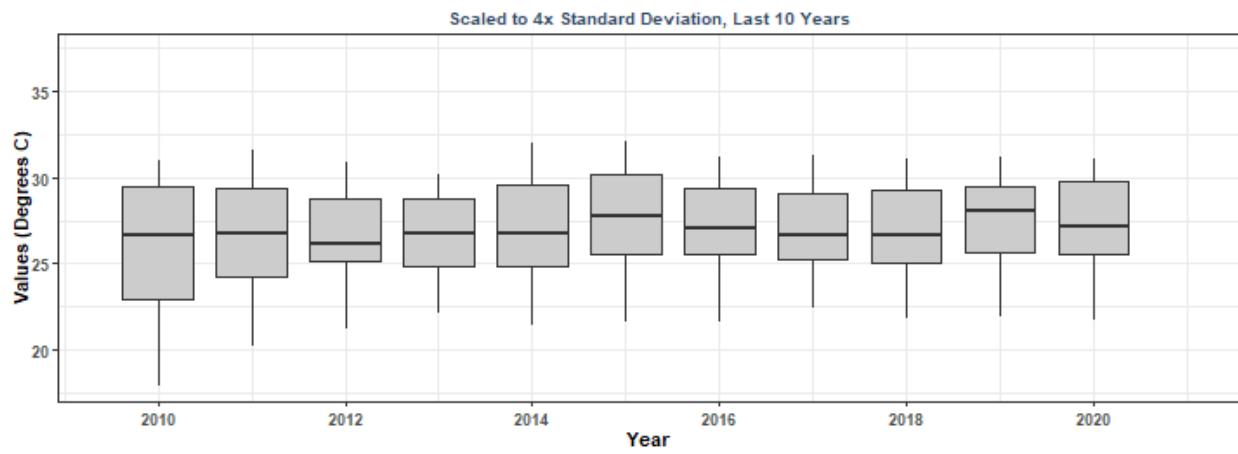
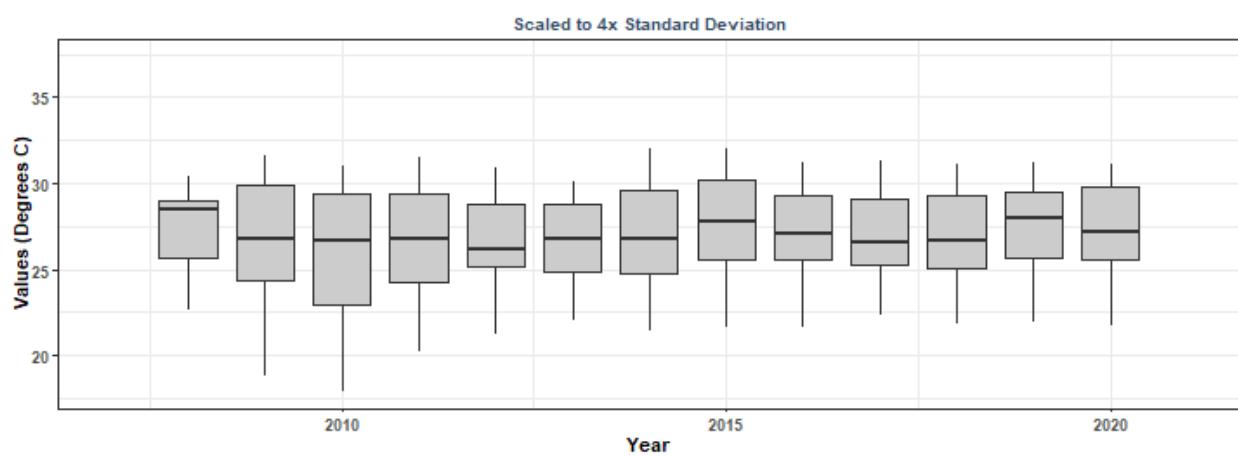
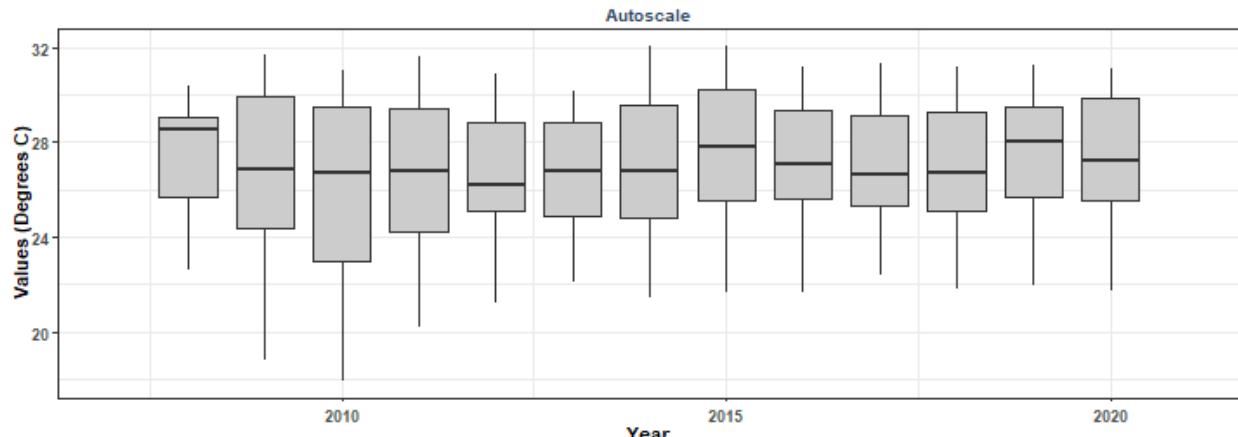


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 76
 By Month

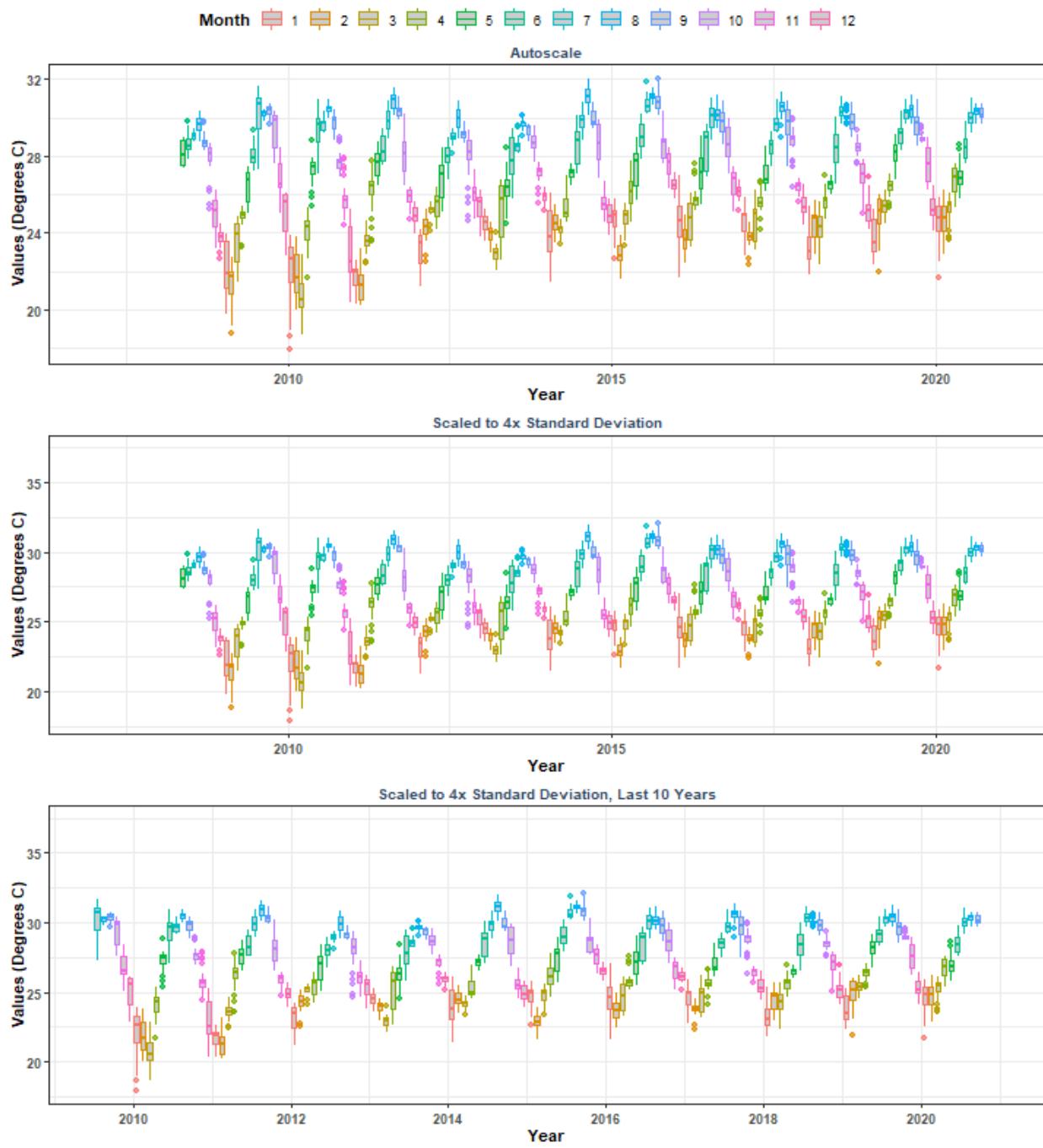


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 77**

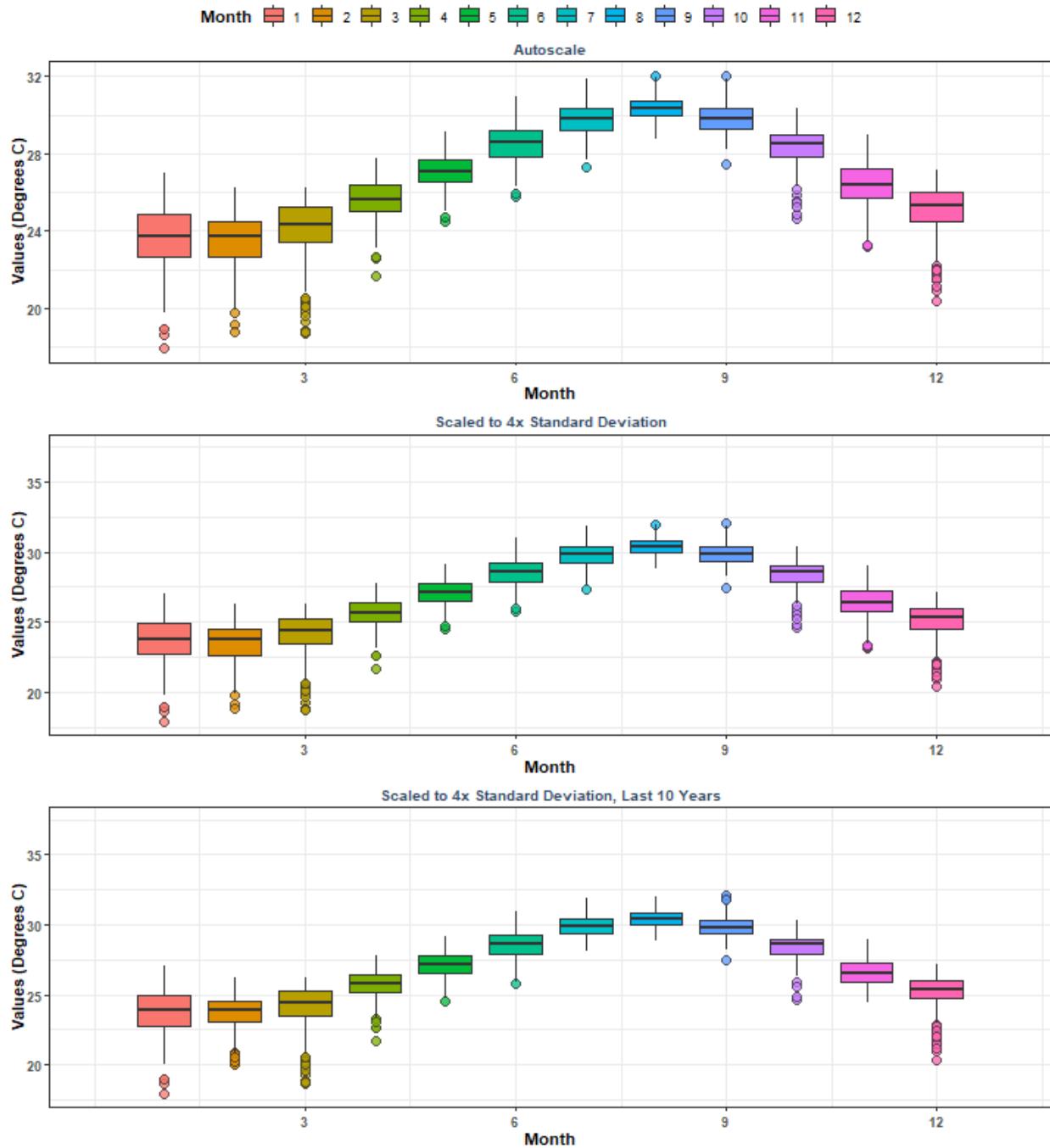
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 77
 By Year & Month

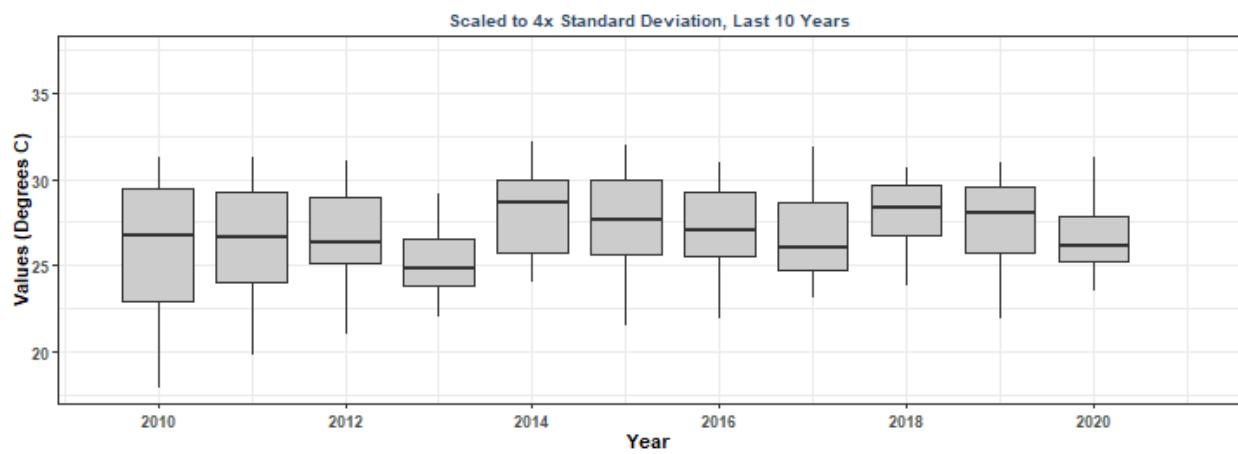
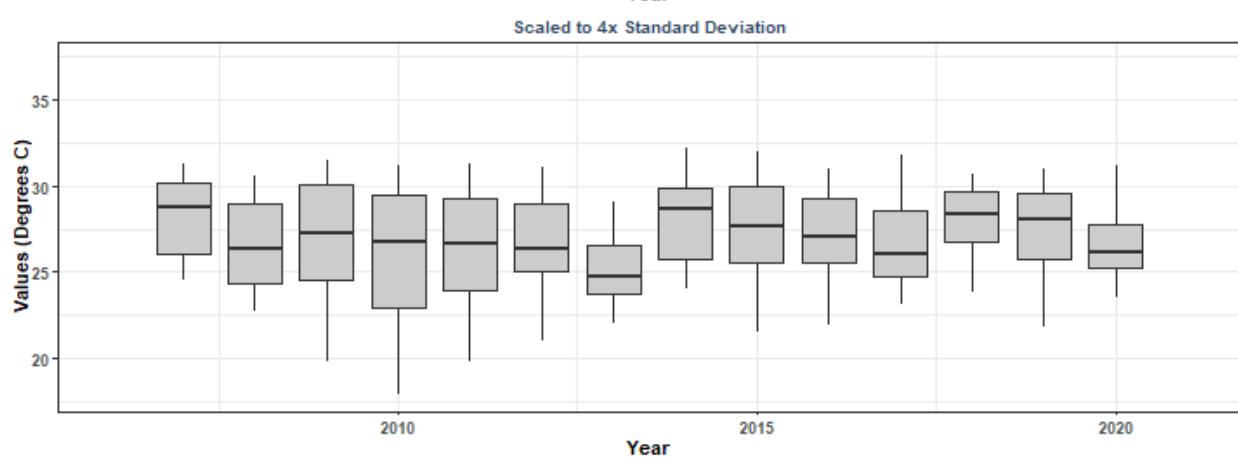
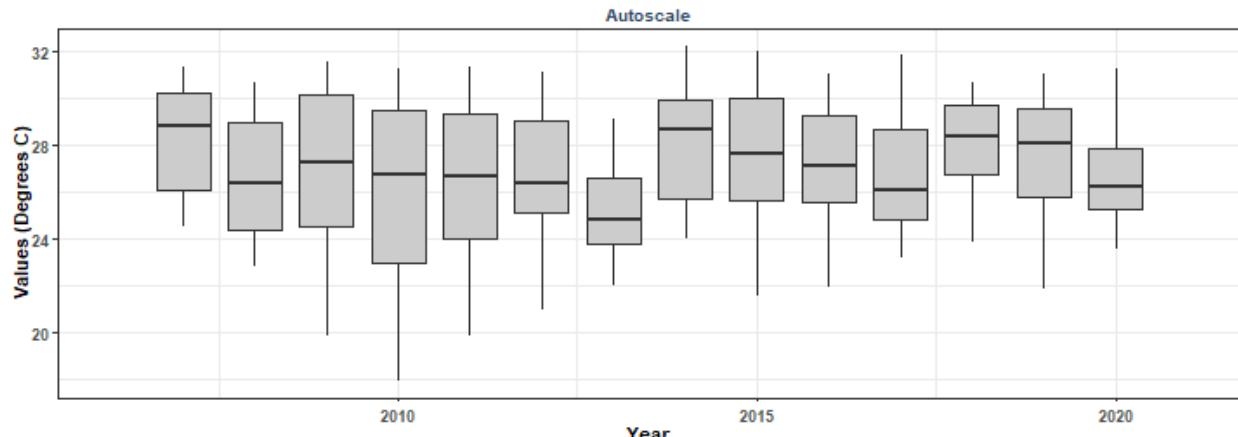


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 77
 By Month

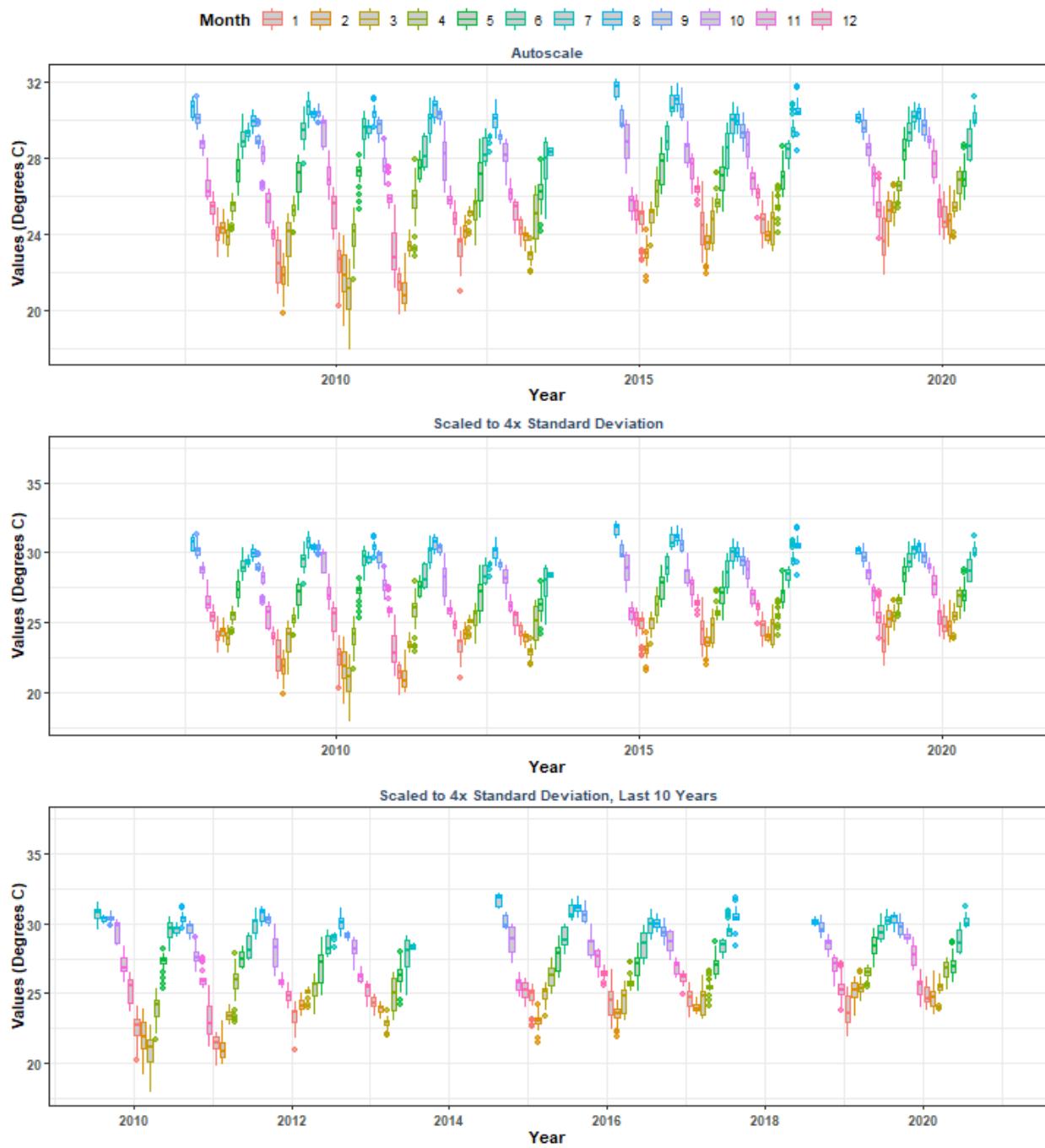


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 79**

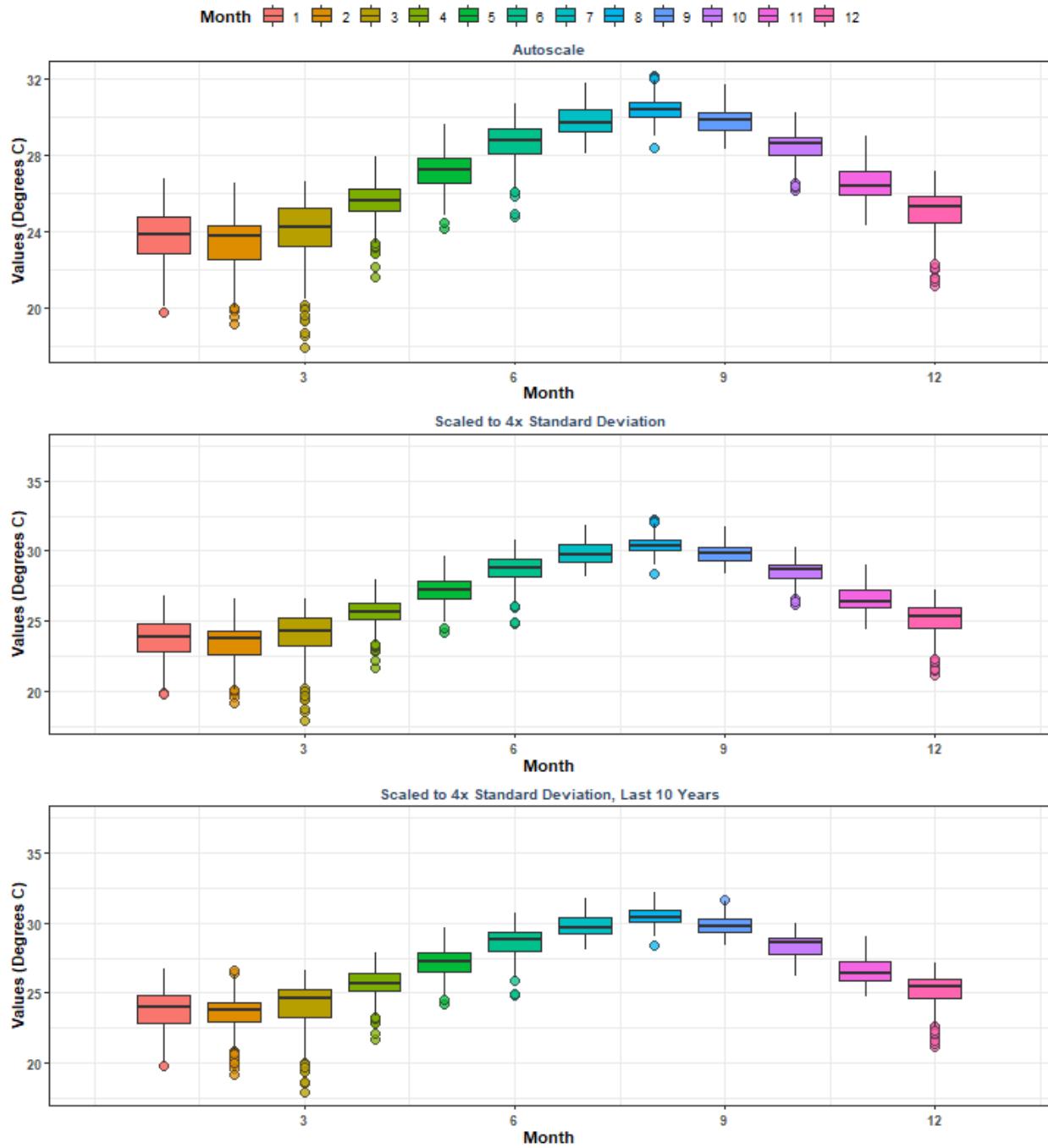
By Year



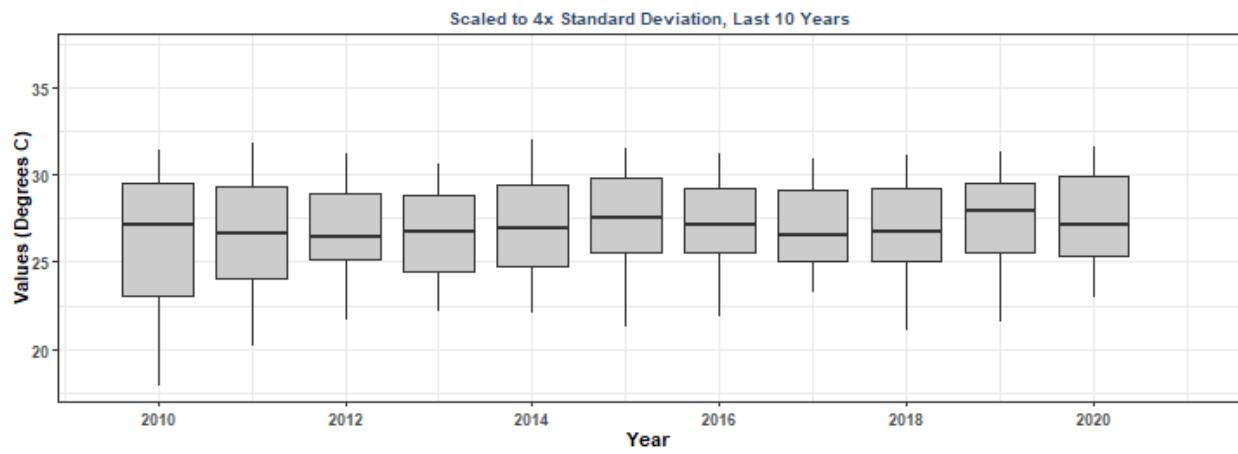
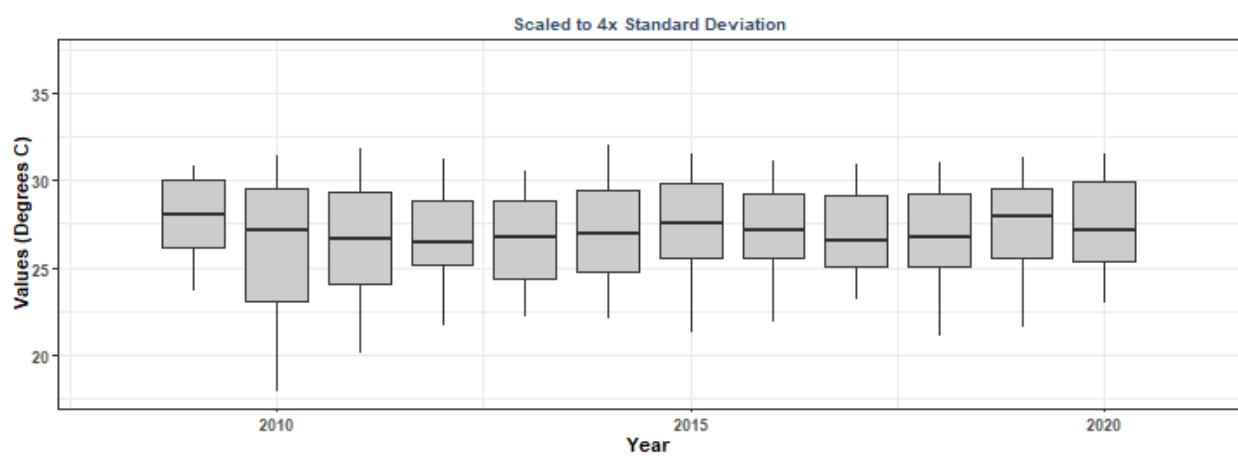
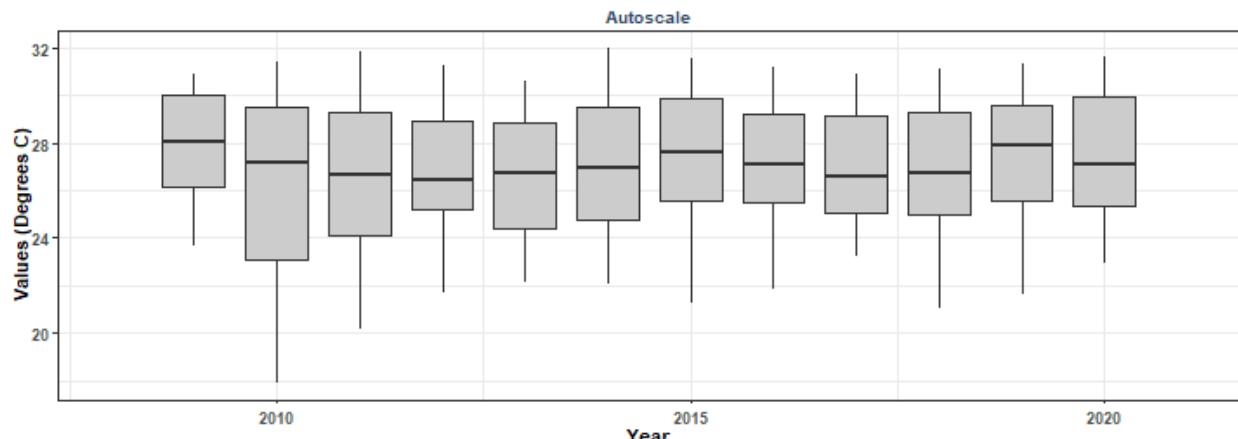
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 79**
By Year & Month



