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# 2007 Cumulative Annual Report for the Coastal Water Quality Monitoring Network (Agreement 4600000352)

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# **2007 Cumulative Annual Report for the Coastal Water Quality Monitoring Network (Agreement 4600000352)**

For the period  
January – December 2007



Submitted to the  
Environmental Resource Assessment Department  
Water Quality Analysis Division  
South Florida Water Management District  
1480 Skees Road  
West Palm Beach, FL 33411-2642

May 23, 2008

by  
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# **2007 Cumulative Annual Report for the Coastal Water Quality Monitoring Network (Agreement 4600000352)**

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## **1. EXECUTIVE SUMMARY**

This report summarizes the existing data from the FIU Coastal Water Quality Monitoring Network for calendar year January 1 – December 31, 2007. This includes water quality data collected from 28 stations in Florida Bay, 22 stations in Whitewater Bay, 25 stations in Ten Thousand Islands, 25 stations in Biscayne Bay, 49 stations on the Southwest Florida Shelf (Shelf), and 28 stations in the Cape Romano-Pine Island Sound area. Each of the stations in Florida Bay were monitored on a monthly basis with monitoring beginning in March 1991; Whitewater Bay monitoring began in September 1992; Biscayne Bay monthly monitoring began September 1993; the SW Florida Shelf was sampled quarterly beginning in spring 1995; and monthly sampling in the Cape Romano-Pine Island Sound area started January 1999.

Effective Oct. 1, 2007, the SFWMD contract deleted field sampling and lab analyses at 4 sites in Whitewater Bay area #31, 45, 46, and 50; 5 sites in Ten Thousand Islands #51, 60, 62, 68, and 73; 6 sites in Biscayne Bay #103, 109, 113, 116, 126, and 132; and all 49 sites on the SW Florida Shelf. Also effective Oct. 1, 2007 as per SFWMD contract, no samples were analyzed for silicate and field duplicates were reduced to 10% of sites collected.

Trend analysis is an ongoing process; ecosystems change with climate and management strategy, therefore, analytical results may change as more data is collected. It is also important to understand that trend analysis alone will not necessarily provide cause and effect relationships. One of the purposes of any monitoring program should be to use the data gained by routine sampling to extend our understanding of the system by developing new hypotheses as to the underlying driving processes. Much inference into the behavior of South Florida estuaries can be made from the observed magnitude and distribution of water quality parameters. This type of multivariate approach should prove useful to scientists and managers faced with the task

of interpreting large water quality datasets. This monitoring program has been very useful in helping to define restoration targets and will be even more valuable in determining whether these goals are met.

### **Climatological Conditions**

Climate variability has major effects on the health of South Florida ecosystems because precipitation, temperature, evaporation and wind-driven water flow affect circulation, salinity, water exchange and biogeochemical processes. Furthermore, in a significant proportion water flow from Everglades managed canals partially follow precipitation cycles contributing further to complexity in response from coastal waters. Precipitation on the region has not been uniform over the data collection period of record, neither in space nor in time. 2007 was an average precipitation year from Palm Beach south, but the northern watershed, including Lake Okeechobee itself, experienced an extreme drought. This unusual dry year forced the SFWMD to curtail water supply to South Florida ecosystems, especially affecting those stations influenced by the Loxahatchee. Dryness plus reduced canal flows significantly affected the SW Florida coast during 2007. Precipitation in the Everglades rebounded from the drought of the late 1980's and reached levels equal or greater than the long term average (1949-2007; 141.68 cm yr<sup>-1</sup>) for 10 of the last 17 years. Total precipitation for 2007 was 150.27 cm yr<sup>-1</sup> making it equal to the median value year since 1991. Nevertheless, July and August were above their respective medians by about 11 cm.

### **Florida Bay**

The main external influences on water quality in Florida Bay are water exchange with the Gulf of Mexico at the western boundary, atmospheric precipitation, and terrestrial input from Taylor Slough and C-111 panhandle. The two largest impacts cannot be managed by man and even freshwater inputs from land are highly tied to climactic conditions and events.

Eastern Bay: Salinity was higher in the early months due to the drier than normal dry season. This points out the impact that the long water residence time has on Eastern Bay. Temperature, dissolved oxygen (DO), and turbidity were unremarkable. Nitrate (NO<sub>3</sub><sup>-</sup>) was higher than normal especially for the summer months. Ammonium (NH<sub>4</sub><sup>+</sup>) was higher than the grand median for the first half of the year and then rapidly declined to below average levels during

August. Total Phosphorus (TP) was elevated in Eastern Bay throughout most of the year as a result of the previous hurricane and road construction interaction (Rudnick et al. 2006). Chlorophyll *a* (CHLA) showed an inverse pattern to the dissolved inorganic nitrogen (DIN) pool, being highest in the wet season. Total organic nitrogen (TON) and total organic carbon (TOC) were lower than the grand median being indicative of temporal trend towards lower concentration.

Central Florida Bay: Salinity was higher in the early months due to the drier than normal dry season and was also high in Sep.-Nov. This points out the impact that the long water residence time has on Central Bay. Temperature was unremarkable; DO showed deviations from long term median possibly as a function of CHLA fluctuations.  $\text{NO}_3^-$  was normal except for large increases in Nov.-Dec.  $\text{NH}_4^+$  was significantly below average for the year. TP was slightly lower during the wet season than other years. CHLA was high early in the year but declined to normal levels for the remainder. TOC and TON were higher in the winter-spring and lower than normal for rest of the year. pH in Central Bay was elevated relative to other years but unrelated to salinity. Turbidity was lower for 2007 as well.

Western Florida Bay: Salinity was slightly higher than usual but probably not significantly so. Temperature and DO were unremarkable.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were normal for Western Bay. Turbidity and CHLA were generally lower than normal.

### **Whitewater Bay-Ten Thousand Islands Region**

The influence of freshwater input from the Everglades Shark Slough is very influential to water quality of this region. Large salinity variations are the norm, being driven by both climactic events and water management practices. Although 2007 was relatively typical rainfall year, salinity patterns were generally not different from the grand medians. The exception was Whitewater Bay which exhibited elevated salinities until the onset of the wet season.

The influence of freshwater input from the Everglades is very significant to this region. Large salinity variations are the norm, being driven by both climactic events and water management practices. Although 2007 was relatively normal rainfall year, salinity patterns were elevated from the grand medians during the early part of the year and were higher than normal during the wet season.

Whitewater Bay: Salinity was elevated relative to long term median. Temperature, DO, and pH were unremarkable with values generally fluctuating around the median.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP concentrations were elevated while TON was reduced. TON was lower than the grand median. This is the result of the system-wide long term decline in TON output from the Everglades. TOC was slightly lower for most areas. CHLA varied seasonally and was more volatile than the median.

Mangrove Rivers: Salinity fluctuated widely due to freshwater inputs from Shark Slough but was slightly higher than usual. Temperature and pH were unremarkable with values generally fluctuating around the median. DO was generally higher than normal as was turbidity. Some peaks in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were observed. TON was lower than the grand median. CHLA was lower in the dry season but came up to normal levels for the rest of the year.

Inner Waterway: Salinity fluctuated widely due to freshwater inputs from Shark Slough but was higher than usual. Temperature, DO, and pH were unremarkable with values generally fluctuating around the median.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were all higher than the norm during the wet season. TON was lower than the grand median. CHLA showed a large peak in Jan. and Oct. but was normal for the rest of the year.

Blackwater River: Salinity was elevated relative to long term median and showed a rapid decline in Sep with a quick rebound in Oct. Temperature, DO, turbidity, and pH were unremarkable with values generally fluctuating around the median. Large peaks in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were observed in Apr. and Oct. TON was lower than the grand median. CHLA was lower in the dry season but varied widely for the rest of the year.

## **Biscayne Bay**

Salinity in Biscayne Bay is strongly modulated by its large tidal exchange with the ocean. Nevertheless, canal inputs do have a significant impact on the ecosystem, as evidenced by the reduced nearshore salinity patterns (Caccia and Boyer 2005). The largest intra-annual variations in salinity in this area are typically driven by freshwater releases from the canal system. Nutrient loads and concentrations in Biscayne Bay are strongly driven by canal inputs (Caccia and Boyer 2007). Therefore, precipitation patterns have a great impact on the bay both directly and indirectly.

Alongshore Zone: Because 2007 was a “normal” water year, salinity was generally similar to the long term median. Temperature and DO were unremarkable but both turbidity and pH showed large fluctuations, primarily in the dry season. The Oct. drop in salinity coincided with large increases in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, and TP as we have observed in other years. CHLA remained lower than the long term median.

Inshore Zone: Because the Inshore Zone is a continuation of the offshore gradient, trends were very similar to those observed for the Alongshore Zone. Temperature and DO were unremarkable but both turbidity and pH showed large fluctuations, primarily in the dry season. The Oct. drop in salinity coincided with large increases in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, and TP as we have observed in other years. CHLA remained lower than the long term median.

Main Bay: Fluctuations in water quality in the Main Bay were damped by its large volume and short residence time due to oceanic mixing. Salinity, temperature, DO, nutrients, and CHLA were all very similar to the grand median.

South Card Sound: Water quality in Card Sound was characterized by a large peak in Oct.-Nov. of  $\text{NO}_3^-$ , TON, TP, CHLA and turbidity. We are unsure as to what caused this anomaly as there was no concurrent change in salinity to suggest terrestrial input. One of the reasons for this may have been the advection of the Florida Bay bloom organisms to this part of Biscayne Bay by wind forcing, but there is no circulation data to support this. Other than that event, water quality was similar to long term median values.

North Bay: The North bay is the most compartmentalized and urbanized area of Biscayne Bay. As such nutrients tend to be higher in this region. Because 2007 was a “normal” water year, salinity was generally similar to the long term median. Temperature and DO were unremarkable but turbidity showed large increase in the fall while pH dropped in early spring. Large variations in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, TP, and CHLA occurred throughout the year, often being temporally unrelated. As such, it is difficult to assign a cause to these fluctuations.

### **Southwest Florida Shelf**

Since this component of the monitoring program began in 1995 and is only sampled quarterly, there is not as much trend data to analyze as for other components. Although these analyses are preliminary it is possible to speculate that the clusters are formed as a function of hydrology and circulation patterns. We believe that the most inshore area clearly shows the



input of freshwater from Shark River being transported south and east around the Cape. Water overlying the northern shoal stations probably originates somewhere in or north of the Ten Thousand Islands. Our level of resolution is very low due to the limited numbers of sampling events and by the relatively large spatial gap between coastal and Shelf sampling sites. A better understanding of local circulation patterns in addition to increased density and frequency of sampling in the nearshore region may help define the coupling between freshwater inflow and Shelf water quality

Shark Zone: Because 2007 was a “normal” water year, salinity was generally similar to the long term median. Temperature and turbidity were unremarkable but DO, pH, TON, and CHLA were low.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were similar to other years. CHLA remained lower than the long term median.

Shelf Zone: Because the Shelf Zone is a continuation of the offshore gradient, trends were very similar to those observed for the Shark Zone. Fluctuations in water quality on the Shelf were damped by its large volume mixing with the Gulf of Mexico. Only DO, turbidity, pH, and CHLA deviated from the median being lower than usual.

Shoal Zone: The Shoal area nearest the Ten Thousand Islands also showed similarities to the other SW Shelf sites with DO, turbidity, and pH being lower than usual. However, CHLA levels were more representative of long term median.

### **Cape Romano-Pine Island Sound**

Overall, this part of coastal Florida has significantly higher concentrations of CHLA, TP, and DIN than the rest of the Ten Thousand Islands stations. Much of this is due to geological changes from carbonate rocks to silicates, which facilitates transport of phosphorus, and to major land use changes from the Big Cypress National Preserve to suburban and agricultural.

The largest intra-annual variations in salinity and water quality in this area are driven by freshwater releases from the Caloosahatchee River at Franklin Lock (S-79 water control structure) and associated pathways. This is due to the need to lower the water table inland because of potential flooding from hurricanes and to lower the Lake Okeechobee because of structural problems with the Hover Dike. Releases were minimal this year due to the drought in central Florida.

Marco Island: Salinities remained high all year reflecting the drought conditions in the watershed. Variations in temperature, DO pH, and TON were unremarkable as compared to long term median. TOC was lower than average due to low freshwater inputs.  $\text{NO}_3^-$  and  $\text{NH}_4^+$  were highly variable and did not seem to be driven by freshwater inputs. TP was higher than average in the dry season and lower in the wet season. CHLA was lower than usual but peaked in the fall.

Rookery Bay: Salinities remained high all year reflecting the drought conditions in the watershed. Temperature, DO, pH, TON, and TP were unremarkable as compared to long term median. None of the measured variables help explain why pH dropped to 7.4 in May. TOC was lower than average due to low freshwater inputs but mirrored the annual pattern.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and turbidity were highly variable and did not seem to be driven by freshwater inputs. CHLA was generally lower than usual.

Naples Bay: Salinity was marginally higher in the fall but was not different for the bulk of the year. Temperature, TON, and TP were unremarkable as compared to long term median. pH was higher than normal and also highly variable. DO was slightly higher than usual while  $\text{NO}_3^-$  and CHLA were down. Turbidity, pH, and  $\text{NH}_4^+$  were highly variable but did not seem to be driven by freshwater inputs. CHLA was generally lower than usual.

San Carlos Bay: This is the region most affected by Lake Okeechobee water releases through the Caloosahatchee River (S-79). The drought of 2007 was reflected in the high salinities throughout the region. We did not observe the usual 10-15 psu drop during the wet season nor the concomitant increase in  $\text{NO}_3^-$ . Temperature, DO, and TON were unremarkable as compared to long term median. Turbidity,  $\text{NO}_3^-$ , TP, TOC, and CHLA were generally lower than usual, especially during the wet season.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs.

Estero Bay: Salinity was relatively invariant during 2007 and did not show the usual decline during the wet season. Temperature, TON, TP, and TOC were unremarkable as compared to long term median. DO was slightly elevated while pH was higher than normal in the spring-summer. Turbidity,  $\text{NO}_3^-$ , TOC, and CHLA were generally lower than usual, especially during the wet season. Peaks in CHLA sometimes corresponded with peaks in TP and  $\text{NH}_4^+$ . TP was higher in the first 8 months and then declined to below the average.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs.

Pine Island Sound: Salinity was relatively invariant during 2007 and did not show the usual decline during the wet season. Temperature,  $\text{NO}_3^-$ , TON, and TP were unremarkable as compared to long term median. DO was elevated for the first 2 months then declined to usual levels. pH was generally lower than normal but peaked in May for no obvious reason. Turbidity was higher during the summer but quickly dropped to very low levels in Sept.-Dec.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs. TOC and CHLA were generally lower than usual, especially during the wet season. Peaks in CHLA sometimes corresponded with peaks in TP and  $\text{NH}_4^+$ .

Cocohatchee River: Like the Caloosahatchee, the Cocohatchee River at Wiggins Pass was under low flow conditions due to the drought. Salinity dipped only slightly during the wet season in contrast to the large declines usually observed. We did not observe the usual 20-25 psu drop during the wet season or the concomitant increase in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$  and TOC. Most all water quality variables were lower than the long term median with the exception of pH and DO which were higher.

### **Acknowledgements**

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## **2. PROJECT BACKGROUND**

One of the primary purposes for conducting long-term monitoring projects is to be able to detect trends in the measured parameters over time. These programs are usually initiated as a response to public perception (and possibly some scientific data) that “the river-bay-prairie-forest-etc. is dying”. In the case of Florida Bay, the major impetus was the combination of a seagrass die-off, increased phytoplankton abundance, sponge mortality, and a perceived decline in fisheries beginning in 1987. In response to these phenomena, a network of water quality monitoring stations was established in 1989 to explicate both spatial patterns and temporal trends in water quality in an effort to elucidate mechanisms behind the recent ecological change.

This report summarizes the existing data from our South Florida Coastal Water Quality Monitoring Network through December 31, 2007 (Fig. 1.1). This network includes water quality data collected from 28 stations in Florida Bay, 22 stations in Whitewater Bay to Lostmans River, 25 stations in Ten Thousand Islands, 25 stations in Biscayne Bay, 49 stations on the Southwest Florida Shelf (Shelf), and 28 stations in the Cape Romano-Pine Island Sound area.

Each of the stations in Florida Bay were sampled on a monthly basis with monitoring beginning in March 1991 (except stations 14, 19, 22, and 23 which began April 1991). In July 1992, stations 25 through 28 were added in Florida Bay. Monthly sampling at stations 29-50 in Whitewater Bay were added to the monitoring program in September 1992. Biscayne Bay monthly monitoring began September 1993 for stations 100-125. In May 1996 an analysis of the data was performed to address the adequacy of spatial coverage. At that time, 10 station locations in the Biscayne Bay monitoring network were moved to provide coverage of North Biscayne Bay. The Ten Thousand Islands sites 51-75 were begun in Sept. 1994, the Shelf was sampled quarterly beginning in spring 1995, and the Cape Romano-Pine Island Sound area was started Jan. 1999. A summary of station locations and sampling period of record is shown in Table 1.

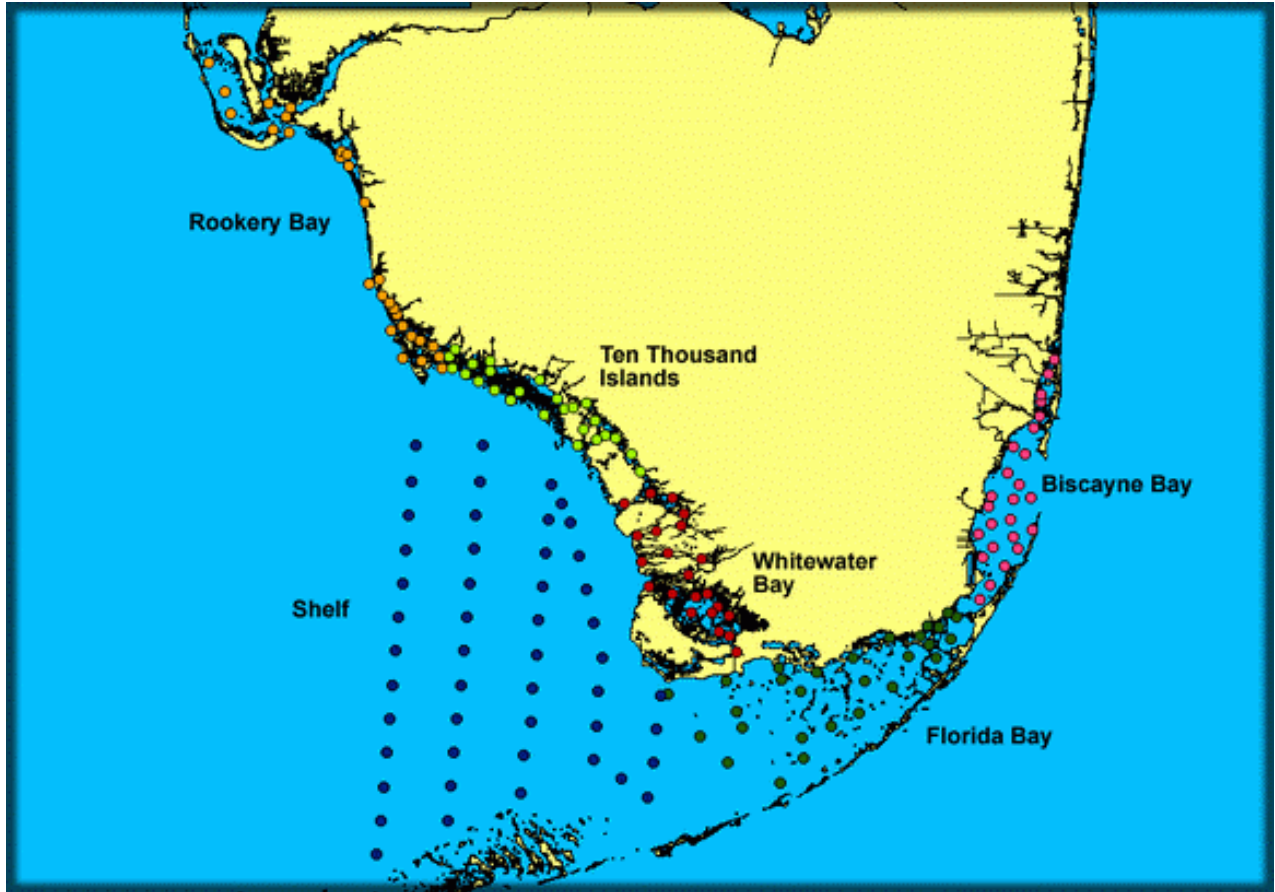


Figure 1.1. Fixed station locations for the SFWMD funded portion of the South Florida Coastal Water Quality Monitoring Network.

### **3. METHODS**

Water samples were collected and analyzed using standard methodology outlined in the Quality Assurance Plan with prior approval from SFWMD and FDEP. Salinity, temperature (°C), dissolved oxygen (DO, mg l<sup>-1</sup>), and pH were measured 10 cm below the surface and 10 cm above the bottom using a combination sonde (YSI 600XL). Sondes were calibrated prior to and after sampling to ensure accuracy.

Duplicate, unfiltered water samples were collected from 10 cm below the surface using sample rinsed 120 ml HDPE bottles and kept at ambient temperature in the dark during transport. Duplicate water samples for dissolved nutrient analysis were collected using sample rinsed 150 ml syringes. These samples were filtered by hand (25 mm glass fiber GF/F) into acetone-washed and sample rinsed 60 ml HDPE bottles, which were then capped and immediately placed on ice in the dark for transport. The wet filters, used for chlorophyll *a* analysis (CHLA), were placed in 2 ml plastic centrifuge tubes to which 1.5 ml of 90% acetone was added. They were then immediately capped and put into a dark bottle on ice for transport (APHA 1999).

Unfiltered water samples were analyzed for total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), alkaline phosphatase activity (APA), and turbidity (NTU). TOC was measured by direct injection onto hot platinum catalyst in a Shimadzu TOC-5000 after first acidifying to pH<2 and purging with CO<sub>2</sub>-free air. TN was measured using an ANTEK 7000N Nitrogen Analyzer using O<sub>2</sub> as carrier gas instead of argon to promote complete recovery of the nitrogen in the water samples (Frankovich and Jones 1998). TP was determined using a dry ashing, acid hydrolysis technique (Solorzano and Sharp 1980). The APA assay measures the activity of alkaline phosphatase, an enzyme used by bacteria to mineralize phosphate from organic compounds (Hashimoto et al. 1985). This assay is performed by adding a known concentration of an organic phosphate compound (o-methylfluorescein phosphate) to an unfiltered water sample. Alkaline phosphatase in the water sample cleaves the phosphate, leaving o-methylfluorescein, a highly fluorescent compound. The fluorescence of initial and 2 hr incubations were measured using a Gilford Fluoro IV spectrofluorometer (excitation = 430 nm, emission = 507 nm) and subtracted to give APA (μM h<sup>-1</sup>). APA measurements were discontinued after Sept. 30, 2006 at the request of SFWMD. Turbidity was measured using an HF Scientific model DRT-15C turbidimeter and reported in NTU.



Filtrates were analyzed for soluble reactive phosphorus (SRP), nitrate + nitrite ( $\text{NO}_x^-$ ), nitrite ( $\text{NO}_2^-$ ), ammonium ( $\text{NH}_4^+$ ), and silicate ( $\text{SiO}_2$ ) by flow injection analysis (Alpkem model RFA 300). Filters for CHLA content ( $\mu\text{g l}^{-1}$ ) were allowed to extract for a minimum of 2 days at  $-20^\circ\text{C}$  before analysis. Extracts were analyzed using a Gilford Fluoro IV Spectrofluorometer (excitation = 435 nm, emission = 667 nm) and compared to a standard curve of pure CHLA (Sigma).

Some parameters were not measured directly, but were calculated by difference. Nitrate ( $\text{NO}_3^-$ ) was calculated as  $\text{NO}_x^- - \text{NO}_2^-$ . Dissolved inorganic nitrogen (DIN) was calculated as  $\text{NO}_x^- + \text{NH}_4^+$ . Total organic nitrogen (TON) was defined as  $\text{TN} - \text{DIN}$ . Concentrations for all of these water quality variables are reported in units of milligrams per liter ( $\text{mg l}^{-1}$ ) or the equivalent parts per million (ppm), except where noted. All nutrient concentrations are based on the atomic weight of primary nutrient species (ppm-N, ppm-P, and ppm-C), not the molecular weight. All N:P ratios discussed are calculated on a molar basis.

### **3.1. LABORATORY ANALYSIS QUALITY CONTROL**

All laboratory QC data and results are included as a separate Project QA report file on the CD. This report includes discussion on the following topics:

#### **3.1.1. ACCURACY AND PRECISION**

#### **3.1.2. CALIBRATION DATA**

#### **3.1.3. PROBLEMS**

#### **3.1.4. SOLUTION TO PROBLEMS**

#### **3.1.5. EFFECTS OF THE RESULT ANALYSIS DATE-TIME**

#### **3.1.6. ALL QC PROBLEMS AND LISTING OF AFFECTED SAMPLES**

### **3.2. FIELD MONITORING PROBLEMS**

All field monitoring QC data and results are included as a separate Project QA report file on the CD. This report includes discussion on the following topics:

### **3.2.1. WEATHER RELATED ISSUES**

### **3.2.2. EQUIPMENT FAILURES**

### **3.2.3. SCHEDULING PROBLEMS**

### **3.2.4. OTHER**

## **3.3. STATISTICAL ANALYSIS**

### **3.3.1. DISCUSSION**

#### **3.3.1.1. OBJECTIVE CLASSIFICATION ANALYSIS**

Stations were stratified according to water quality characteristics (i.e. physical, chemical, and biological variables) using a statistical approach. Multivariate statistical techniques have been shown to be useful in reducing a large data set into a smaller set of independent, synthetic variables that capture much of the original variance. The method we chose was a type of objective classification analysis (OCA) which uses principal component analysis (PCA) followed by k-means clustering algorithm to classify sites as to their overall water quality. This approach has been very useful in understanding the factors influencing nutrient biogeochemistry in Florida Bay (Boyer et al., 1997), Biscayne Bay, and the Ten Thousand Islands (Boyer 2006). We have found that water quality at a specific site is the result of the interaction of a variety of driving forces including oceanic and freshwater inputs/outputs, sinks, and internal cycling.

Briefly, data were first standardized as Z-scores prior to analysis to reduce artifacts of differences in magnitude among variables and to convert values to deviations from the mean and express them as multiples of standard deviation. PCA was used to extract statistically significant composite variables (principal components) from the original data (Overland and Preisendorfer 1982). The PCA solution was rotated (using VARIMAX) in order to facilitate the interpretation of the principal components and the factor scores were saved for each data record. Both the mean and SD of the factor scores for each station over the entire period of record were then used as independent variables in a cluster analysis (k-means algorithm) in order to aggregate stations into groups of similar water quality. The purpose of this analysis was to collapse the 154 stations into a few groups which could then be analyzed in more detail.

### **3.3.1.2. BOX AND WHISKER PLOTS**

Typically, water quality data are skewed to the left (low concentrations and below detects) resulting in non-normal distributions. Therefore it is more appropriate to use the median as the measure of central tendency because the mean is inflated by high outliers (Christian et al. 1991). Data distributions of water quality variables are reported as box-and-whiskers plots. The box-and-whisker plot is a powerful statistic as it shows the median, range, the data distribution as well as serving as a graphical, nonparametric ANOVA. The center horizontal line of the box is the median of the data, the top and bottom of the box are the 25<sup>th</sup> and 75<sup>th</sup> percentiles (quartiles), and the ends of the whiskers are the 5<sup>th</sup> and 95<sup>th</sup> percentiles. The notch in the box is the 95% confidence interval of the median. When notches between boxes do not overlap, the medians are considered significantly different. Outliers (<5<sup>th</sup> and >95<sup>th</sup> percentiles) were excluded from the graphs to reduce visual compression. Differences in variables were also tested between groups using the Wilcoxon Ranked Sign test (comparable to a *t*-test) and among groups by the Kruskal-Wallis test (ANOVA) with significance set at  $P < 0.05$ .

### **3.3.1.3. CONTOUR MAPS**

In an effort to elucidate the contribution of external factors to the water quality of the region and to visualize gradients in water quality over the region, we combined data from other portions of our water quality monitoring network including the Florida Keys national Marine Sanctuary (<http://serc.fiu.edu/wqmnetwork/CONTOUR%20MAPS/ContourMaps.htm>). Data from these additional stations were collected during the same month as the SFWMD surveys and analyzed by the SERC laboratory using identical methods. Contour maps were produced using Surfer (Golden Software). The most important aspect of generating contour maps is the geostatistical algorithm used for interpolating the data values. Care should be taken in the selection of the algorithm because automated interpolation to a regular rectangular grid can produce artifacts, especially around the edges and when the area of interest is irregularly shaped. The kriging algorithm was used because it is designed to minimize the error variance while at the same time maintaining point pattern continuity (Isaaks & Srivastava, 1989). Kriging is a global approach which uses standard geostatistics to determine the "distance" of influence around each point and

the "clustering" of similar samples sites (autocorrelation). Therefore, unlike the inverse distance procedure, kriging will not produce valleys in the contour between neighboring points of similar value.

### **3.3.2. SOFTWARE USED**

Data were analyzed using Statview (SAS), JMP (SAS), and SURFER (Golden Software).

### **3.3.3. GRAPHICAL TREND ANALYSIS**

Times series were plotted by zone as medians of monthly data for the complete period of record to illustrate any temporal trend that might have occurred. Secular trends were quantified by simple regression with significance set at  $P < 0.05$ .

## **4. RESULTS AND DISCUSSION**

### **4.1. REGIONAL CLIMATOLOGY**

Climate variability has major effects on the health of South Florida ecosystems because precipitation, temperature, evaporation and wind-driven water flow affect circulation, salinity, water exchange and biogeochemical processes. Furthermore, in a significant proportion water flow from Everglades managed canals partially follow precipitation cycles contributing further to complexity in response from coastal waters. Precipitation on the region has not been uniform over the data collection period of record, neither in space nor in time. 2007 was an average precipitation year from Palm Beach south, but the northern watershed, including Lake Okeechobee itself, experienced an extreme drought (Fig. 4.1.2). This unusual dry year forced the SFWMD to curtail water supply to South Florida ecosystems, especially affecting those stations influenced by the Loxahatchee. Dryness plus reduced canal flows significantly affected the SW Florida coast during 2007. Precipitation in the Everglades (Royal Palm) rebounded from the drought of the late 1980's and reached levels equal or greater than the long term average (1949-2007;  $141.68 \text{ cm yr}^{-1}$ ) for 10 of the last 17 years (Fig 4.1.3). Total precipitation for 2007 was  $150.27 \text{ cm yr}^{-1}$  making it equal to the median value year since 1991. Nevertheless, July and August were above their respective medians by about 11 cm.

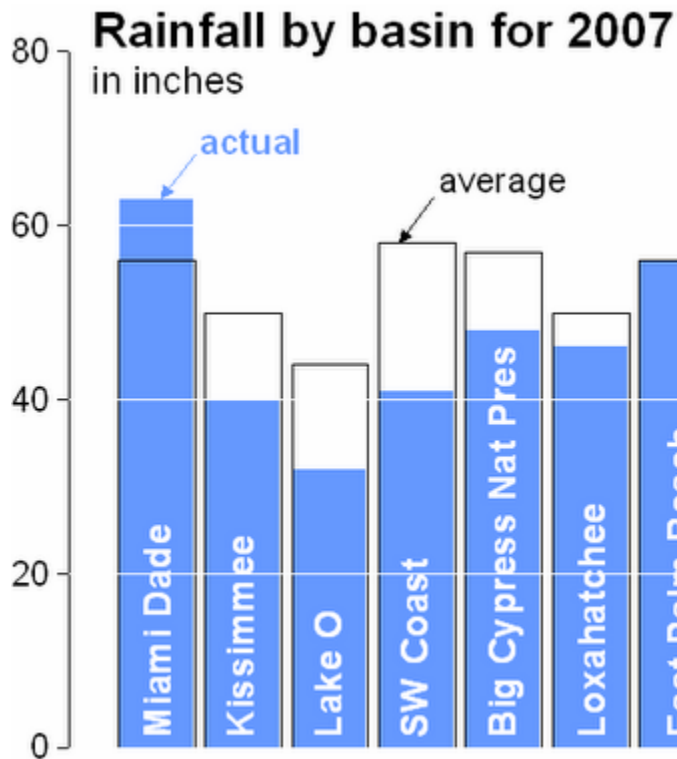


Figure 4.1.2. Precipitation of Central and South Florida (modified from Sobczak 2008)

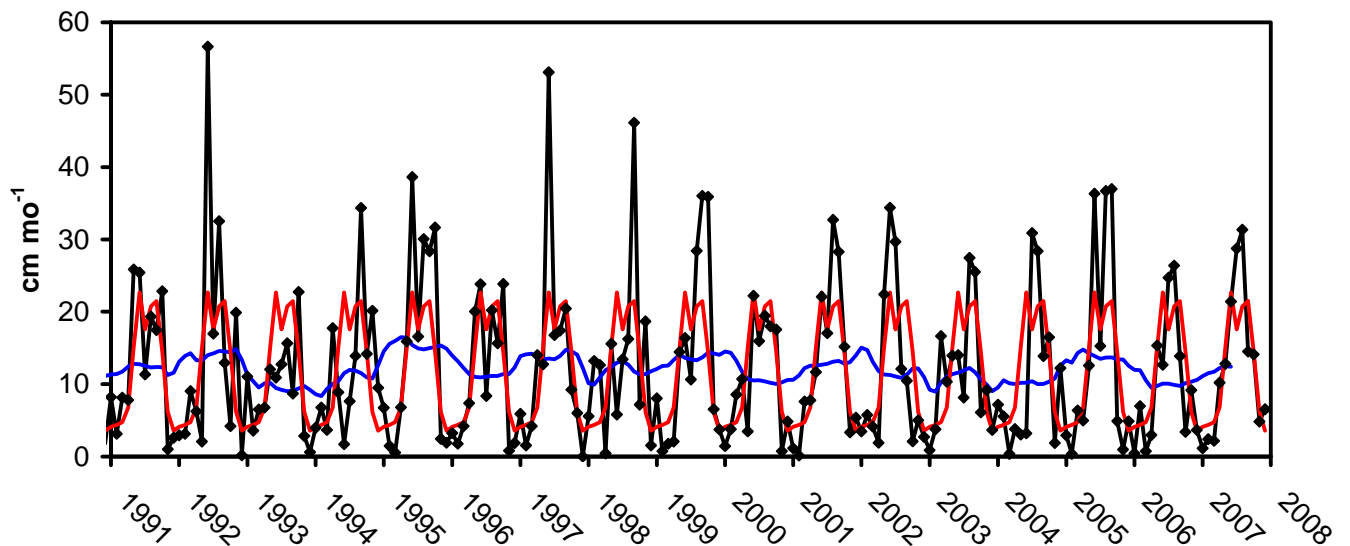


Figure 4.1.3. Monthly rainfall in South Florida (Royal Palm gage). The red line is long term monthly average (since 1948); the blue line is 12 month moving average.

## **4.2.STATE OF WATER QUALITY IN FLORIDA BAY**

### Overall Period of Record

Effective Oct. 1, 2007 as per SFWMD contract, no samples were analyzed for silicate and field duplicates were reduced to 10% of all sites collected.

The main external influences on water quality in Florida Bay are water exchange with the Gulf of Mexico at the western boundary, atmospheric precipitation, and terrestrial input from Taylor Slough and C-111 panhandle (Rudnick et al. 1999). The two largest impacts cannot be managed by man and even freshwater inputs from land are highly tied to climactic conditions and events.

A spatial analysis of data from our monitoring program resulted in the delineation of 3 groups of stations, which have robust similarities in water quality (Fig. 4.1.1). We contend that these spatially contiguous groups of stations are the result of similar hydrodynamic forcing and processing of materials, hence we call them 'zones of similar influence'. The Eastern Bay zone acts most like a 'conventional' estuary in that it has a quasi-longitudinal salinity gradient caused by the mixing of freshwater runoff with seawater. In contrast, the Central Bay is a hydrographically isolated area with low and infrequent terrestrial freshwater input, a long water residence time, and high evaporative potential. The Western Bay zone is the most influenced by the Gulf of Mexico tides and is also isolated from direct overland freshwater sources.

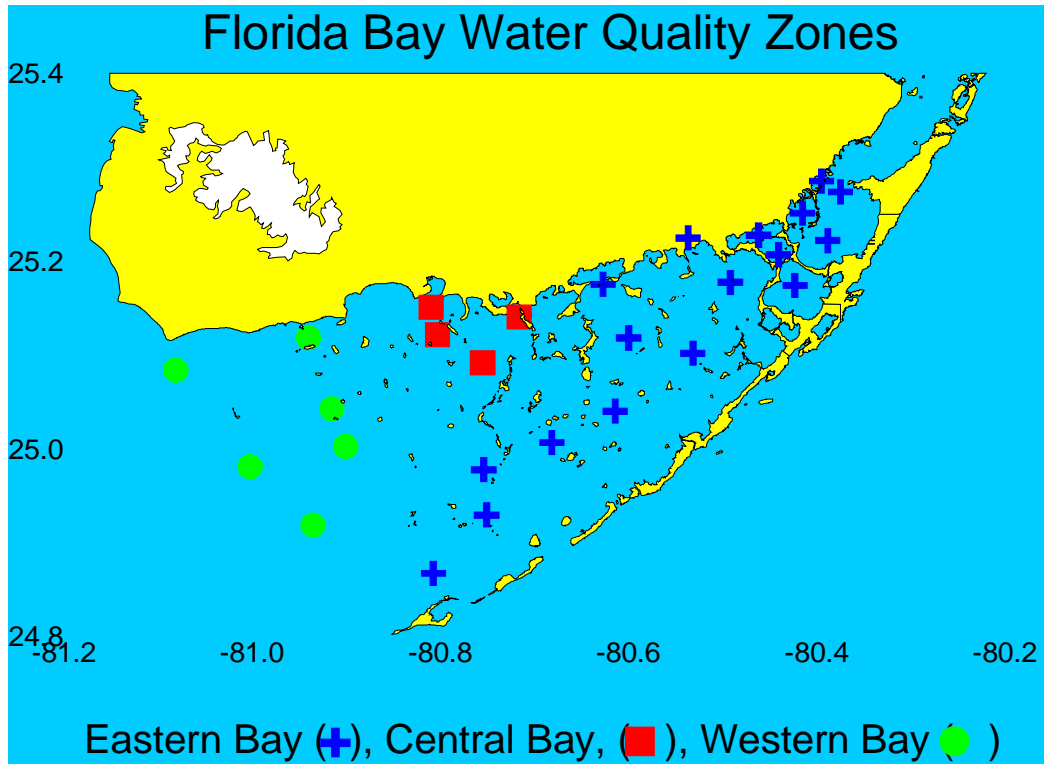


Figure 4.1.1. Zones of similar water quality in Florida Bay

Early in the record, salinity and total phosphorus (TP) concentrations declined baywide while turbidity (cloudiness of the water) increased dramatically. The salinity decline in Eastern and Central Florida Bay was dramatic early on and has since stabilized into a regular seasonal cycle (Fig. 4.1.4-4.1.6). The box-and-whisker plots presented in this and following figures show the range (boxes are quartiles; whiskers include 90% of data) and median (line in box) of the monthly data. Some of this decrease in Eastern Bay could be accounted for by increased freshwater flows from the Everglades but declines in other areas point to the climactic effect of increased rainfall during this period. The Central Bay continues to experience hypersaline conditions ( $>35$ ) during the summer but the extent and duration of the events is much shorter.

Chlorophyll *a* concentrations (CHLA), a proxy for phytoplankton biomass, were particularly dynamic and spatially heterogeneous (Fig. 4.1.6-4.1.6). The Eastern Bay generally has the lowest CHLA while the Central Bay is highest. In the Eastern Bay, which makes up roughly half of the surface area of Florida Bay, CHLA has declined by  $0.9 \mu\text{g l}^{-1}$  or 63%. Most of this decline occurred over a few months in the spring/summer of 1994 and had remained relatively stable until the hurricanes of 2005. Since then a large cyanobacterial bloom has been present in this



region (Rudnick et al. 2006). The general consensus was that the bloom formed as a result of water management in response to hurricane activity and disturbance from road construction. The bloom declined in early 2007 but rebounded in the wet season.

The isolated Central Bay zone underwent a 5-fold increase in CHLA from 1989-94 then rapidly declined to previous levels by 1996. In Western Florida Bay, there was a significant increase in CHLA, yet median concentrations remained modest ( $2 \mu\text{g l}^{-1}$ ) by most estuarine standards. There were significant blooms in Central and Western Bay immediately following Hurricanes Georges (Nov. 1998) but it was Hurricane Irene's large rainfall input (Oct. 1999) which spiked the largest blooms in this region of the bay. It is important to note that these changes in CHLA (and turbidity) happened years after the poorly-understood seagrass die-off in 1987. It is possible that the death and decomposition of large amounts of seagrass biomass might partially explain some of the changes in water quality of Florida Bay but the connections are temporally disjoint and the processes indirect and not well understood.

As mentioned previously, TP concentrations have declined baywide over the 14 year period of record (until the 2005 hurricane season). As with salinity, most of these declines occurred early in the record. Unlike most other estuaries, increased terrestrial runoff may have been partially responsible for the decrease in TP concentrations in the Eastern Bay. This is because the TP concentrations of the runoff are at or below ambient levels in the bay. It is also important to understand that almost all the phosphorus measured as TP is in the form of organic matter which is less accessible to plants and algae than inorganic phosphate. The elevated TP in the Central Bay is mostly due to concentration effect of high evaporation. Recently, there have been significant peaks during the fall season in both Eastern and Western Bays. The 2005 hurricane season impacted the Eastern Bay with large loading of TP. In addition, the US Route 1 road construction may have had an impact as well (Rudnick et al. 2006). TP has declined but remained elevated in Eastern Bay through 2007.

The dissolved inorganic nitrogen assemblage (DIN) is made up of ammonium ( $\text{NH}_4^+$ ), nitrate ( $\text{NO}_3^-$ ), and nitrite ( $\text{NO}_2^-$ ). The Western Bay is lowest in DIN; phytoplankton in this region may be limited by N availability on a regular basis. DIN in the Eastern Bay is a little higher and is mostly in the form of  $\text{NO}_3^-$  while highest levels are found in the Central Bay as  $\text{NH}_4^+$ .

Turbidity in the Central and Western Bays have increased greatly since 1991 (not shown). Turbidity in Eastern Bay increased 2-fold from 1991-93, while Central and Western Bays

increased by factors of 20 and 4, respectively. Turbidity across the bay has since stabilized and possibly declined but certainly not to previous levels. In general, the Eastern Bay has the clearest water, which is due to a combination of factors such as high seagrass cover, more protected basins, low tidal energy, and shallow sediment coverage. We are unsure as to the cause, but the loss of seagrass coverage may have destabilized the bottom so that it is more easily disturbed by wind events.

# Eastern Florida Bay Zone

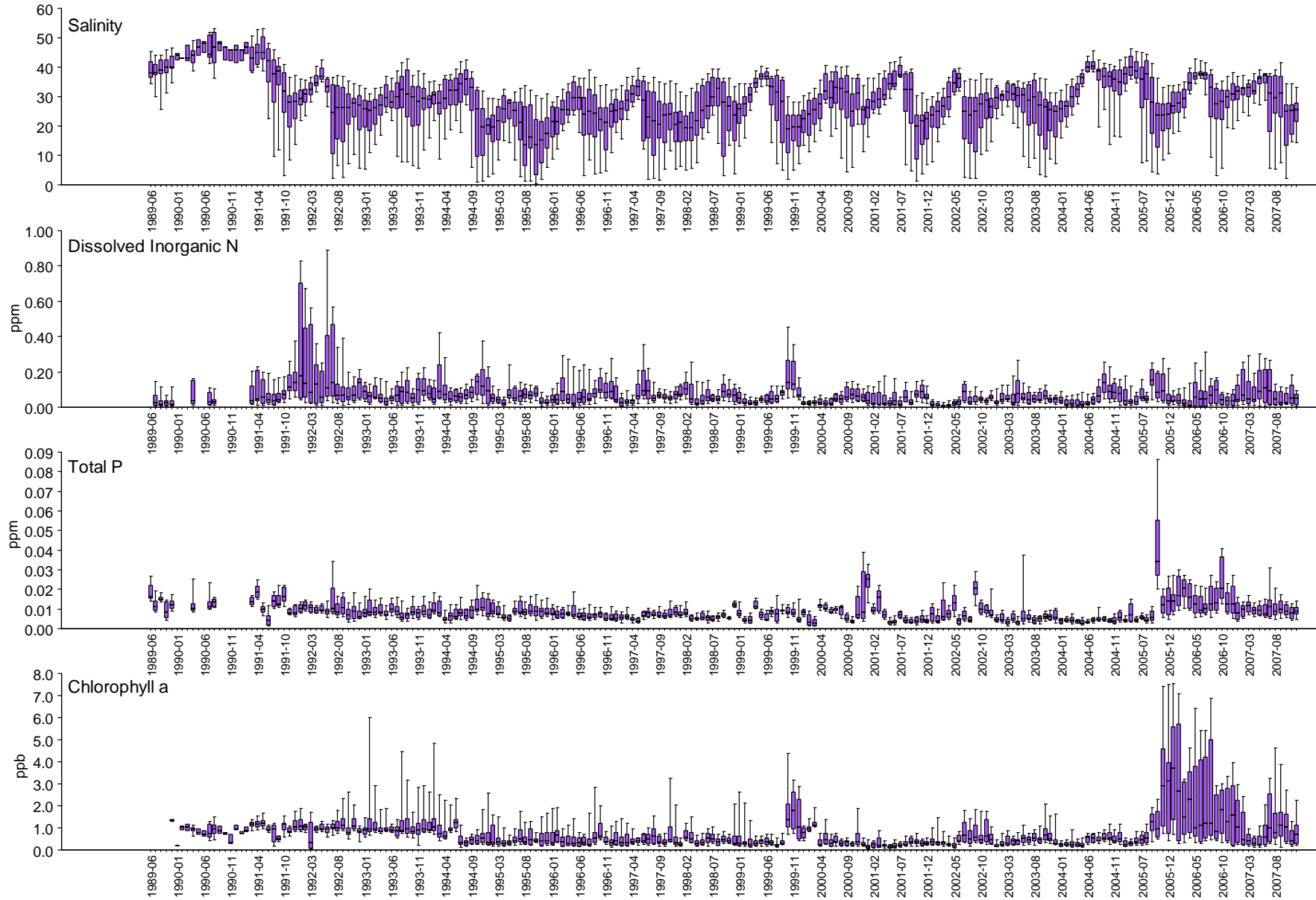


Figure 4.1.4. Box-and-whisker plots of water quality in Eastern Florida Bay by survey.

# Central Florida Bay Zone

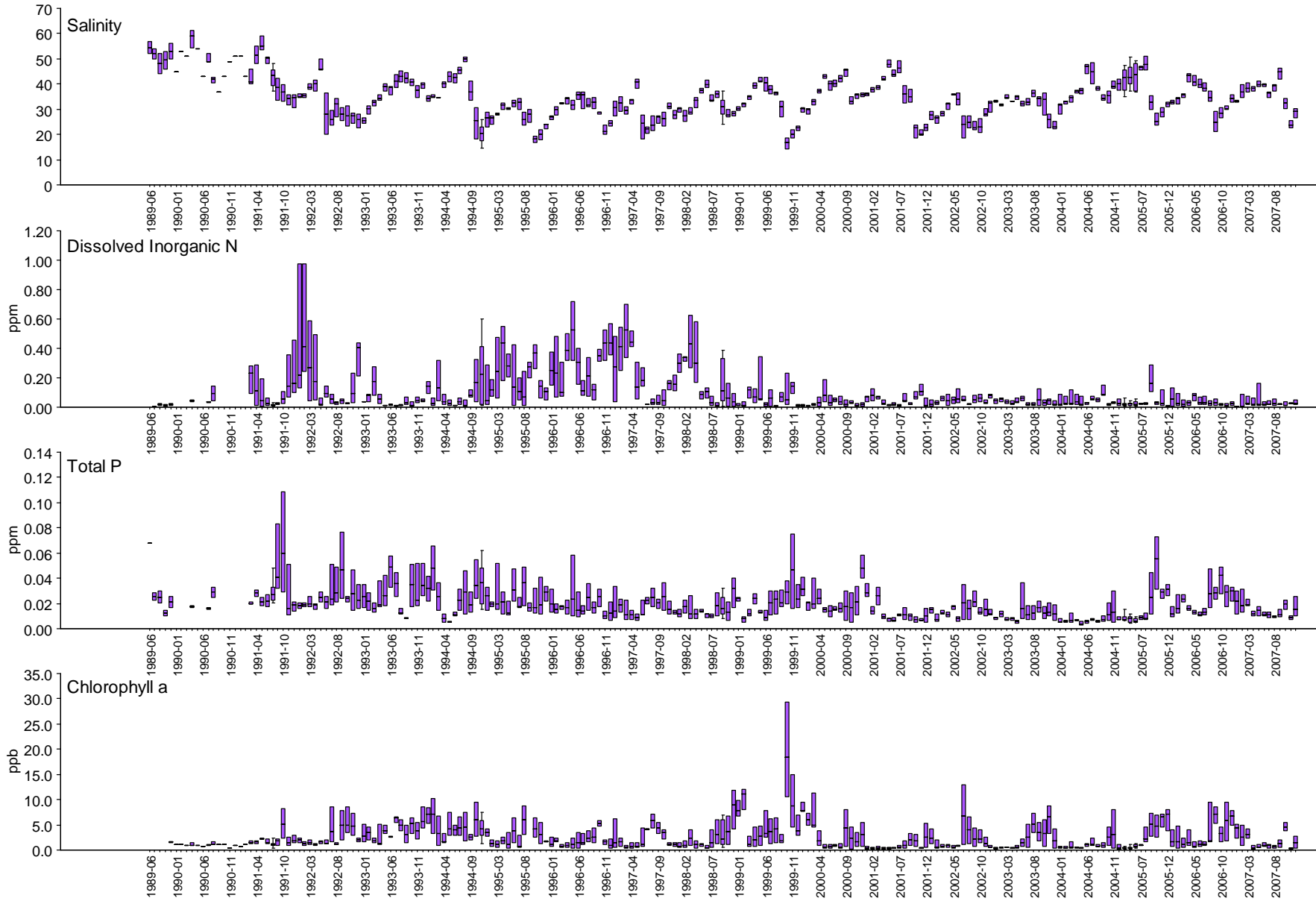


Figure 4.1.5. Box-and-whisker plots of water quality in Central Florida Bay by survey.

# Western Florida Bay Zone

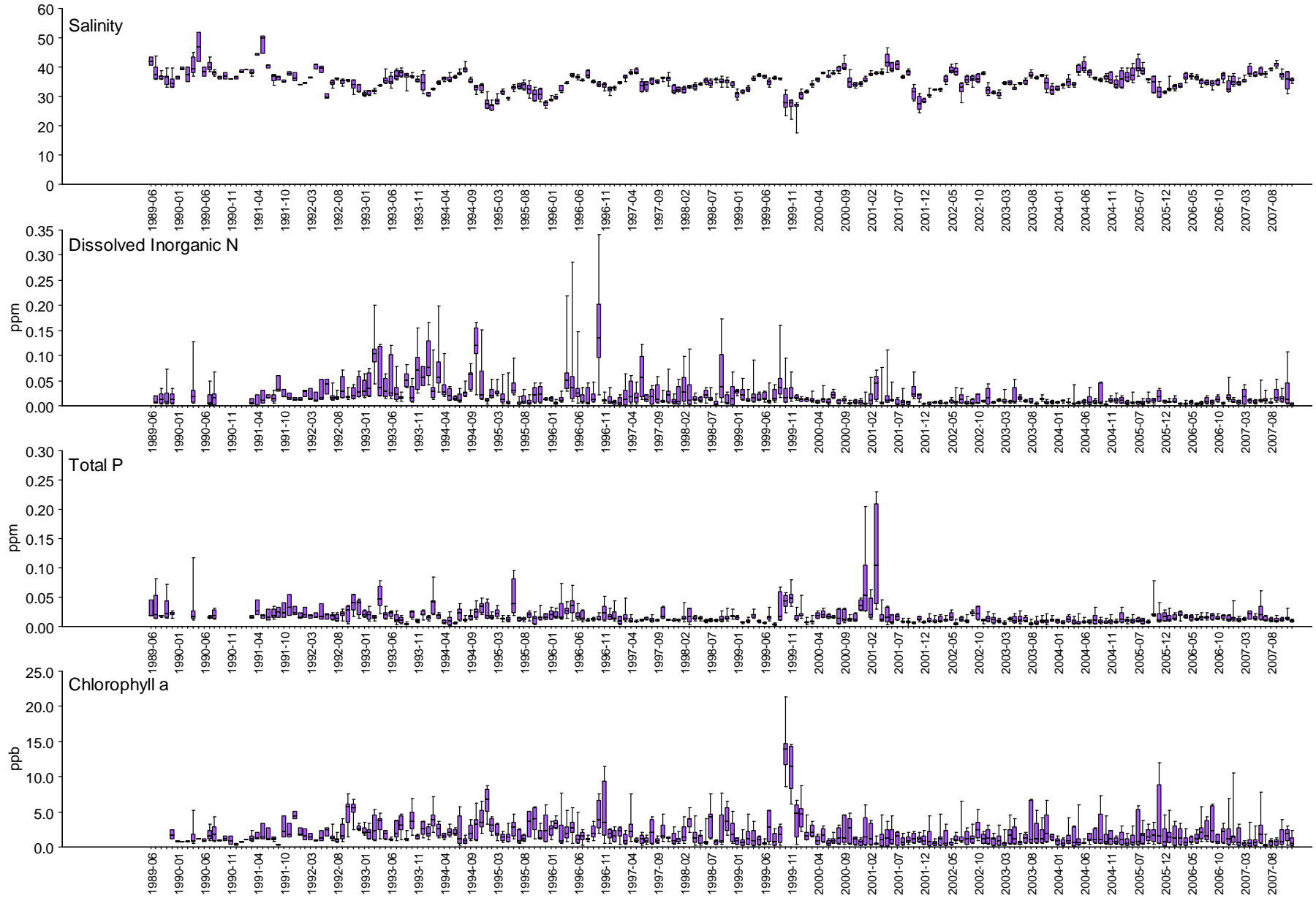


Figure 4.1.6. Box-and-whisker plots of water quality in Western Florida Bay by survey.

### 2007 Alone

The following Figures 4.1.7-4.1.9 show the monthly median of 2007 data from each zone compared to the long term median for each zone. We feel that this graphical approach is useful in pointing out anomalies and present some possible explanations for these differences.

2007 was a typical rainfall year (since 1991), however it showed higher salinity in the bay during the first few months than usual, perhaps caused by precipitation deficits (below grand median) for January, February, March, May, June and September. There were no direct hurricane impacts to Florida Bay during 2007.

### Eastern Bay

Salinity was higher in the early months due to the drier than normal dry season (Fig 4.1.7). This points out the impact that the long water residence time has on Eastern Bay and the importance of rainfall. Temperature, DO, and turbidity were unremarkable.  $\text{NO}_3^-$  was higher than normal especially for the summer months (Fig 4.1.7).  $\text{NH}_4^+$  was higher than the grand median for the first half of the year and then rapidly declined to below average levels during August. TP was elevated in Eastern Bay throughout most of the year as a result of the previous hurricane and road construction interaction (Rudnick et al. 2006). CHLA showed an inverse pattern to DIN, being highest in the wet season. TON and TOC were lower than the grand median being indicative of temporal trend towards lower concentration.

### Central Bay

Salinity was higher in the early months due to the drier than normal dry season and was also high in Sep.-Nov. (Fig 4.1.8). This points out the impact that the long water residence time has on Central Bay. Temperature was unremarkable; DO showed deviations from long term median possibly as a function of CHLA fluctuations.  $\text{NO}_3^-$  was normal except for large increases in Nov.-Dec. (Fig 4.1.8).  $\text{NH}_4^+$  was significantly below average for the year. TP was slightly lower during the wet season than other years. CHLA was high early in the year but declined to normal levels for the remainder. TOC and TON were higher in the winter-spring and lower than normal for rest of the year. pH in Central Bay was elevated relative to other years but unrelated to salinity. Turbidity was lower for 2007 as well.

### Western Bay

Salinity was slightly higher than usual (Fig 4.1.9) but probably not significantly so. Temperature and DO were unremarkable.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were normal for Western Bay. Turbidity and CHLA were generally lower than normal.

### Data, Graphs, and Figures

All data for the period of record are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm>

Contour maps showing spatial distributions of all measured variables (quarterly) are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm>

### Eastern Florida Bay (FBE)

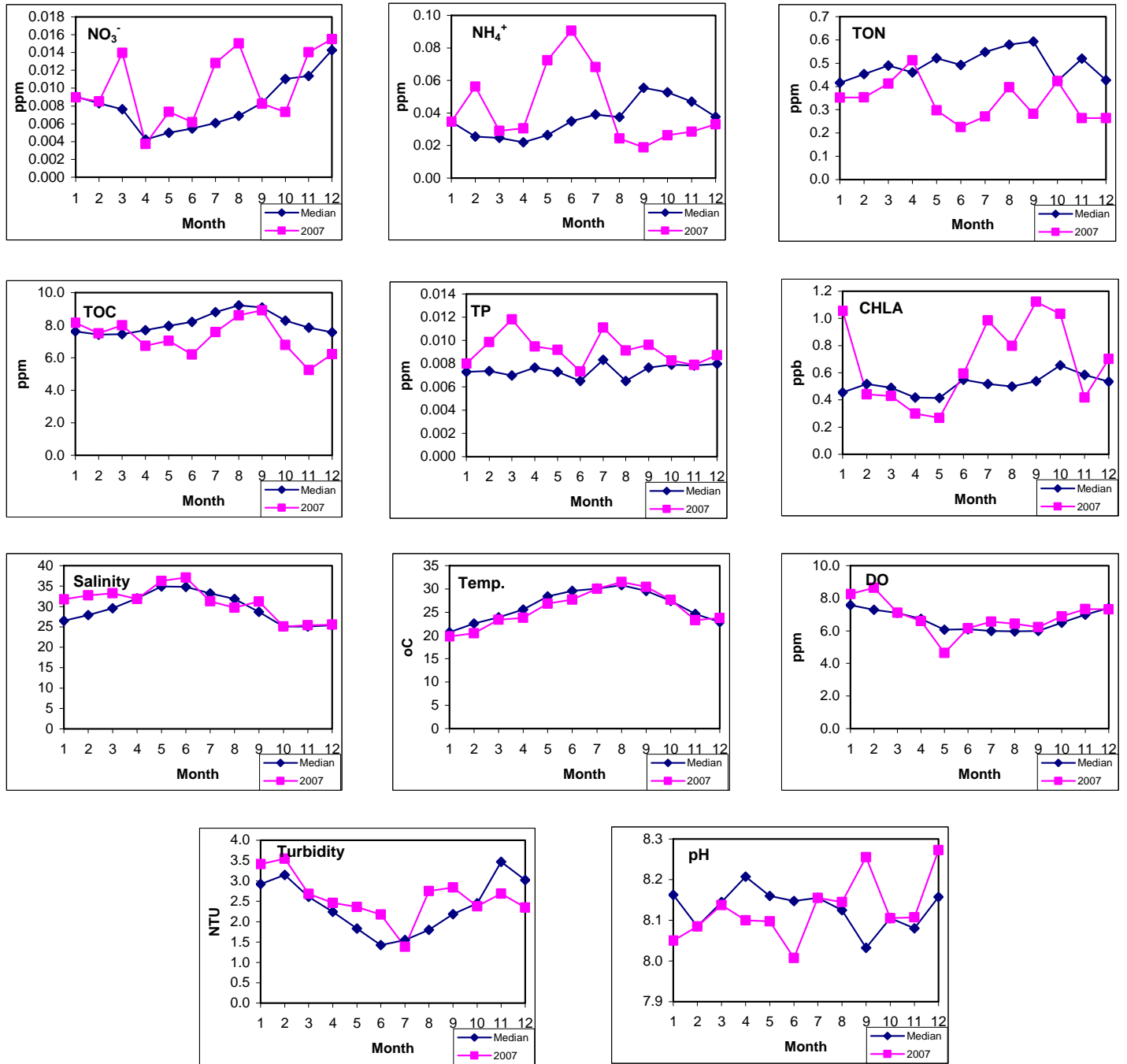


Figure 4.1.7. Comparison of long-term median with 2007 data.