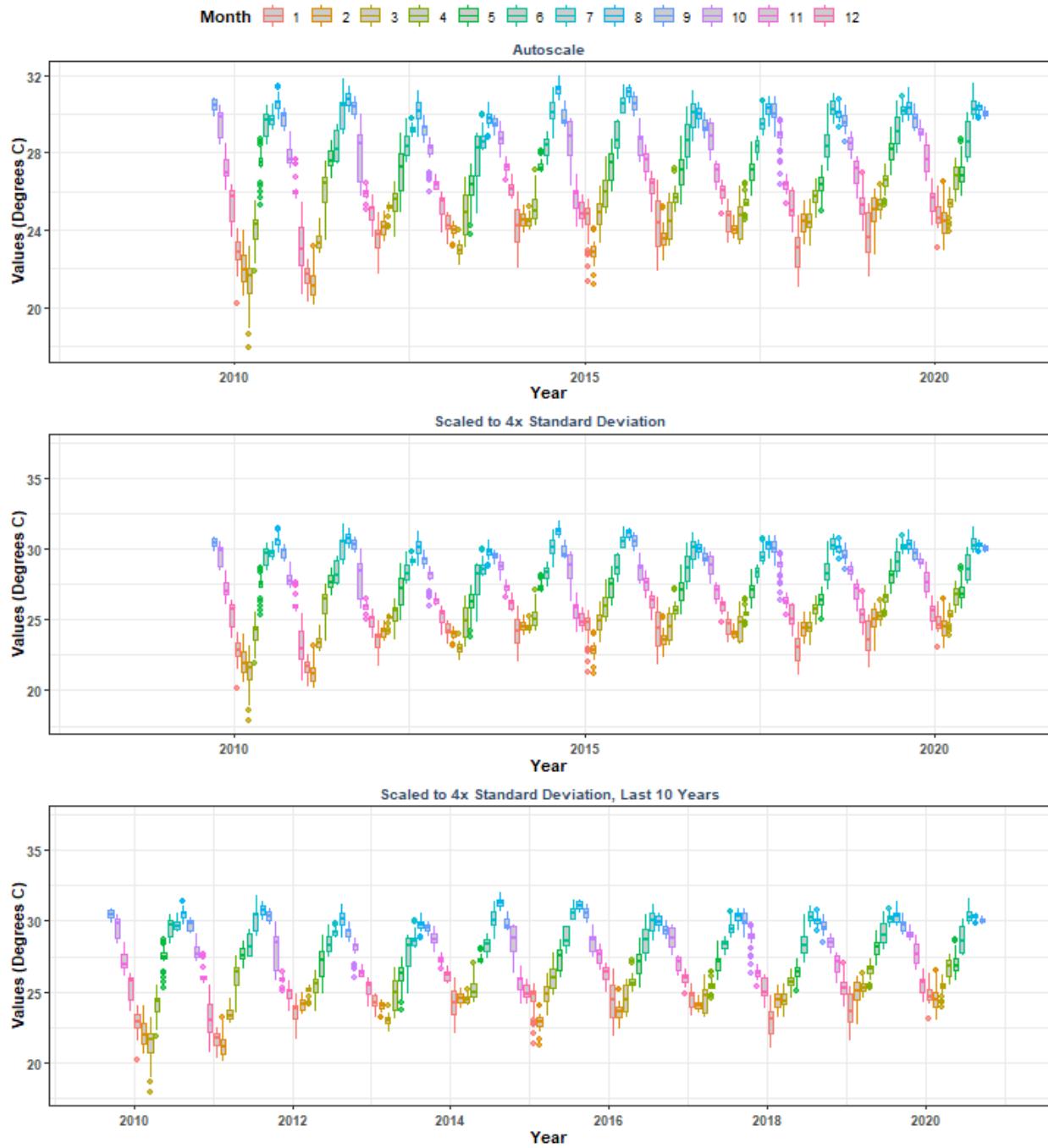
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 79
 By Month



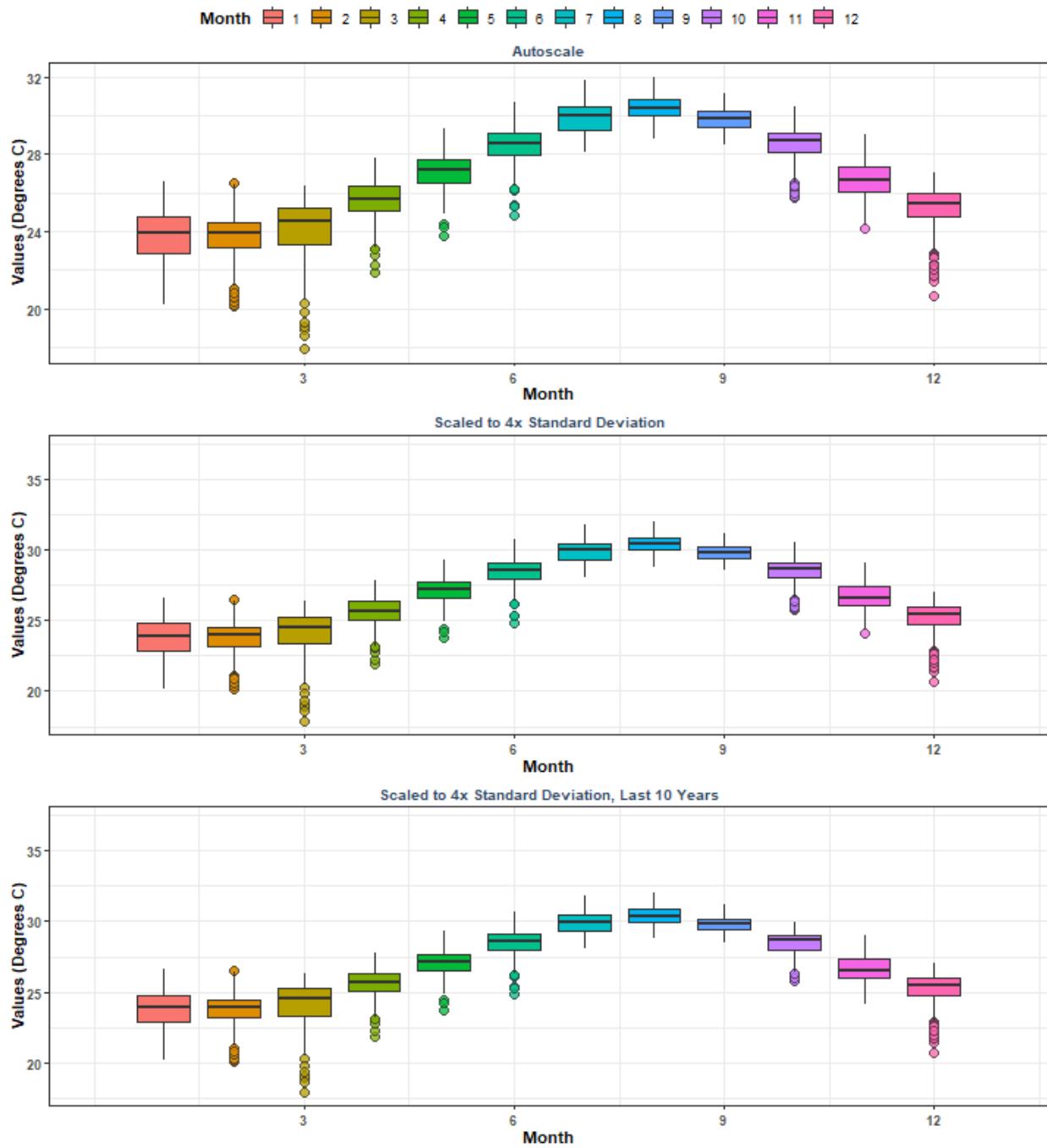
**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 80**
By Year



Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 80
By Year & Month

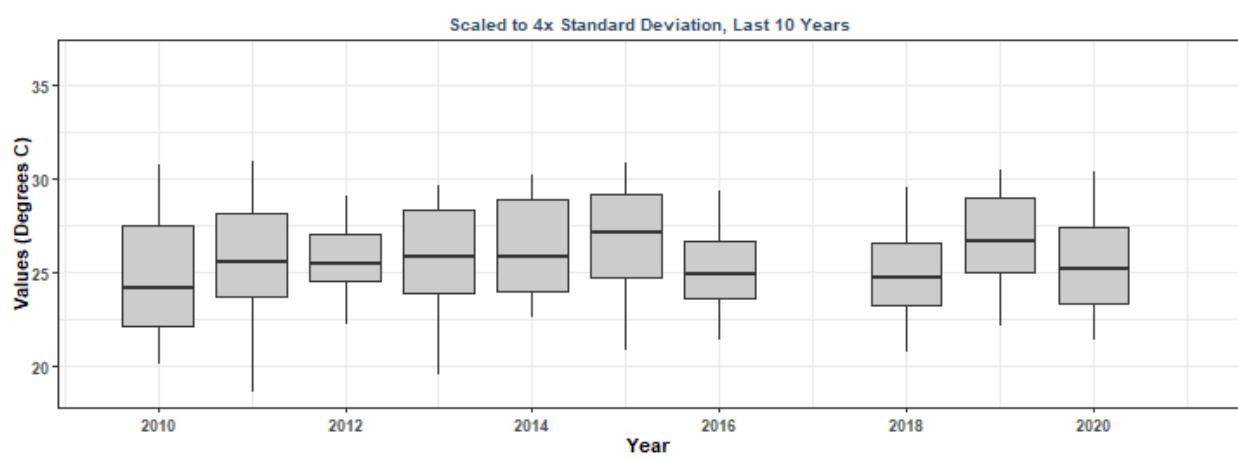
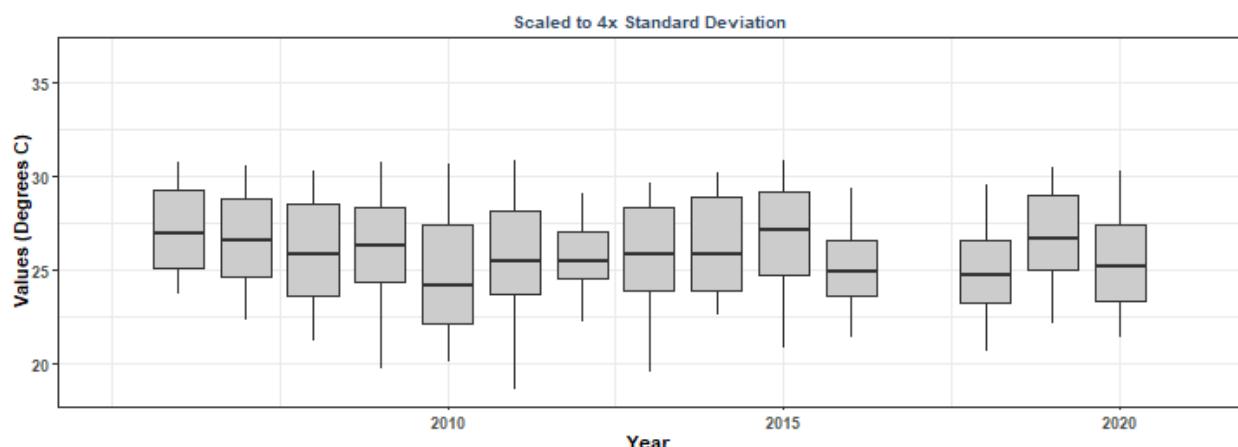
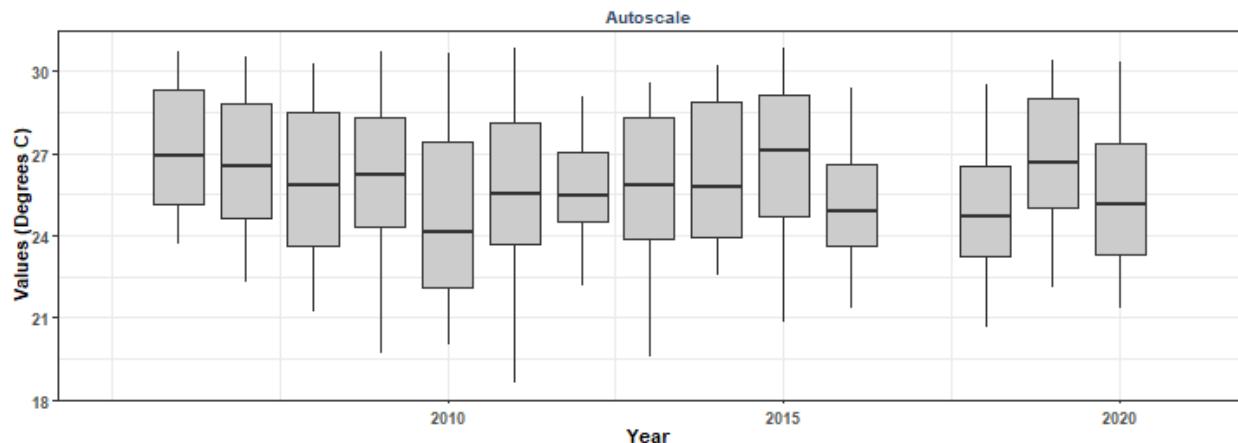


Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 80
 By Month

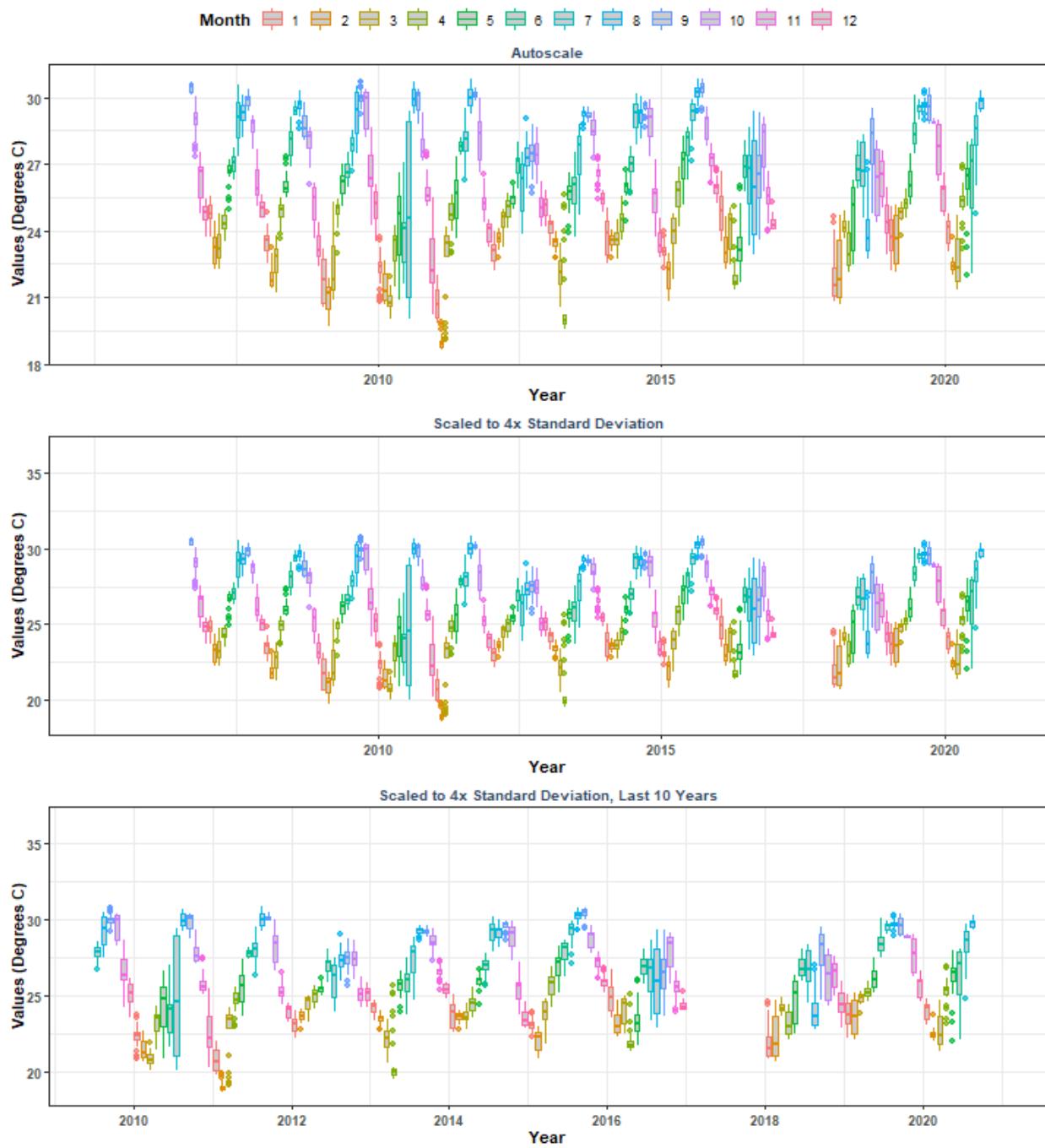


**Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 83**

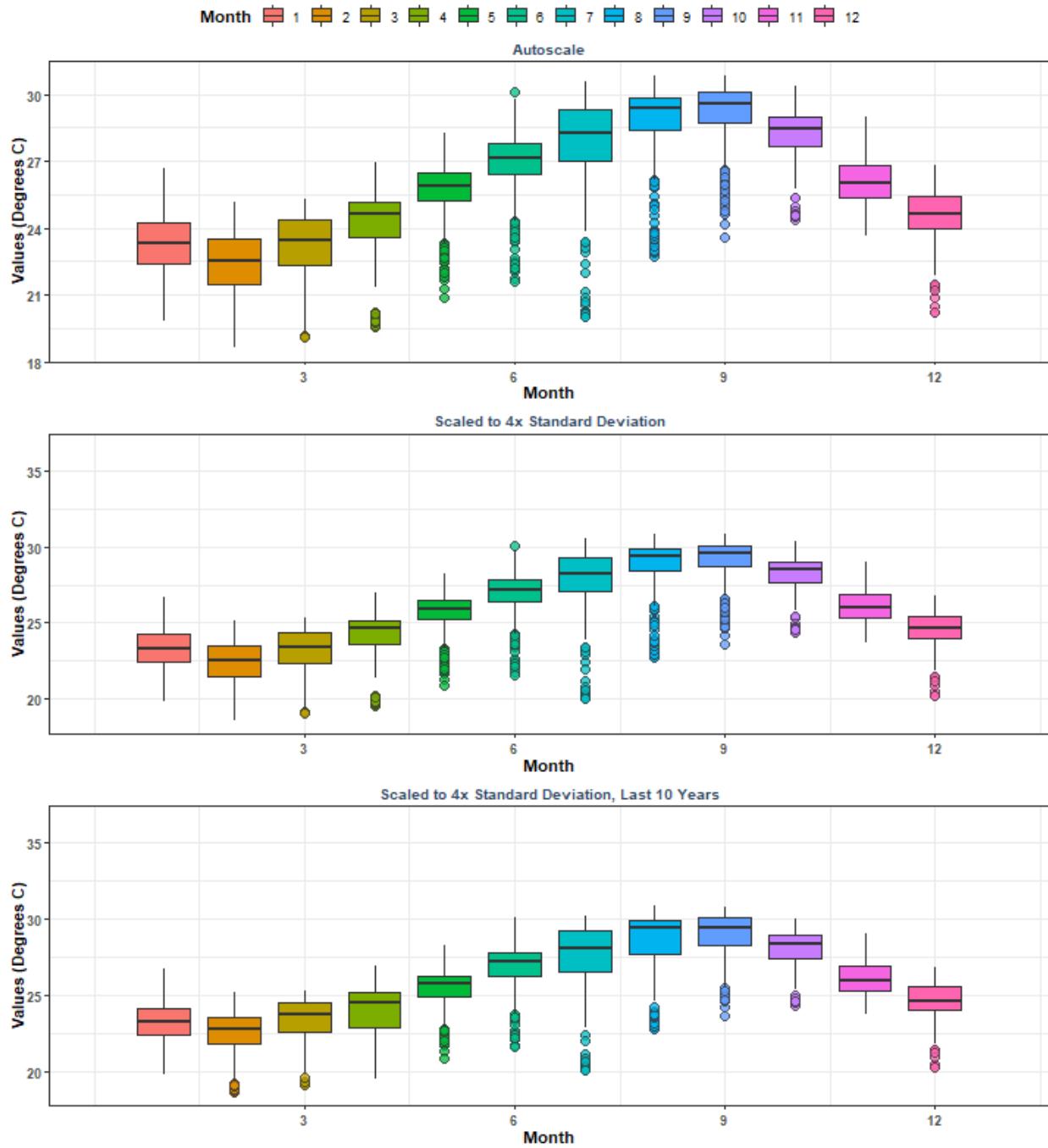
By Year



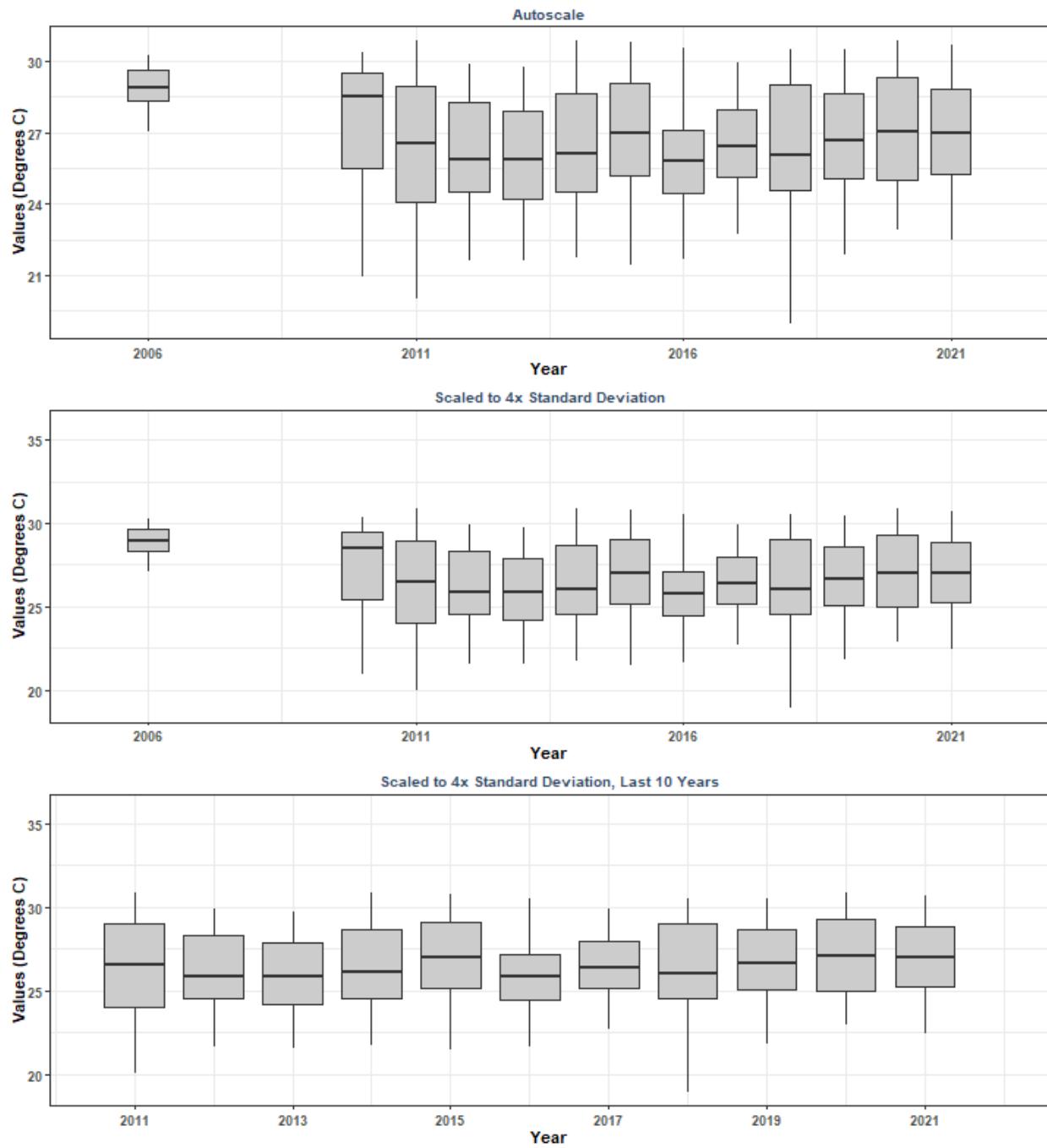
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 83
By Year & Month