### Central Florida Bay (FBC)

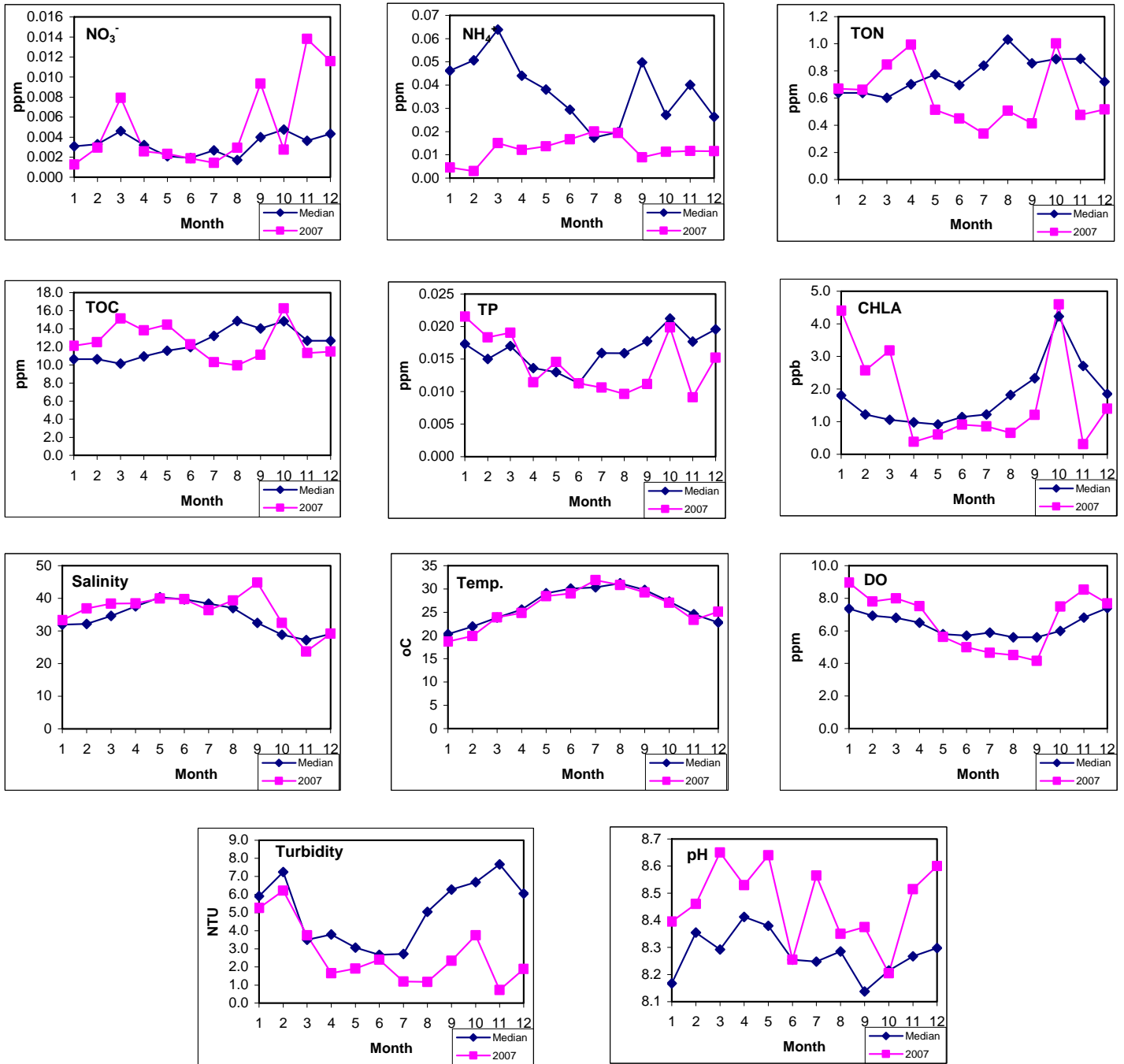


Figure 4.1.8. Comparison of long-term median with 2007 data.

### Western Florida Bay (FBW)

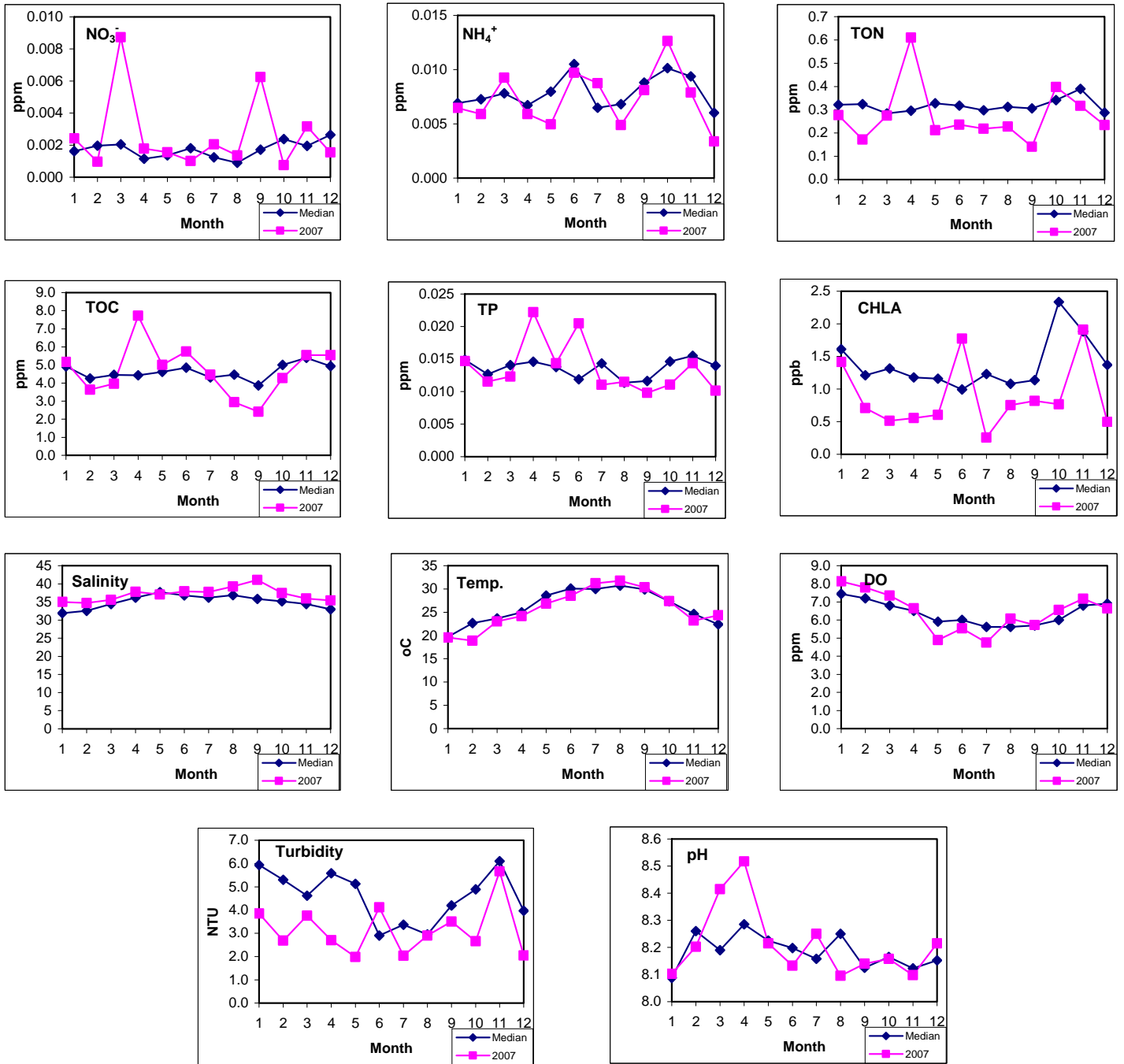


Figure 4.1.9. Comparison of long-term median with 2007 data.

### **4.3. STATE OF WATER QUALITY IN WHITEWATER BAY - TEN THOUSAND ISLANDS COMPLEX**

#### Overall Period of Record

As of Oct. 1, 2007 the SFWMD contract no longer includes sampling at 4 sites in Whitewater Bay area, # 31, 45, 46, and 50. As of Oct. 1, 2007 the SFWMD contract no longer includes sampling at 5 sites in Ten Thousand Islands area, #51, 60, 62, 68, and 73. Also effective Oct. 1, 2007 as per SFWMD contract, no samples were analyzed for silicate and field duplicates were reduced to 10% of all sites collected.

A spatial analysis of data from our monitoring program resulted in the delineation of 6 groups of stations, which have robust similarities in water quality (Fig. 4.2.1). The first cluster was composed of 13 stations in and around the Shark, Harney, Broad, and Lostmans Rivers and is called the Mangrove River (MR) group. This cluster also included a sampling station just off the Faka Union Canal. The second cluster was made up of the 8 stations enclosed within Whitewater Bay proper (WWB). Twelve stations were sited mostly in and around the coastal islands of TTI-WWB formed the Gulf Island group (GI). The water quality characteristics at the Coot Bay site (COOT) were sufficiently different so as to be a cluster of its own. The next cluster contained the northernmost 2 stations in the Blackwater River estuary (BLK). Finally, the Inland Wilderness Waterway zone (IWW) included 11 stations distributed throughout the inside passage as well as the Chatham River and the station off Everglades City.

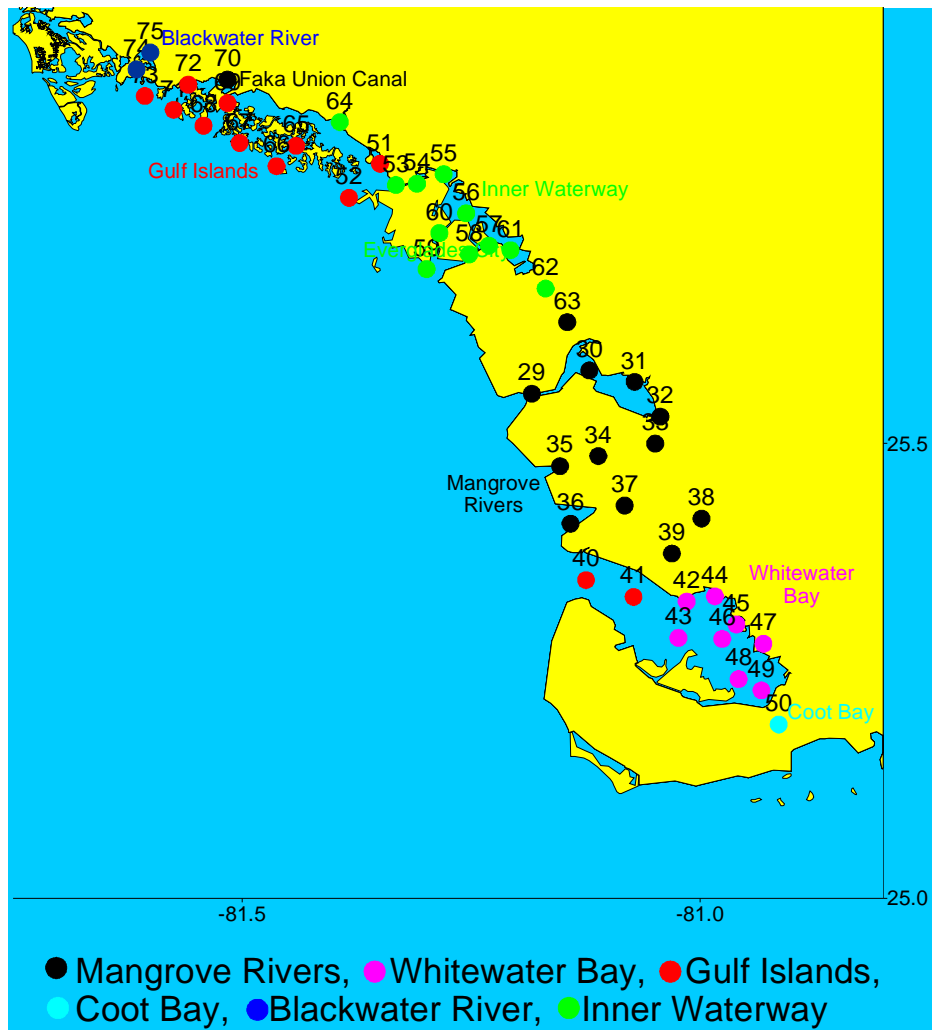


Figure 4.2.1. Zones of similar water quality in Whitewater Bay-Ten Thousand Islands complex

Marked differences in physical, chemical, and biological characteristics among zones were illustrated by this technique. The general spatial trend is one of highly variable salinity as a result of Shark Slough inputs in the south (Fig. 4.1.2-4.1.6). Salinity in the Gulf Islands zone was more consistent due to Gulf of Mexico influence but also is affected by Caloosahatchee River outputs. CHLA concentrations were relatively high in this region compared to Florida Bay and the Shelf. Highest CHLA were observed in the semi-enclosed areas such as Whitewater Bay and the Inner Wilderness Waterway. It is possible that the longer water residence times exhibited in these areas promoted the intensification of algal biomass. TP tended to be lowest in Whitewater Bay and Mangrove Rivers but increased northward along the coast. The spatial distribution of DIN was generally opposite to that of TP. The net effect was the formation of a gradient with strong phosphorus limitation occurring in the southern region which shifted to a

more balanced N:P ratio in the northern area around the Blackwater River. The Mangrove Rivers were a significant source of TOC to the Shelf. TOC was highest in the south and declined northward along the coast.

We believe these gradients are the result of coastal geomorphology and watershed characteristics in the region. The width of the mangrove forest is widest in the south (15 km) but grades to only 4 km wide in the northern TTI; this being a function of elevation and sediment type. Whitewater Bay is a semi-enclosed body of water with a relatively long residence time, which receives overland freshwater input from the Everglades marsh. The long water residence time may explain the very low P concentrations (from biological uptake), while the high evaporation rate would tend to concentrate dissolved organic matter (DOM). The Mangrove Rivers are directly connected to the Shark River Slough and therefore have a huge watershed relative to their volume. Freshwater inputs from this source are very low in P while the extensive mangrove forest contributes much DOM. The Inner Waterway is an intermediate zone in all respects; having extensive channelization but low freshwater input. The Gulf Island zone has very low freshwater input due to the poorly drained watershed of the Big Cypress Basin. Instead of mangrove river channels there are many mangrove islands set in low tidal energy environment situated behind the Cape Romano Shoals. Finally there is the Blackwater River cluster with highest TP concentrations. There is considerable agriculture (tomatoes, etc.) in the Blackwater River watershed, which may contribute significant amounts of P to the system via drainage ditches. Further analysis of this relationship is planned.

# Whitewater Bay Zone

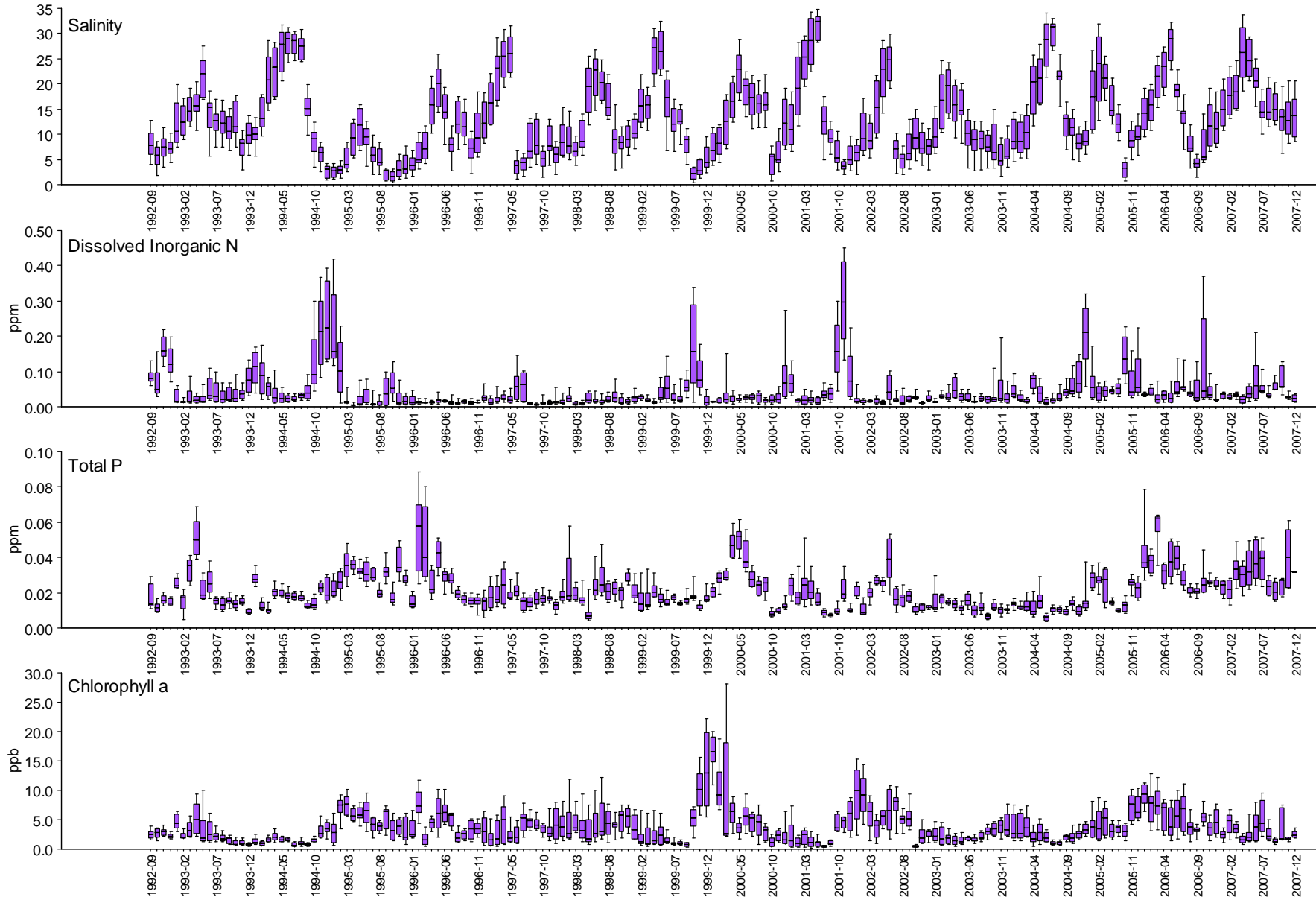


Figure 4.2.2. Box-and-whisker plots of water quality in WWB-TTI by survey.

# Mangrove Rivers Zone

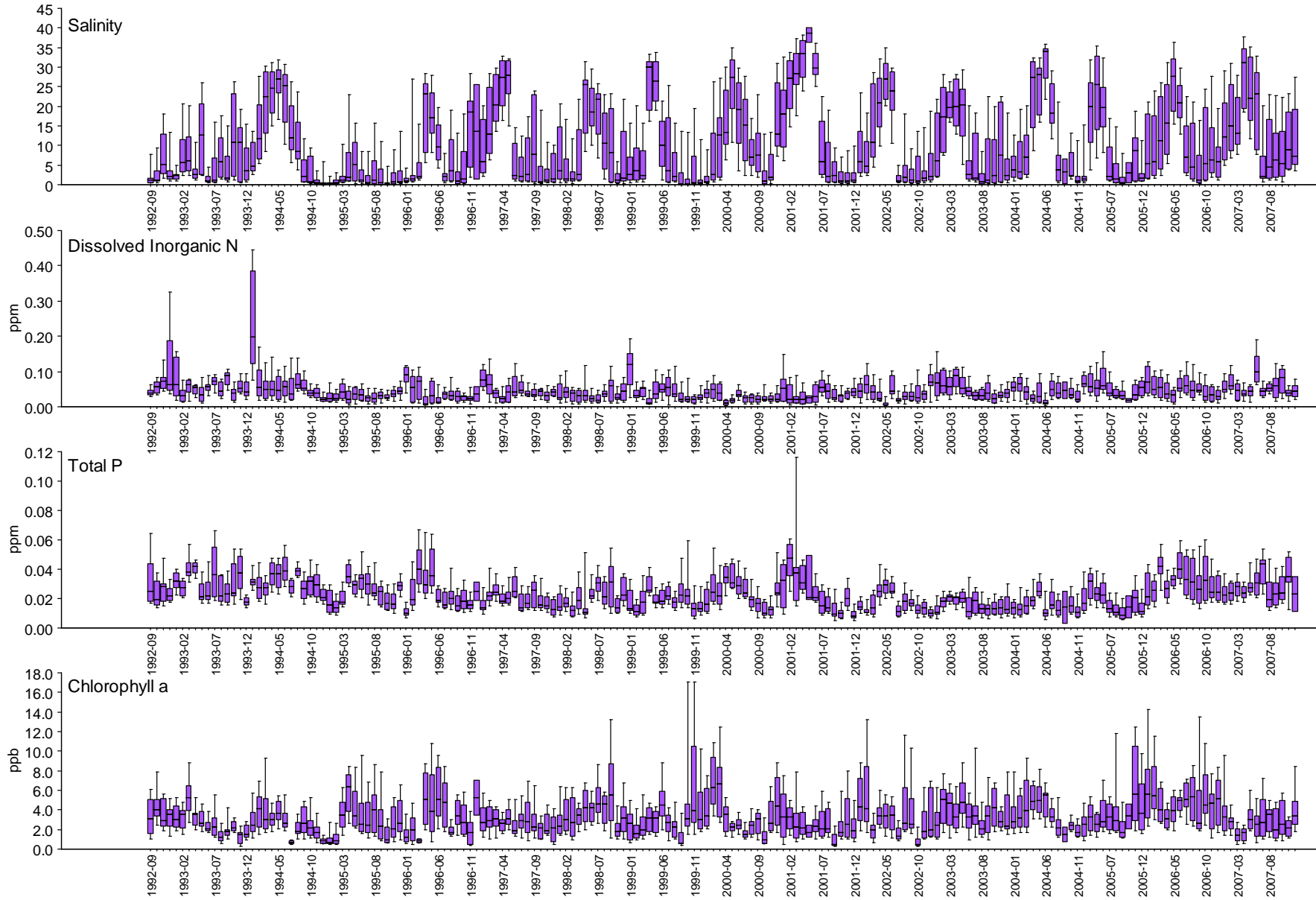


Figure 4.2.3. Box-and-whisker plots of water quality in WWB-TTI by survey.

# Gulf Islands Zone

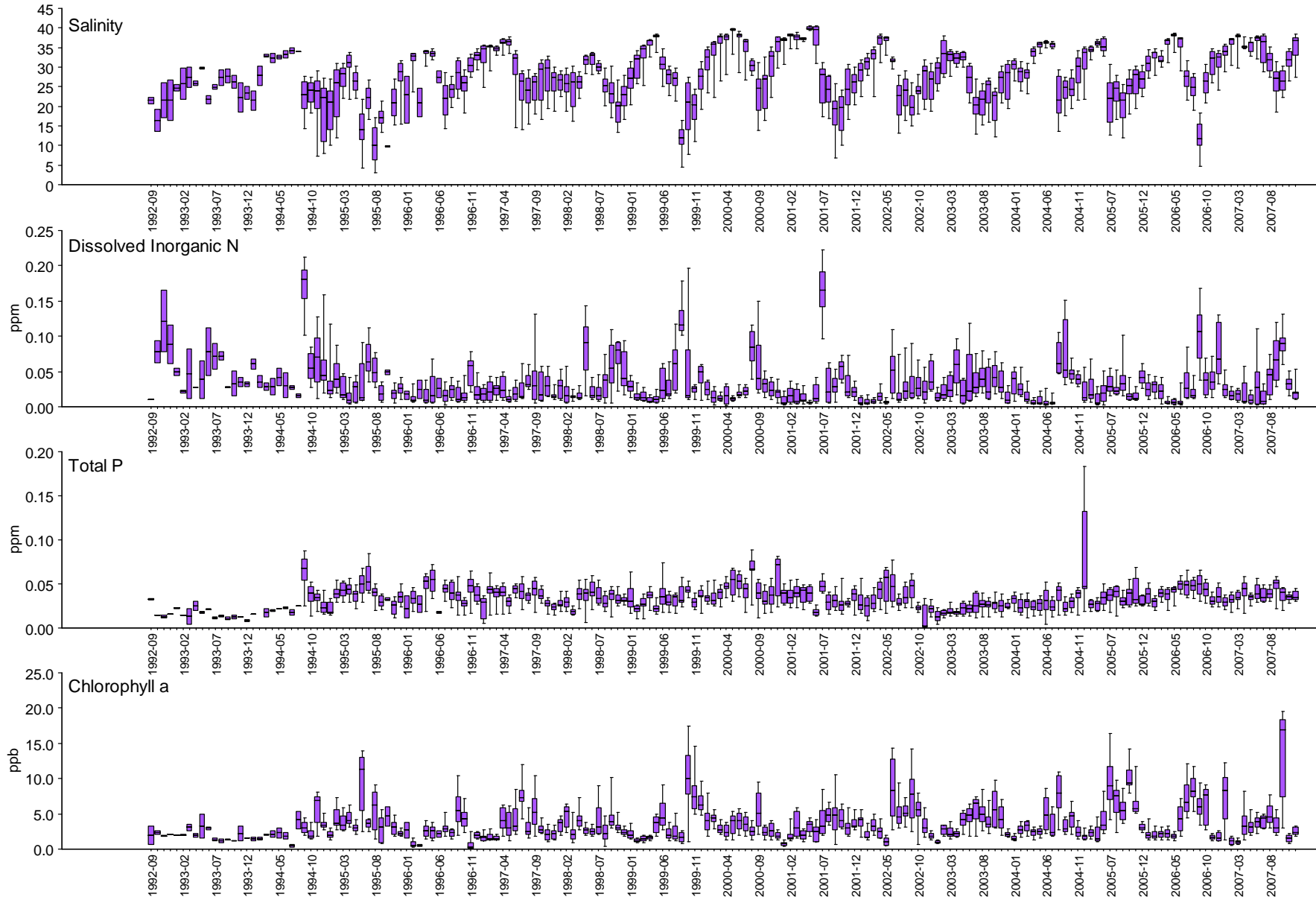


Figure 4.2.4. Box-and-whisker plots of water quality in WWB-TTI by survey.



# Inner Waterway Zone

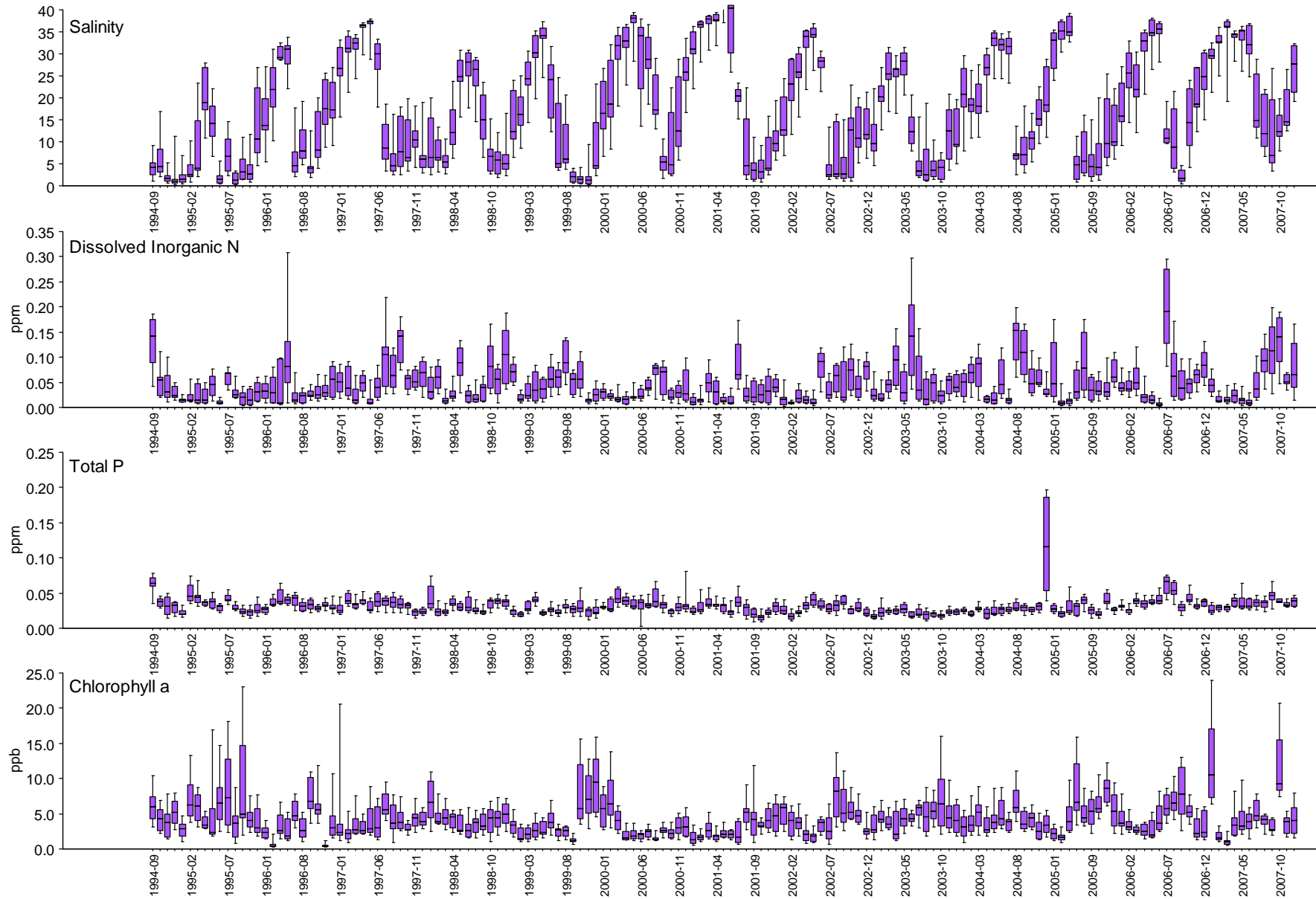


Figure 4.2.5. Box-and-whisker plots of water quality in WWB-TTI by survey.

# Blackwater River Zone

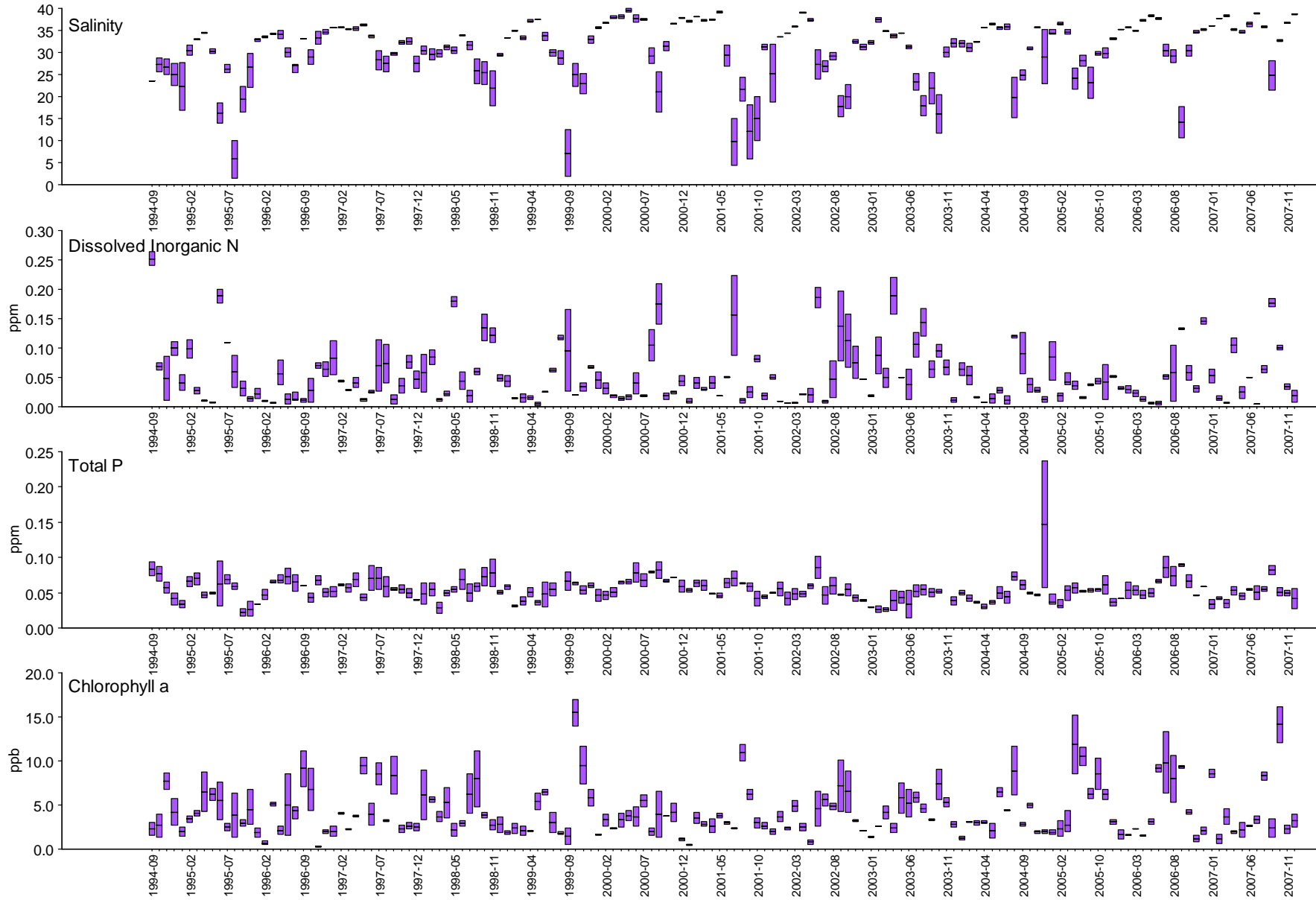


Figure 4.2.6. Box-and-whisker plots of water quality in WWB-TTI by survey.

### 2007 Alone

The influence of freshwater input from the Everglades is very significant to this region. Large salinity variations are the norm, being driven by both climactic events and water management practices (Fig. 4.2.7-4.2.10). Although 2007 was relatively normal rainfall year, salinity patterns were elevated from the grand medians during the early part of the year and were higher than normal during the wet season, as result of precipitation deficits (below grand median) for January, February, March, May, June and September

### Whitewater Bay

Salinity was elevated relative to long term median (Fig. 4.2.7). Temperature, DO, and pH were unremarkable with values generally fluctuating around the median.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP concentrations were elevated while TON was reduced. TON was lower than the grand median. This is the result of the system-wide long term decline in TON output from the Everglades. TOC was slightly lower for most areas. CHLA varied seasonally and was more volatile than the median.

### Mangrove Rivers

Salinity fluctuated widely due to freshwater inputs from Shark Slough but was slightly higher than usual (Fig. 4.2.8). Temperature and pH were unremarkable with values generally fluctuating around the median. DO was generally higher than normal as was turbidity. Some peaks in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were observed. TON was lower than the grand median. CHLA was lower in the dry season but came up to normal levels for the rest of the year.

### Inner Waterway

Salinity fluctuated widely due to freshwater inputs from Shark Slough but was higher than usual (Fig. 4.2.9). Temperature, DO, and pH were unremarkable with values generally fluctuating around the median.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were all higher than the norm during the wet season. TON was lower than the grand median. CHLA showed a large peak in Jan. and Oct. but was normal for the rest of the year.

## Blackwater River

Salinity was elevated relative to long term median and showed a rapid decline in Sep with a quick rebound in Oct. (Fig. 4.2.10). Temperature, DO, turbidity, and pH were unremarkable with values generally fluctuating around the median. Large peaks in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were observed in Apr. and Oct. TON was lower than the grand median. CHLA was lower in the dry season but varied widely for the rest of the year.

## Data, Graphs, and Figures

All data for the period of record are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm>

Contour maps showing spatial distributions of all measured variables (quarterly) are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm>

### Whitewater Bay (WWB)

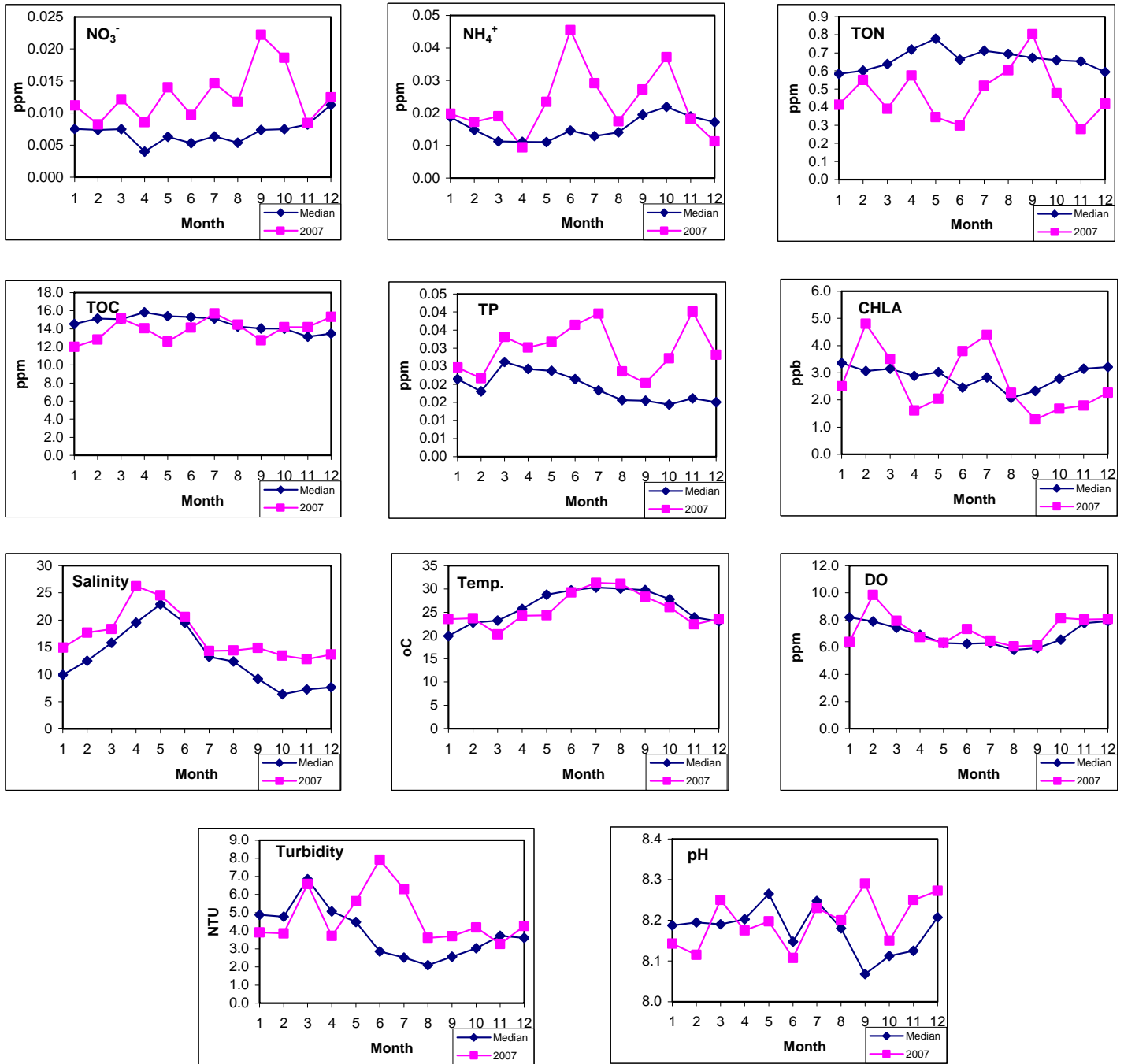


Figure 4.2.7. Comparison of long-term median with 2007 data.

### Mangrove Rivers (MR)

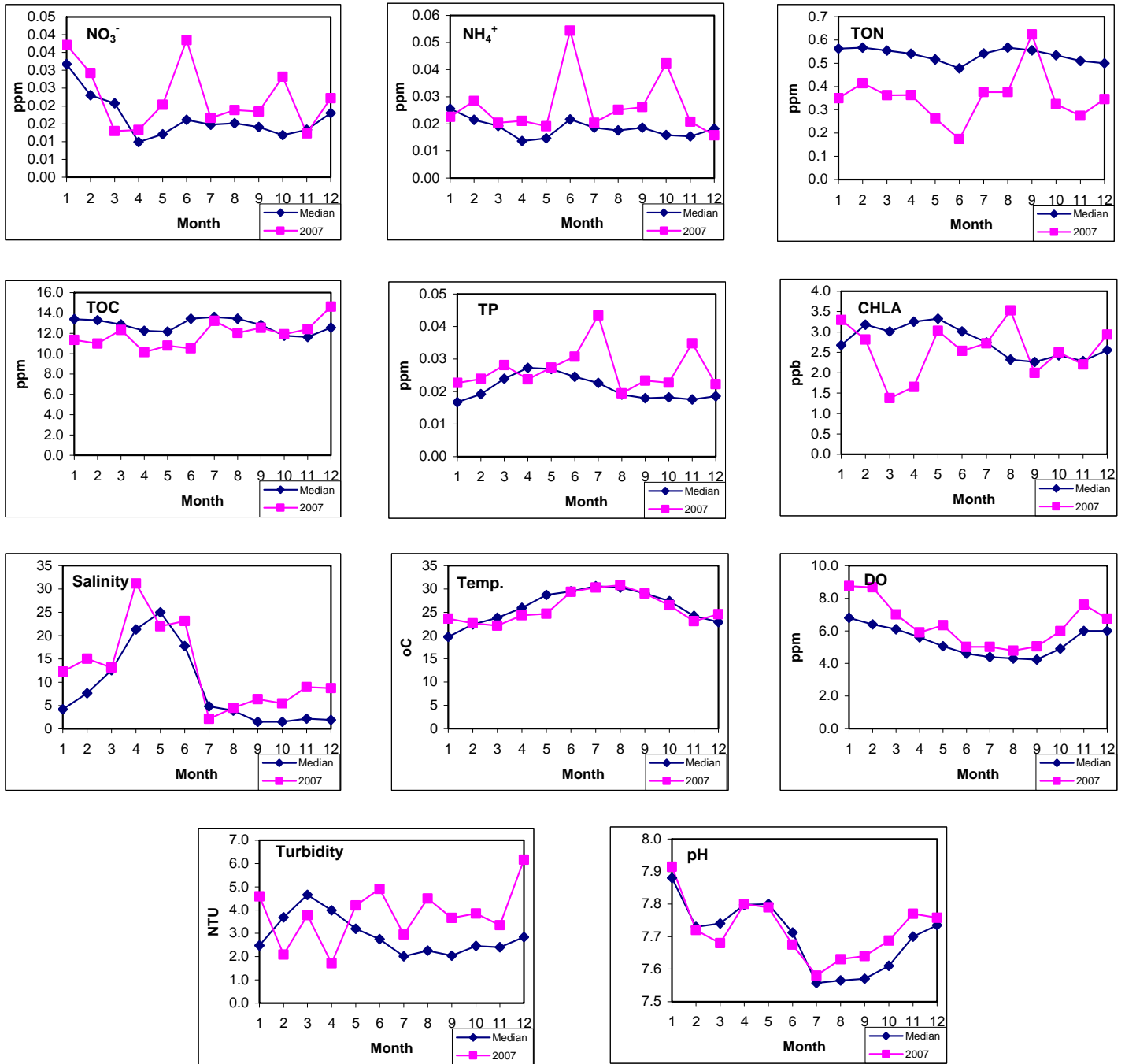


Figure 4.2.8. Comparison of long-term median with 2007 data.

### Inner Waterway (IWW)

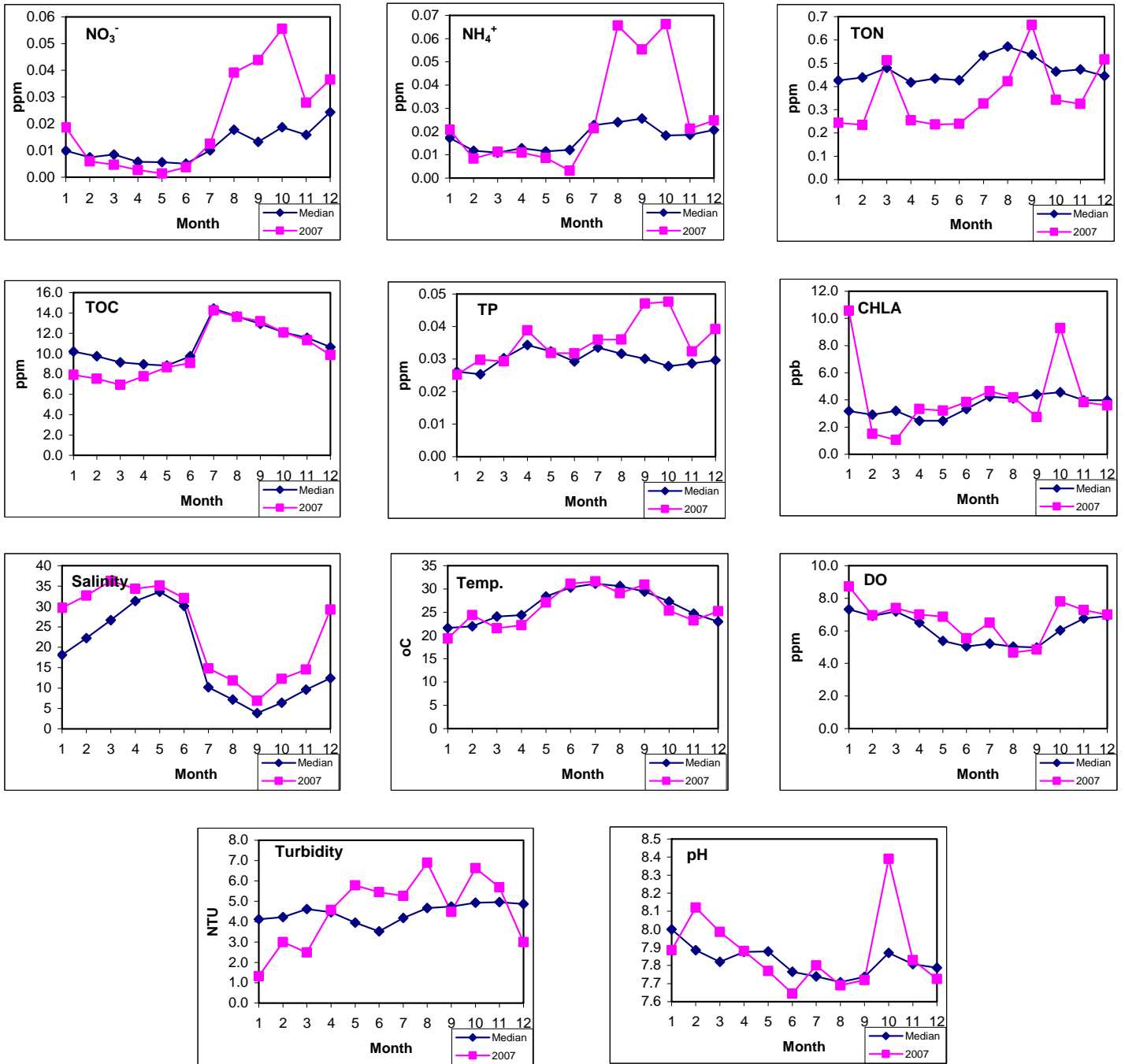


Figure 4.2.9. Comparison of long-term median with 2007 data.

### Blackwater River (BLK)

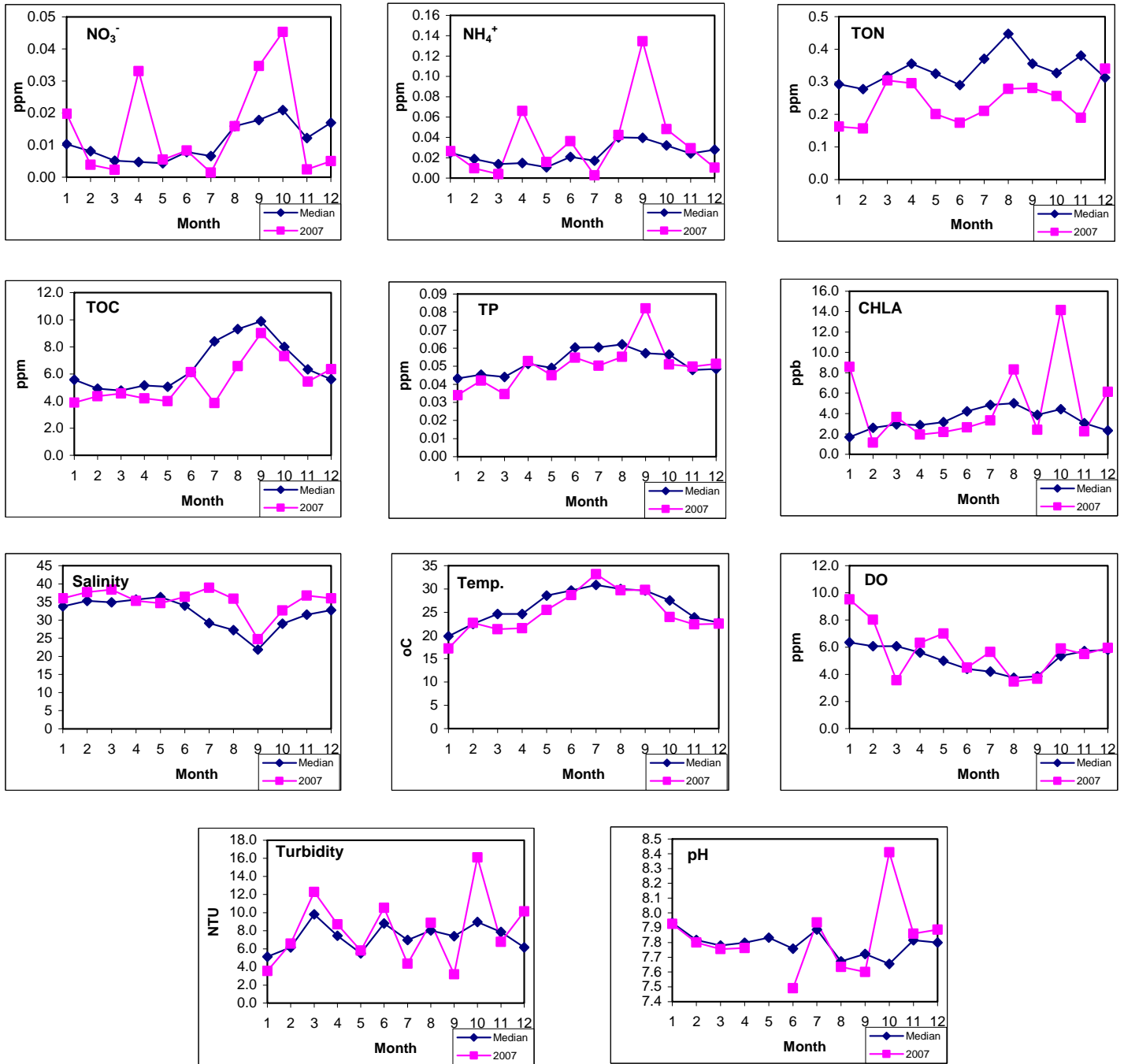


Figure 4.2.10. Comparison of long-term median with 2007 data.



#### **4.4. STATE OF WATER QUALITY IN BISCAYNE BAY**

##### Overall Period of Record

As of Oct. 1, 2007 the SFWMD contract no longer includes sampling at 6 sites in Biscayne Bay #103, 109, 113, 116, 126, and 132. Also effective Oct. 1, 2007 as per SFWMD contract, no samples were analyzed for silicate and field duplicates were reduced to 10% of all sites collected.

A spatial analysis of data from our monitoring program resulted in the delineation of 6 groups of stations, which have robust similarities in water quality (Fig. 4.3.1). The first cluster was composed of 2 stations closest to the shore in the south Bay and was called the Alongshore group (AS). These are stations most influenced by the Goulds, Military and Mowry Canals. The second cluster was made up of the 5 stations farther from the coast called Inshore (IS). Thirteen stations situated mostly in the bay proper were called the main Bay (MAIN) group. The next cluster contained 3 stations situated in areas of great tidal exchange (ocean channel, not shown). Two stations in Card Sound grouped together SCARD. Finally, the Turkey Point station comprised its own cluster (not shown).

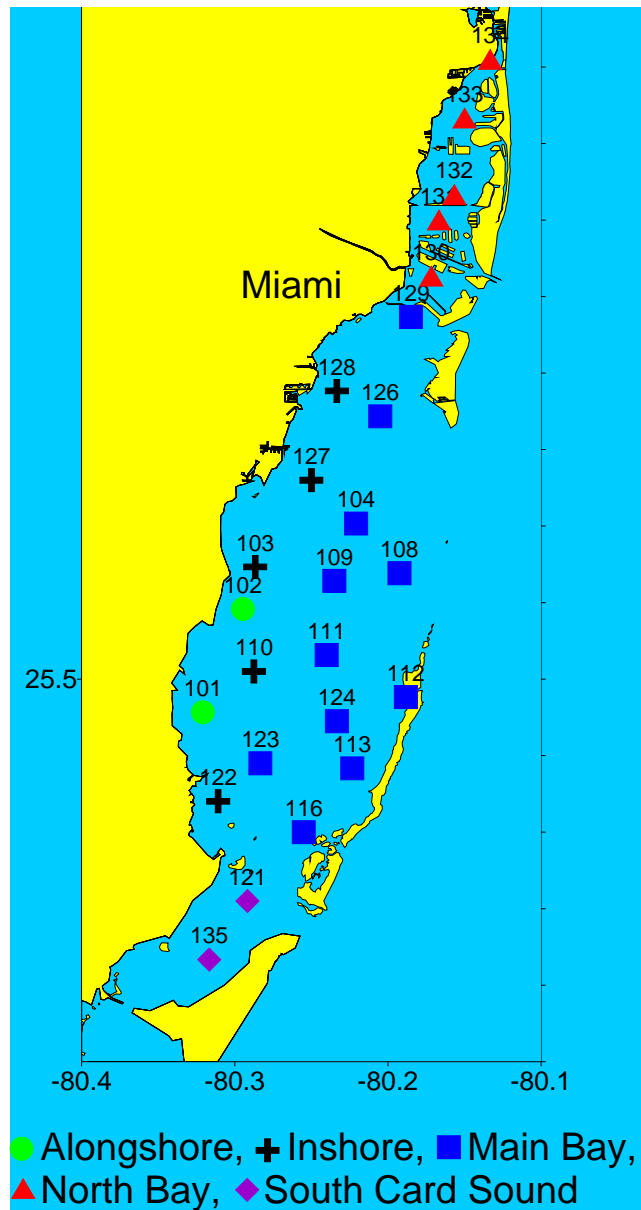


Figure 4.3.1. Zones of similar water quality in Biscayne Bay.

There was a gradient of increasing salinity with distance from the west coast of the Bay (AS < IS < MAIN clusters Fig. 4.3.2-4.3.6). Opposite to the salinity gradient, highest concentrations of CHLA, DIN, and TP were observed near the coast. This types of gradient are indicative of anthropogenic inputs. NBAY showed DIN levels comparable to the high concentrations seen AS but had a higher median salinity. In addition, NBAY had the highest median TP concentration of any zone. SCARD had relatively high DIN concentrations relative to the other nutrients. Some of this may be attributed to the long water residence time of this basin as evidence by near ocean salinities. TOC concentrations were highest in AS > IS > MAIN,

denoting a freshwater source (not shown). CHLA was low in most areas showing the same general gradient as TP. The cyanobacterial bloom in Eastern Florida Bay which had occasionally intruded into South Card Sound during 2006 was generally not an issue in 2007.

# Alongshore Zone

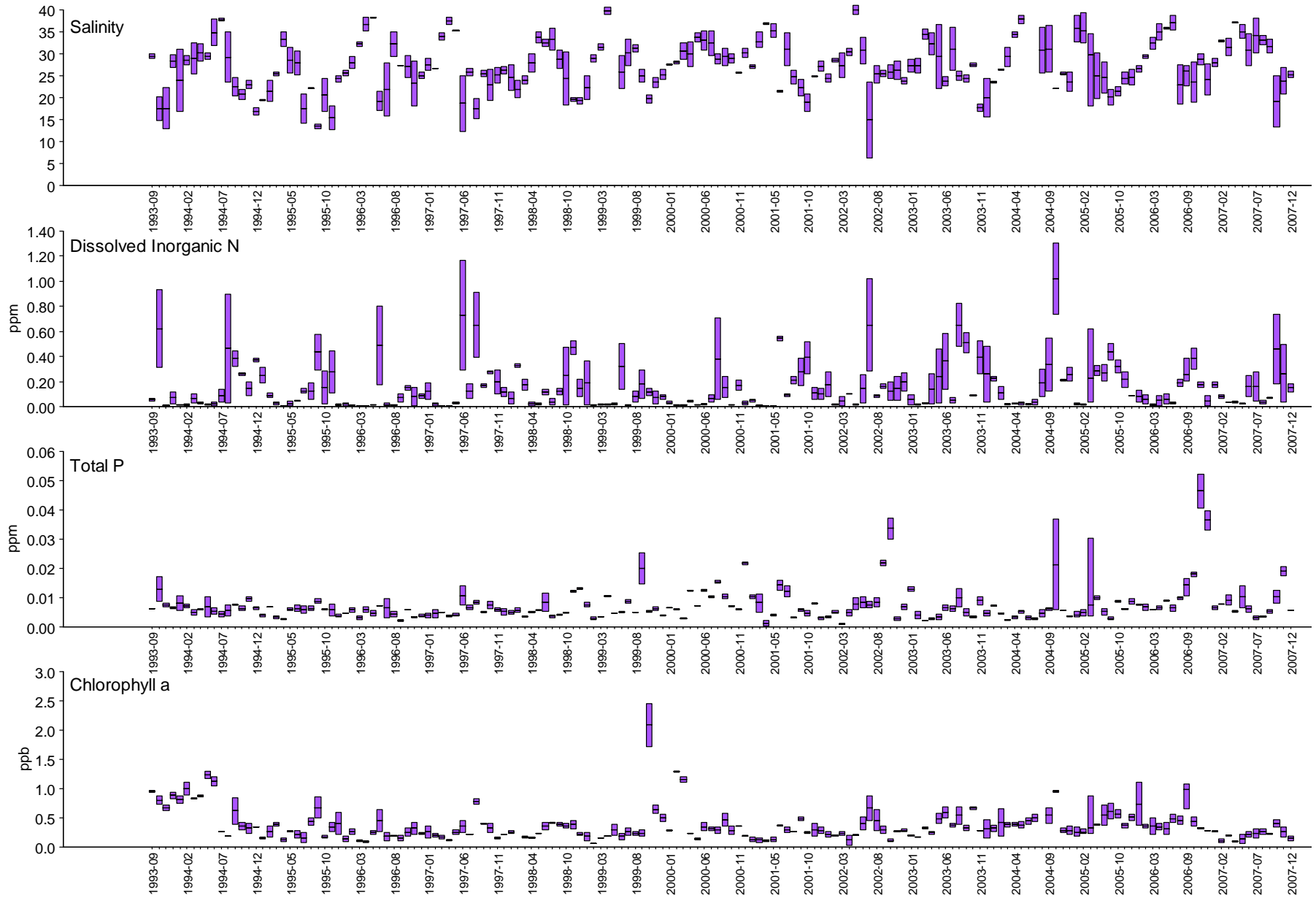


Figure 4.3.2. Box-and-whisker plots of water quality in Biscayne Bay by survey.

# Inshore Zone

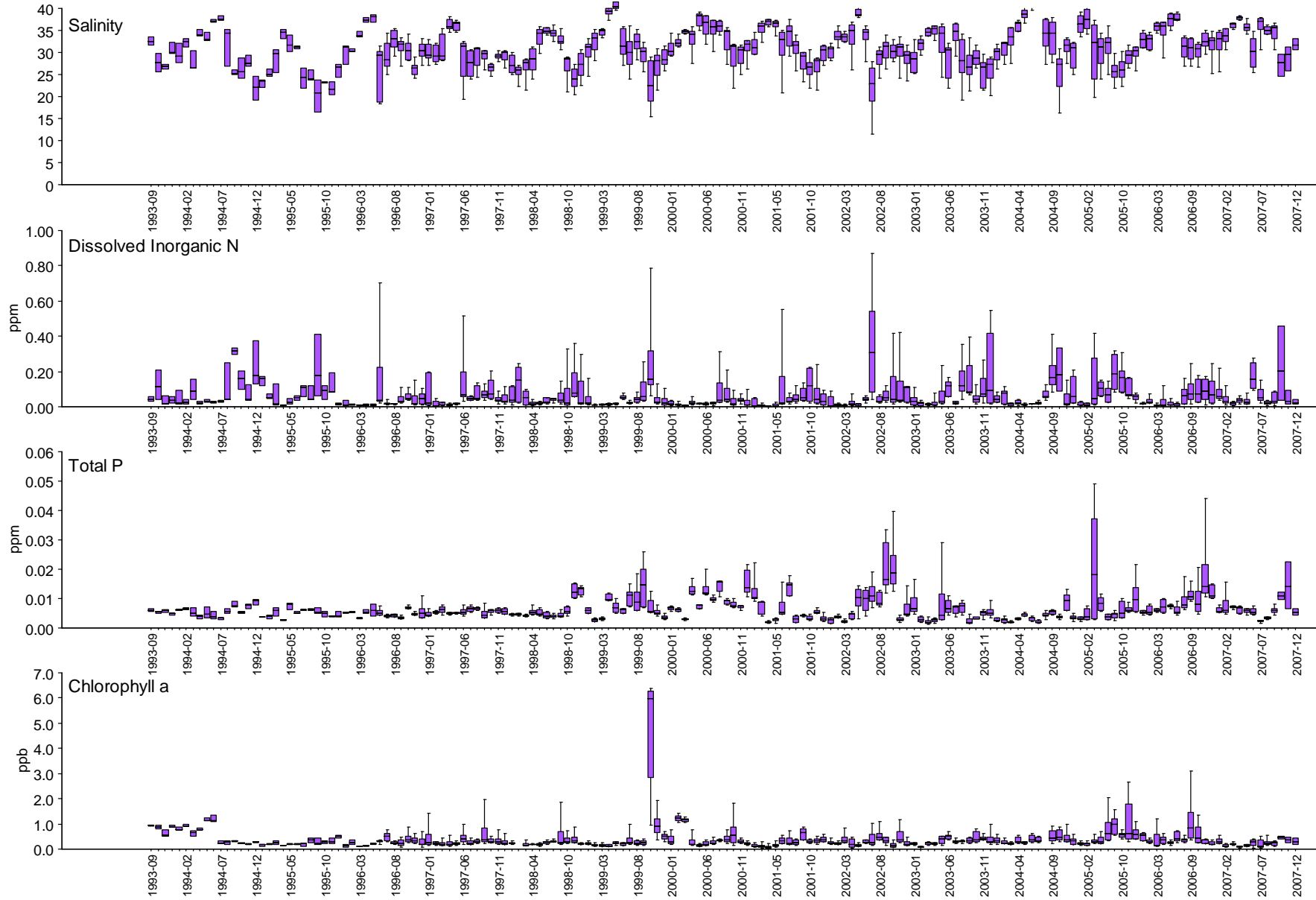


Figure 4.3.3. Box-and-whisker plots of water quality in Biscayne Bay by survey.