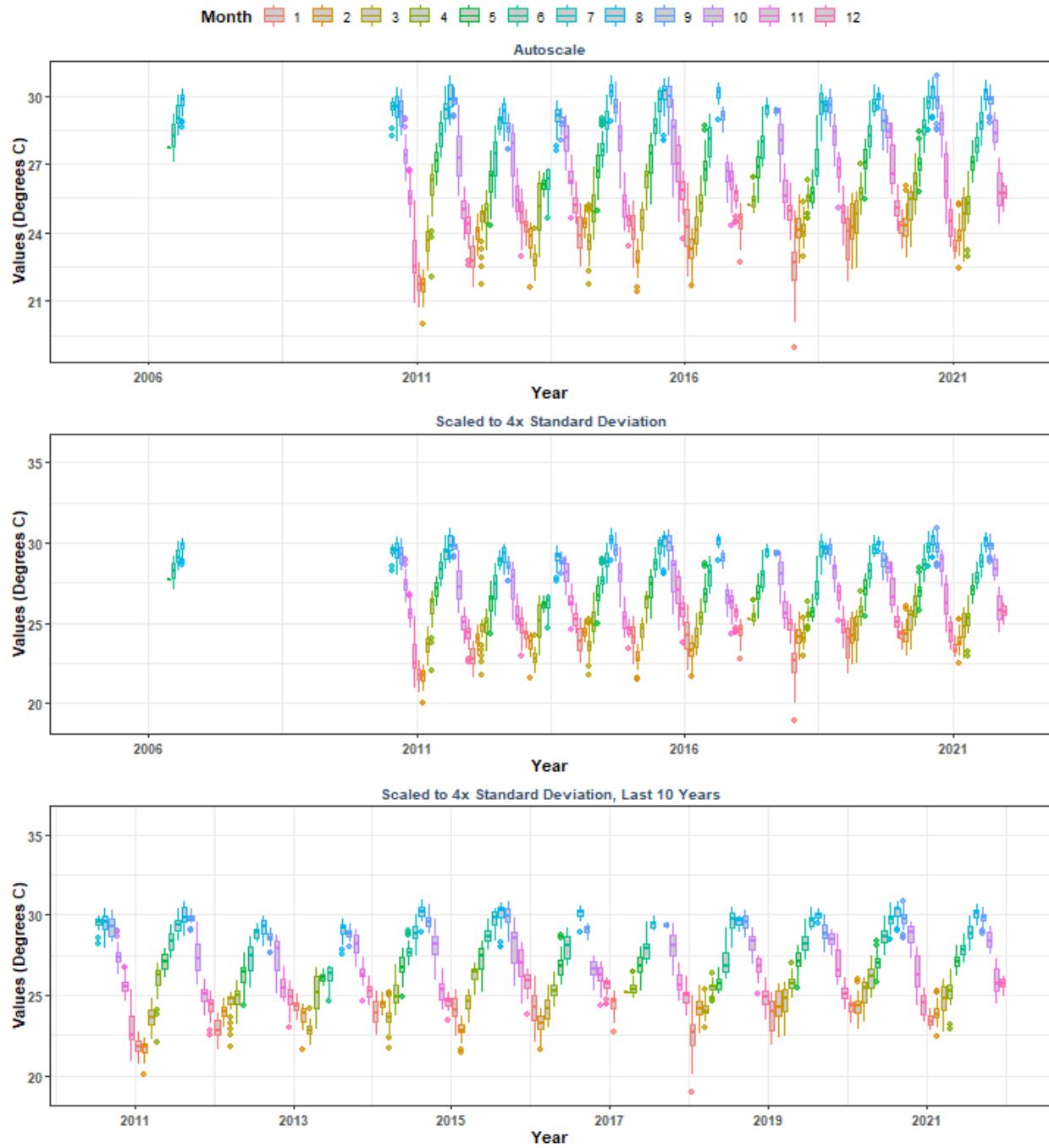
Summary Box Plots for Florida Keys National Marine Sanctuary
986 | Water Temperature on Coral Reefs in the Florida Keys | 83
 By Month



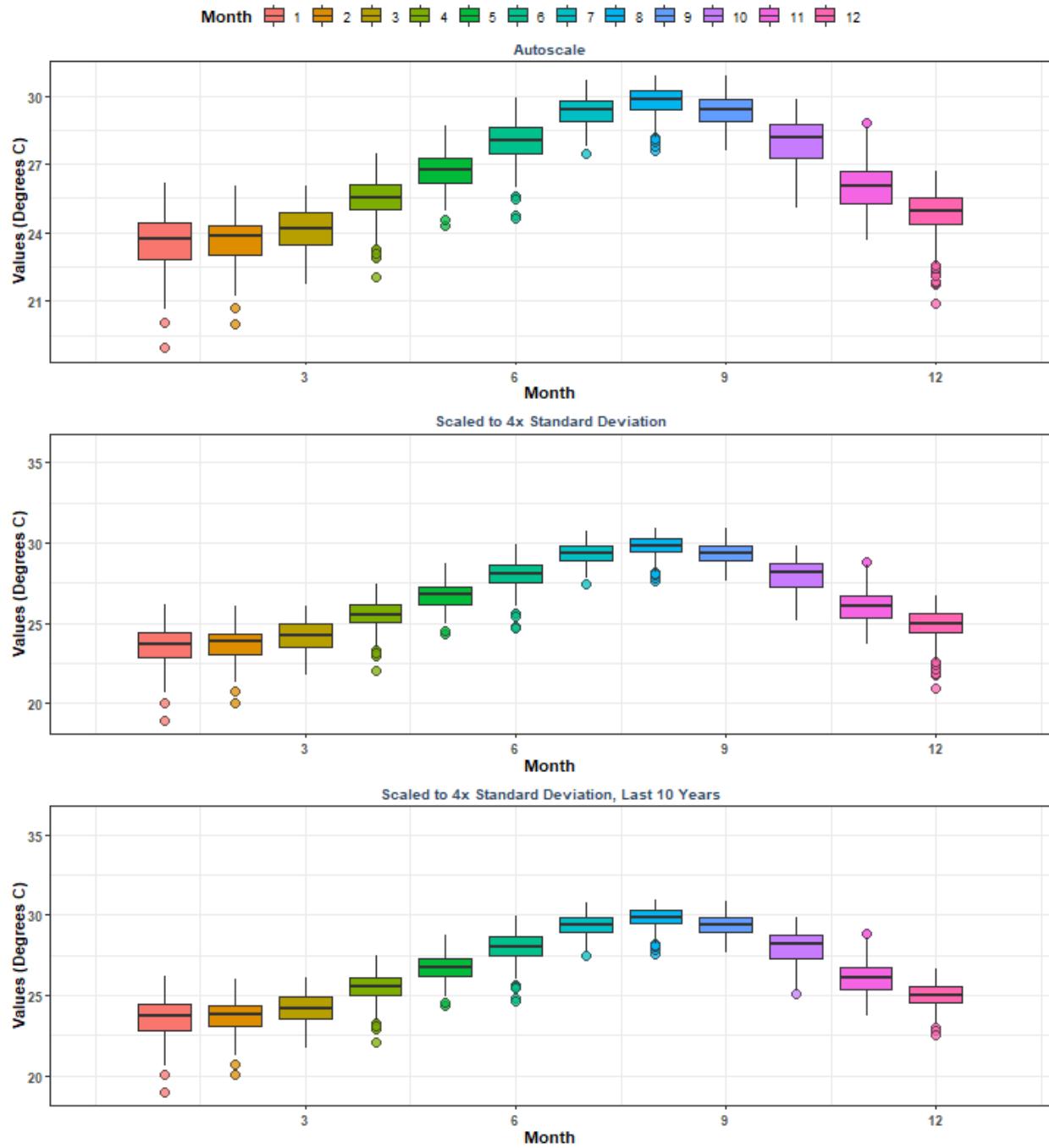
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
5 | National Data Buoy Center | LKWF1
By Year



Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
5 | National Data Buoy Center | LKWF1
 By Year & Month

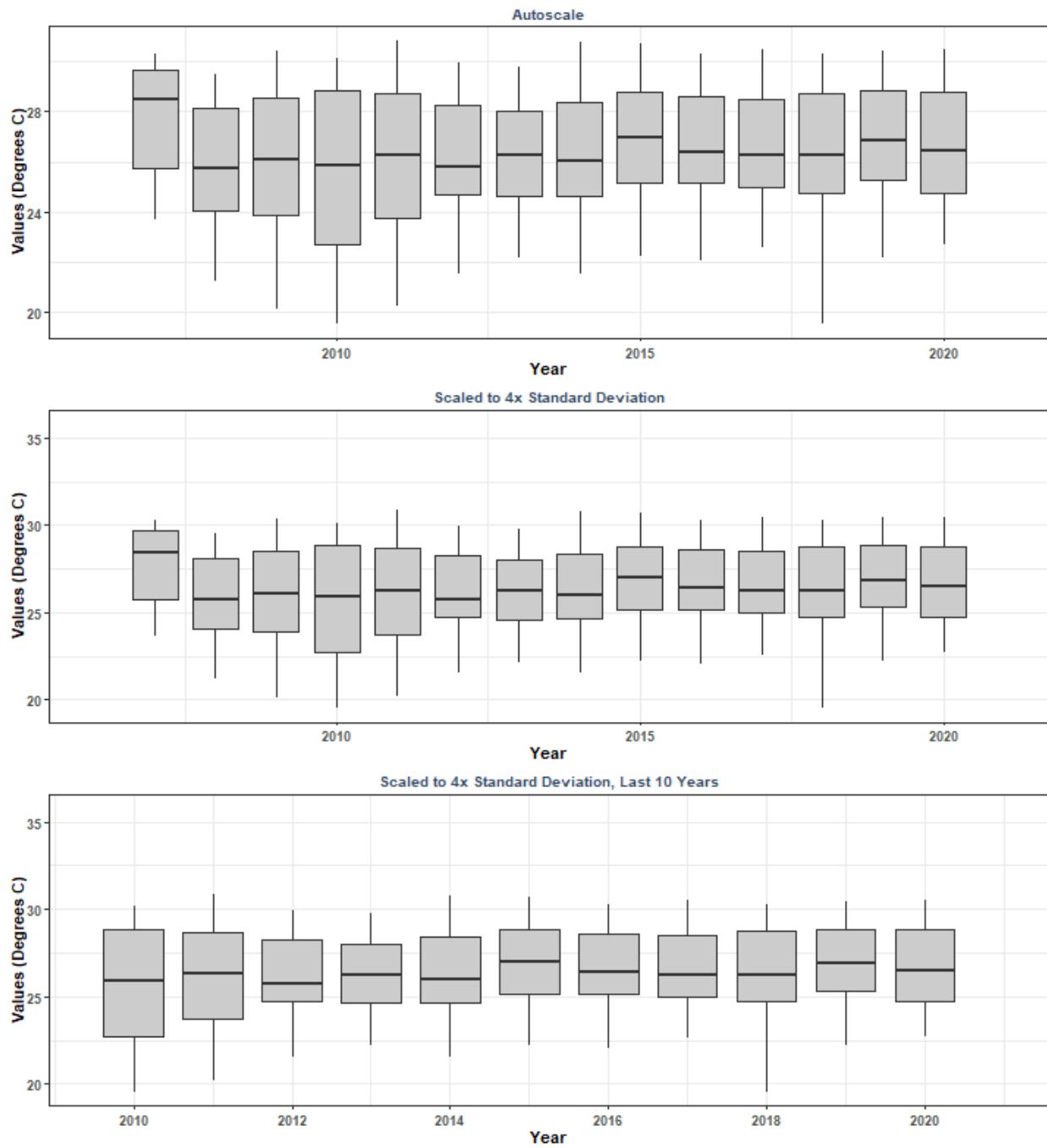


Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
5 | National Data Buoy Center | LKWF1
 By Month

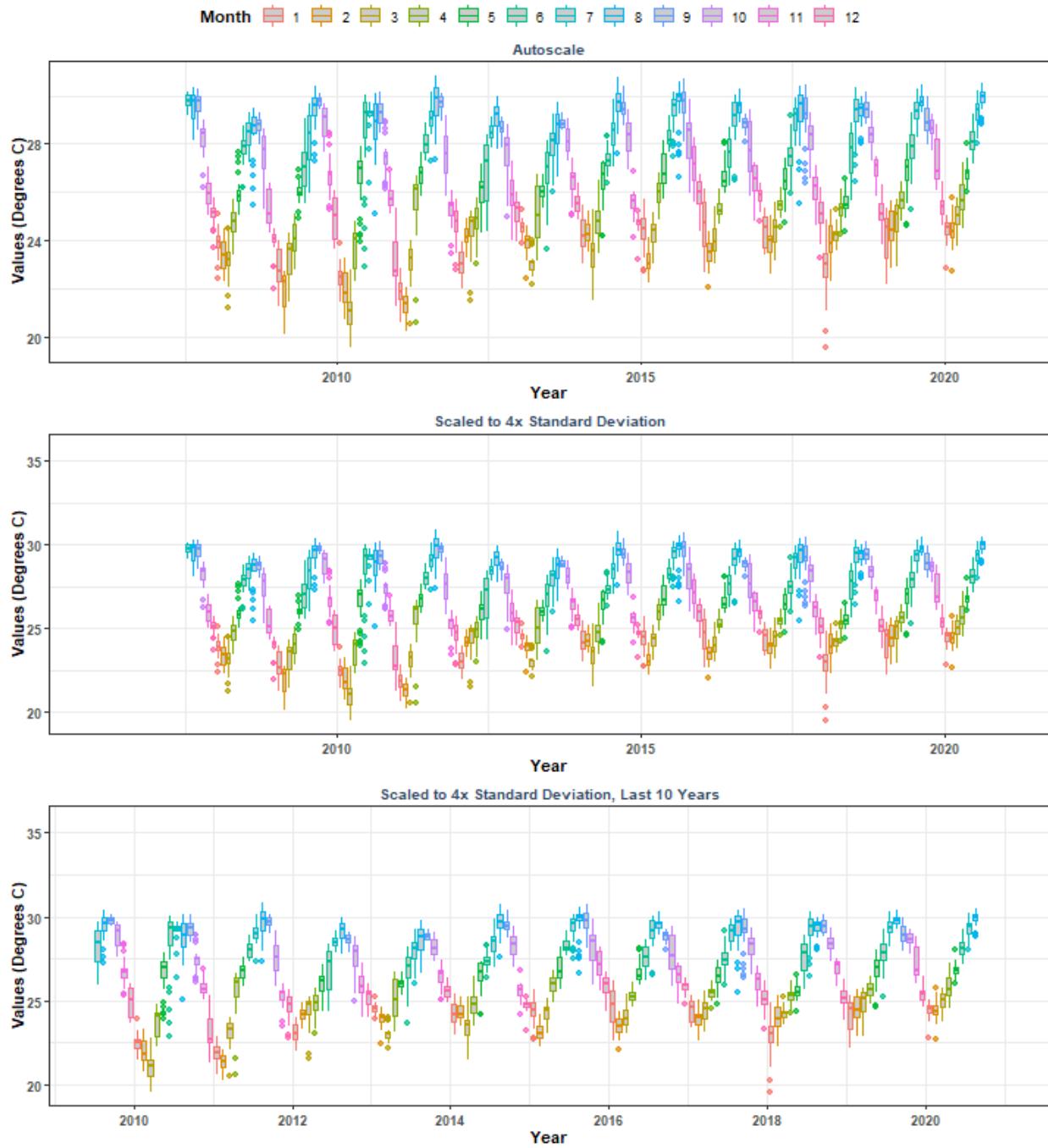


**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 84**

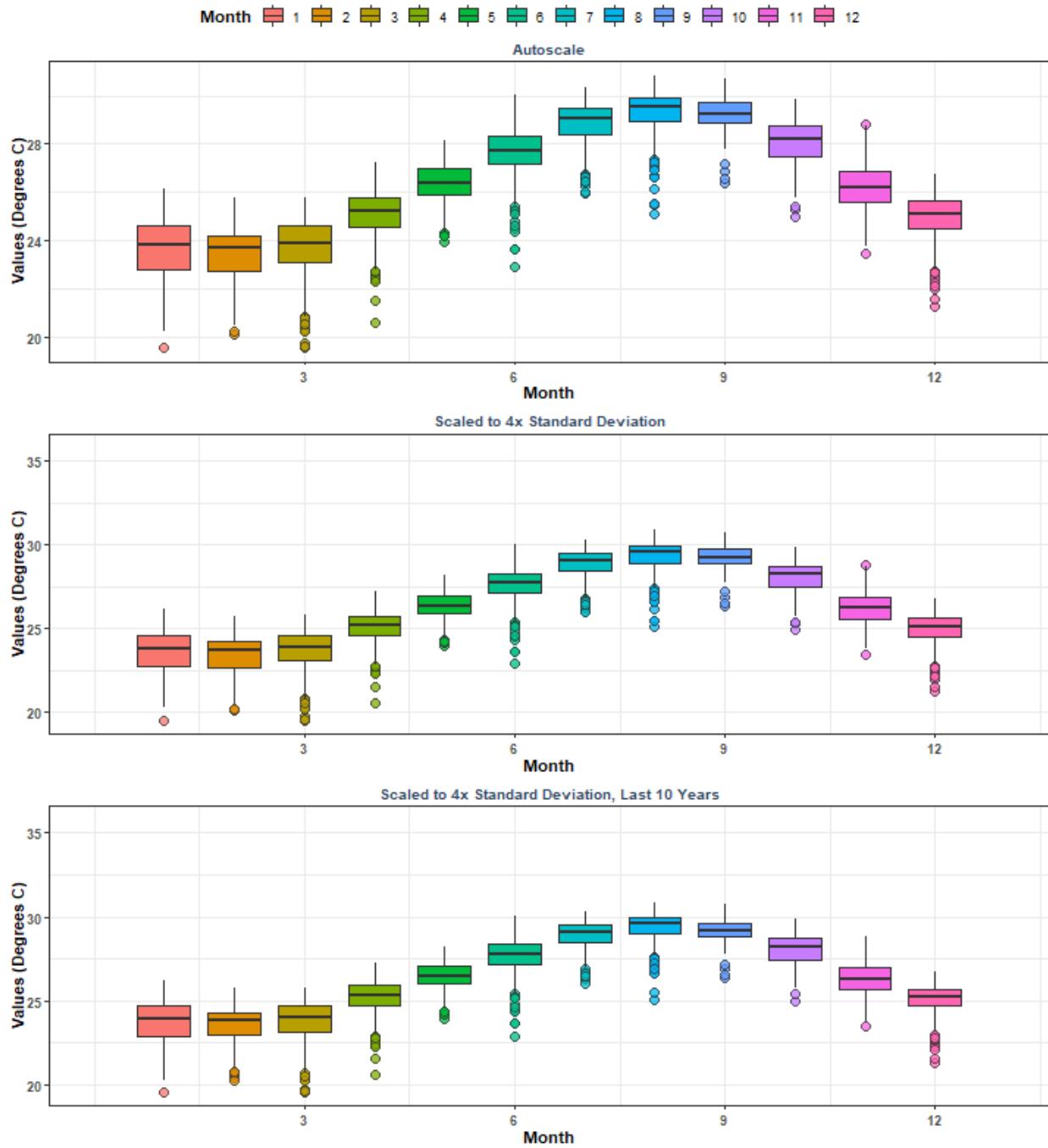
By Year



Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 84
 By Year & Month

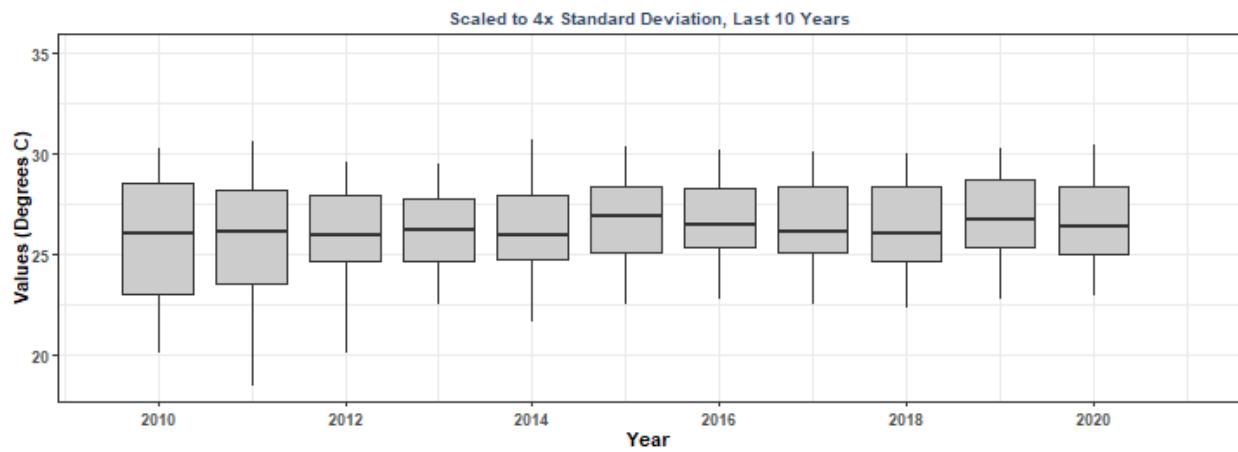
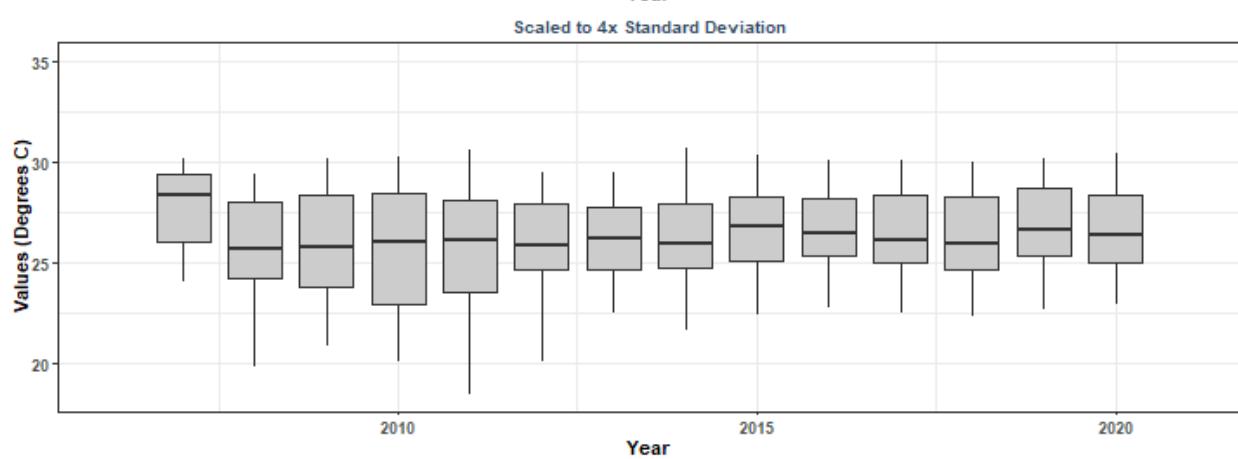
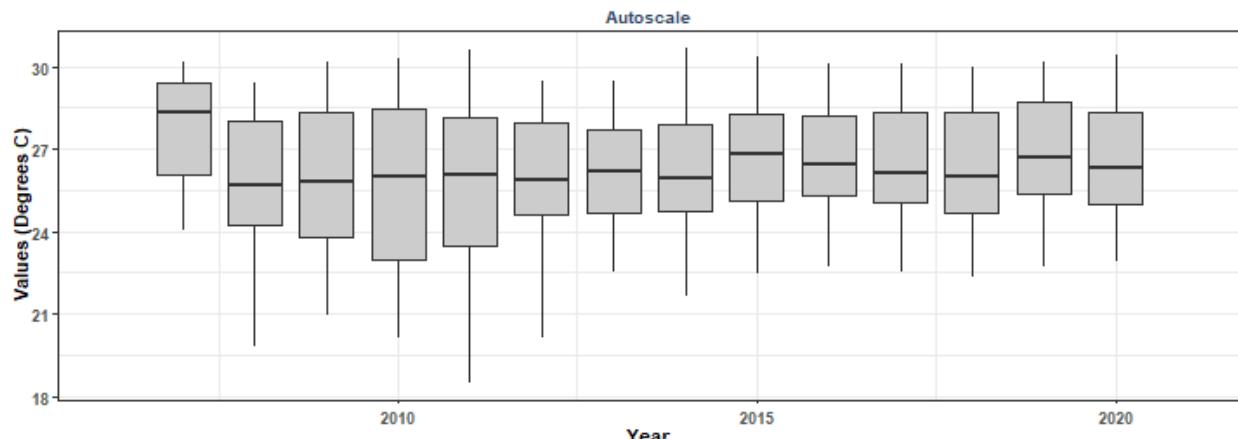


Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 84
 By Month

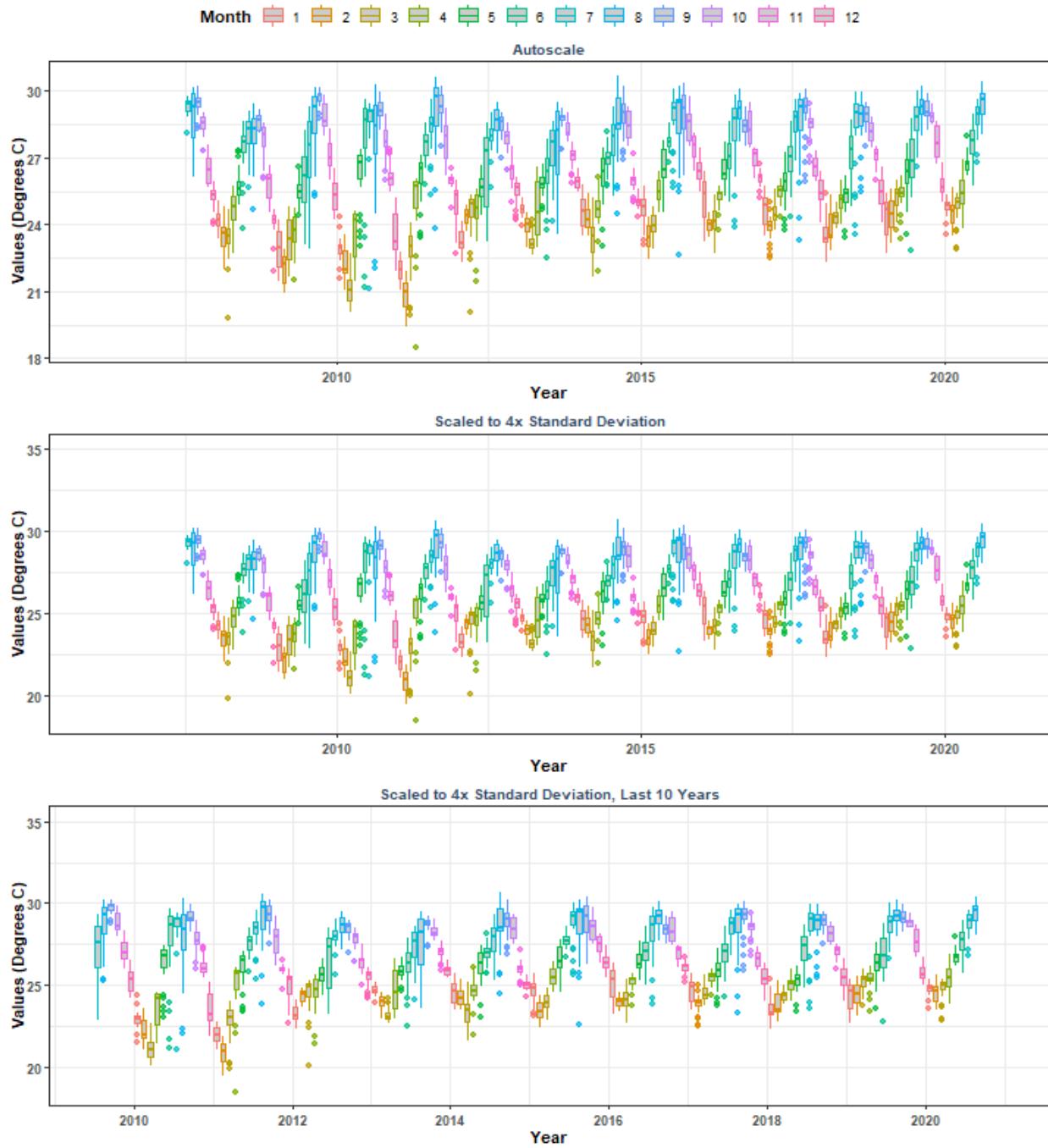


**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 85**

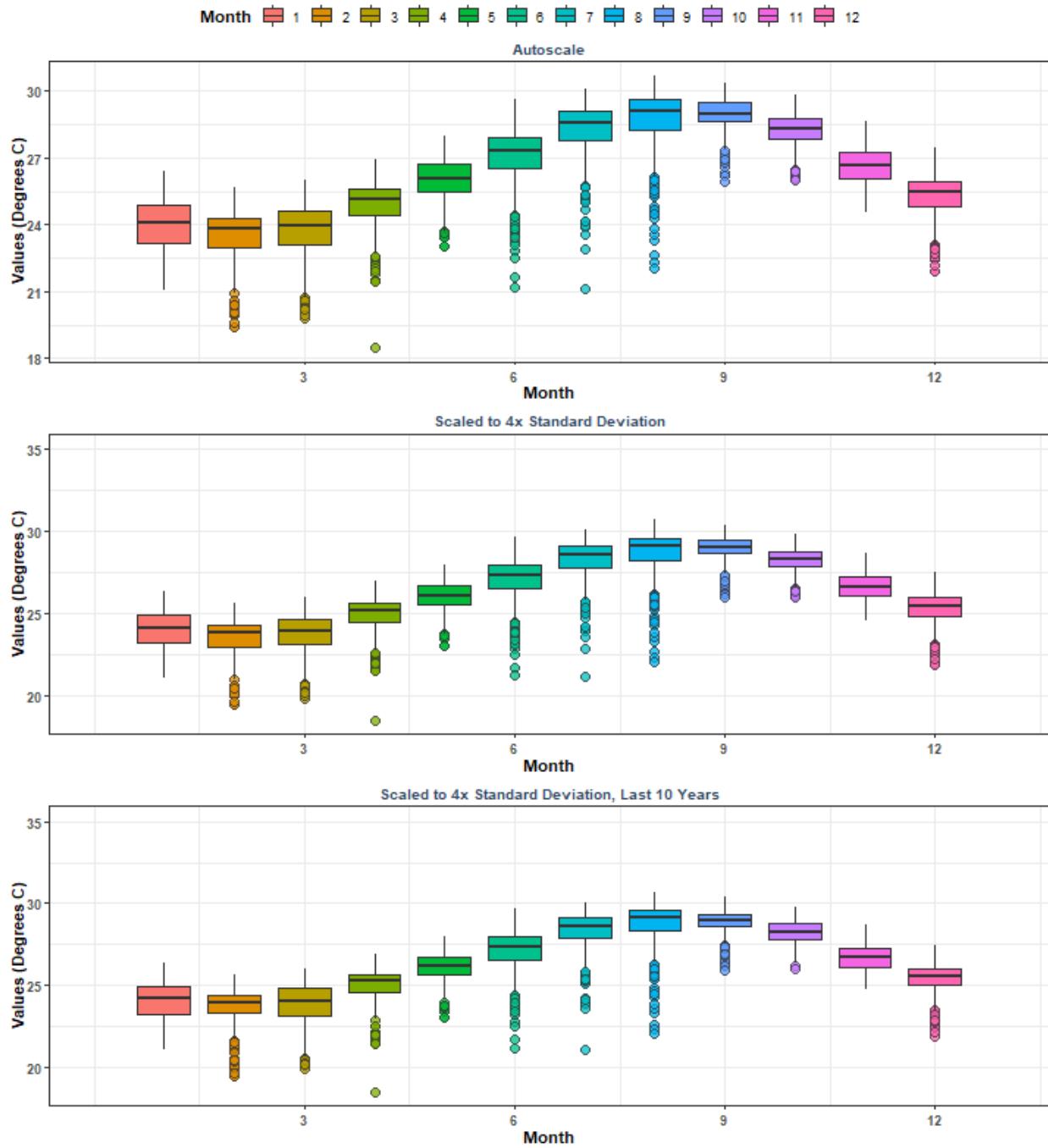
By Year



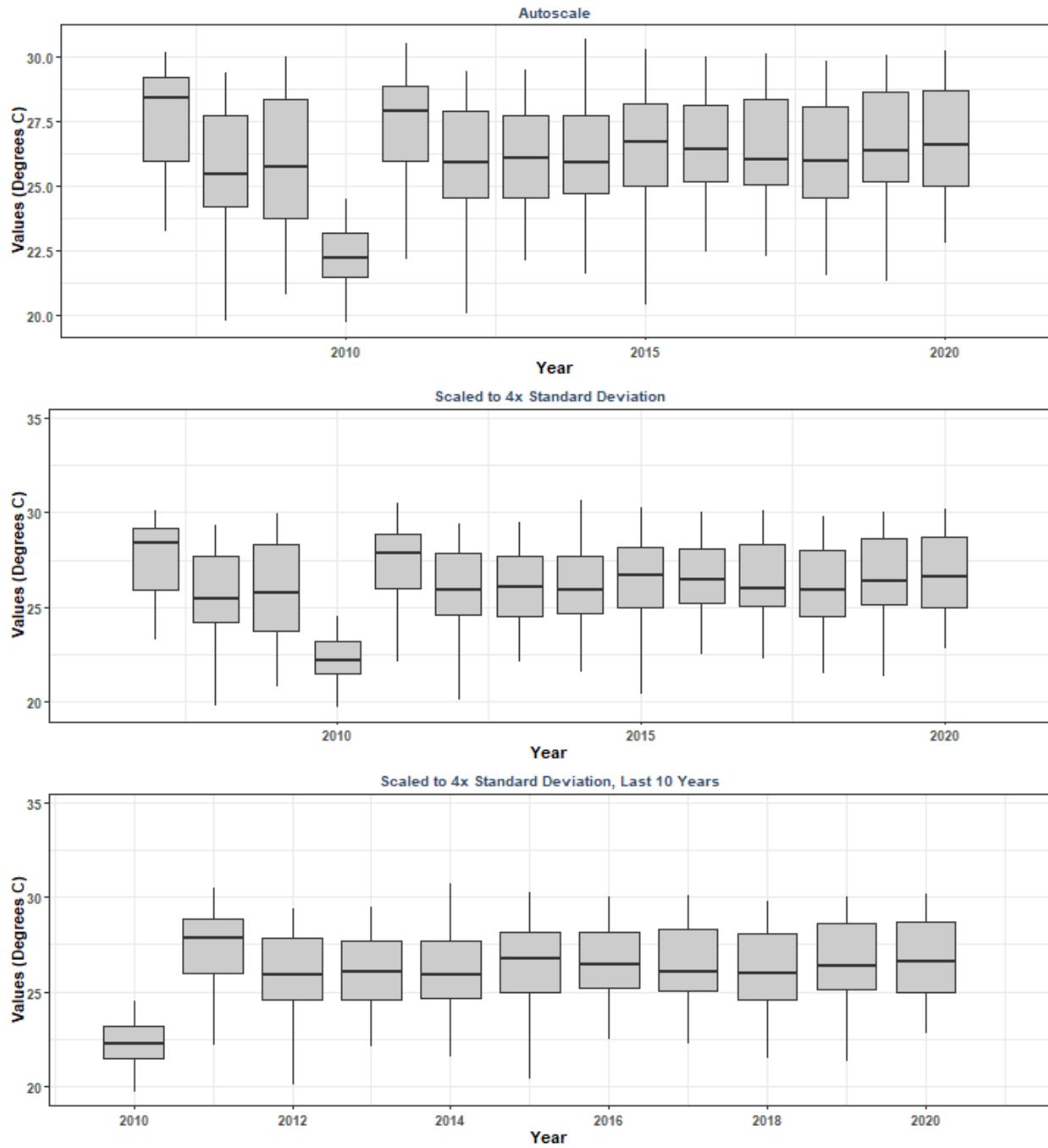
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 85
 By Year & Month



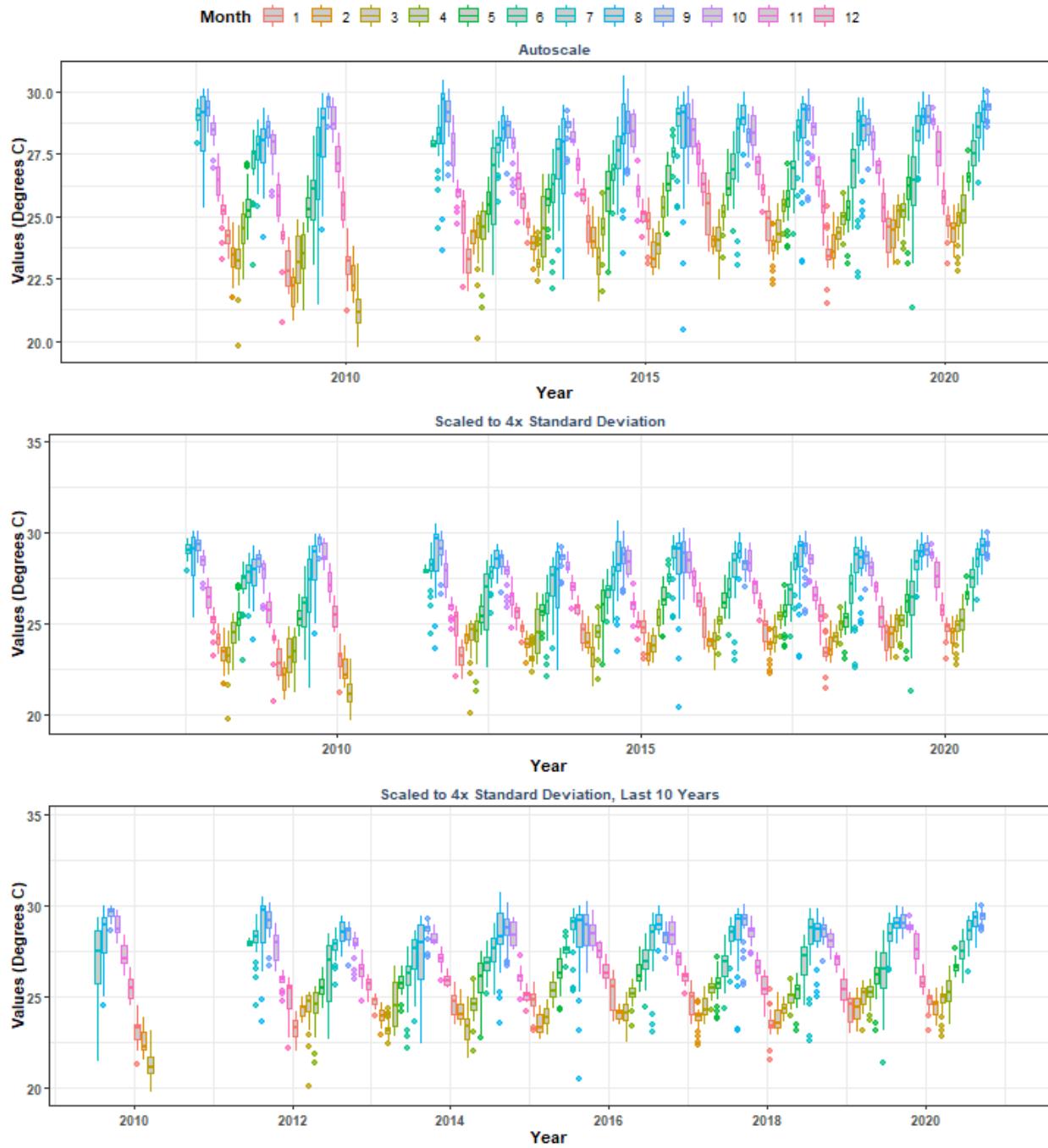
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 85
 By Month



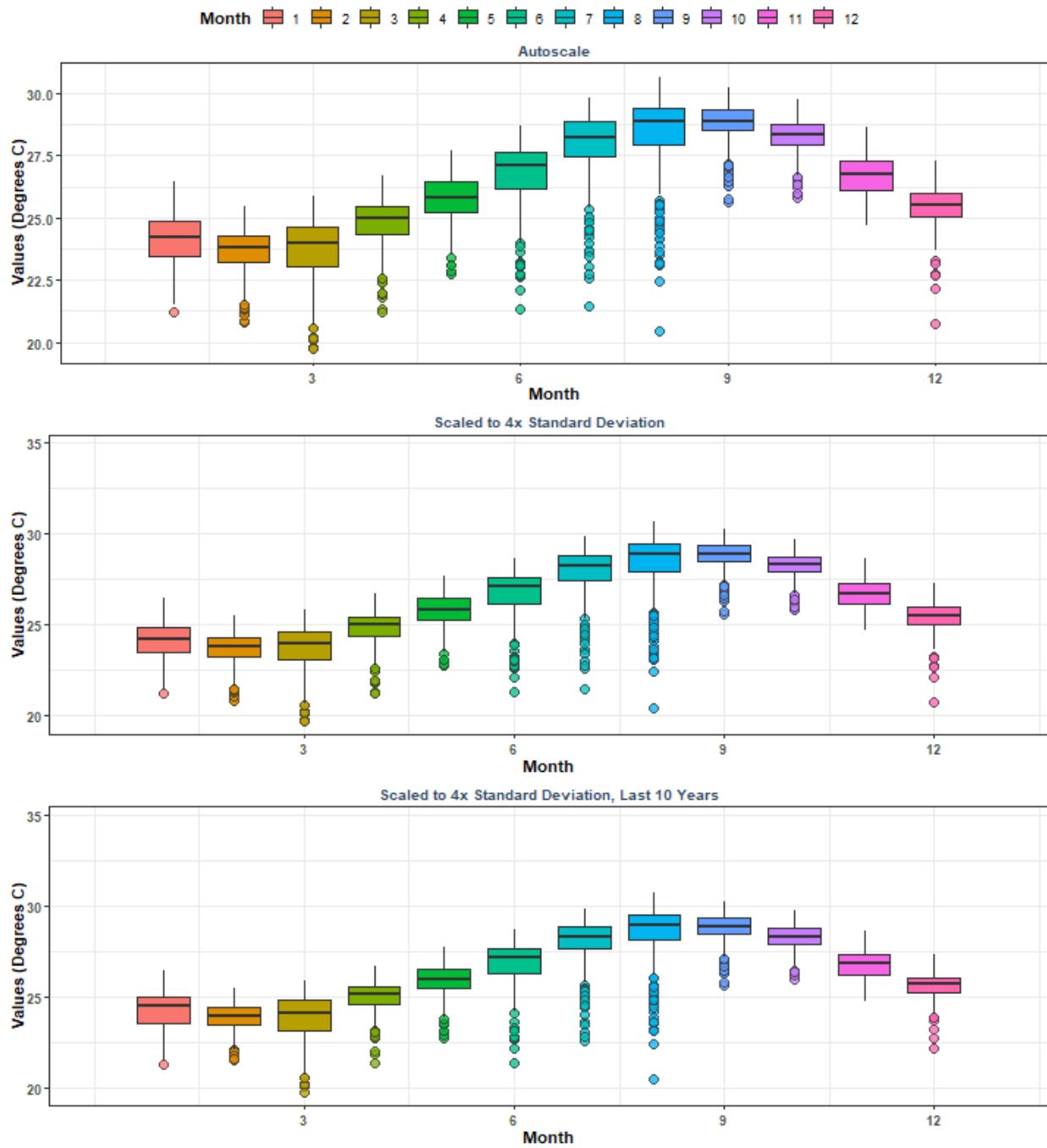
**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 86**
By Year



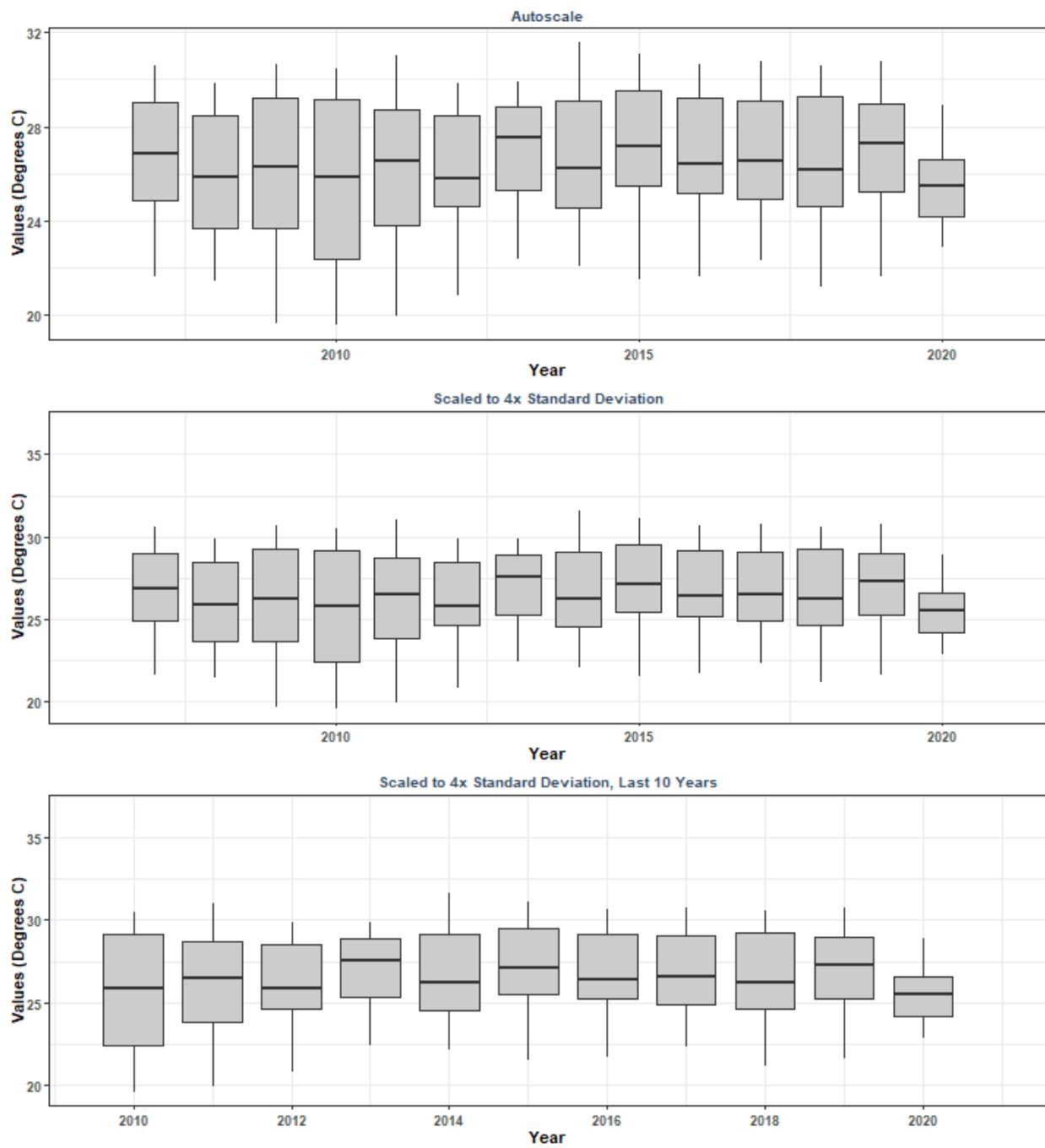
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 86
 By Year & Month



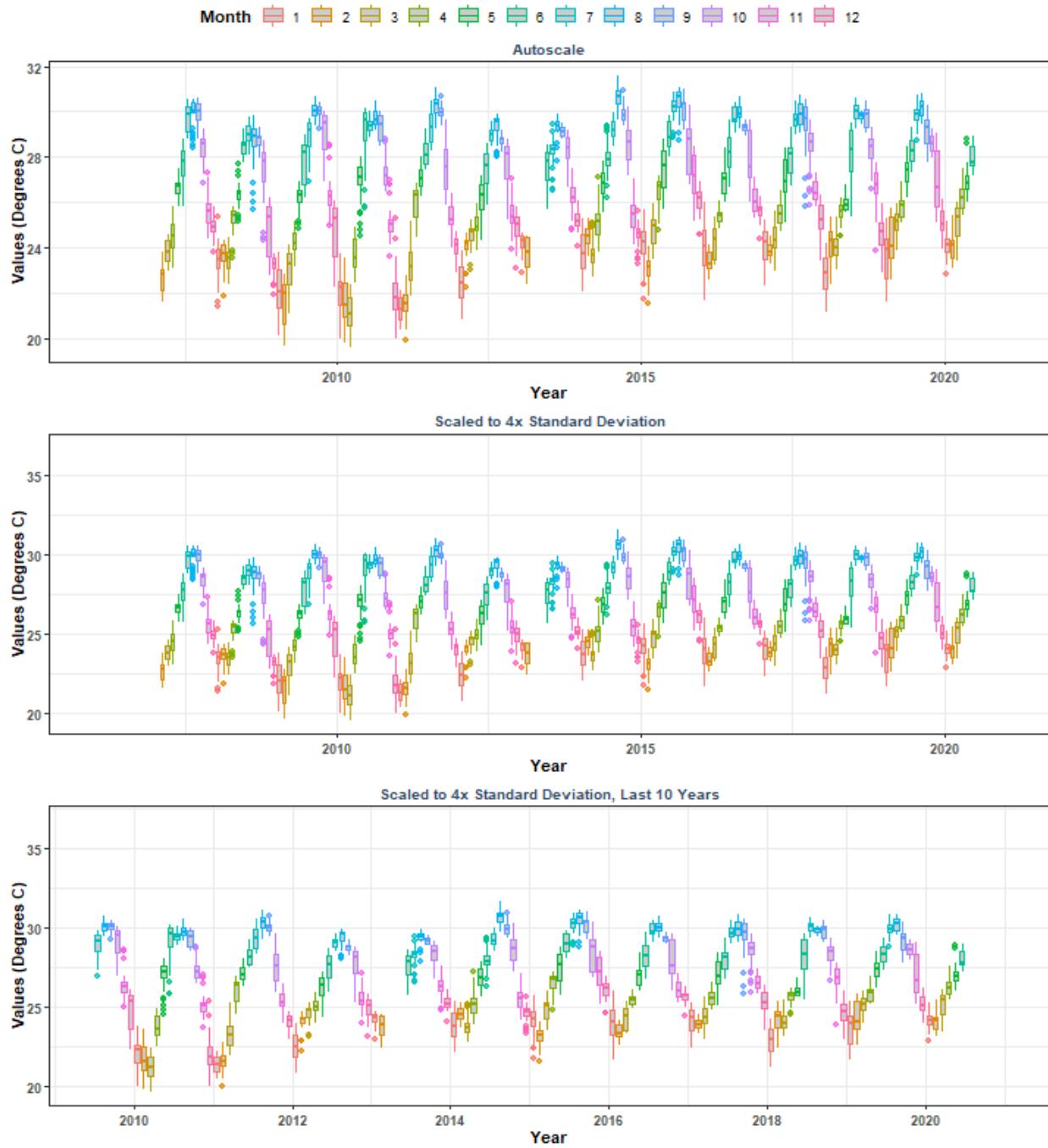
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 86
 By Month



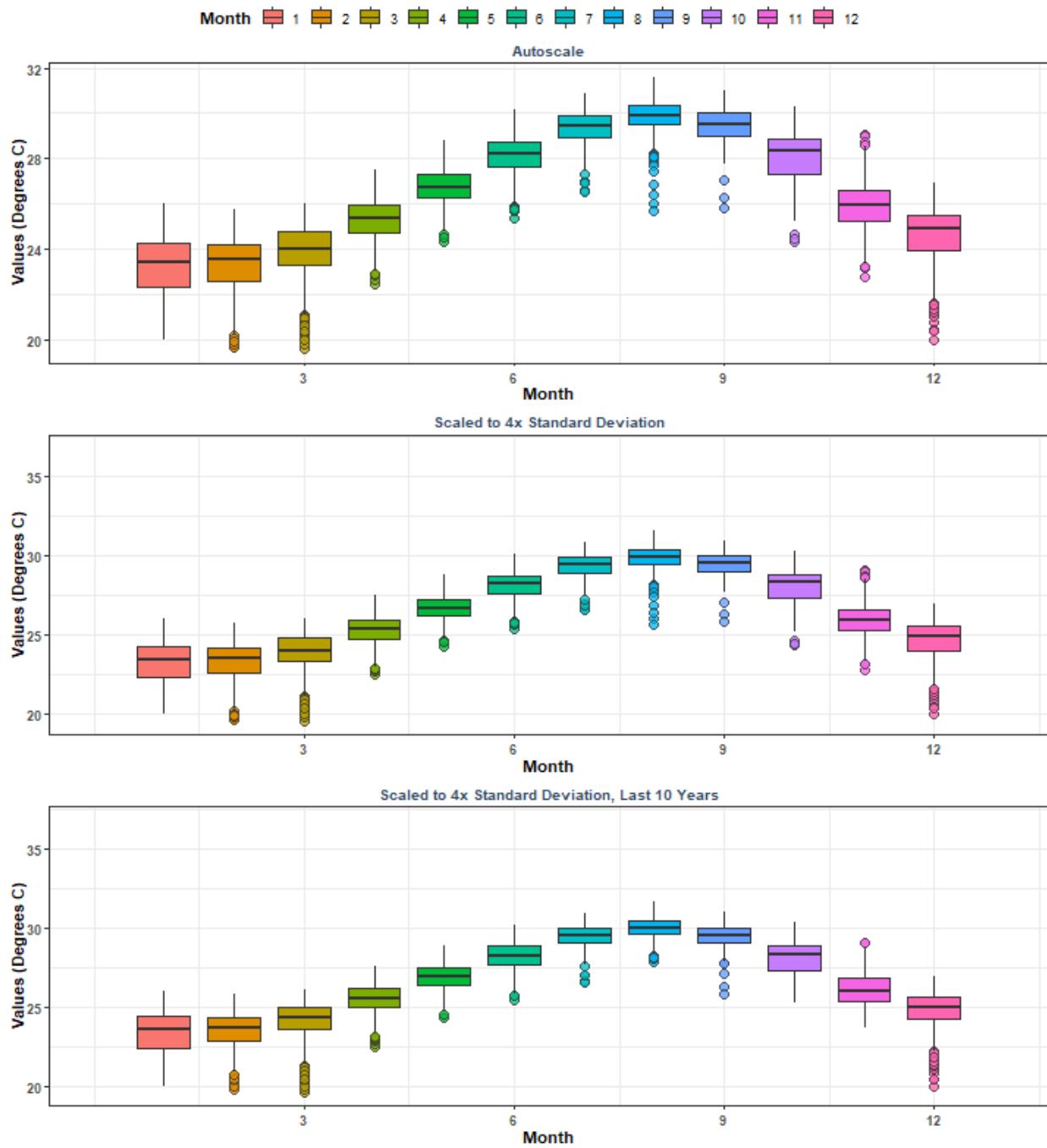
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 87
By Year



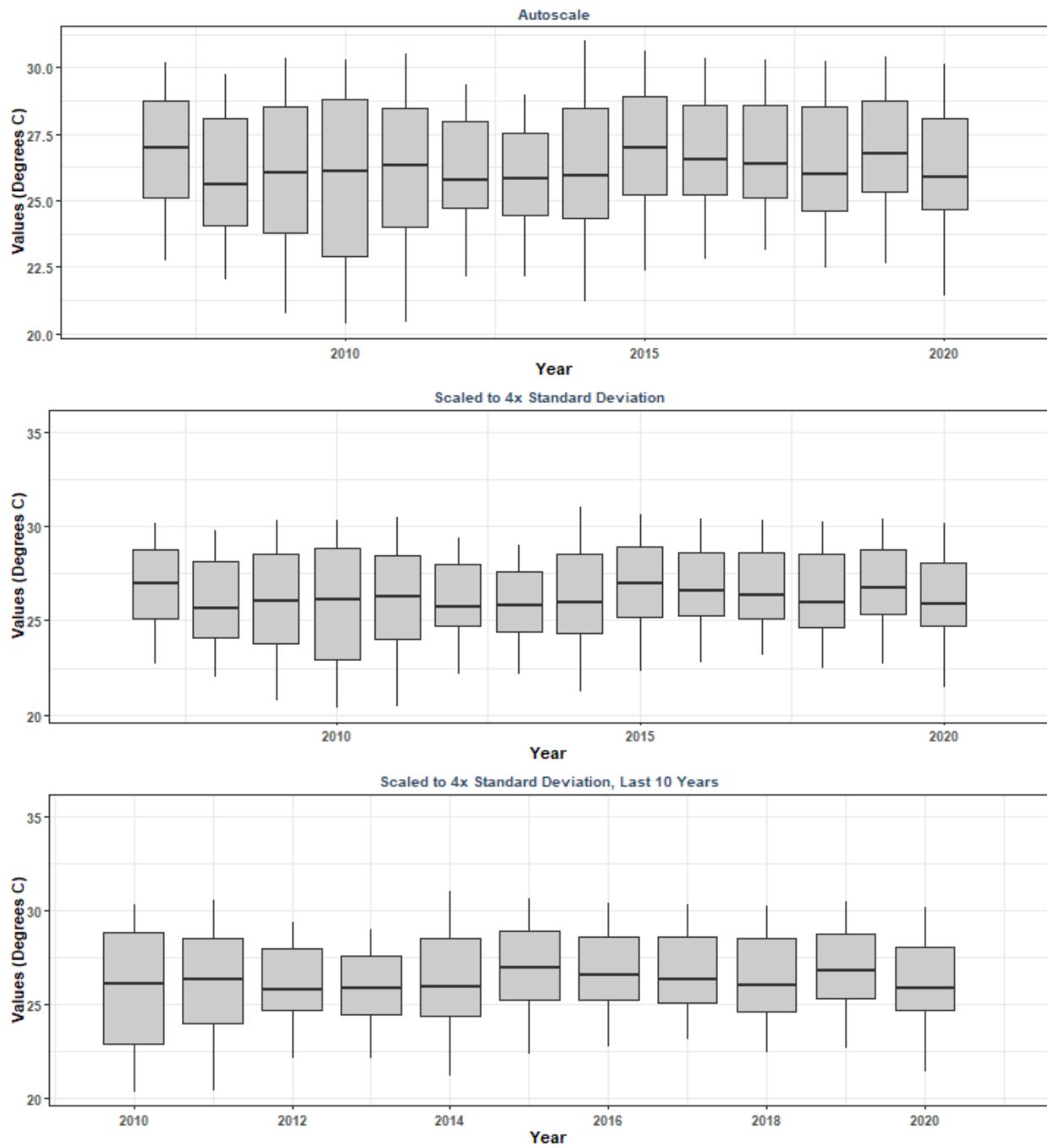
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 87
 By Year & Month



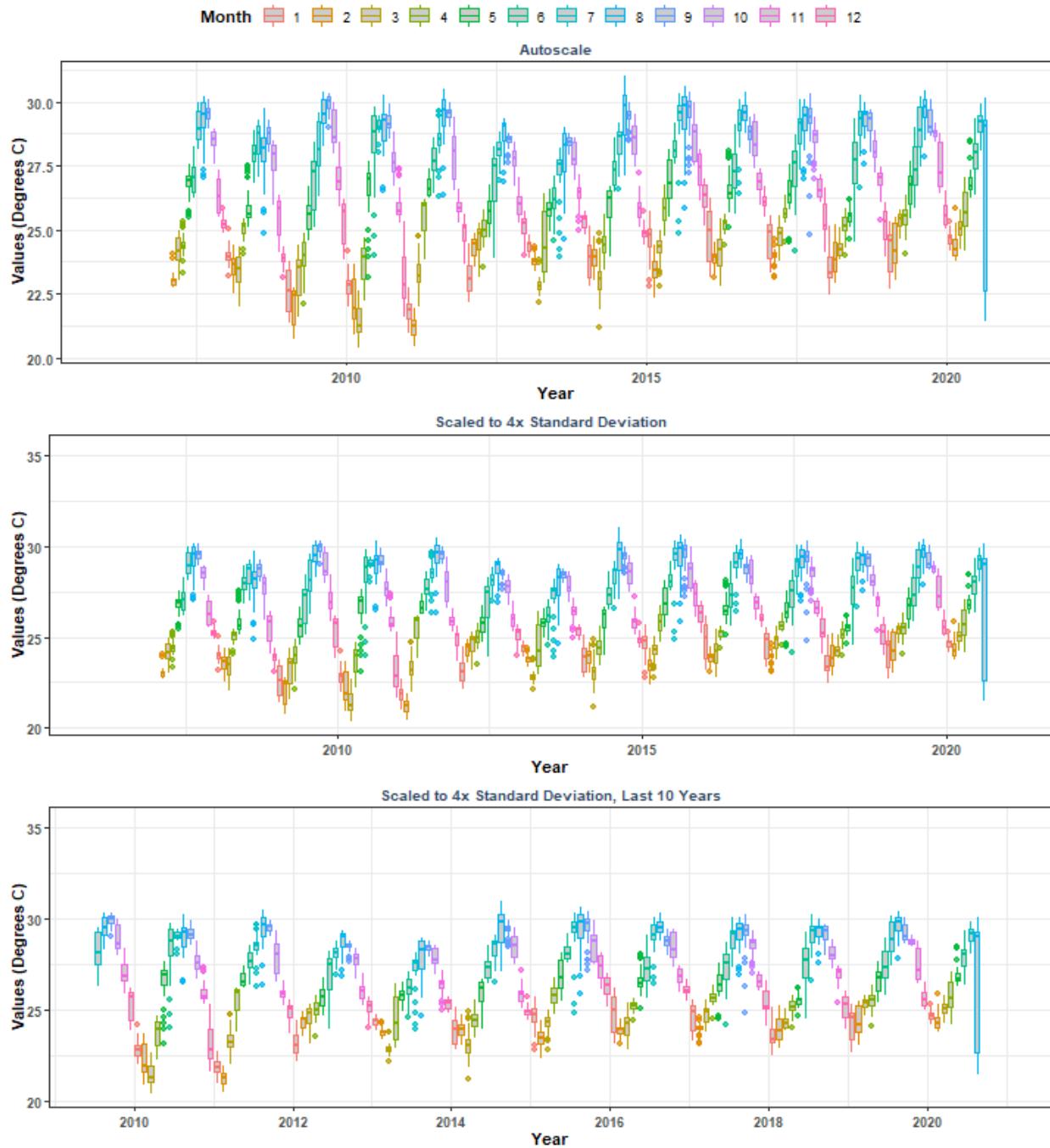
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 87
 By Month



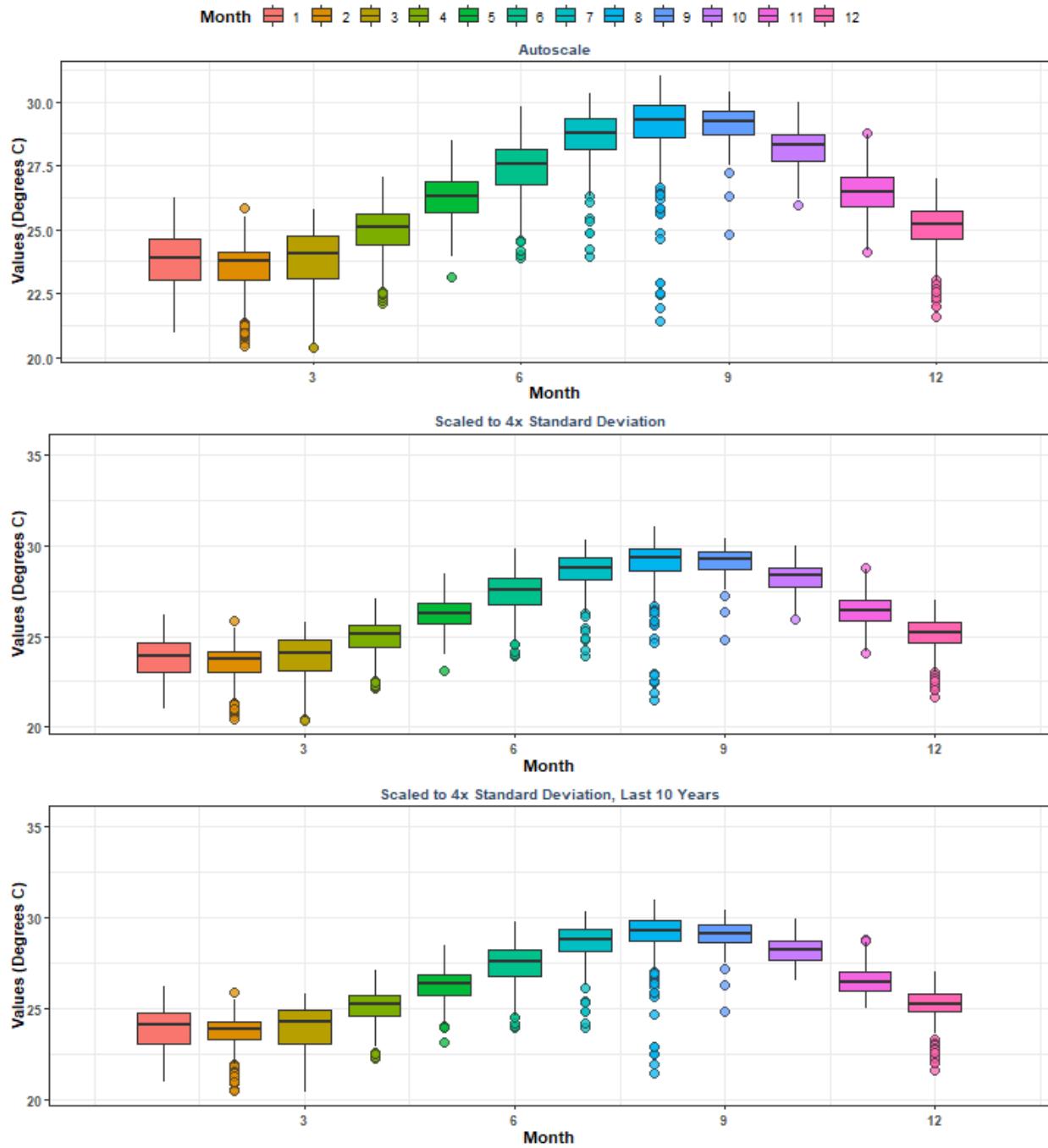
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 88
By Year



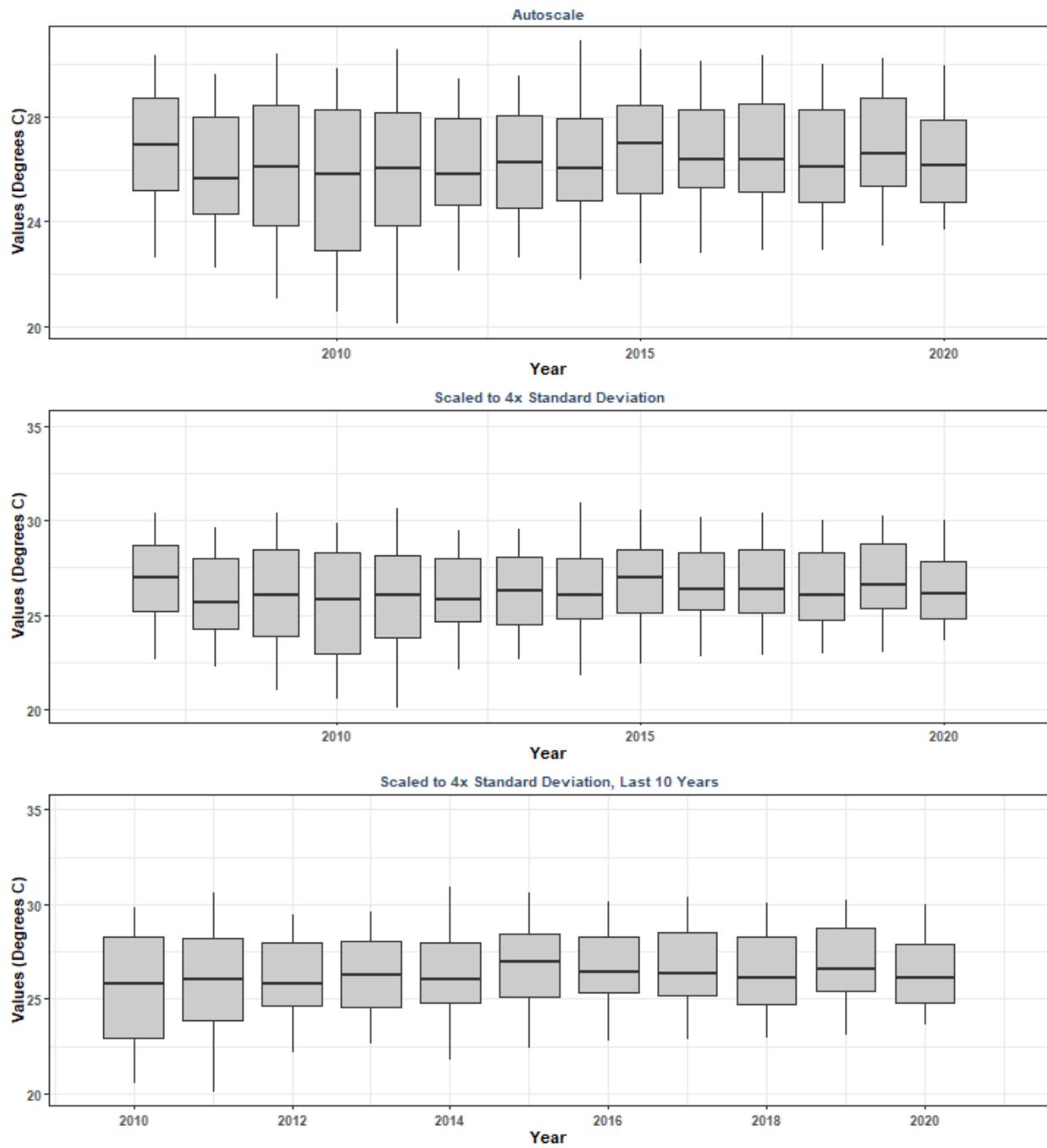
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 88
By Year & Month



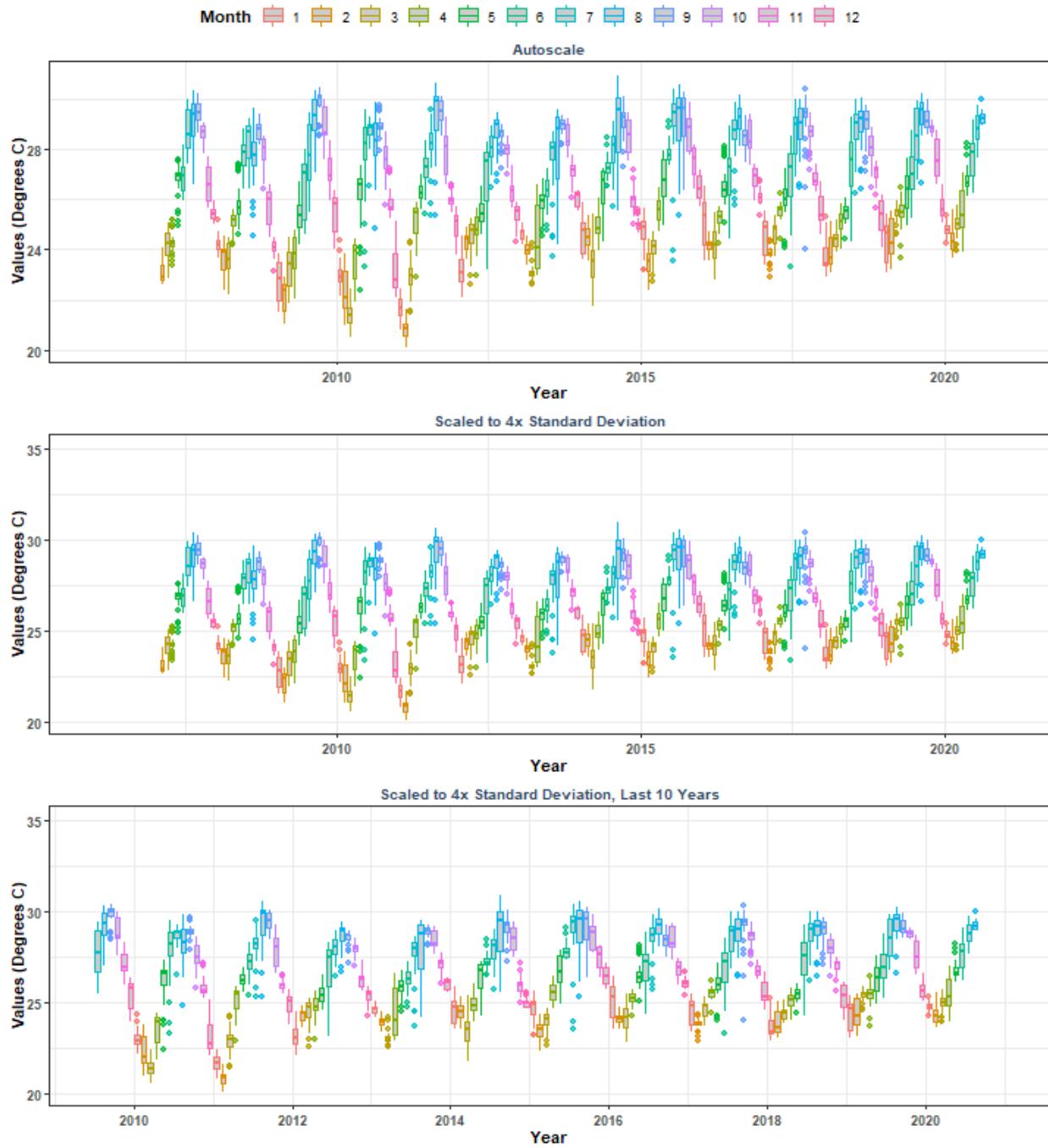
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 88
 By Month



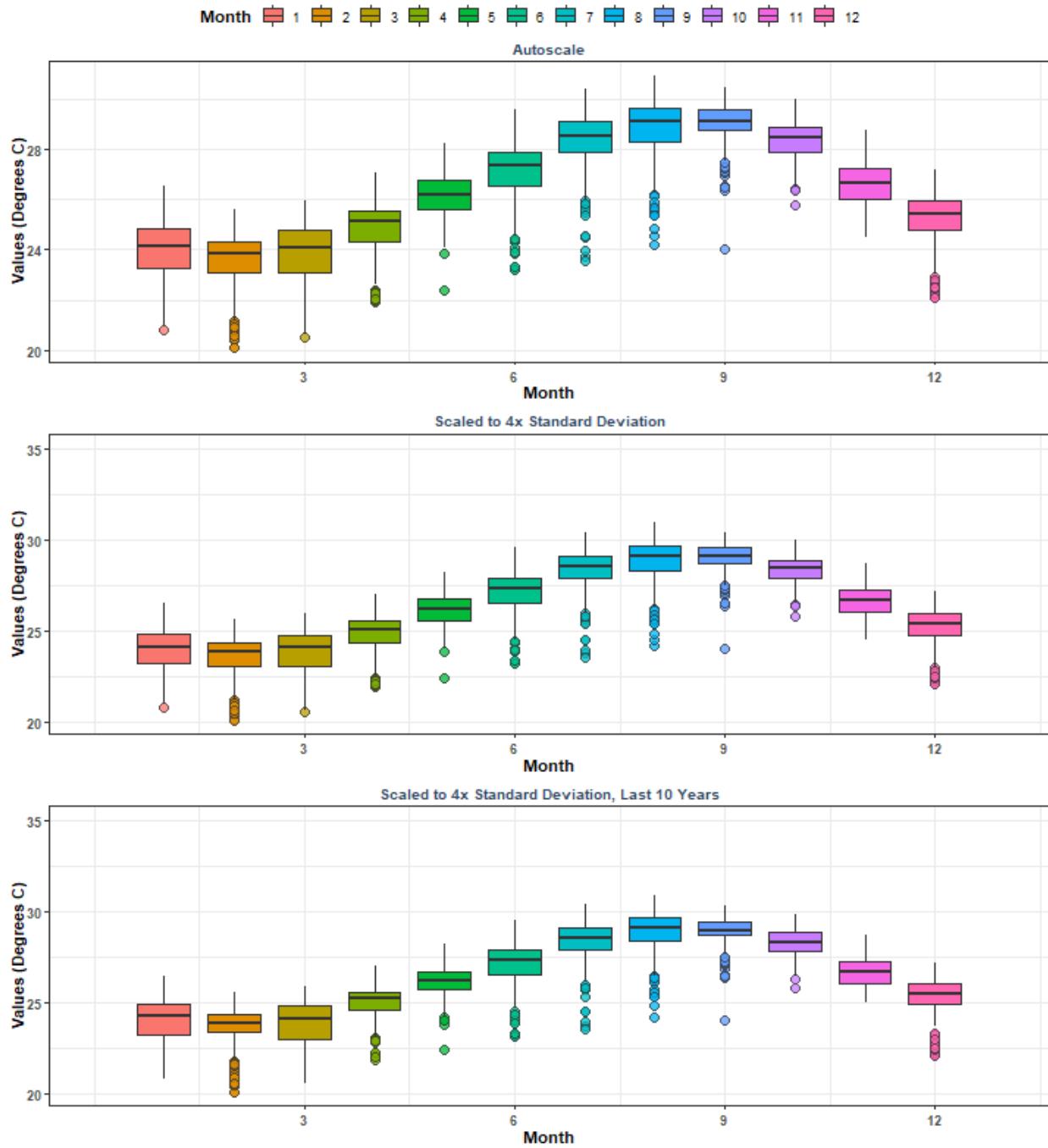
**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 89**
By Year



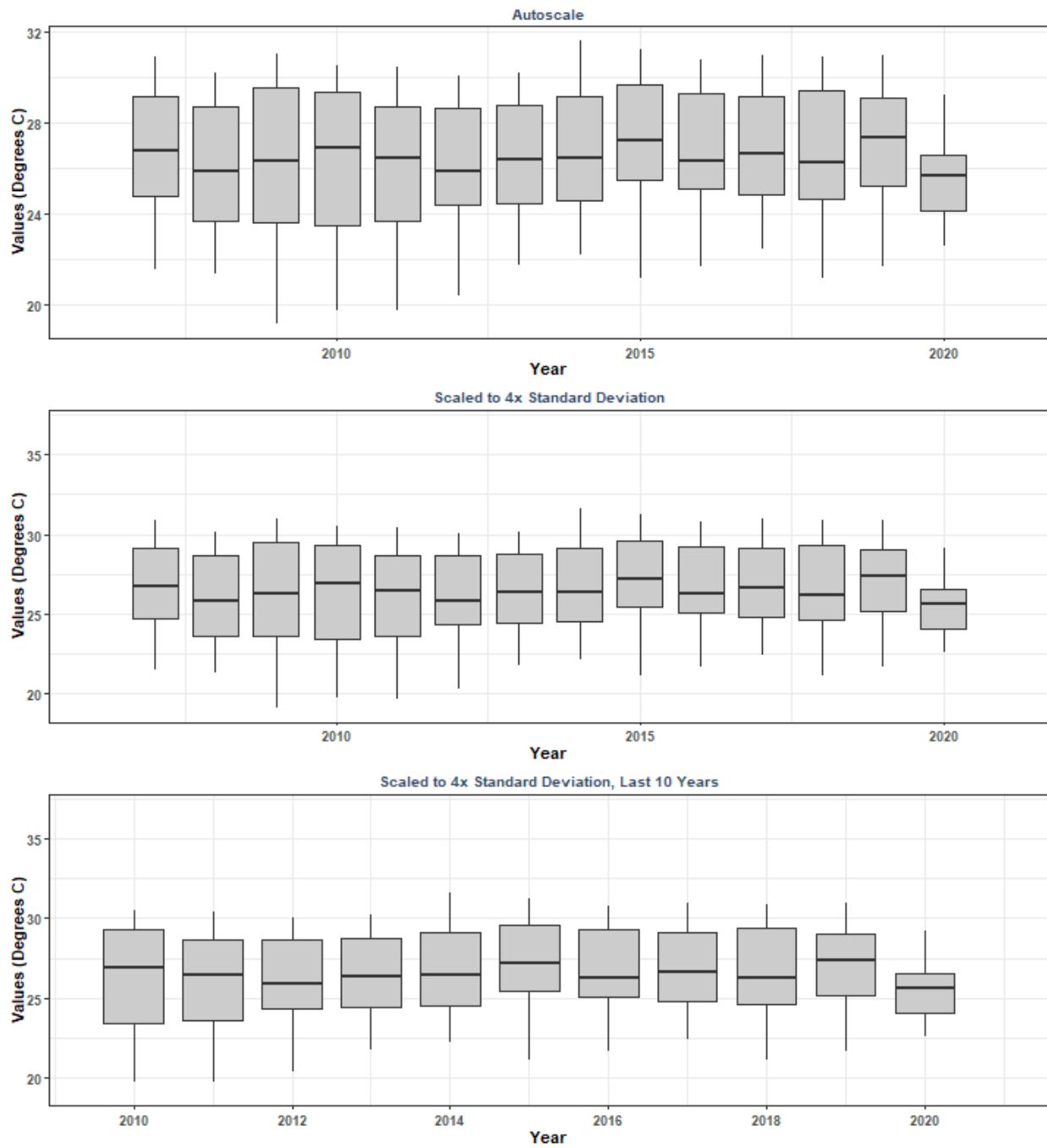
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 89
 By Year & Month