# Main Bay Zone

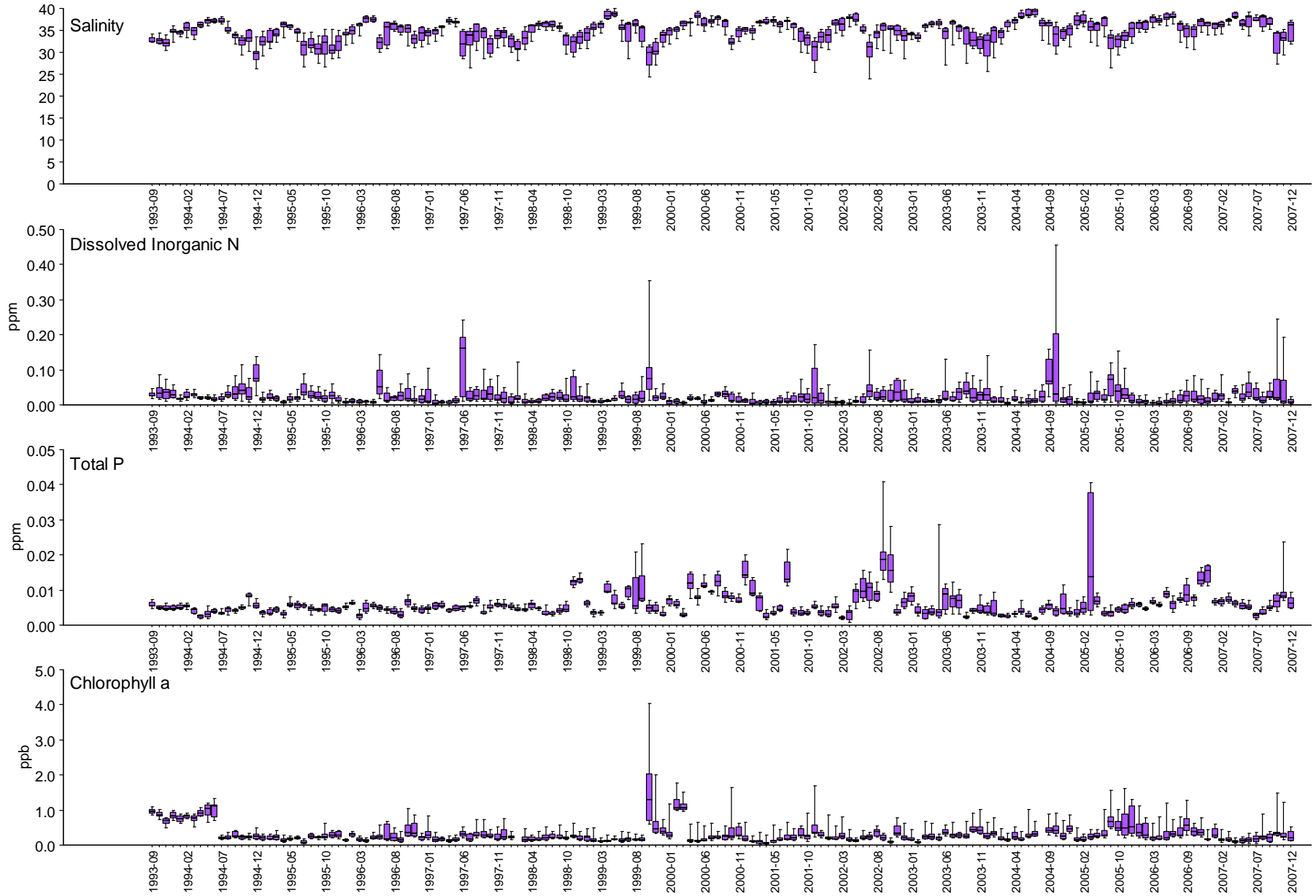


Figure 4.3.4. Box-and-whisker plots of water quality in Biscayne Bay by survey.

# South Card Sound Zone

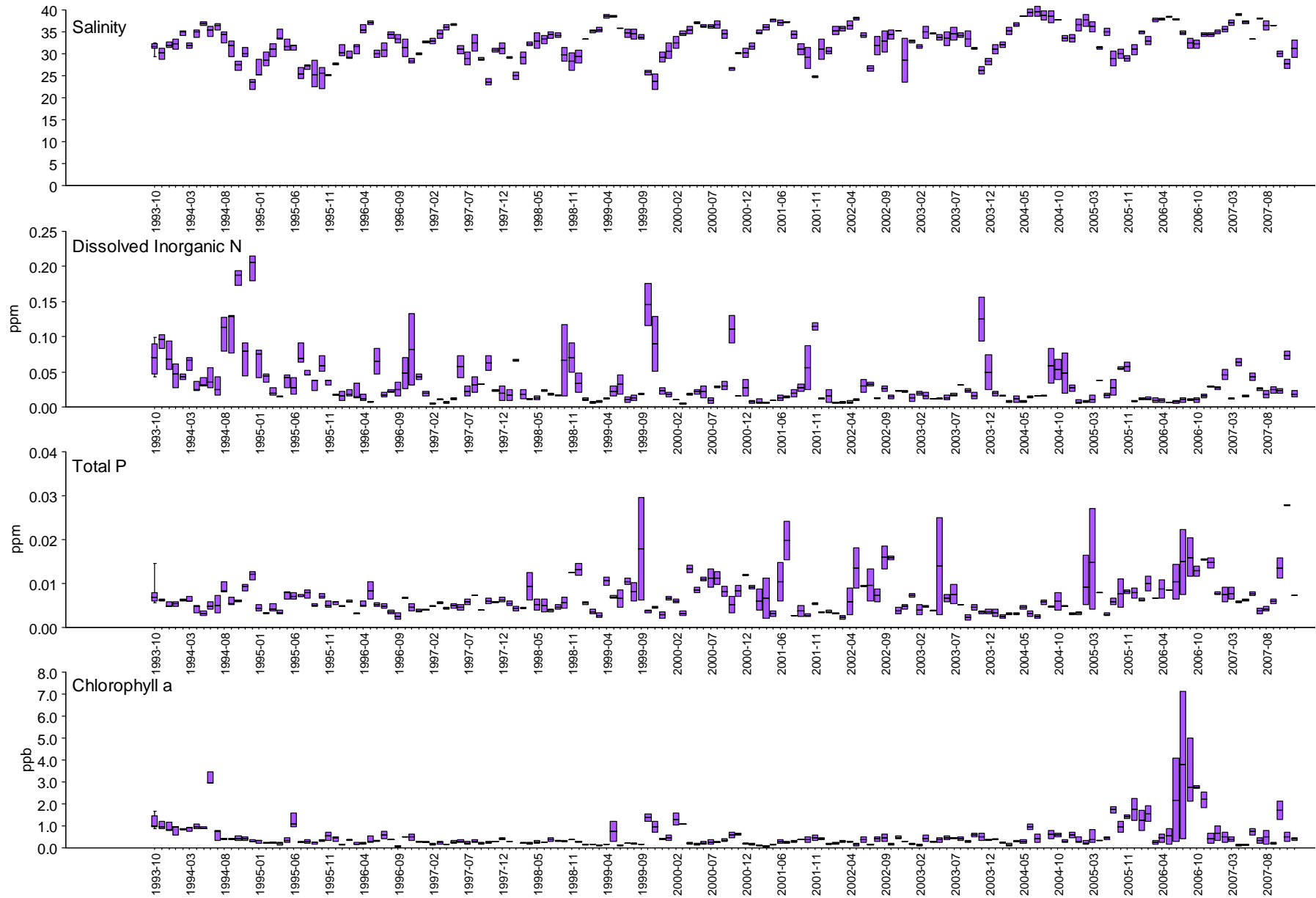


Figure 4.3.5. Box-and-whisker plots of water quality in Biscayne Bay by survey.

# North Bay Zone

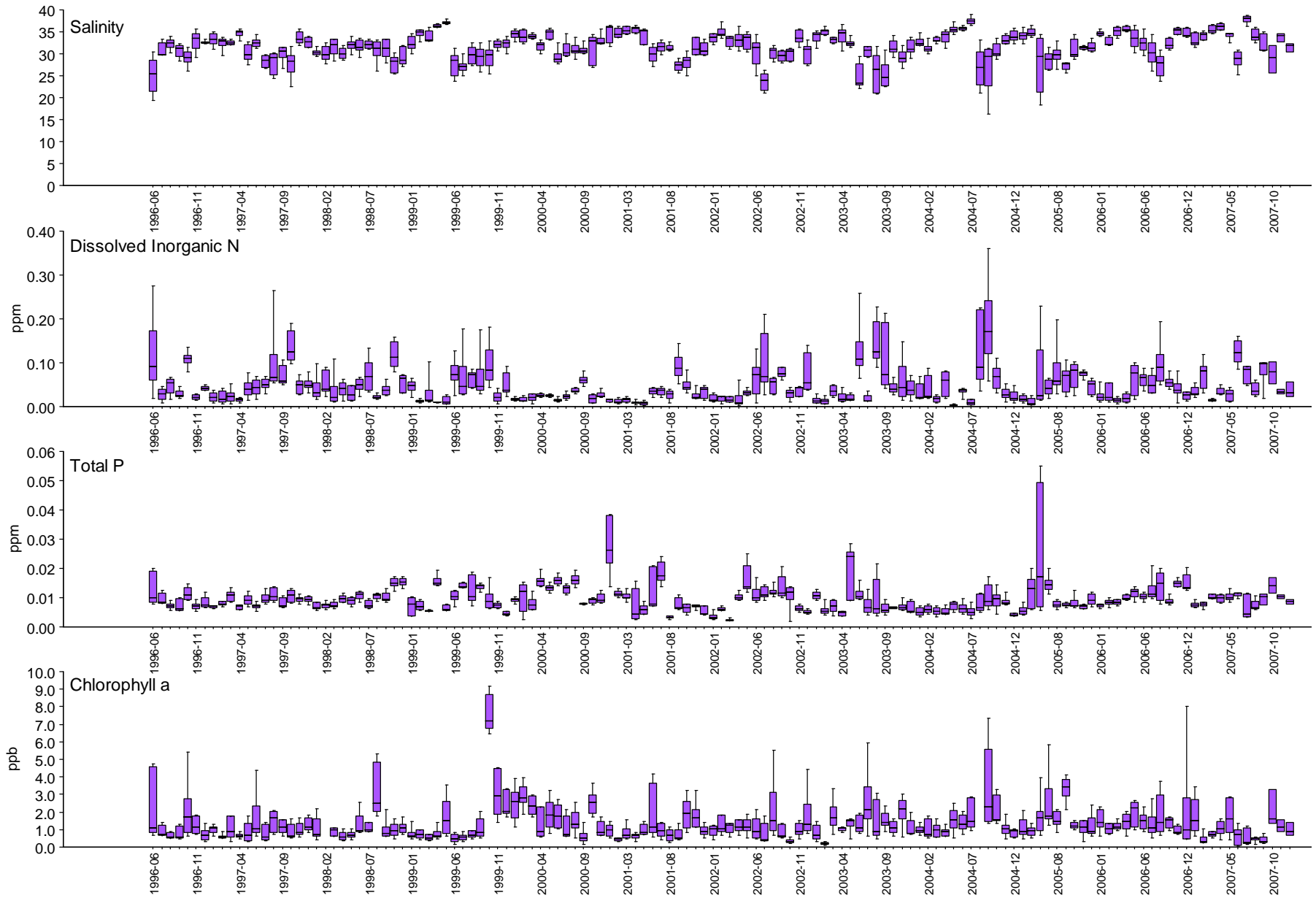


Figure 4.3.6. Box-and-whisker plots of water quality in Biscayne Bay by survey.



### 2007 Alone

Salinity in Biscayne Bay is strongly modulated by its large tidal exchange with the ocean. Nevertheless, canal inputs do have a significant impact on the ecosystem, as evidenced by the reduced nearshore salinity patterns (Caccia and Boyer 2005). The largest intra-annual variations in salinity in this area are typically driven by freshwater releases from the canal system. Nutrient loads and concentrations in Biscayne Bay are strongly driven by canal inputs (Caccia and Boyer 2007). Therefore, precipitation patterns have a great impact on the bay both directly and indirectly. Unexplained low pHs for March and April were observed baywide.

### Alongshore Zone

Because 2007 was a “normal” water year, salinity was generally similar to the long term median (Fig. 4.3.7). Temperature and DO were unremarkable but both turbidity and pH showed large fluctuations, primarily in the dry season. The Oct. drop in salinity coincided with large increases in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, and TP as we have observed in other years. CHLA remained lower than the long term median.

### Inshore Zone

Because the Inshore Zone is a continuation of the offshore gradient, trends were very similar to those observed for the Alongshore Zone (Fig. 4.3.8). Temperature and DO were unremarkable but both turbidity and pH showed large fluctuations, primarily in the dry season. The Oct. drop in salinity coincided with large increases in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, and TP as we have observed in other years. CHLA remained lower than the long term median.

### Main Bay

Fluctuations in water quality in the Main Bay were damped by its large volume and short residence time due to oceanic mixing. Salinity, temperature, DO, nutrients, and CHLA were all very similar to the grand median (Fig. 4.3.9).

### South Card Sound

Water quality in Card Sound was characterized by a large peak in Oct.-Nov. of  $\text{NO}_3^-$ , TON, TP, CHLA and turbidity. (Fig. 4.3.10) We are unsure as to what caused this anomaly as there

was no concurrent change in salinity to suggest terrestrial input. One of the reasons for this may have been the advection of the Florida Bay bloom organisms to this part of Biscayne Bay by wind forcing, but there is no circulation data to support this. Other than that event, water quality was similar to long term median values.

### North Bay

The North bay is the most compartmentalized and urbanized area of Biscayne Bay. As such nutrients tend to be higher in this region (Fig. 4.3.11). Because 2007 was a “normal” water year, salinity was generally similar to the long term median. Temperature and DO were unremarkable but turbidity showed large increase in the fall while pH dropped in early spring. Large variations in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , TON, TP, and CHLA occurred throughout the year, often being temporally unrelated. As such, it is difficult to assign a cause to these fluctuations.

### Data, Graphs, and Figures

All data for the period of record are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm>

Contour maps showing spatial distributions of all measured variables (quarterly) are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm>

### Alongshore (AS)

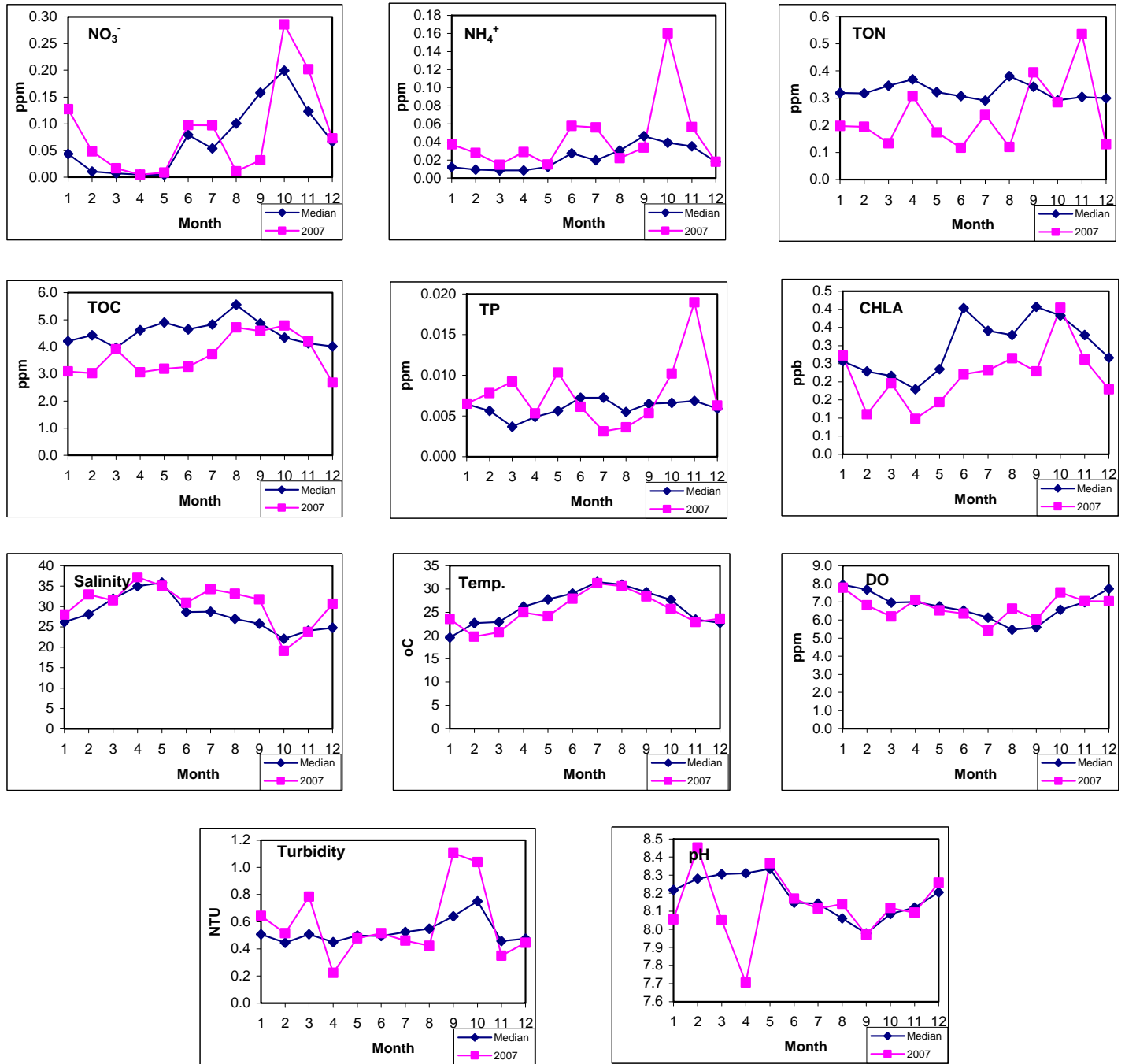


Figure 4.3.7. Comparison of long-term median with 2007 data.

### Inshore (IS)

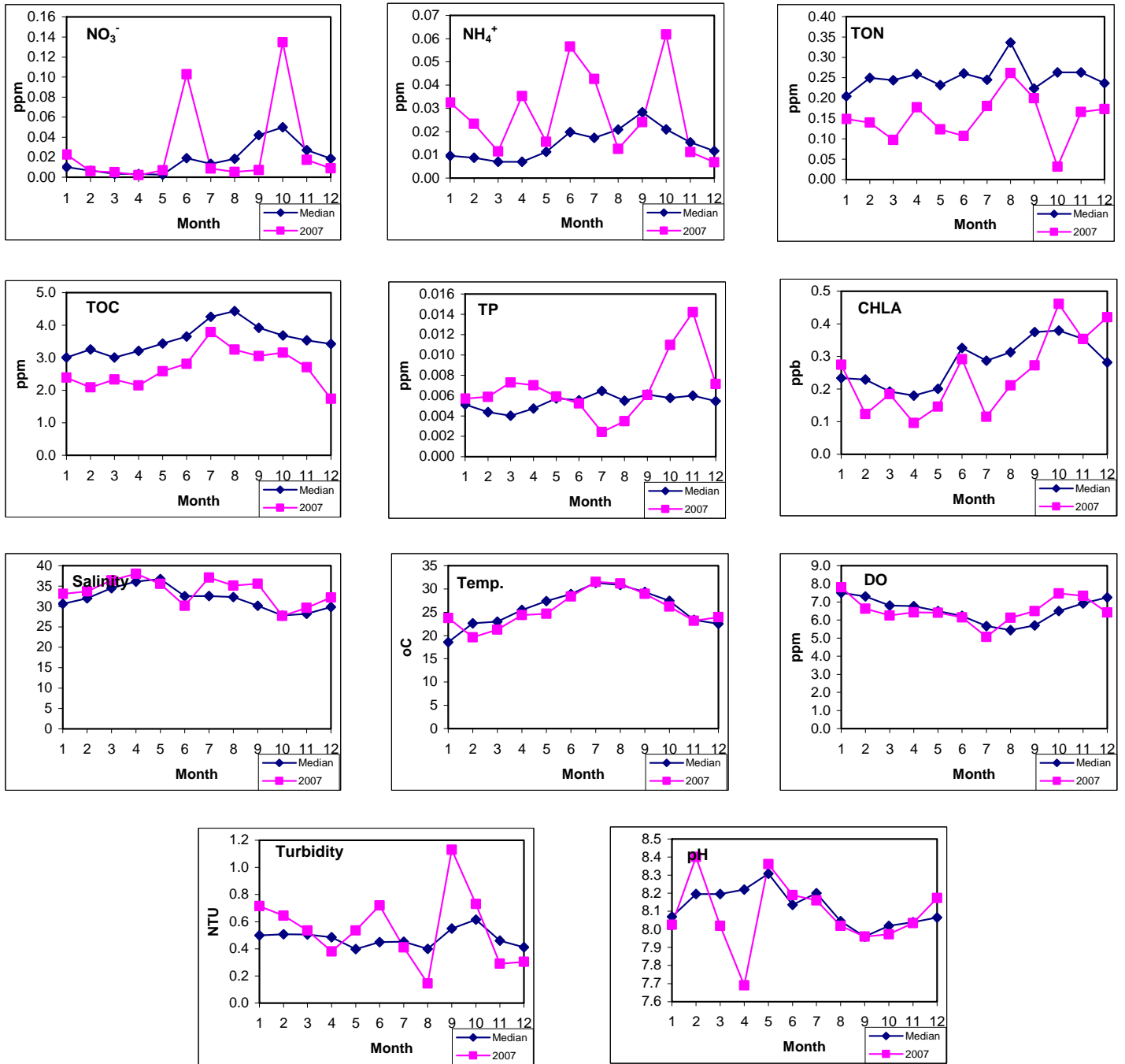


Figure 4.3.8. Comparison of long-term median with 2007 data.

### Main Bay (MAIN)

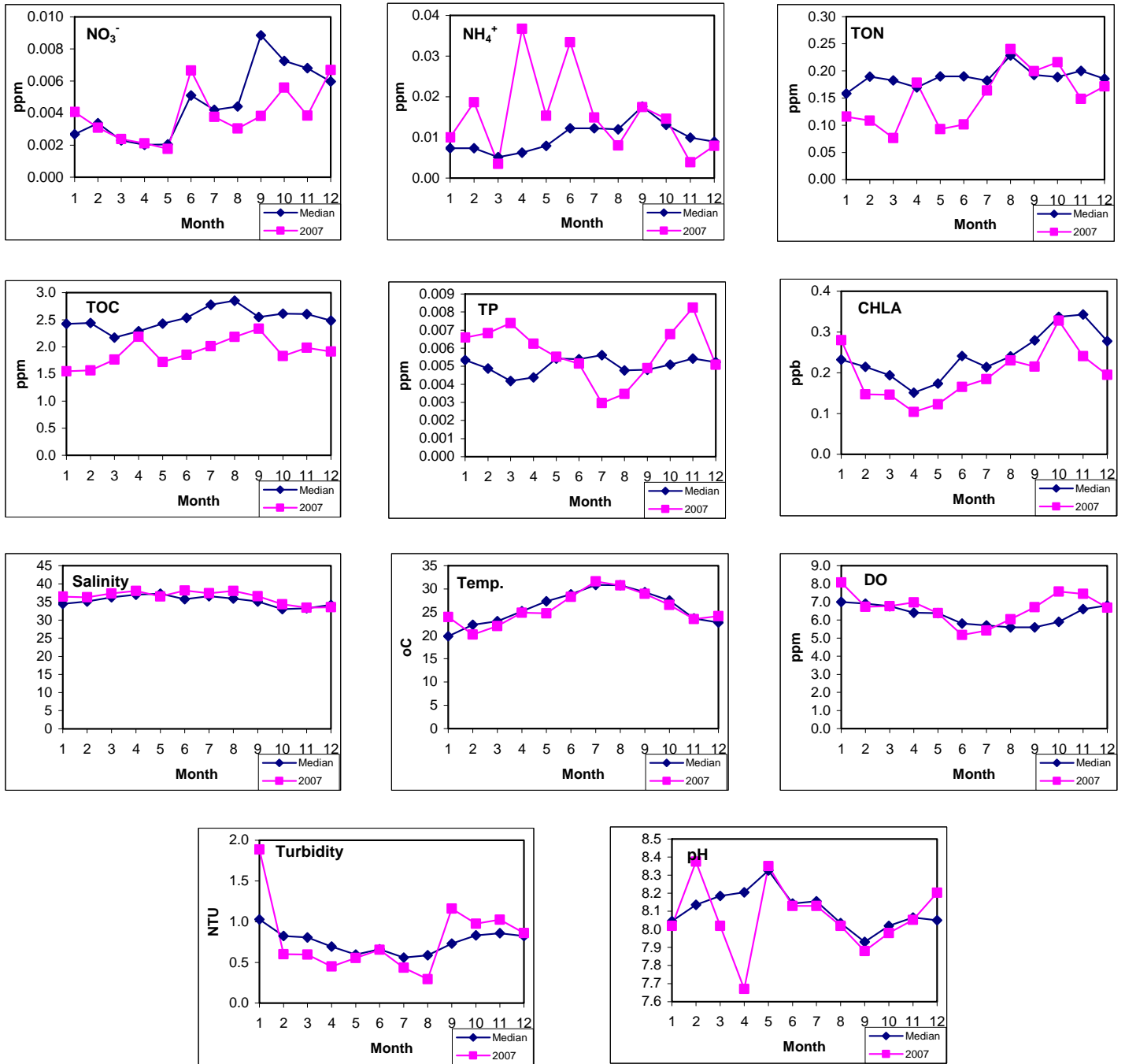


Figure 4.3.9. Comparison of long-term median with 2007 data.

### South Card Sound(SCARD)



Figure 4.3.10. Comparison of long-term median with 2007 data.

### North Bay (NBAY)

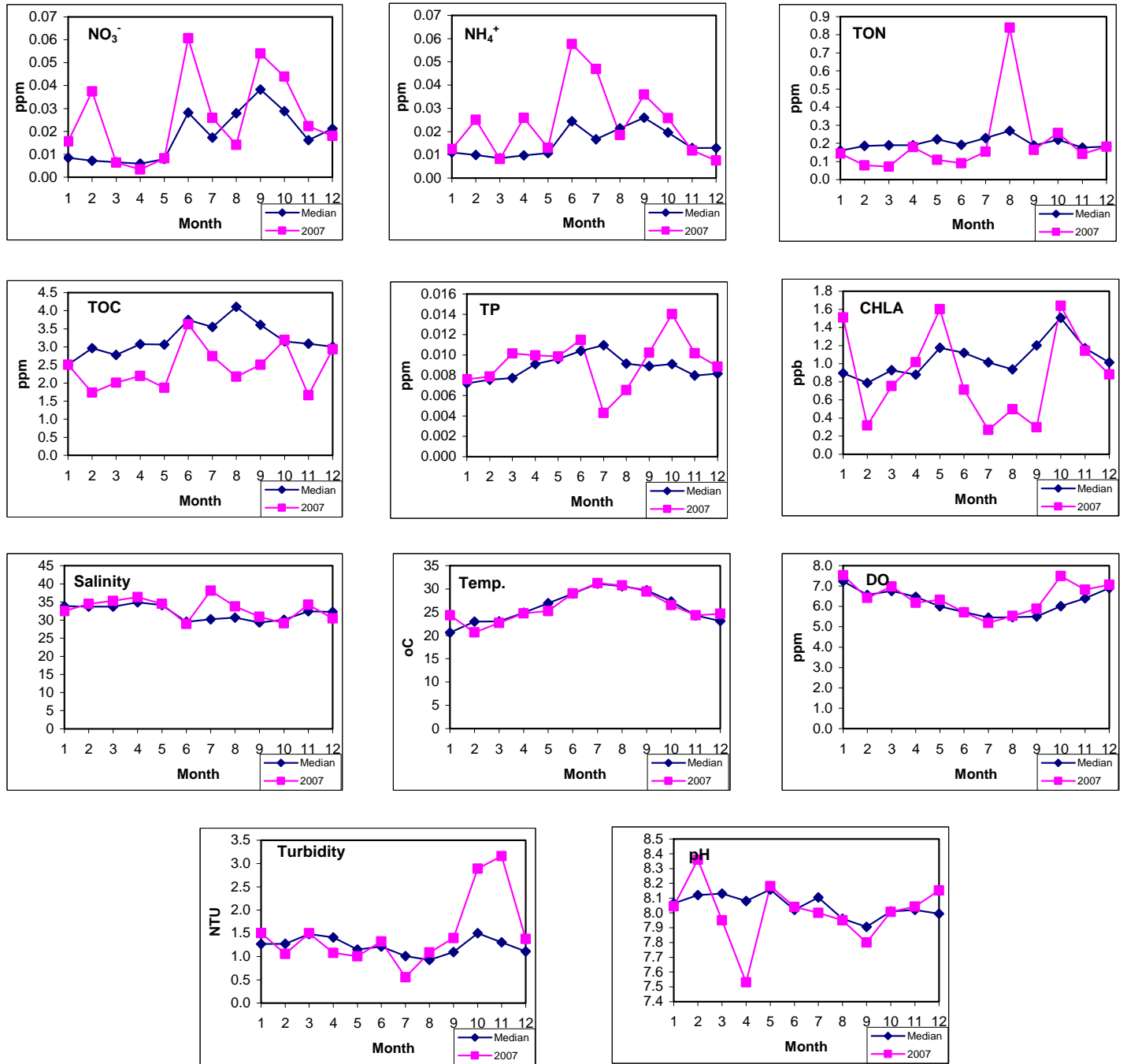


Figure 4.3.11. Comparison of long-term median with 2007 data.

## 4.5. STATE OF WATER QUALITY ON THE SW FLORIDA SHELF

### Overall Period of Record

As of Oct. 1, 2007 the SFWMD contract no longer includes sampling of any of the 49 SW Shelf sites.