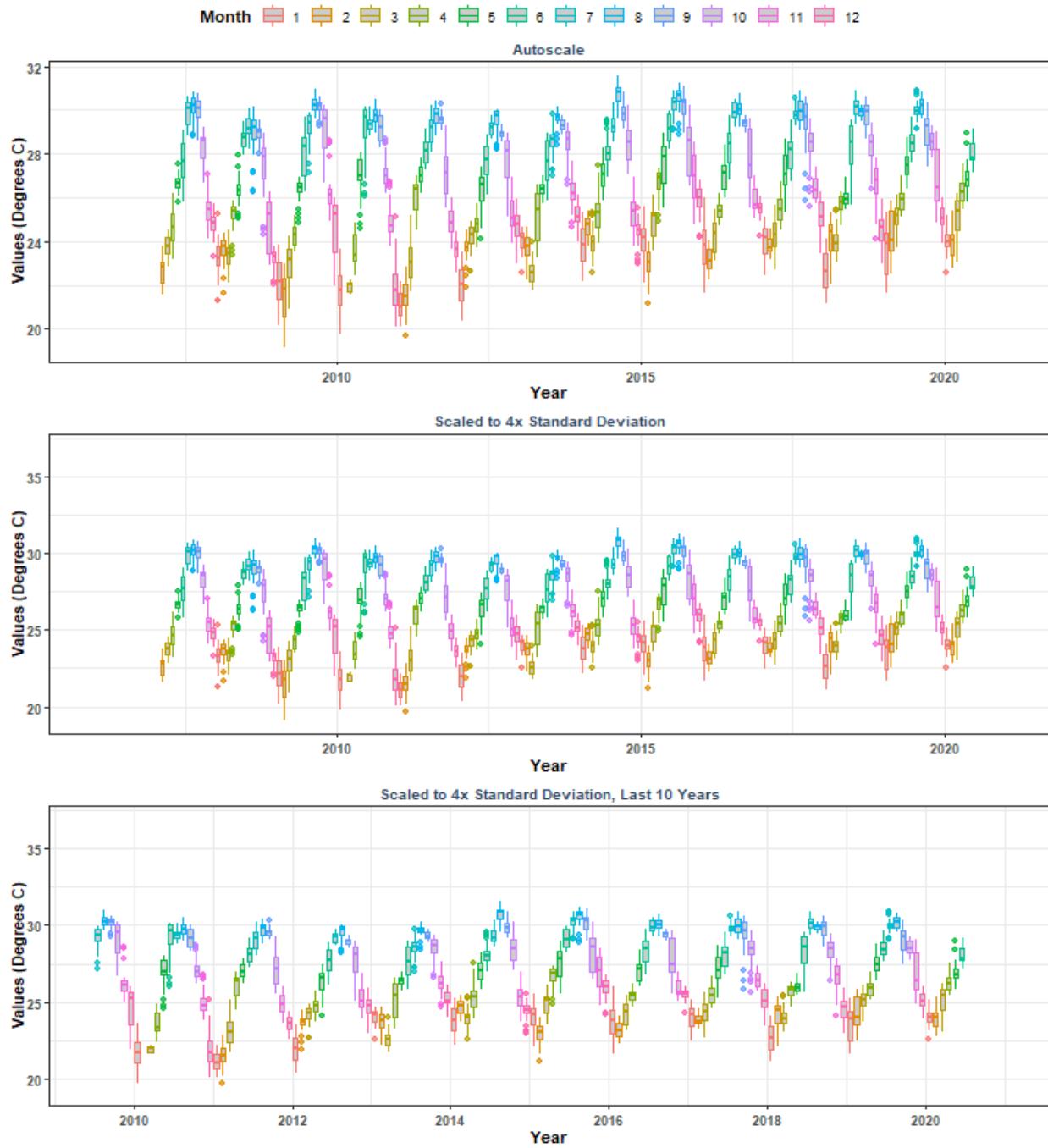
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 89
 By Month



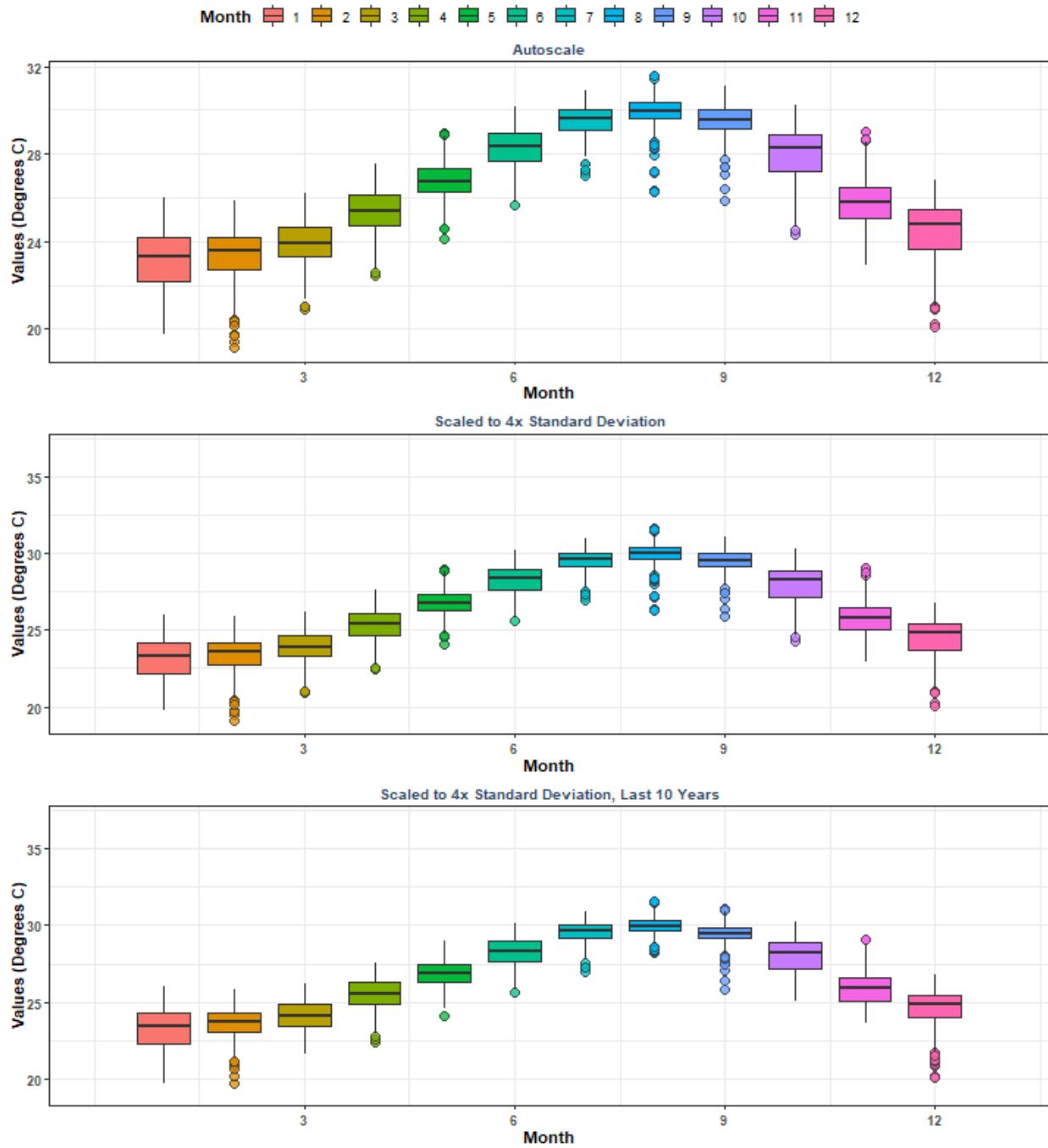
**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 90**
By Year



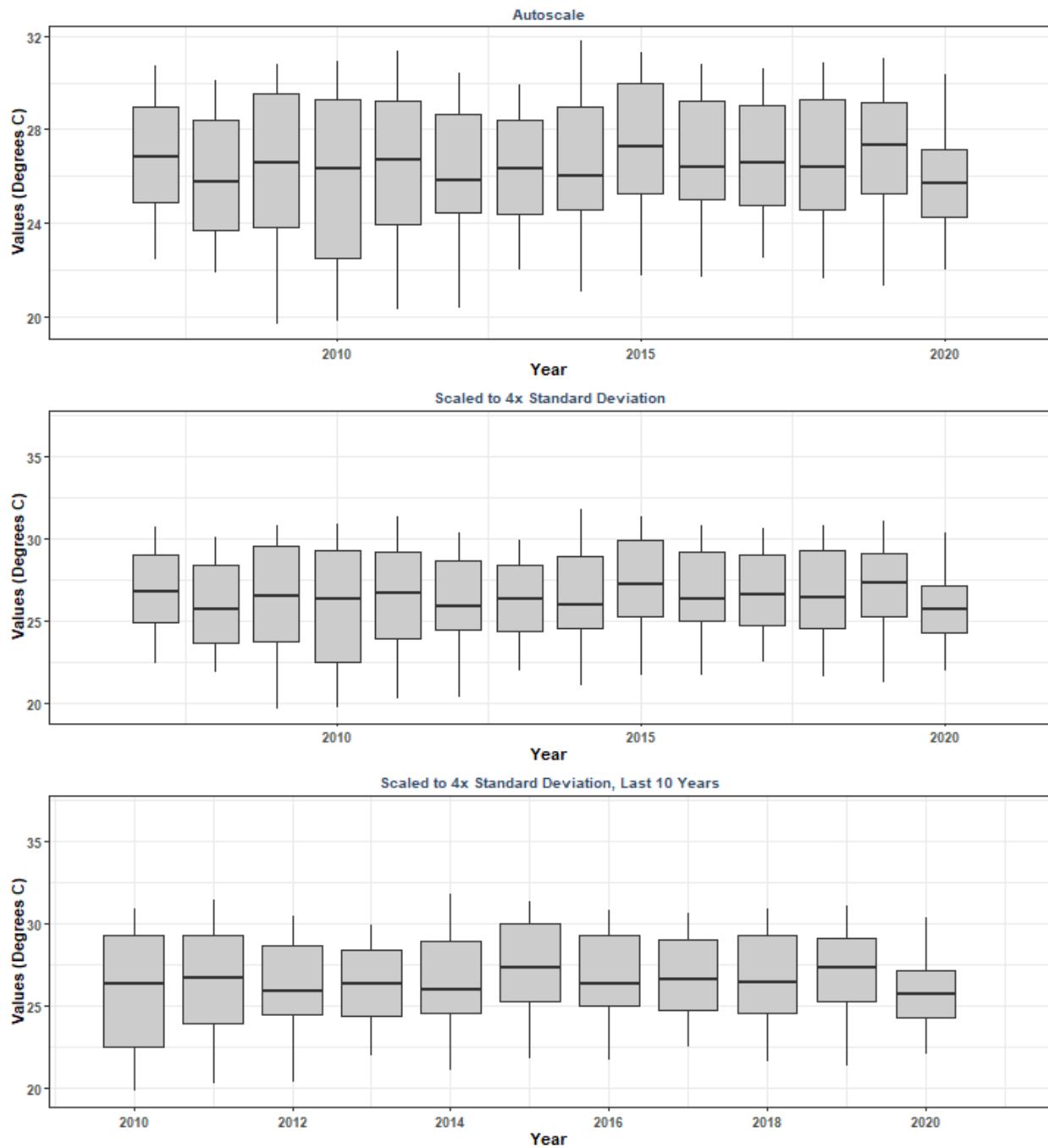
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 90
 By Year & Month



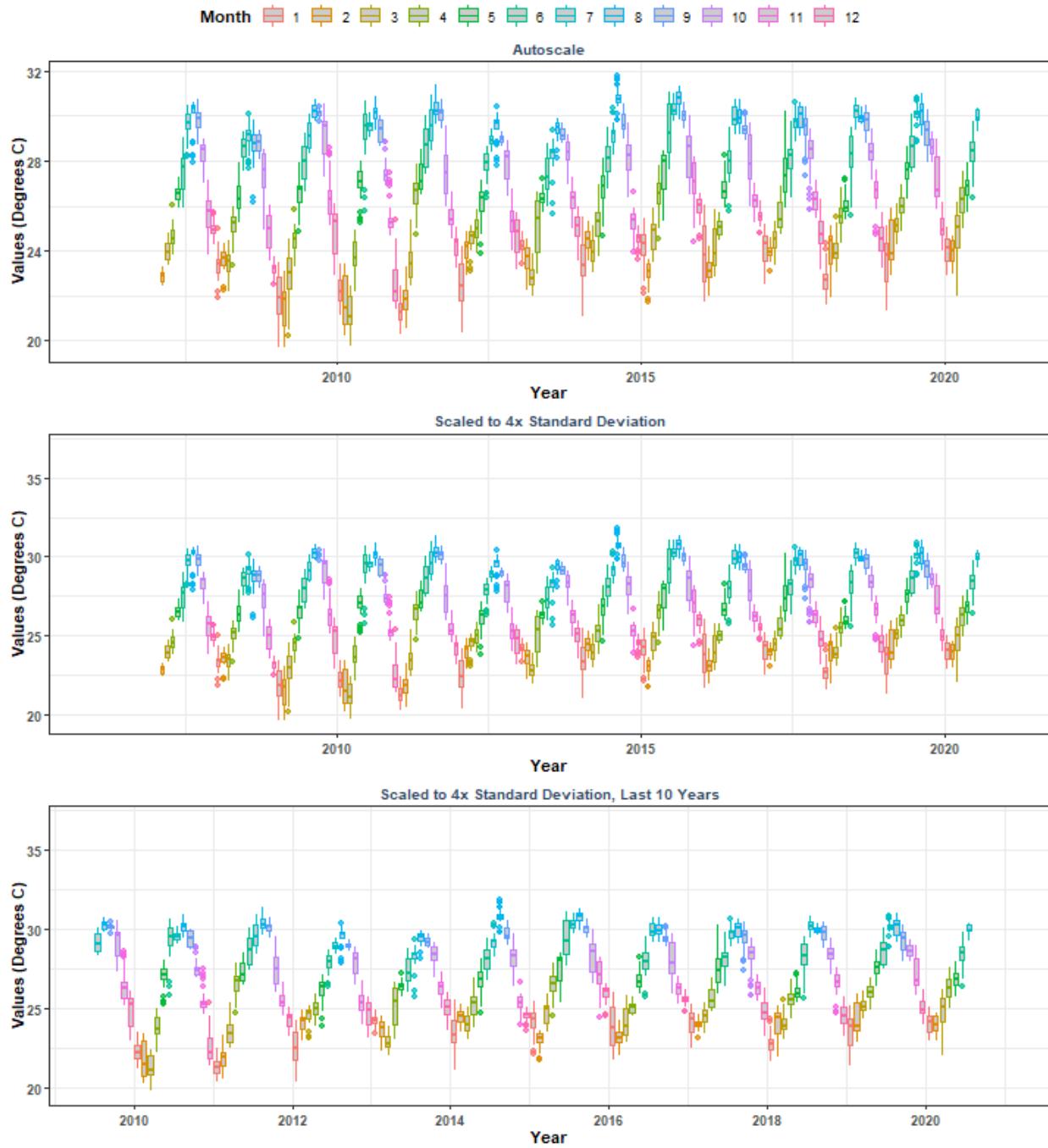
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 90
 By Month



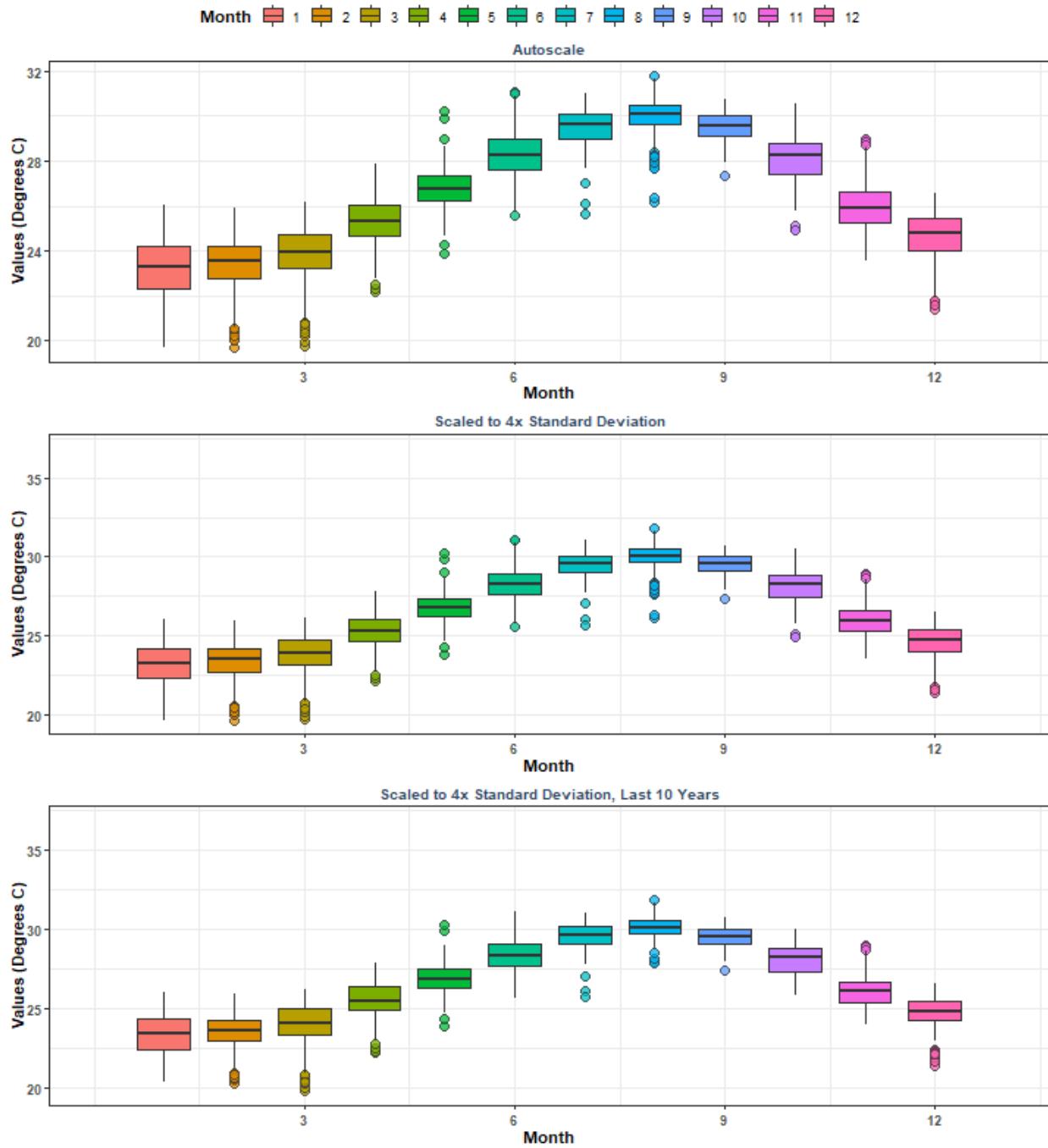
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 91
By Year



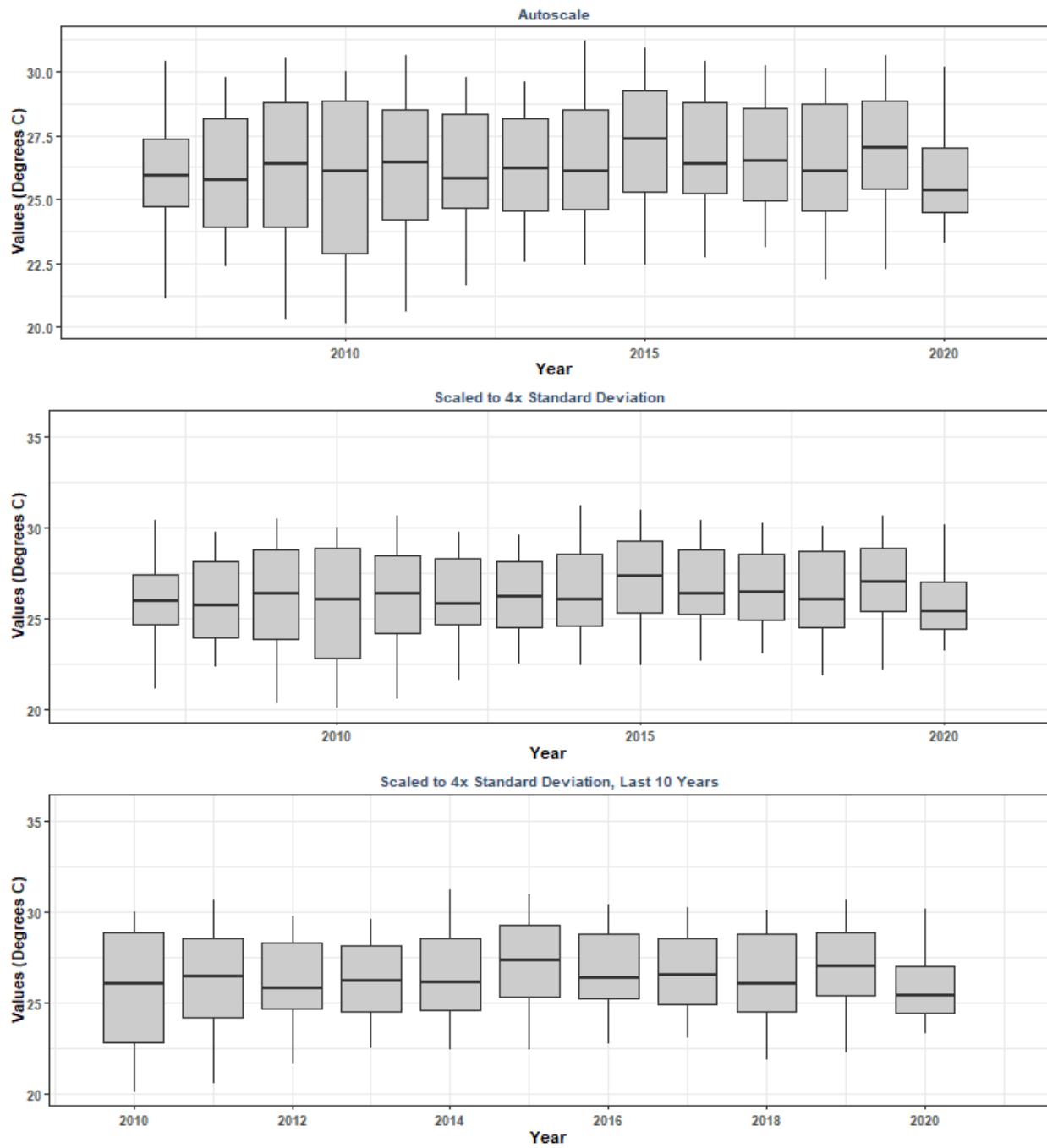
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 91
 By Year & Month



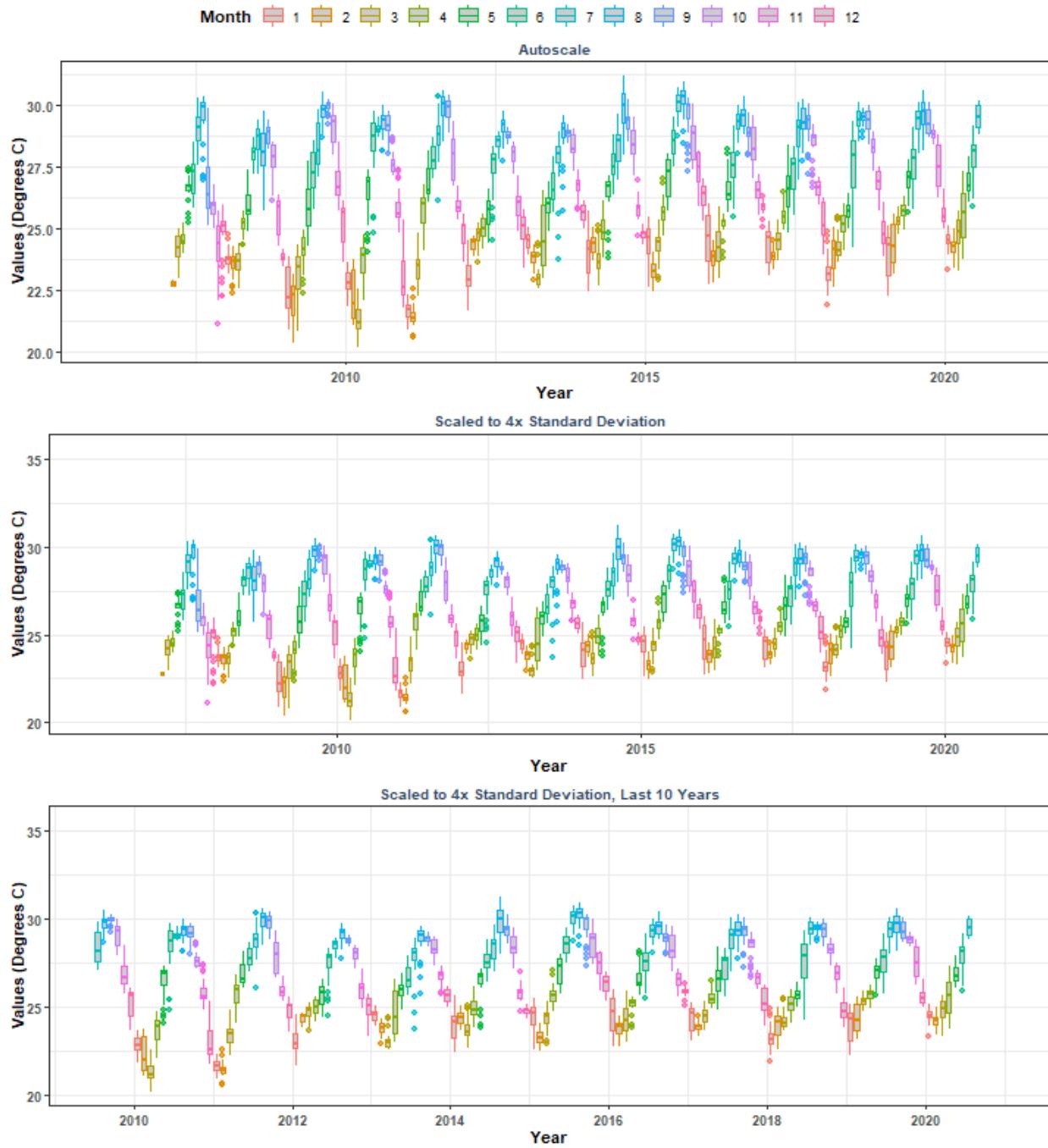
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 91
 By Month



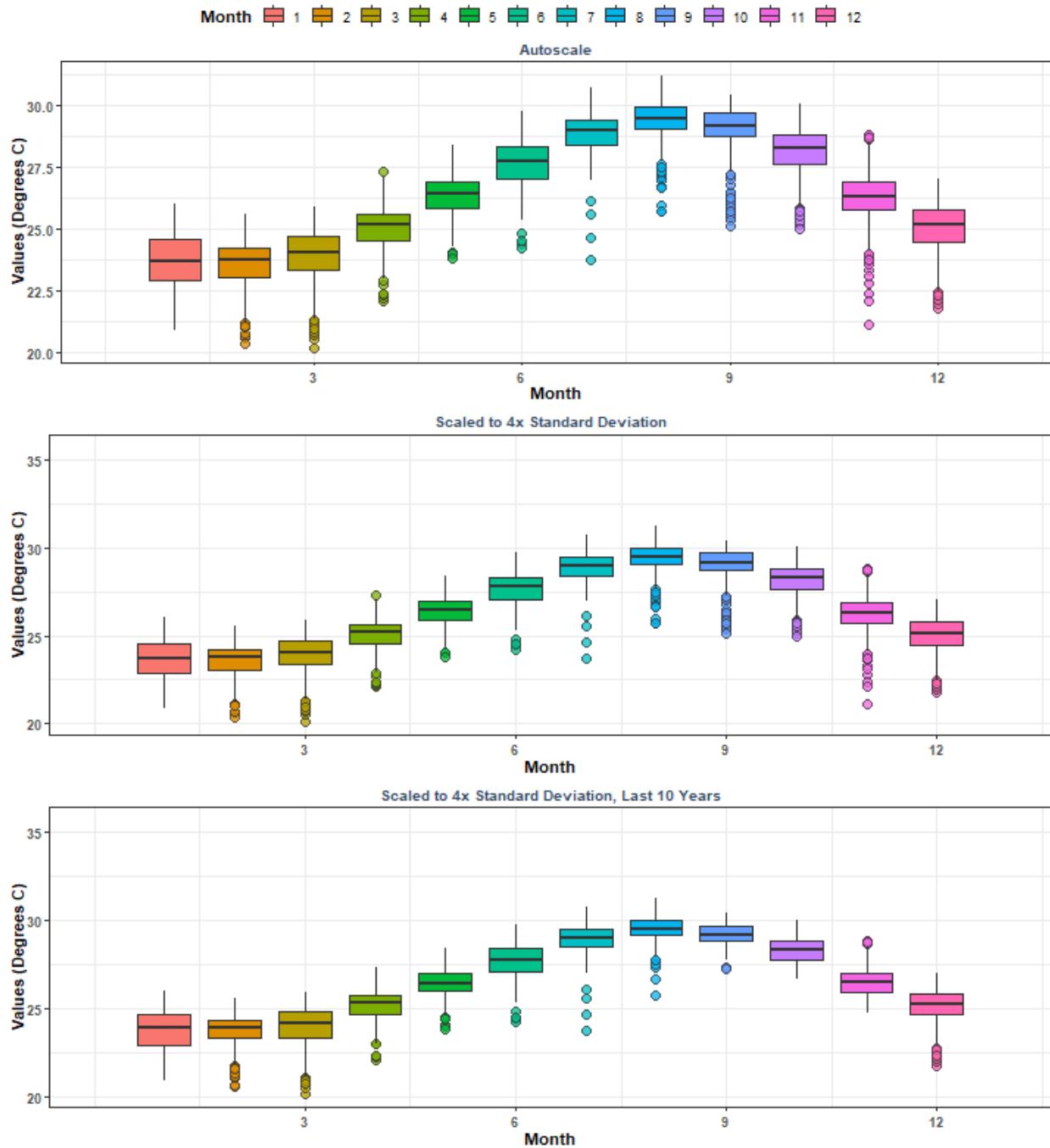
**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 92**
By Year