A spatial analysis of data from our monitoring program resulted in the delineation of 3 groups of stations, which have robust similarities in water quality (Fig. 4.4.1). The first cluster was composed of only 2 stations, which were closest to the shore off Cape Sable; they were called the SHARK group after the Shark River, the main source of freshwater to the region. The second cluster was made up of the 7 more northerly stations nearest the coast and called SHOAL. The remaining stations were called the SHELF group.

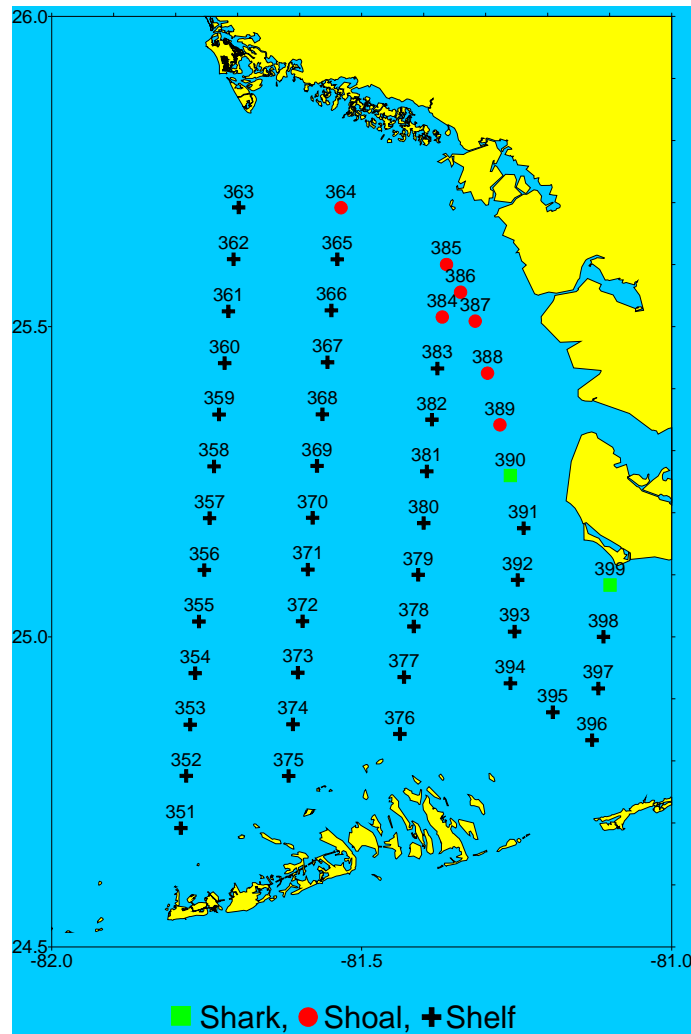


Figure 4.4.1. Zones of similar water quality on the SW Shelf.



Salinity is typically lowest in the SHARK zone as a result of its proximity to the Shark River/Everglades influence (Fig. 4.4.2-4.4.4). There is a decreasing concentration gradient of SHARK > SHOAL > SHELF for CHLA, TP, and TOC. It is clear that the SHARK stations have higher DIN concentrations while the SHOAL and SHELF stations were more similar.

The clustering is driven by hydrology and circulation patterns as related to nutrient gradients. The inshore cluster (SHARK) clearly shows the inputs of freshwater from Shark River being transported south and east around the Cape. Water overlying the Shoal stations probably originates somewhere in or north of the Ten Thousand Islands. Our level of resolution is low due to the limited numbers of sampling events and by the relatively large spatial gap between coastal and Shelf sampling sites. A better understanding of local circulation patterns in addition to increased density and frequency of sampling in the nearshore region may help define the coupling between freshwater inflow and Shelf water quality

# Shark Zone

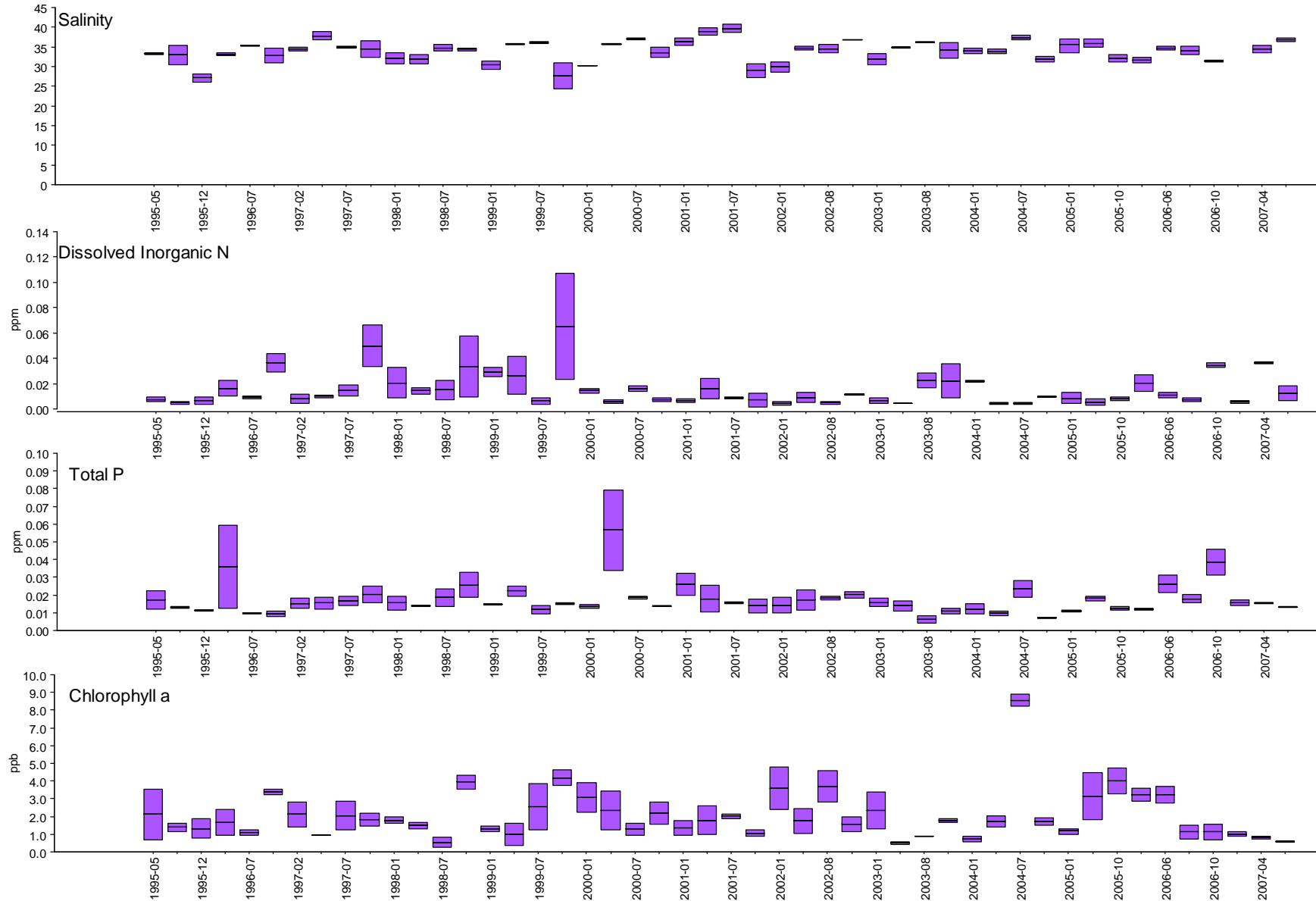


Figure 4.4.2. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

# Shelf Zone

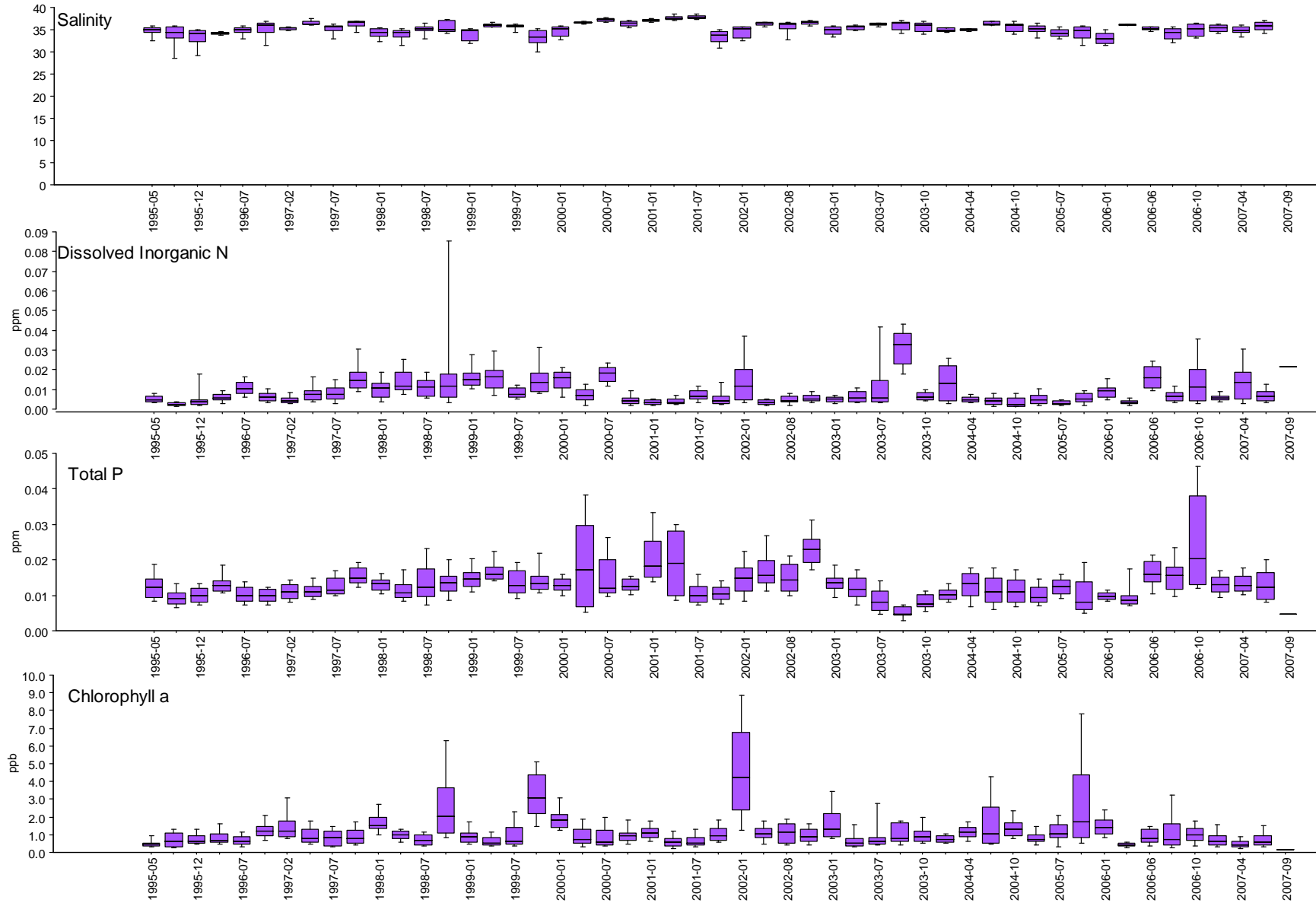


Figure 4.4.3. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

# Shoal Zone

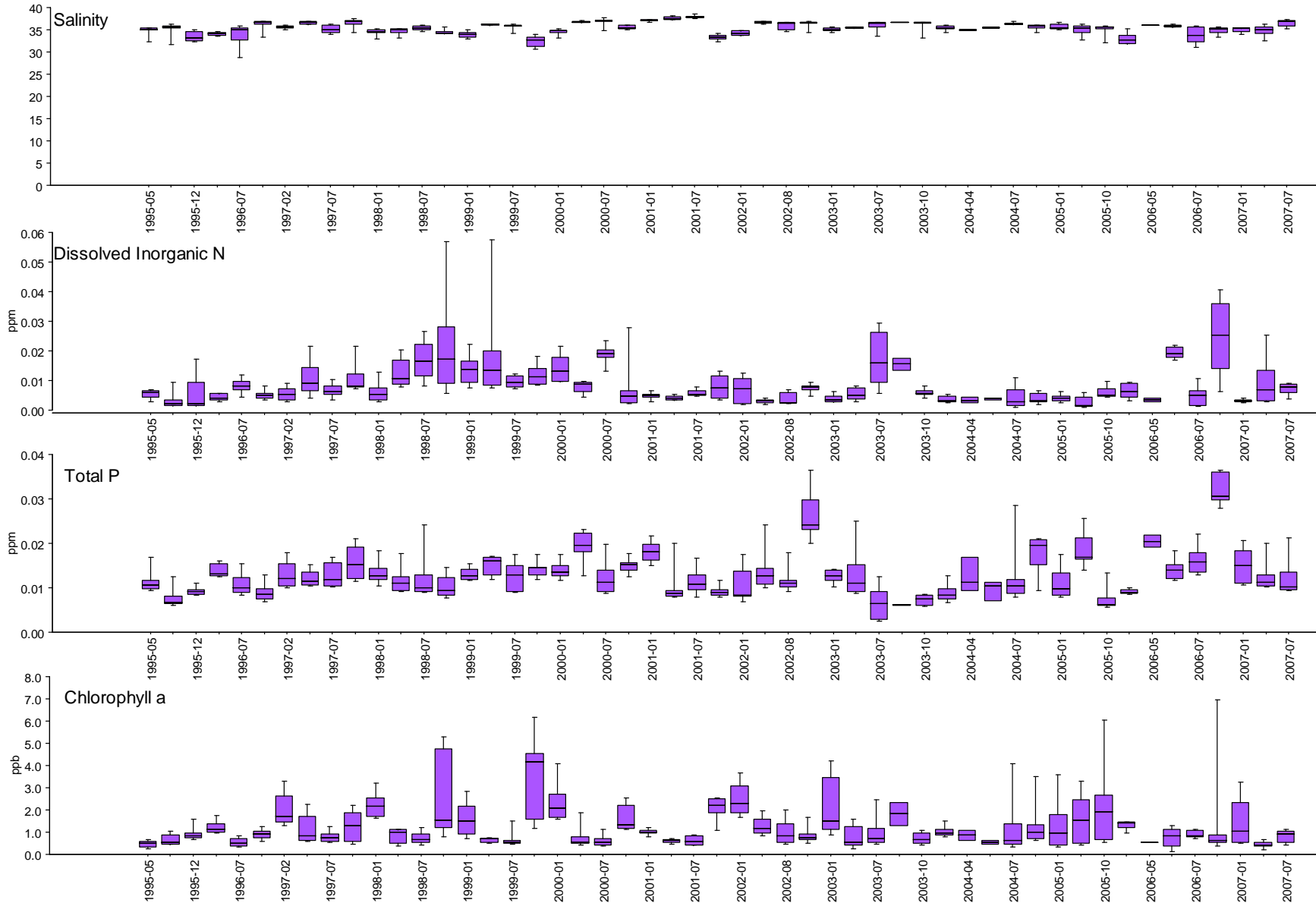


Figure 4.4.4. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

### 2007 Alone

Since this component of the monitoring program began in 1995 and is only sampled quarterly, there is not as much trend data to analyze as for other areas. In addition, the SW Shelf sampling was cancelled as of Oct. 1, 2007 so no new data will be reported after Survey 49.

### Shark Zone

Because 2007 was a “normal” water year, salinity was generally similar to the long term median (Fig. 4.4.5). Temperature and turbidity were unremarkable but DO, pH, TON, and CHLA were low.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and TP were similar to other years. CHLA remained lower than the long term median.

### Shelf Zone

Because the Shelf Zone is a continuation of the offshore gradient, trends were very similar to those observed for the Shark Zone (Fig. 4.4.6). Fluctuations in water quality on the Shelf were damped by its large volume mixing with the Gulf of Mexico. Only DO, turbidity, pH, and CHLA deviated from the median being lower than usual.

### Shoal Zone

The Shoal area nearest the Ten Thousand Islands also showed similarities to the other SW Shelf sites with DO, turbidity, and pH being lower than usual. However, CHLA levels were more representative of long term median.

### Data, Graphs, and Figures

All data for the period of record are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm>

Contour maps showing spatial distributions of all measured variables (quarterly) are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm>

### Shark (SHARK)

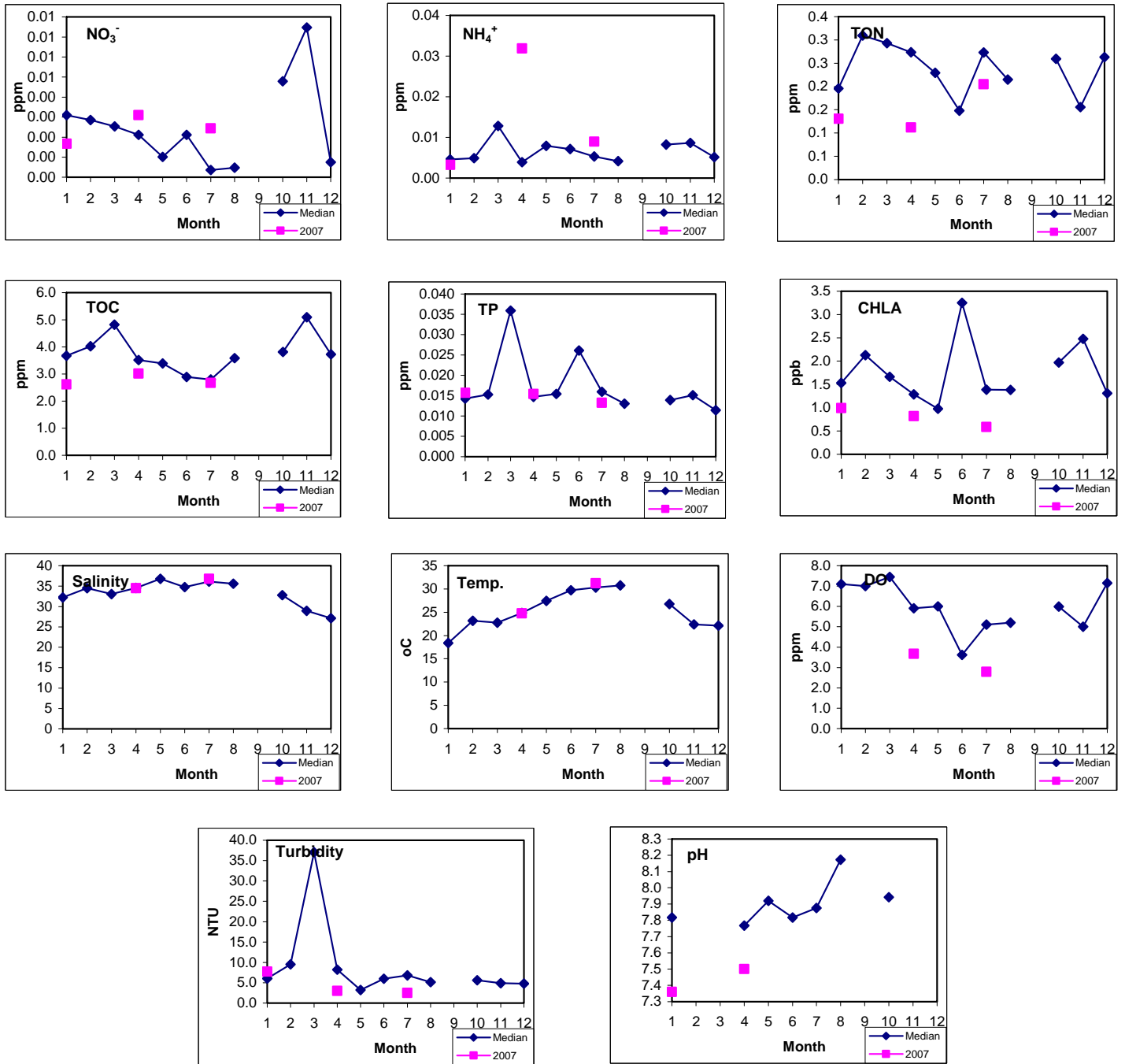


Figure 4.4.5. Comparison of long-term median with 2006 data.

### Shelf (SHELF)

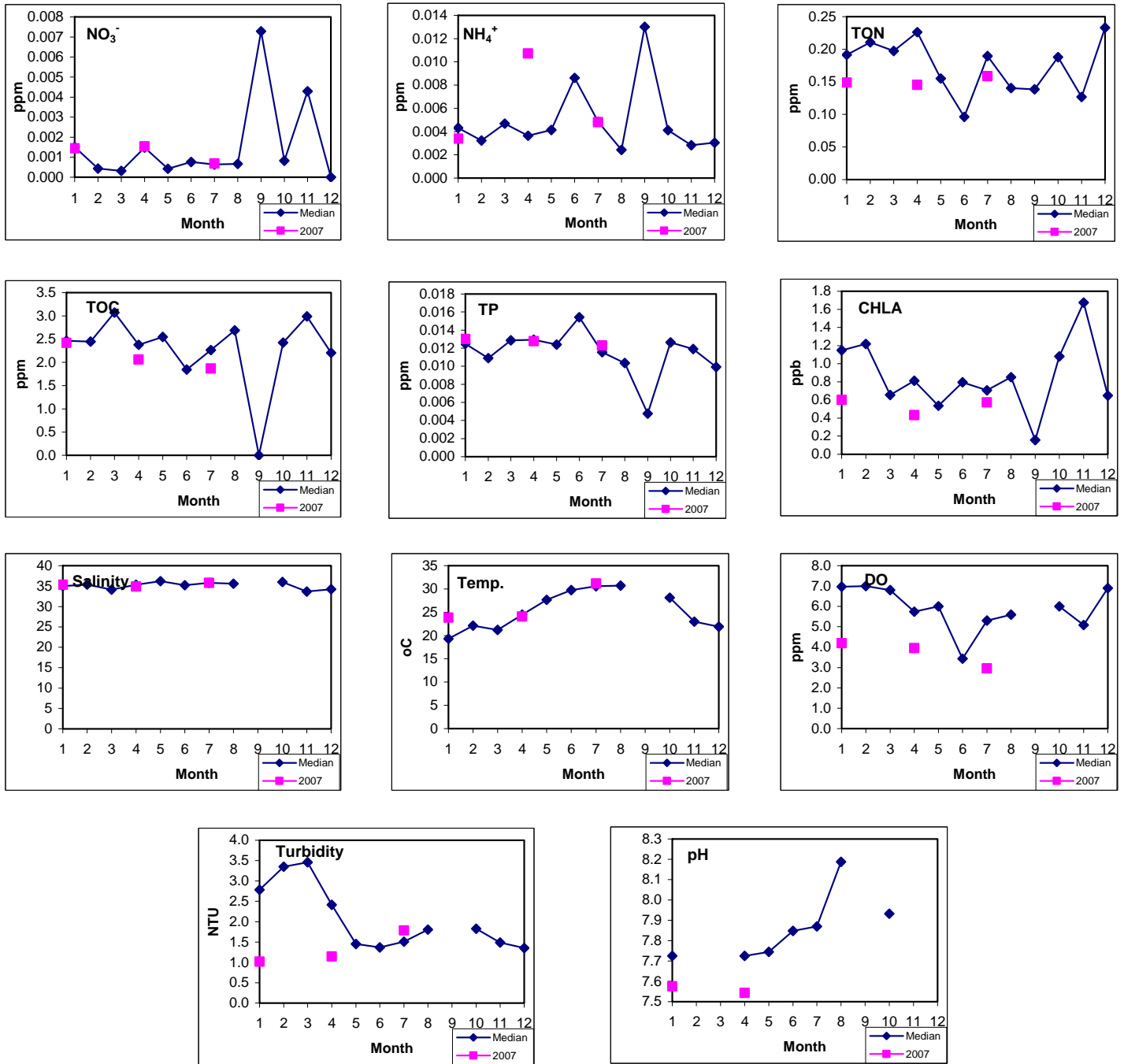


Figure 4.4.6. Comparison of long-term median with 2007 data.

### Shoal (SHOAL)

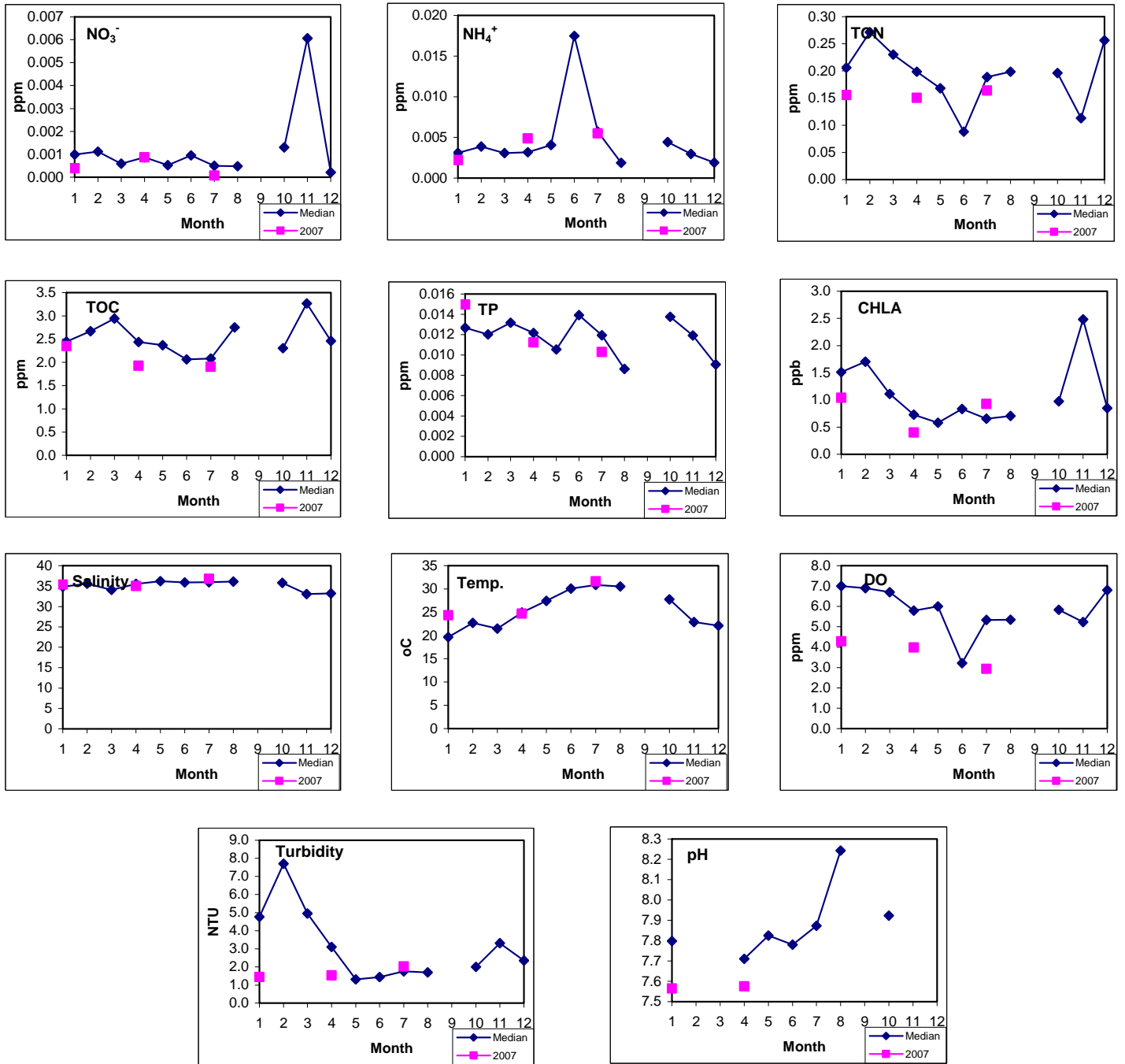


Figure 4.4.7. Comparison of long-term median with 2007 data.



## **4.6. STATE OF WATER QUALITY IN THE CAPE ROMANO - PINE ISLAND SOUND AREA**

### Overall Period of Record

Effective Oct. 1, 2007 as per SFWMD contract, no samples were analyzed for silicate and field duplicates were reduced to 10% of all sites collected.

Because of the heterogeneous nature of the region, we used generally accepted geomorphological characteristics to group the stations (Fig. 4.5.1). These groupings are the Cocohatchee River at Wiggins Pass (COCO), Estero Bay (EST), Cape Romano-Marco Island (MARC), Naples Bay (NPL), Pine Island Sound (PIS), Rookery Bay (RB), and San Carlos Bay (SCB). SCB is located at the mouth of the Caloosahatchee River, a major managed outlet for freshwater from Lake Okeechobee.

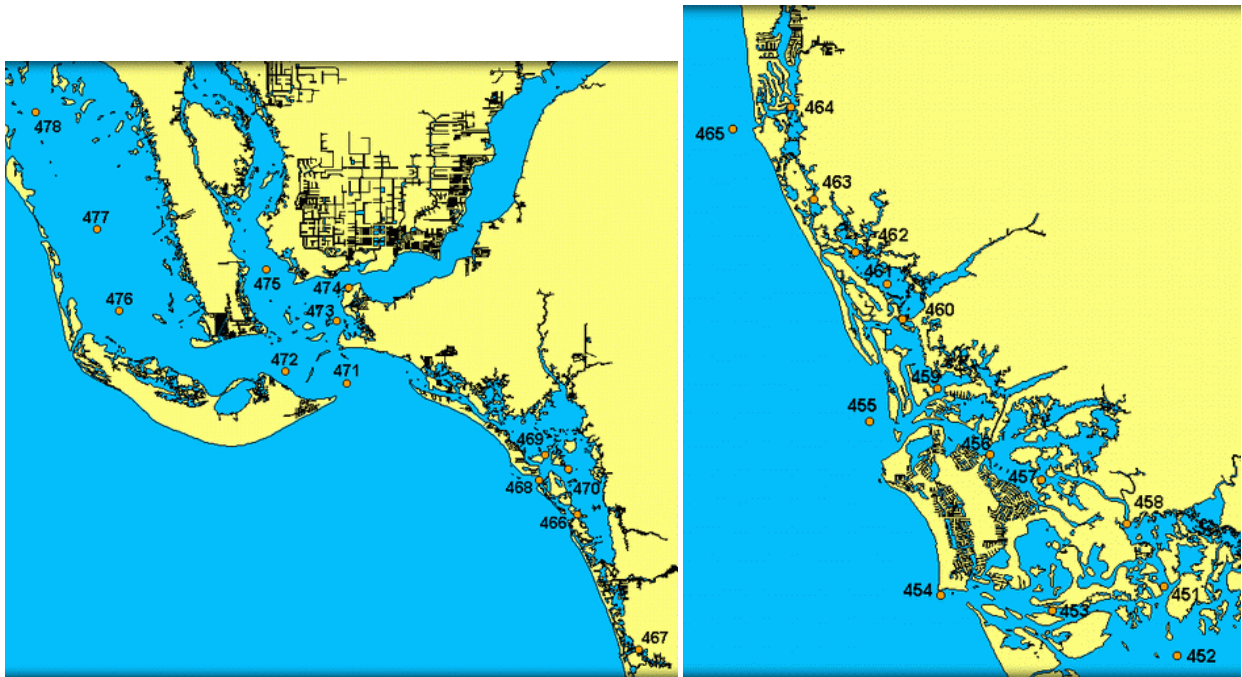


Figure 4.5.1. Map of station locations in Cape Romano-Pine Island Sound area.