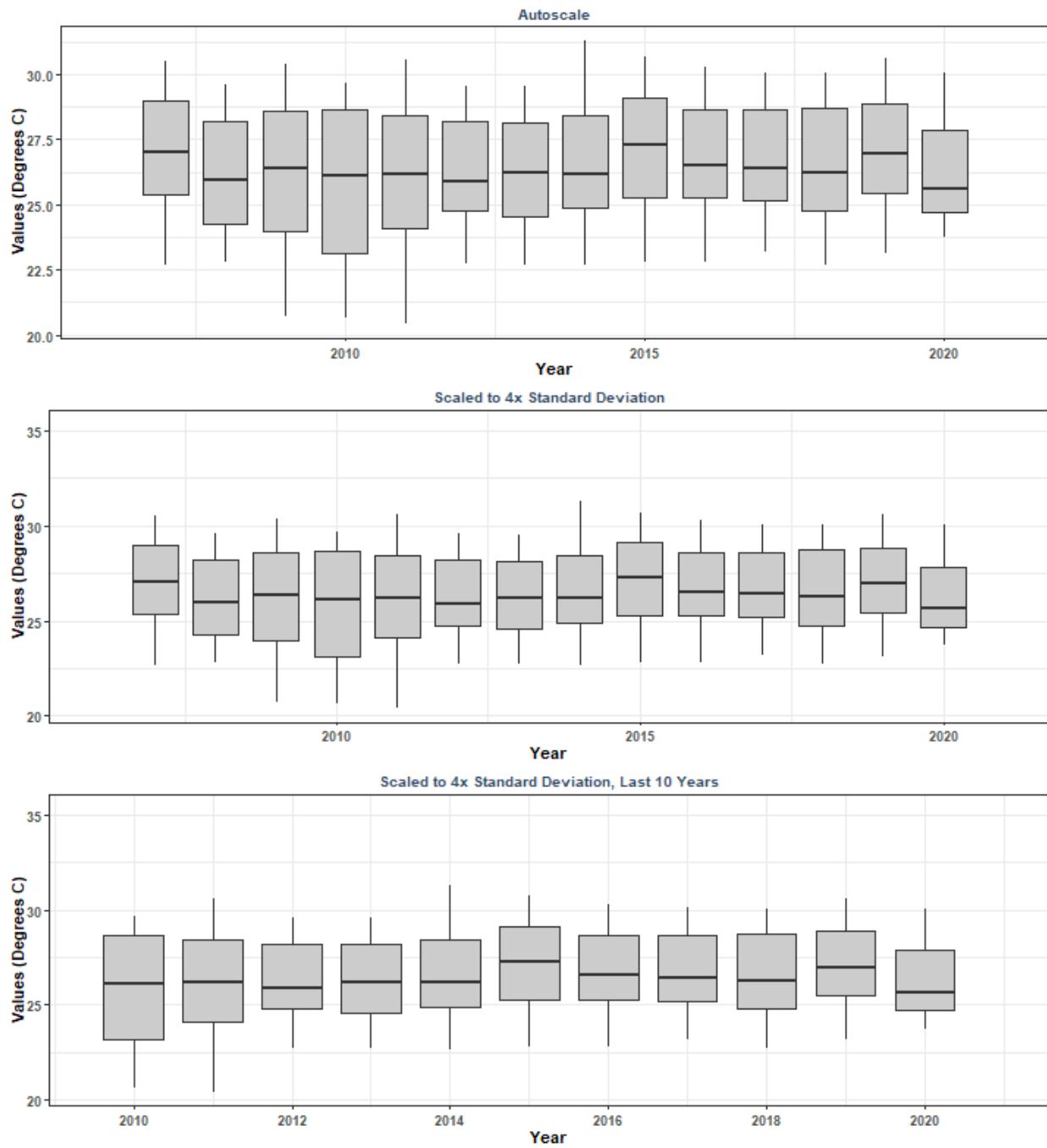
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 92
 By Year & Month



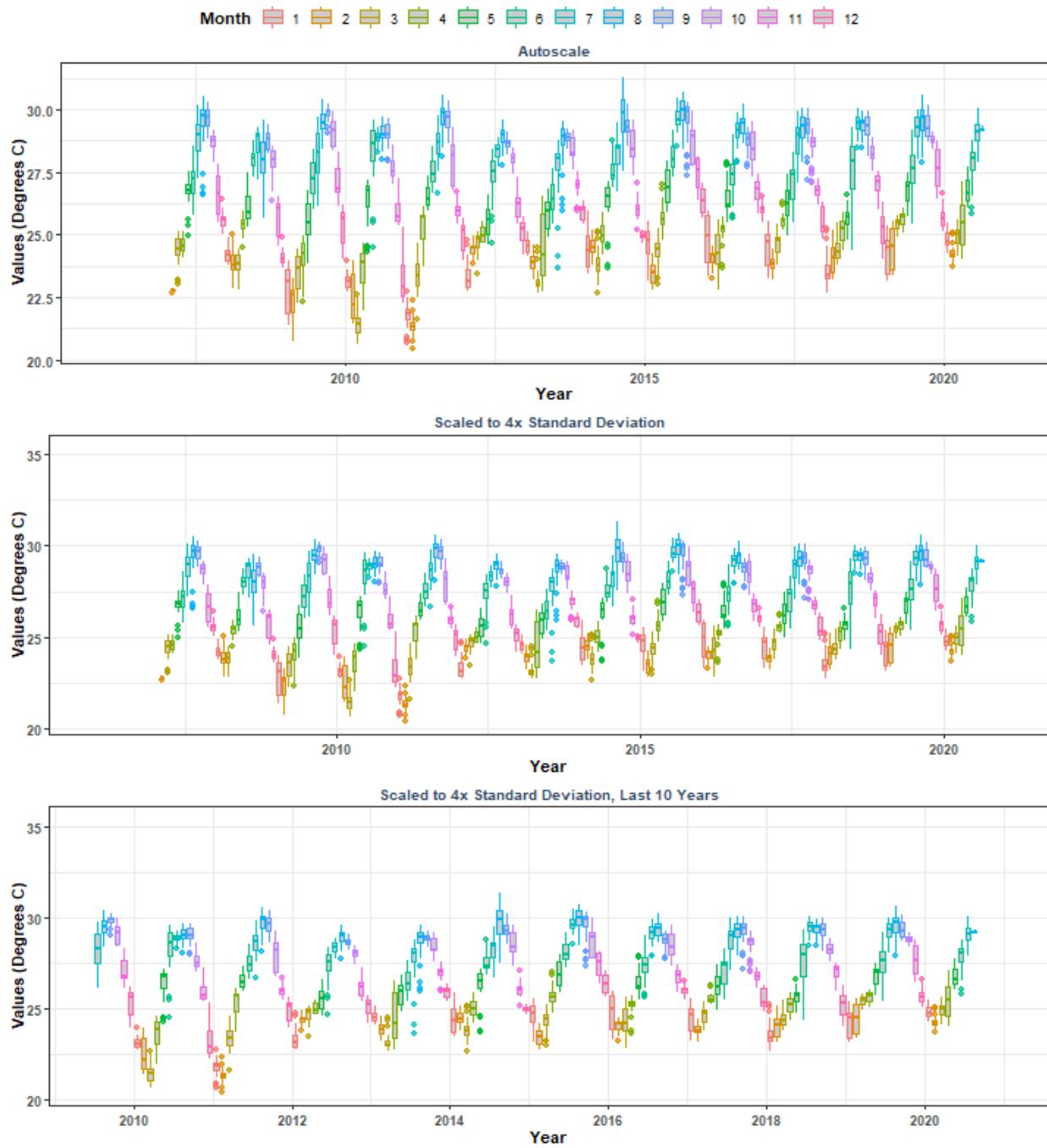
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 92
 By Month



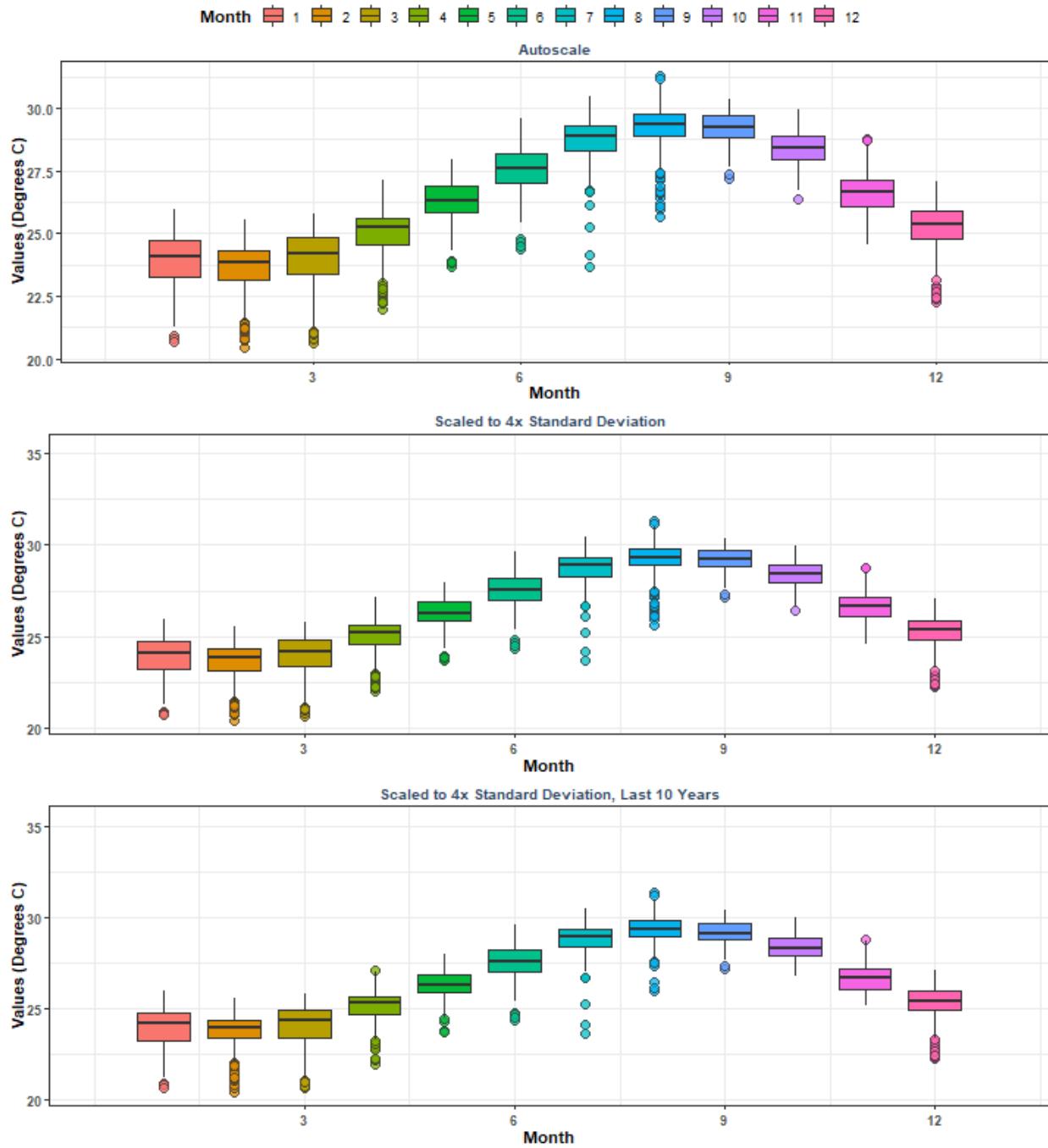
**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 93**
By Year



Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 93
 By Year & Month

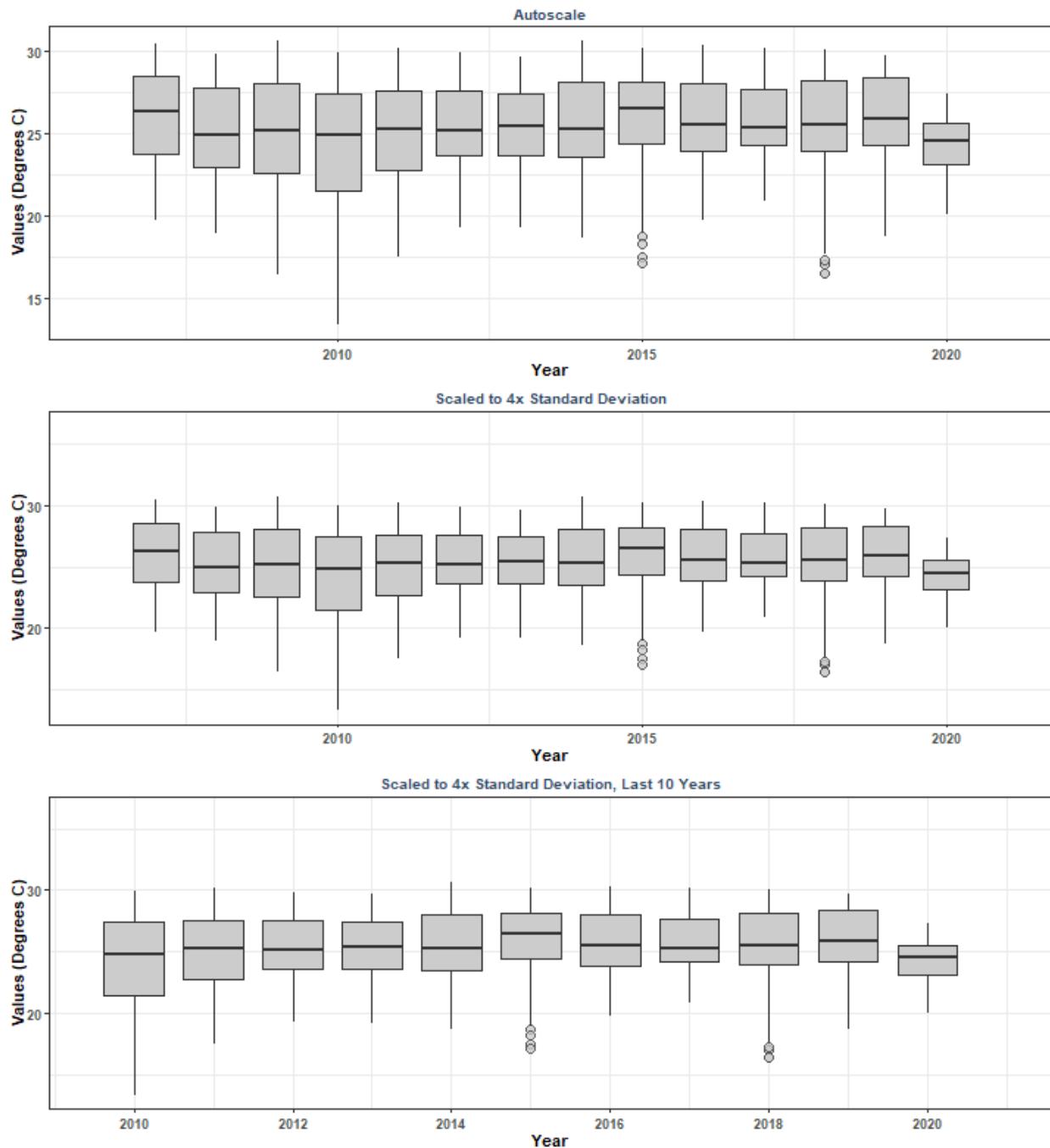


Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 93
 By Month

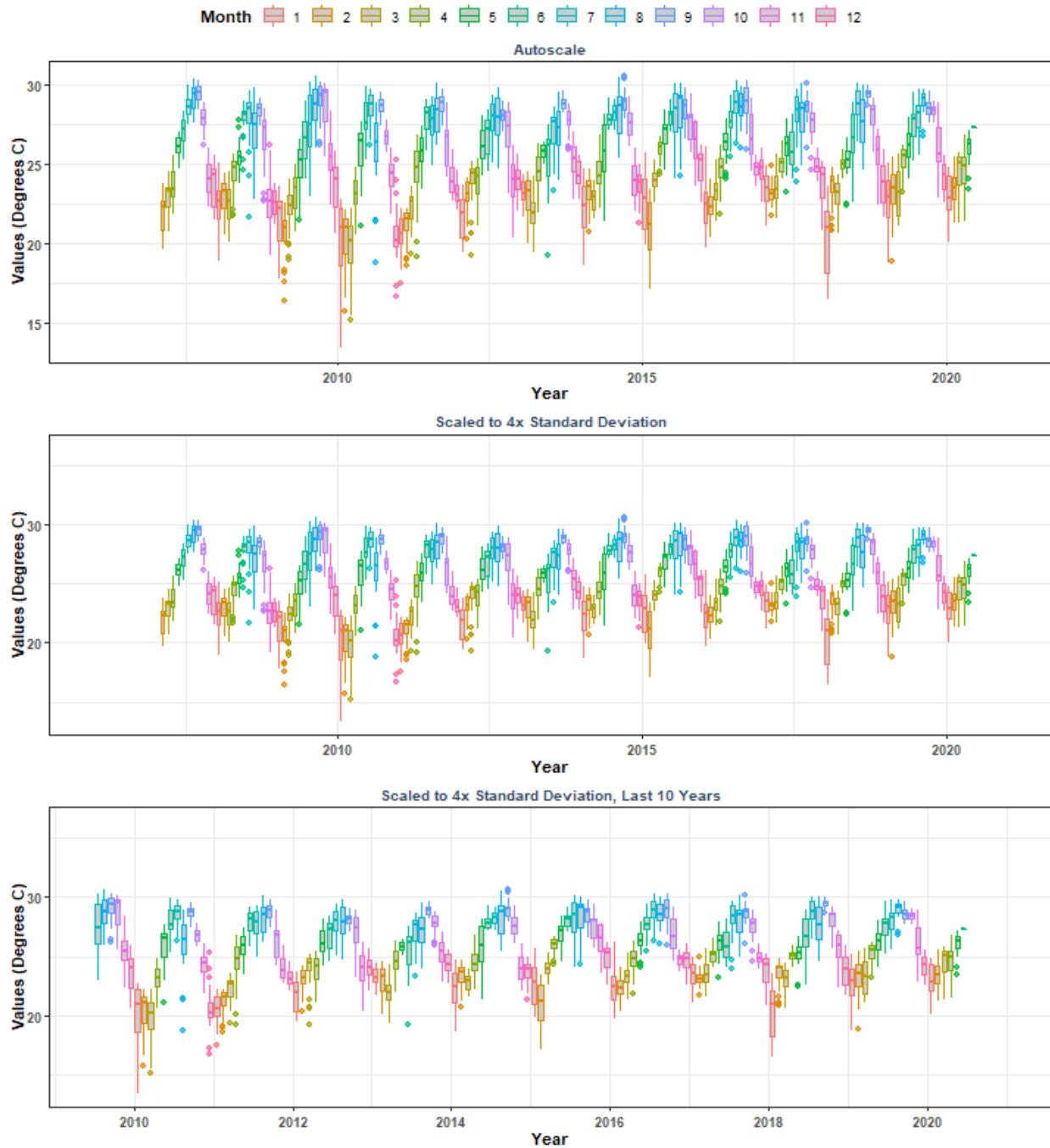


**Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 94**

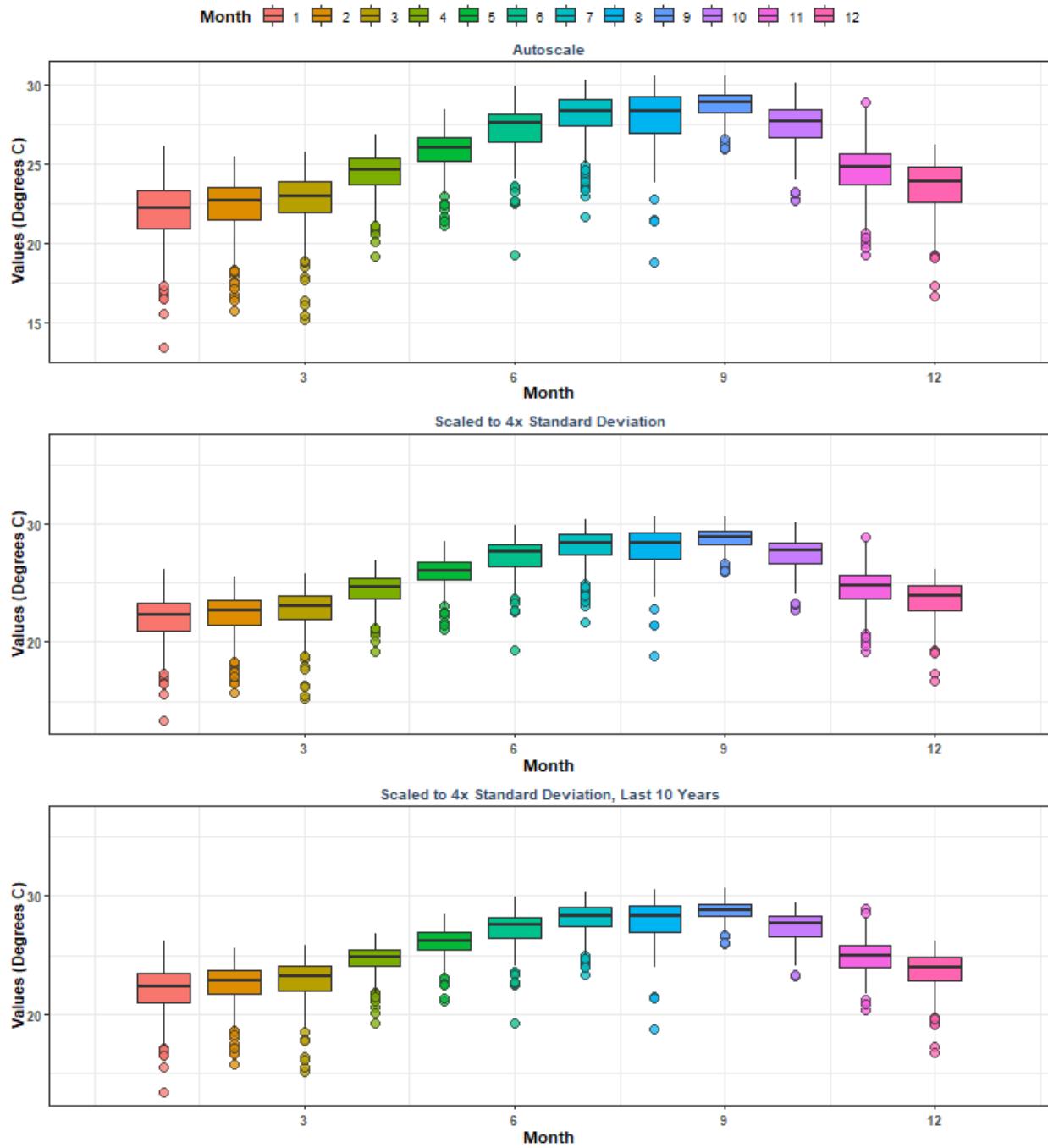
By Year



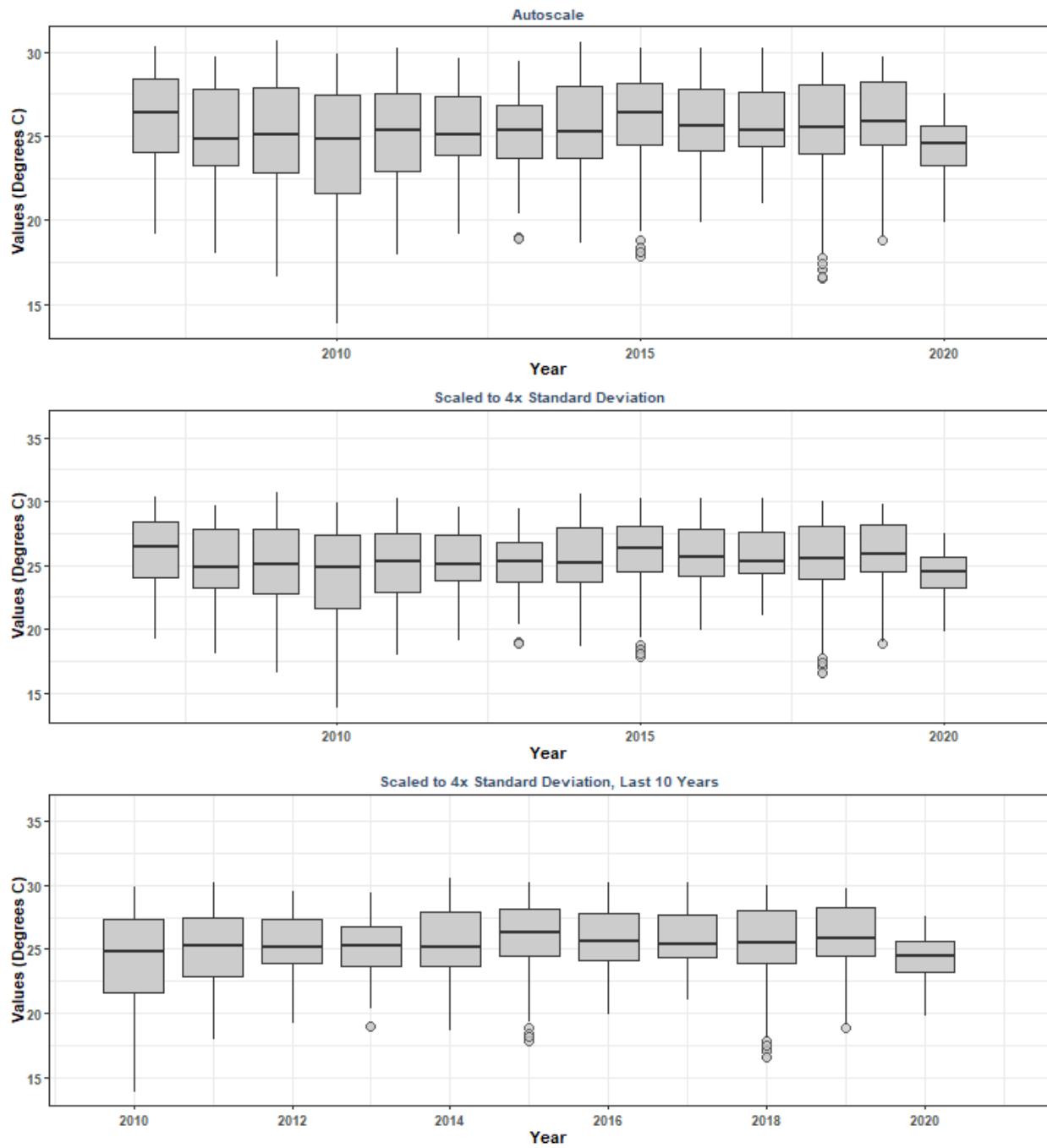
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986 | Water Temperature on Coral Reefs in the Florida Keys | 94
 By Year & Month