All zones experienced low salinity during the beginning of the wet season with the opening of the Caloosahatchee River at Franklin Lock (S-79 water control structure) (Fig. 4.5.2-4.5.8). CHLA is elevated in this area but not excessive when compared to the overall Ten Thousand Islands. SCB is most directly affected by the releases also had highest concentrations of TP, DIN, and TOC. Estero Bay also exhibited lower salinities than the other areas as a result of

freshwater input from the Estero and Imperial Rivers as well as Hendry Creek. EST is relatively enclosed, has a long water residence time, and is bordered on the north by the city of Ft. Meyers. These facts may account for the elevated CHLA, DIN and TP.

Overall, this area has significantly higher concentrations of CHLA, TP, and DIN than the bulk of the Ten Thousand Islands stations. Much of this is due to geological changes from carbonate to silicate bedrock, which facilitates transport of phosphorus, and to major land use changes from the Big Cypress National Preserve to suburban and agricultural. Except San Carlos Bay, all zone share common regime shift for TP in Oct-Nov 2002, when concentrations decreased drastically to gradually return to higher concentrations by 2006. These seem to be related to water management practices.

# Marco Zone

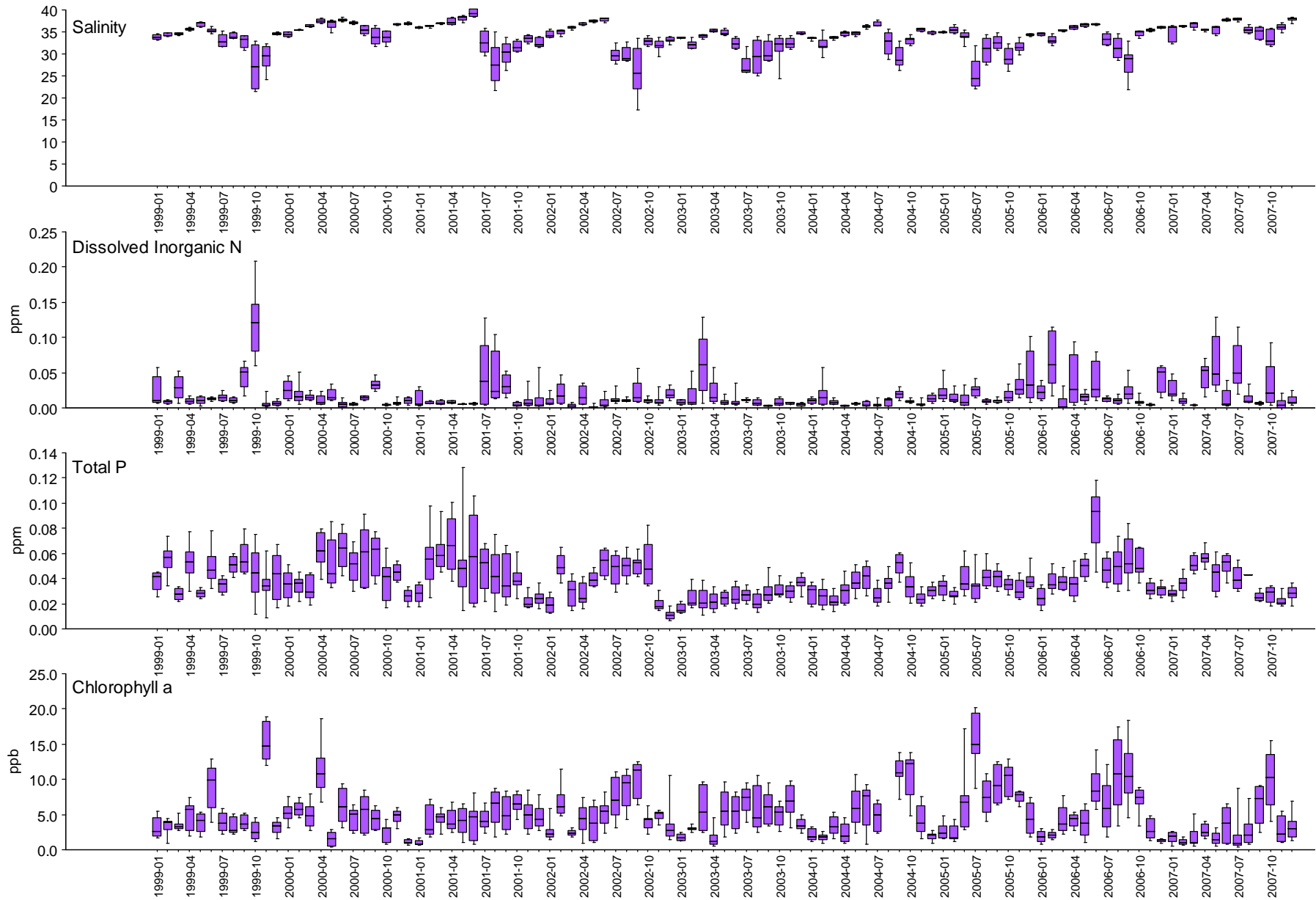


Figure 4.5.2. Box-and-whisker plots of water quality in RB-PIS by survey.

# Rookery Bay Zone

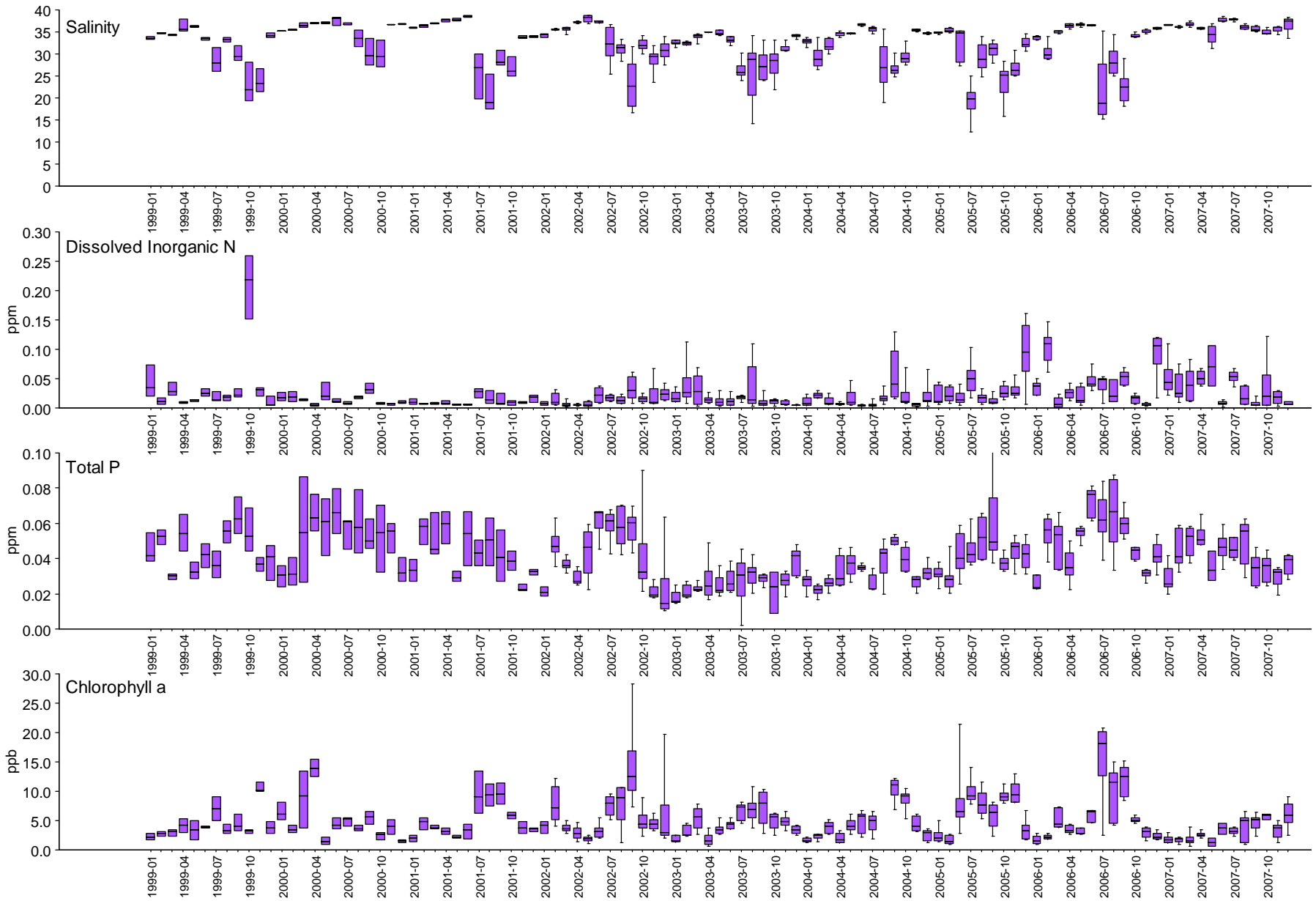


Figure 4.5.3. Box-and-whisker plots of water quality in RB-PIS by survey.

# Naples Zone

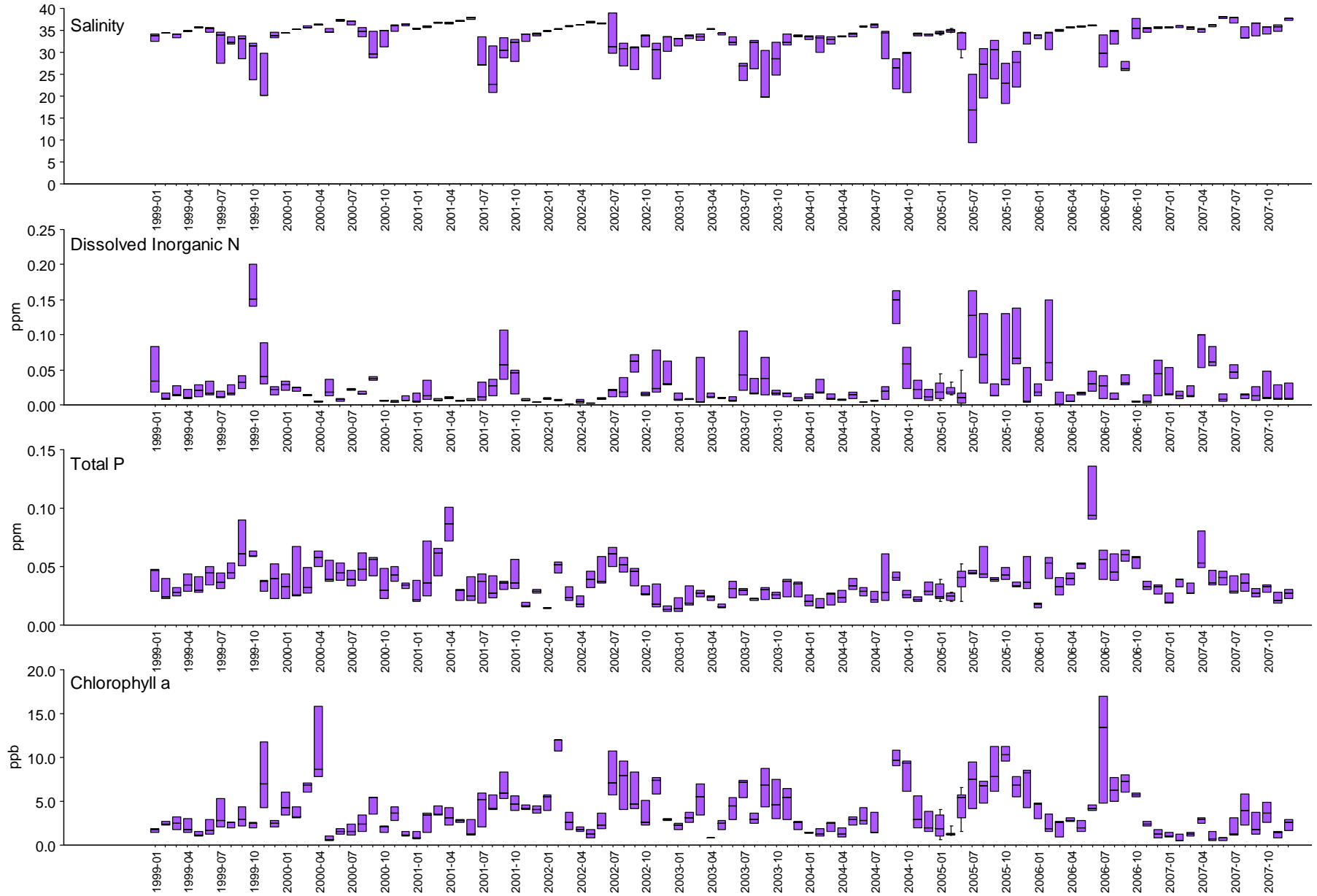


Figure 4.5.4. Box-and-whisker plots of water quality in RB-PIS by survey.

# San Carlos Bay Zone

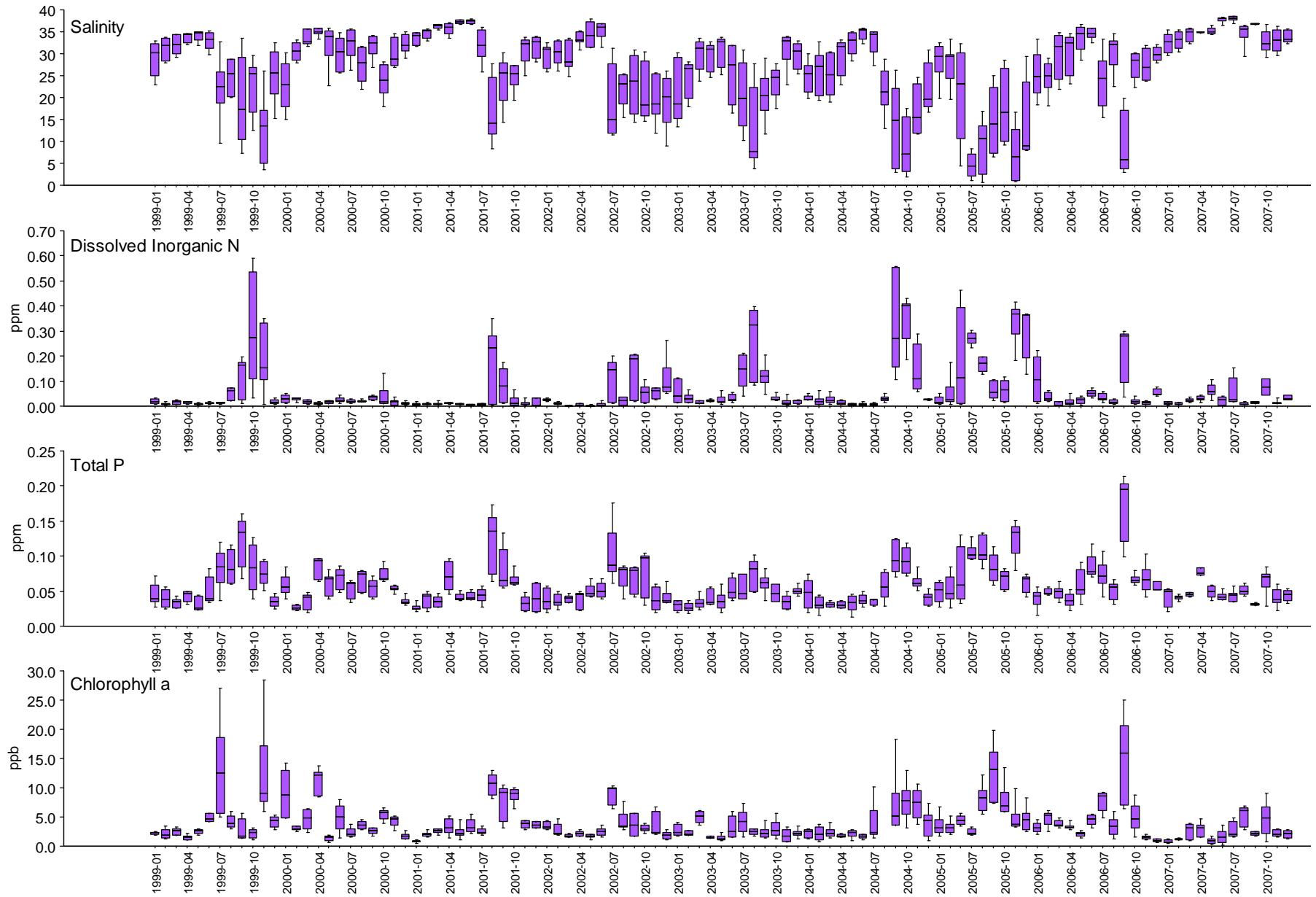


Figure 4.5.5. Box-and-whisker plots of water quality in RB-PIS by survey.

# Estero Bay Zone

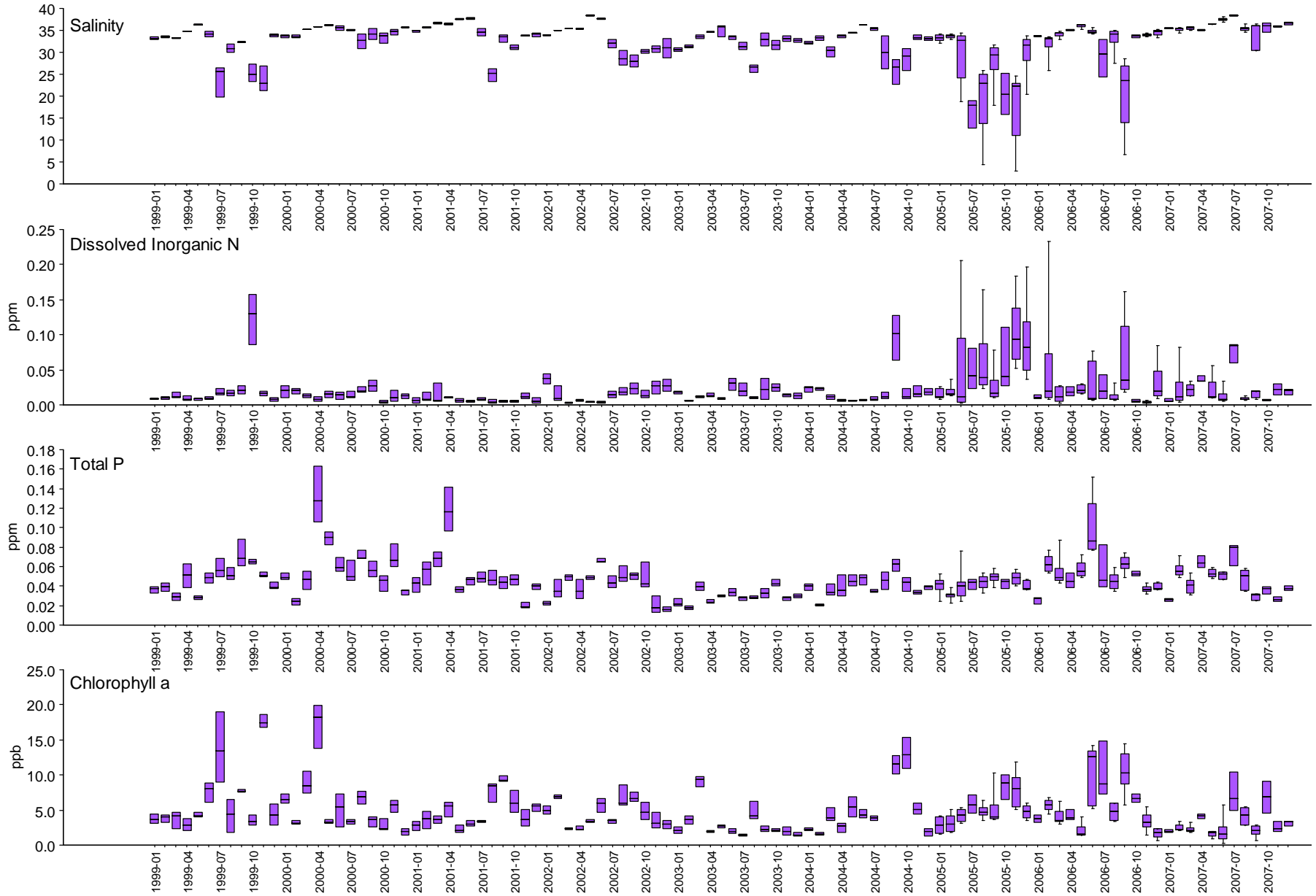


Figure 4.5.6. Box-and-whisker plots of water quality in RB-PIS by survey.

# Pine Island Sound Zone

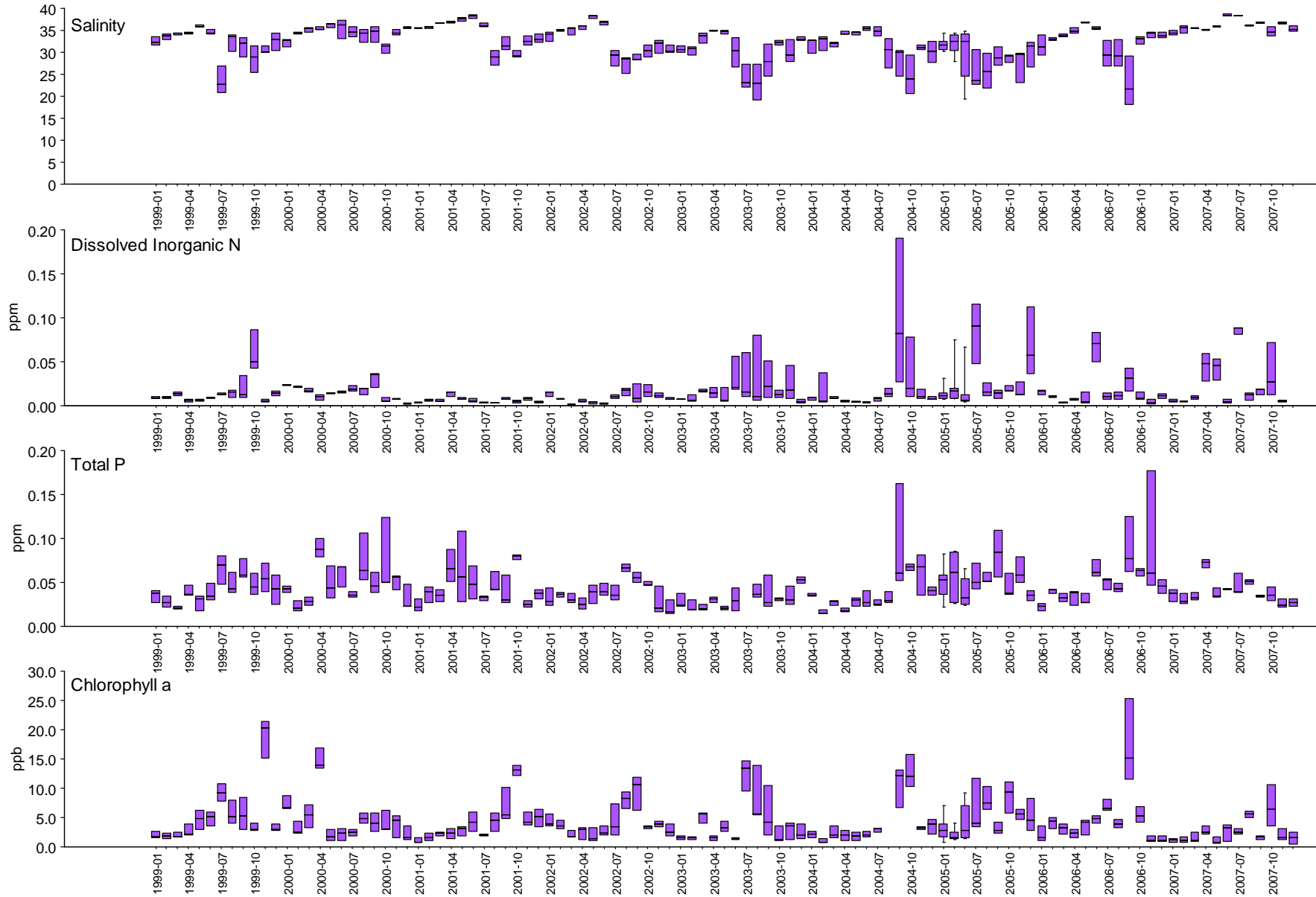


Figure 4.5.7. Box-and-whisker plots of water quality in RB-PIS by survey.



# Cocohatchee River at Wiggins Pass

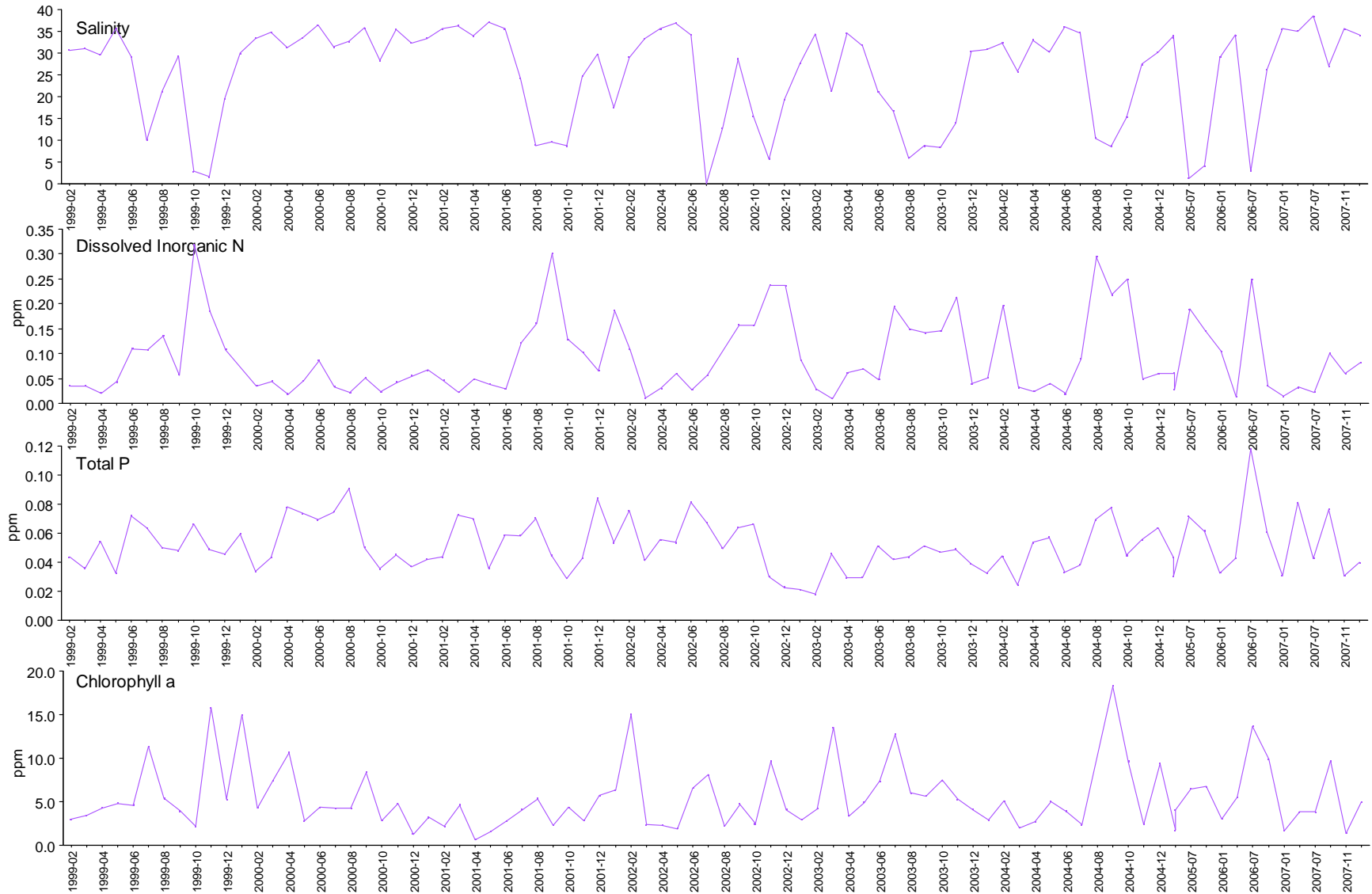


Figure 4.5.8. Single point times series of water quality in the Cocohatchee River by survey.

### 2007 Alone

The largest intra-annual variations in salinity and water quality in this area are driven by freshwater releases from the Caloosahatchee River at Franklin Lock (S-79 water control structure) and associated pathways (Fig. 4.5.8-4.5.14). This is due to the need to lower the water table inland because of potential flooding from hurricanes and to lower the Lake Okeechobee because of structural problems with the Hover Dike. Releases were minimal this year due to the drought in central Florida which caused record low levels in Lake Okeechobee. This added to the rainfall deficit resulted in water quality widely fluctuating and deviating from the grand median during year 2007.

### Marco Island

Salinities remained high all year reflecting the drought conditions in the watershed. Variations in temperature, DO pH, and TON were unremarkable as compared to long term median (Fig. 4.5.8). TOC was lower than average due to low freshwater inputs.  $\text{NO}_3^-$  and  $\text{NH}_4^+$  were highly variable and did not seem to be driven by freshwater inputs. TP was higher than average in the dry season and lower in the wet season. CHLA was lower than usual but peaked in the fall.

### Rookery Bay

Salinities remained high all year reflecting the drought conditions in the watershed. Temperature, DO, pH, TON, and TP were unremarkable as compared to long term median (Fig. 4.5.9). None of the measured variables help explain why pH dropped to 7.4 in May. TOC was lower than average due to low freshwater inputs but mirrored the annual pattern.  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ , and turbidity were highly variable and did not seem to be driven by freshwater inputs. CHLA was generally lower than usual.

### Naples Bay

Salinity was marginally higher in the fall but was not different for the bulk of the year. Temperature, TON, and TP were unremarkable as compared to long term median (Fig. 4.5.10). pH was higher than normal and also highly variable. DO was slightly higher than usual while

$\text{NO}_3^-$  and CHLA were down. Turbidity, pH, and  $\text{NH}_4^+$  were highly variable but did not seem to be driven by freshwater inputs. CHLA was generally lower than usual.

### San Carlos Bay

This is the region most affected by Lake Okeechobee water releases through the Caloosahatchee River (S-79). The drought of 2007 was reflected in the high salinities throughout the region (Fig. 4.5.11). We did not observe the usual 10-15 psu drop during the wet season nor the concomitant increase in  $\text{NO}_3^-$ . Temperature, DO, and TON were unremarkable as compared to long term median. Turbidity,  $\text{NO}_3^-$ , TP, TOC, and CHLA were generally lower than usual, especially during the wet season.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs.