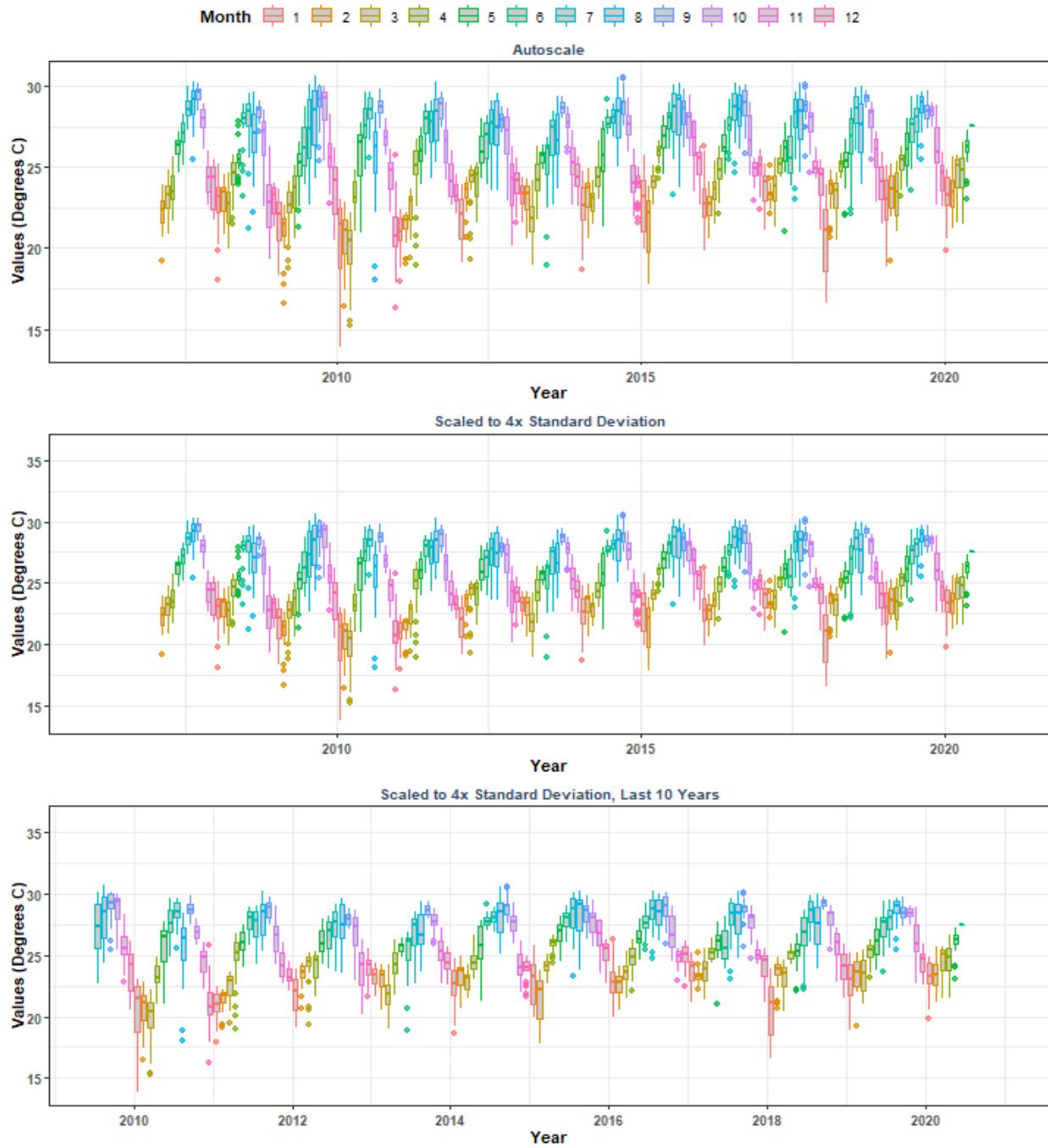
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986 | Water Temperature on Coral Reefs in the Florida Keys | 94
 By Month



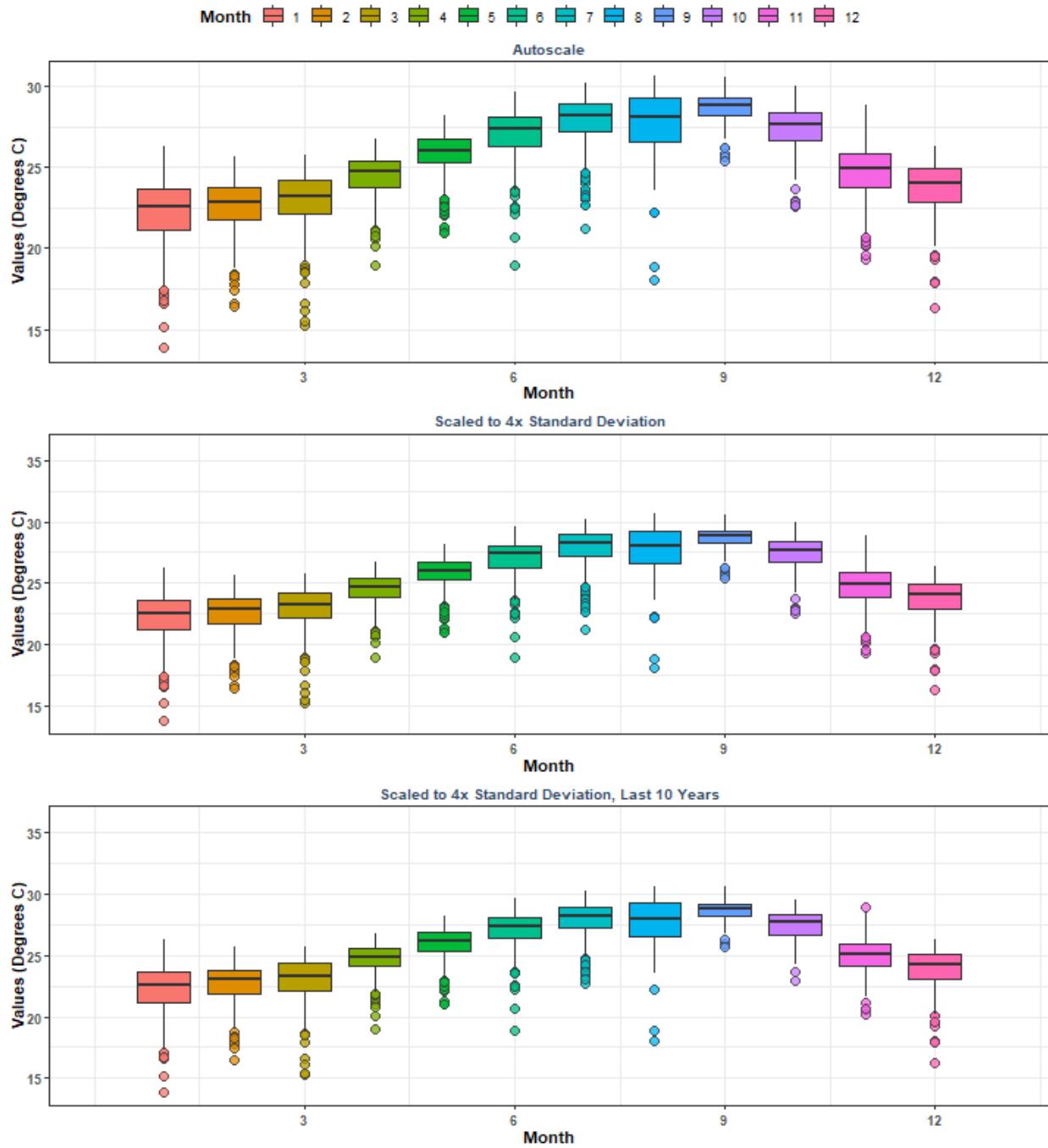
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986 | Water Temperature on Coral Reefs in the Florida Keys | 95**
By Year



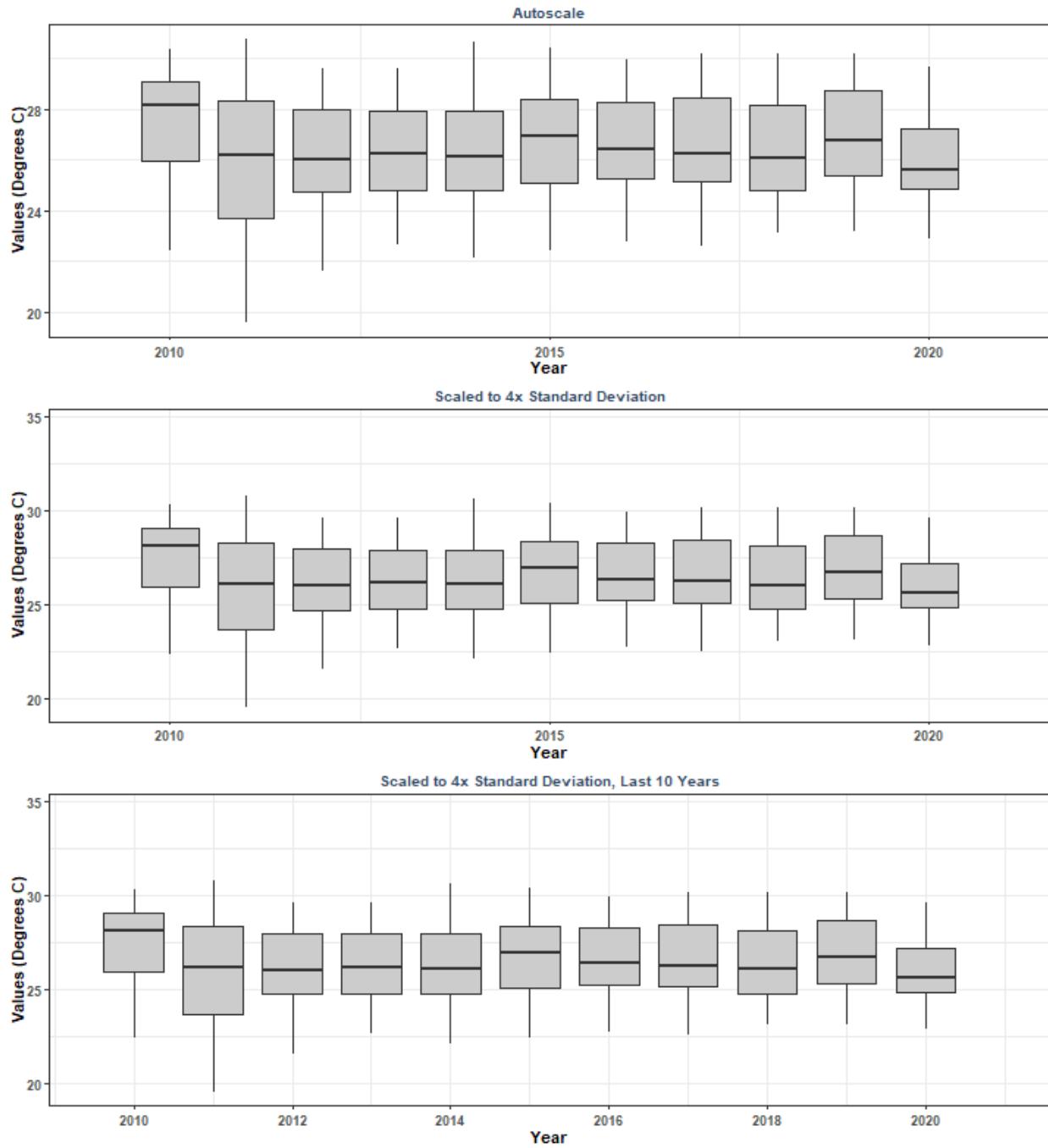
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986 | Water Temperature on Coral Reefs in the Florida Keys | 95
 By Year & Month



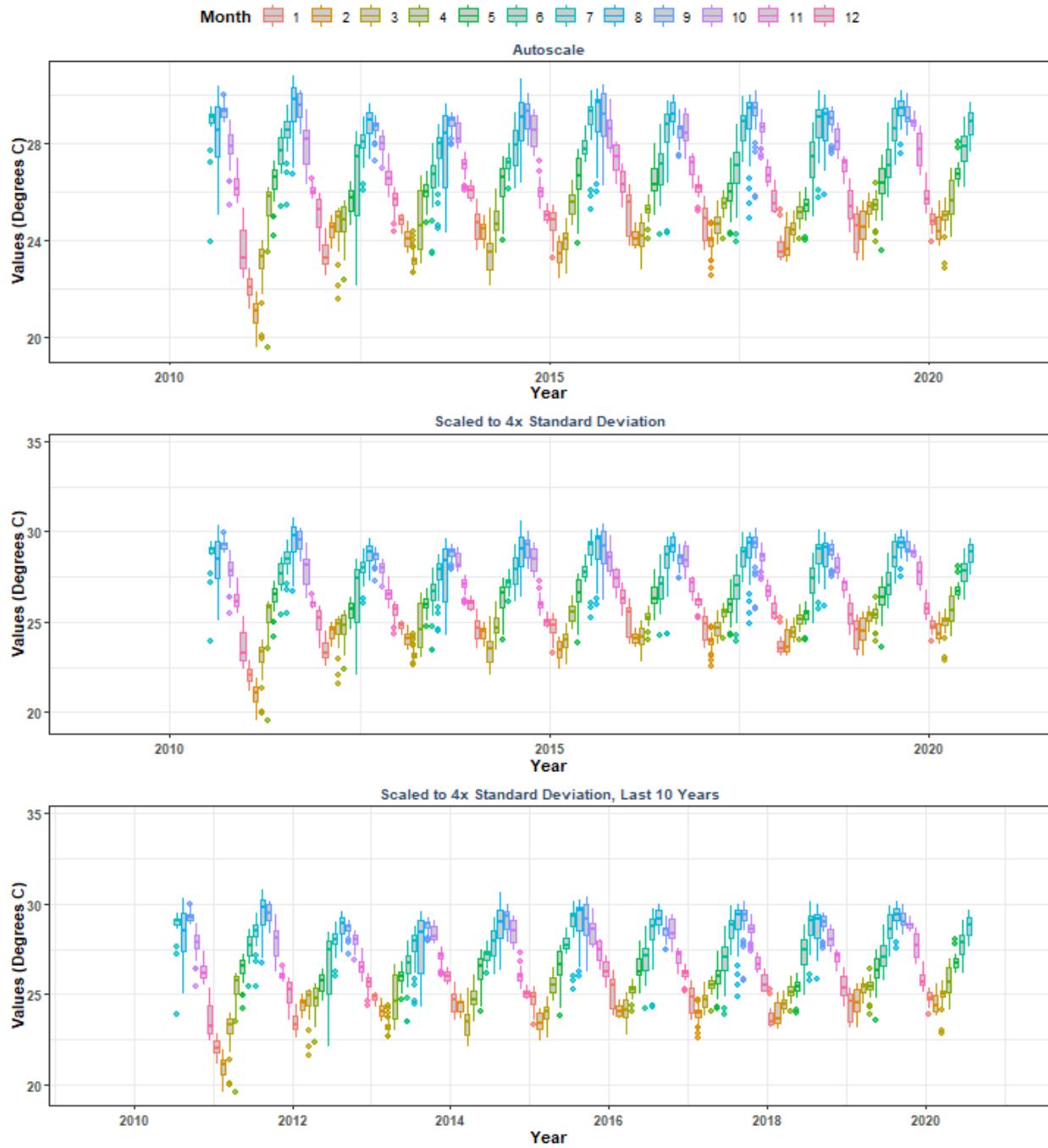
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
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 By Month



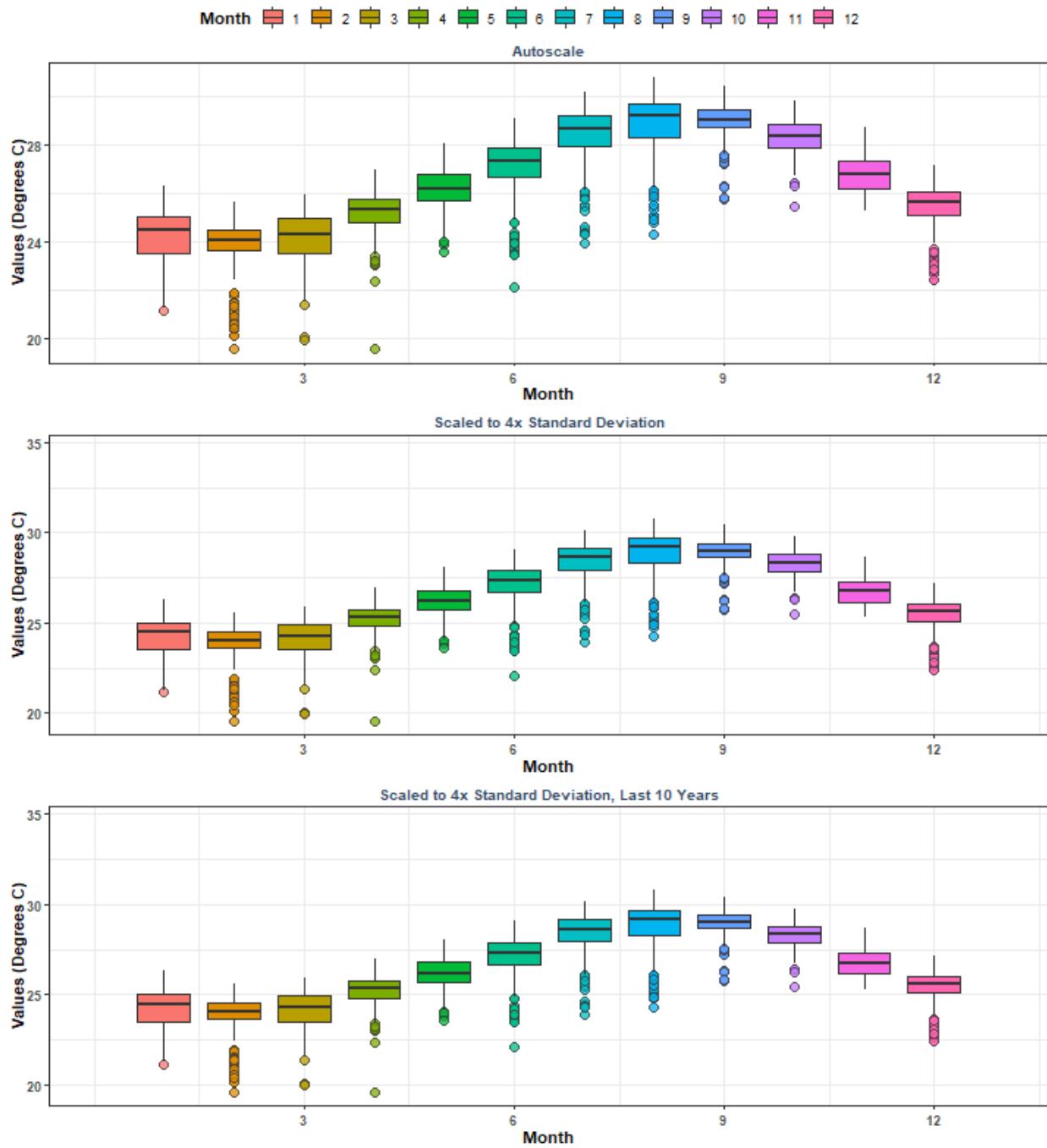
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By Year



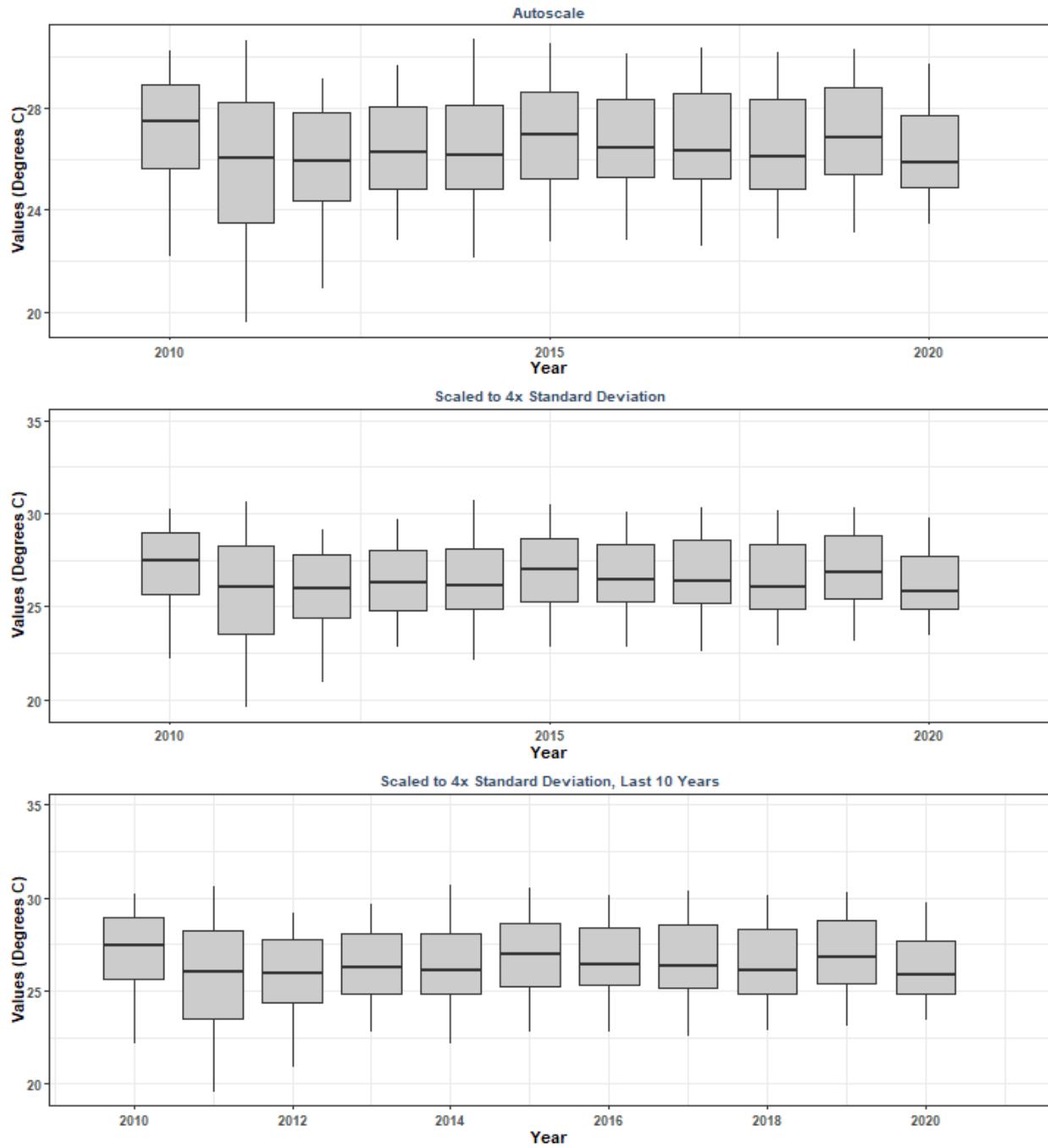
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 By Year & Month



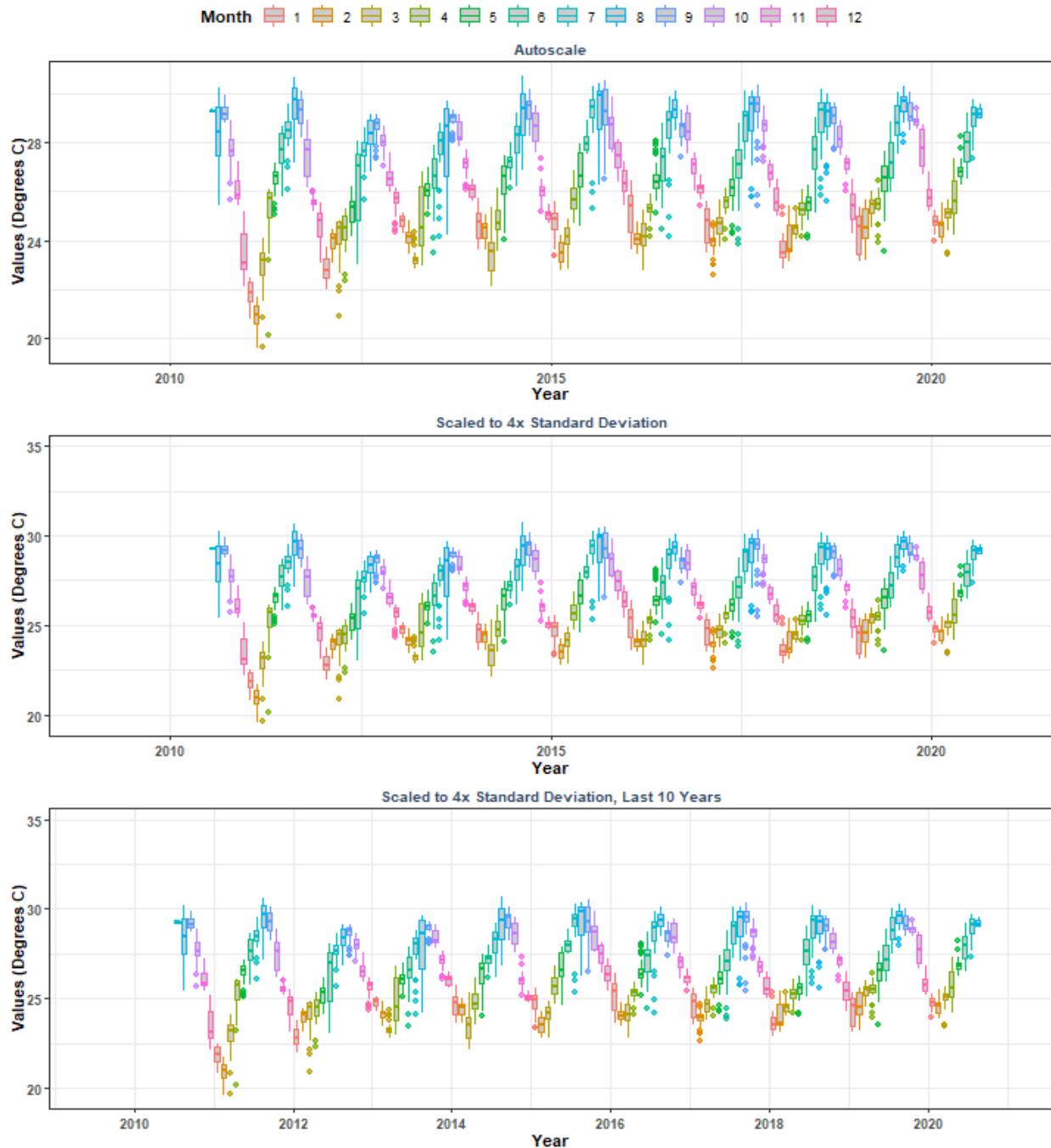
Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
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 By Month



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986 | Water Temperature on Coral Reefs in the Florida Keys | 98**
By Year



Summary Box Plots for Southeast Florida Coral Reef Ecosystem Conservation Area
986 | Water Temperature on Coral Reefs in the Florida Keys | 98
 By Year & Month



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986 | Water Temperature on Coral Reefs in the Florida Keys | 98
 By Month