### Estero Bay

Salinity was relatively invariant during 2007 and did not show the usual decline during the wet season (Fig. 4.5.12). Temperature, TON, TP, and TOC were unremarkable as compared to long term median. DO was slightly elevated while pH was higher than normal in the spring-summer. Turbidity,  $\text{NO}_3^-$ , TOC, and CHLA were generally lower than usual, especially during the wet season. Peaks in CHLA sometimes corresponded with peaks in TP and  $\text{NH}_4^+$ . TP was higher in the first 8 months and then declined to below the average.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs.

### Pine Island Sound

Salinity was relatively invariant during 2007 and did not show the usual decline during the wet season (Fig. 4.5.13). Temperature,  $\text{NO}_3^-$ , TON, and TP were unremarkable as compared to long term median. DO was elevated for the first 2 months then declined to usual levels. pH was generally lower than normal but peaked in May for no obvious reason. Turbidity was higher during the summer but quickly dropped to very low levels in Sept.-Dec.  $\text{NH}_4^+$  was highly variable and did not seem to be driven by freshwater inputs. TOC and CHLA were generally lower than usual, especially during the wet season. Peaks in CHLA sometimes corresponded with peaks in TP and  $\text{NH}_4^+$ .

### Cocohatchee River

Like the Caloosahatchee, the Cocohatchee River was under low flow conditions due to the drought. Salinity dipped only slightly during the wet season in contrast to the large declines usually observed (Fig. 4.5.14). We did not observe the usual 20-25 psu drop during the wet season nor the concomitant increase in  $\text{NO}_3^-$ ,  $\text{NH}_4^+$  and TOC. Most all water quality variables were lower than the long term median with the exception of pH and DO which were higher.

### Data, Graphs, and Figures

All data for the period of record are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm>

Contour maps showing spatial distributions of all measured variables (quarterly) are available at:

<http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm>

### Marco Island (MARC)

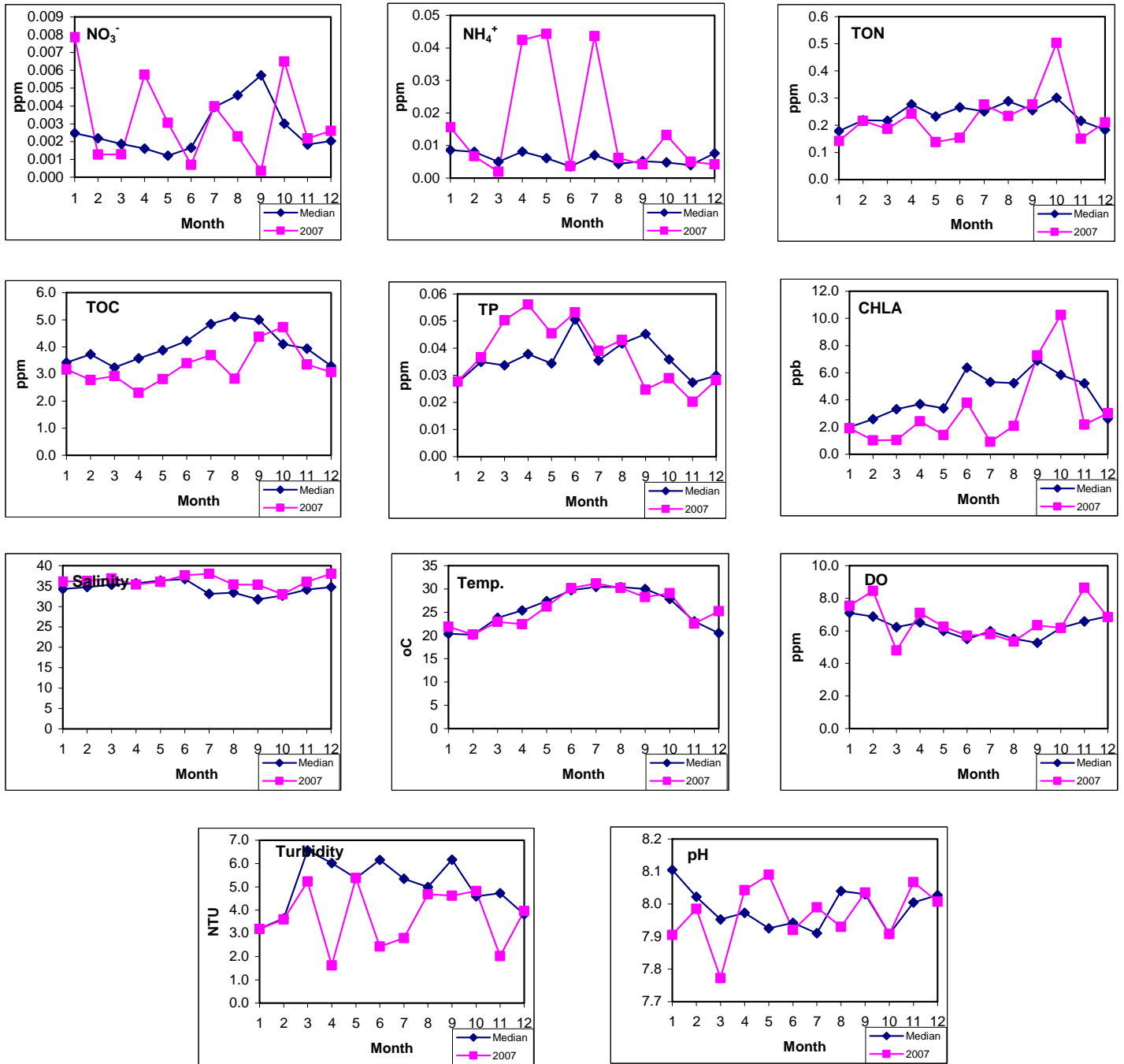


Figure 4.5.8. Comparison of long-term median with 2007 data.

### Rookery Bay (RB)

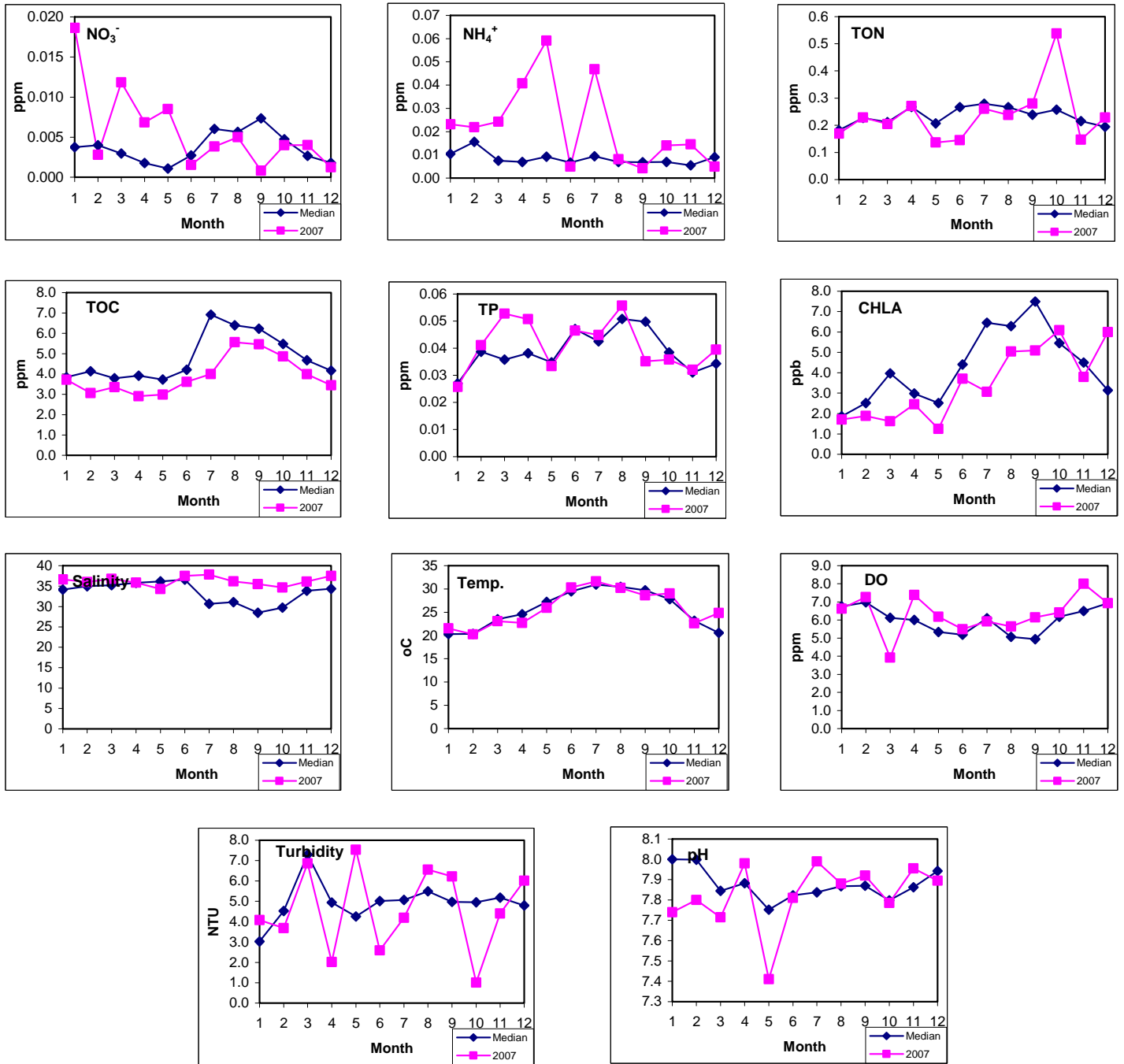


Figure 4.5.9. Comparison of long-term median with 2007 data.

### Naples Bay (NPL)

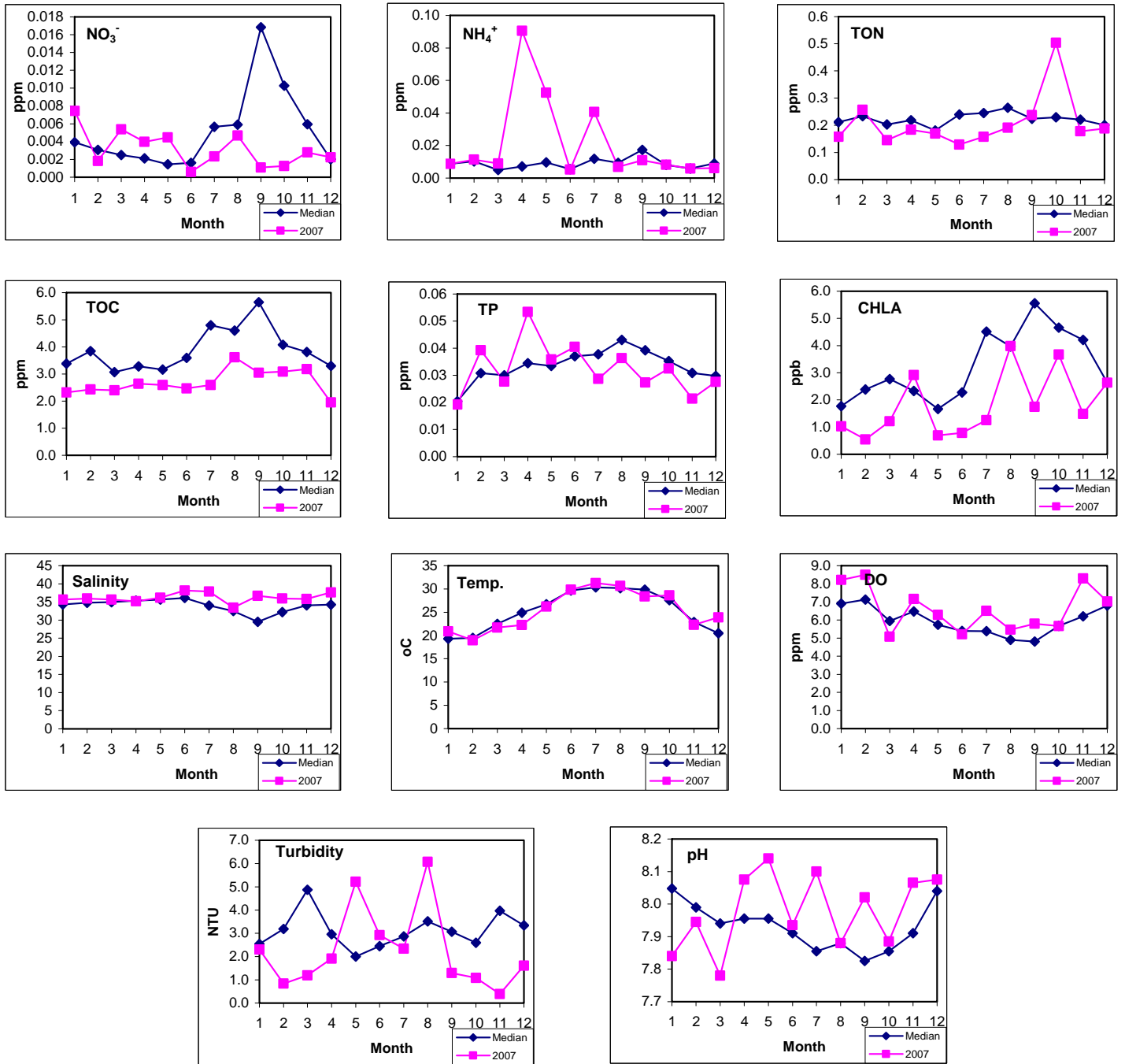


Figure 4.5.10. Comparison of long-term median with 2007 data.

### San Carlos Bay (SCB)

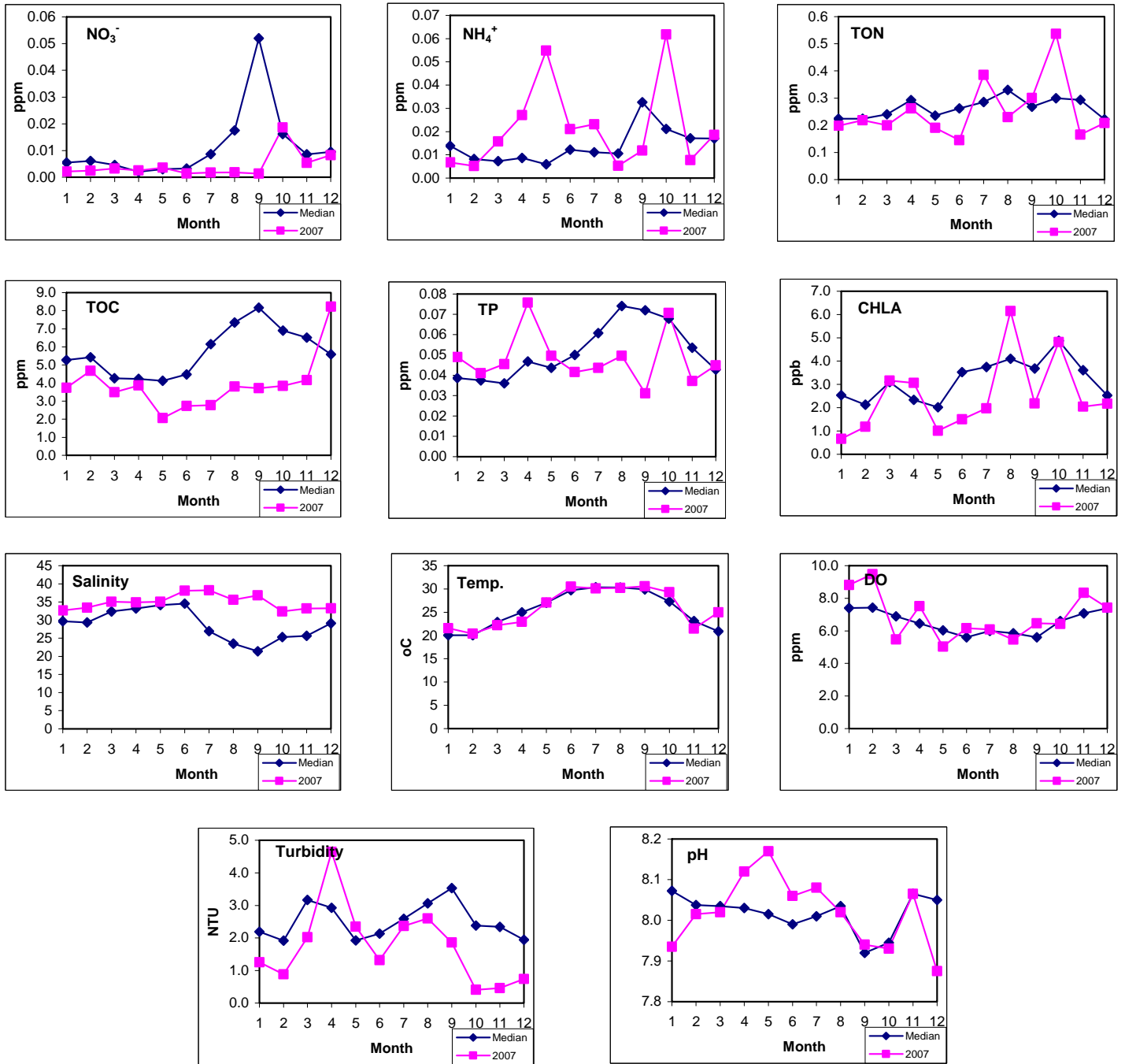


Figure 4.5.11. Comparison of long-term median with 2007 data.



### Estero Bay (EST)

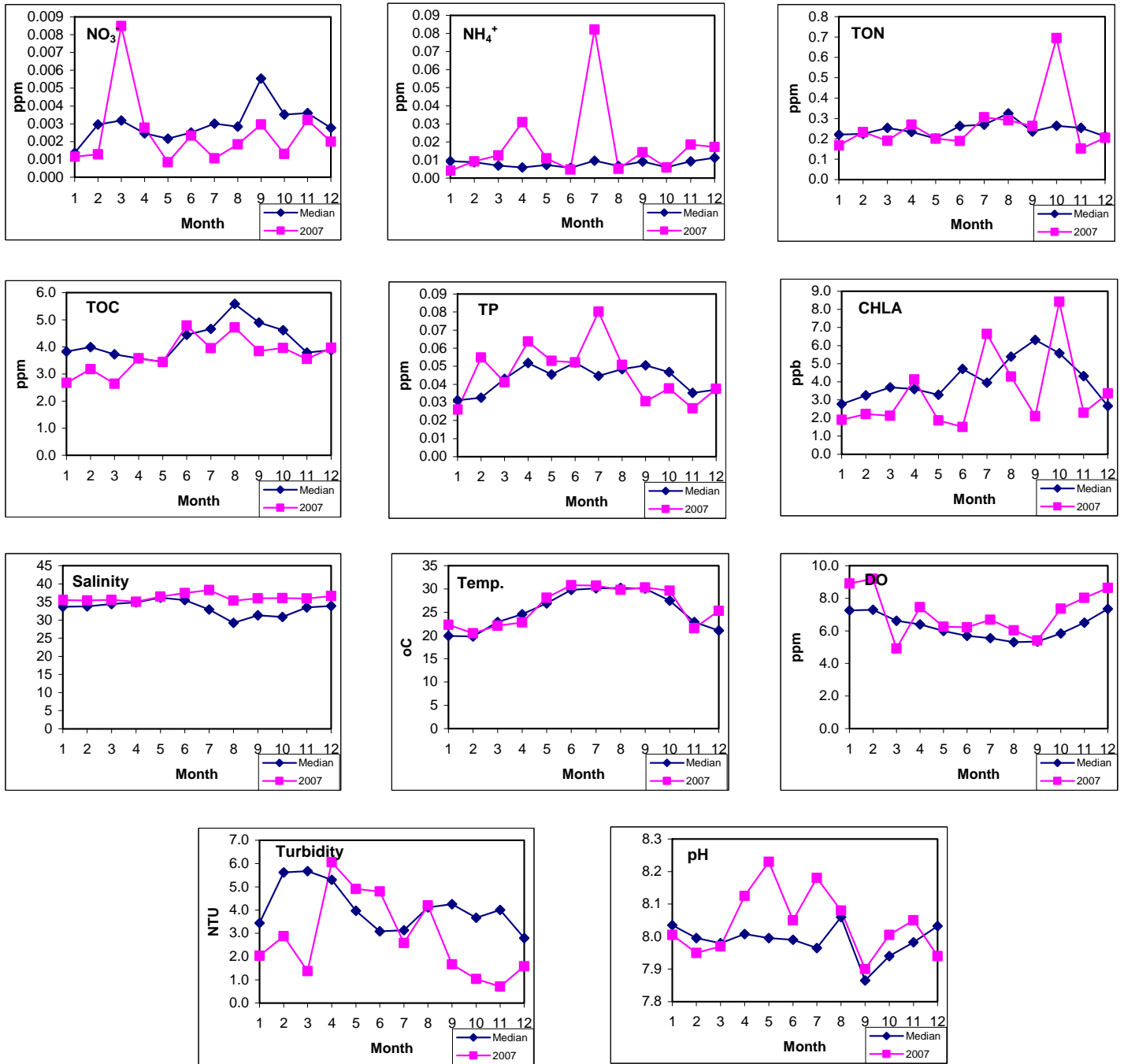


Figure 4.5.12. Comparison of long-term median with 2007 data.

### Pine Island Sound (PIS)

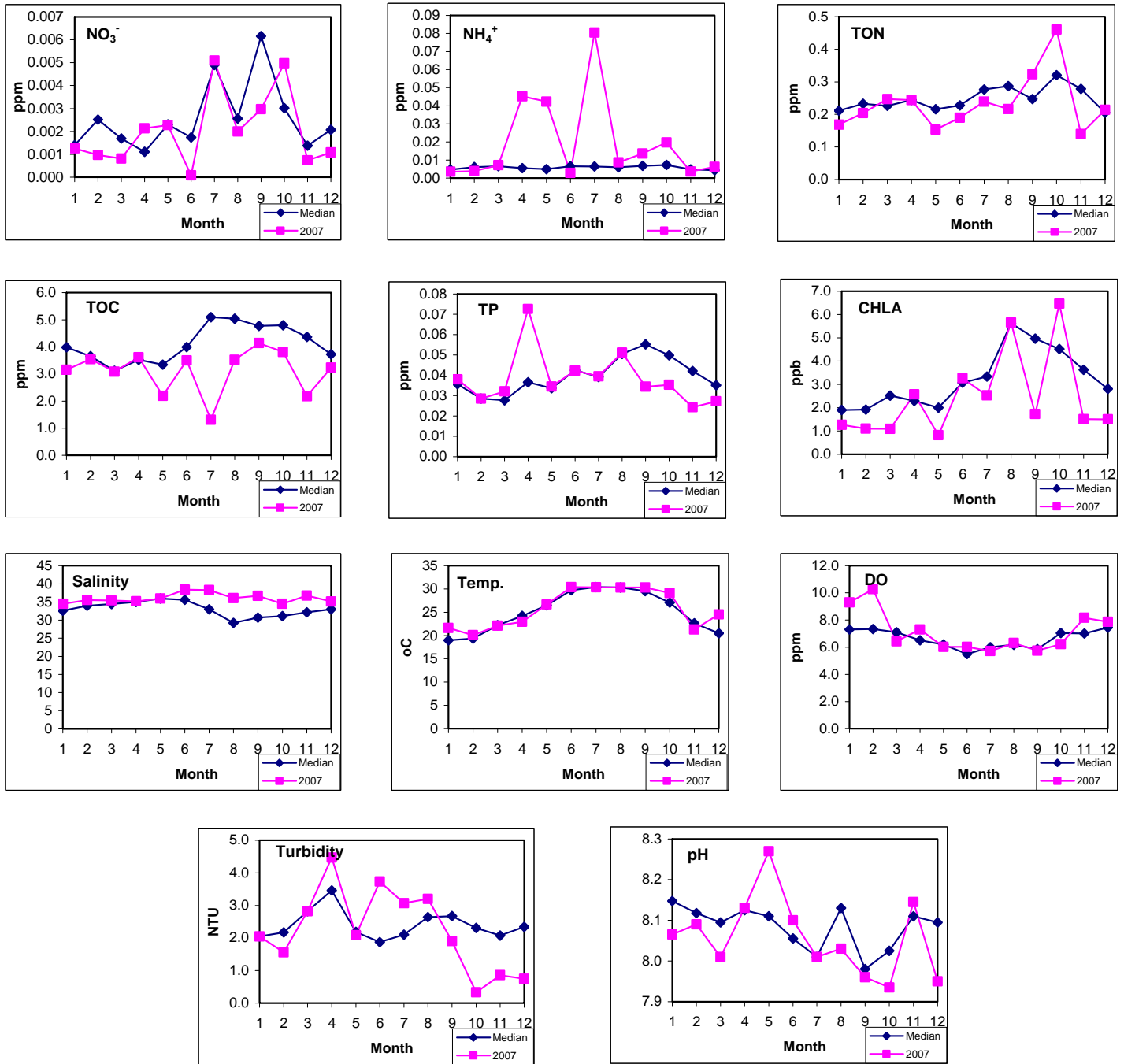


Figure 4.5.13. Comparison of long-term median with 2006 data.

### Cocohatchee River (COCO)

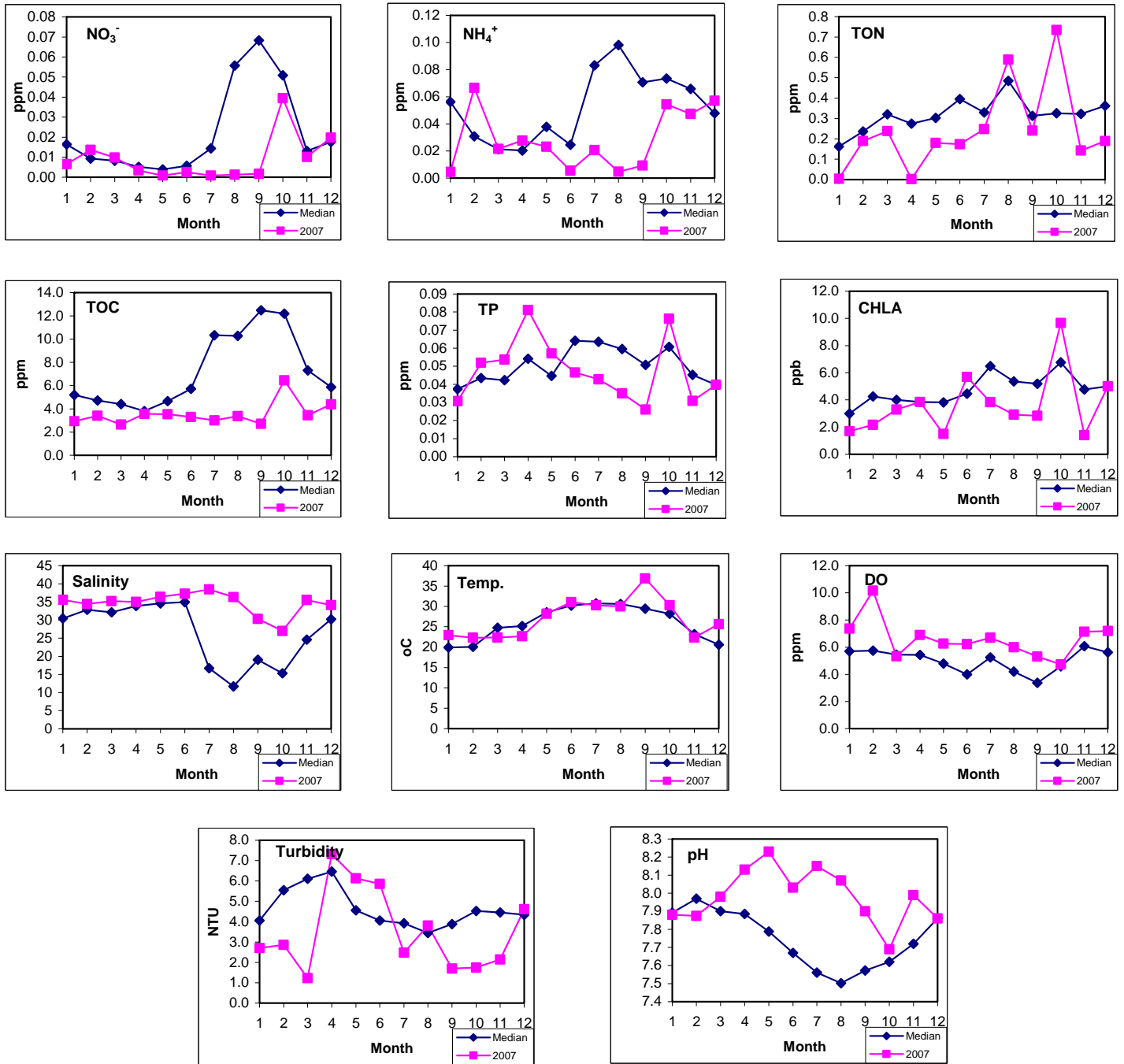


Figure 4.5.14. Comparison of long-term median with 2007 data.

## **5. CHANGES/UPDATES TO PREVIOUS REPORTS**

The quarterly reports for Oct.-Dec., 2006 (188-190); Jan.-Mar., 2007 (191-193); Apr.-Jun., 2007 (194-196); Jul.-Sep., 2007 (197-199); and Oct.-Dec., 2007 (200-202) were revised to include the ADaPT electronic deliverables and expanded QA reports.

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## **9. TABLES**

- 9.1. List of fixed station location and sampling period of record.
- 9.2. Statistical summary of Florida Bay water quality variables by zone.
- 9.3. Statistical summary of Whitewater Bay-Ten Thousand Islands water quality by zone.
- 9.4. Statistical summary of Biscayne Bay water quality variables by zone.
- 9.5. Statistical summary of Southwest Florida Shelf water quality variables by zone.
- 9.6. Statistical summary of Cape Romano-Pine Island Sound variables by zone.

**Table 9.1.** List of fixed station location and sampling period of record. Stations in red were eliminated from the current contract effective Oct 1, 2007.

Station Name	Site	Area	Latitude	Longitude	Record	Surveys
Card Sound Bridge	1	FB	25 16.413	-80 22.475	Mar 91 - Dec 07	1-202
Middle Key	2	FB	25 17.102	-80 23.702	Mar 91 - Dec 07	1-202
Manatee Bay	3	FB	25 15.062	-80 24.910	Mar 91 - Dec 07	1-202
Barnes Sound	4	FB	25 13.304	-80 23.299	Mar 91 - Dec 07	1-202
Blackwater Sound	5	FB	25 10.443	-80 25.385	Mar 91 - Dec 07	1-202
Little Blackwater Sound	6	FB	25 12.401	-80 26.424	Mar 91 - Dec 07	1-202
Highway Creek	7	FB	25 15.216	-80 26.649	Mar 91 - Dec 07	1-202
Long Sound	8	FB	25 13.642	-80 27.700	Mar 91 - Dec 07	1-202
Duck Key	9	FB	25 10.624	-80 29.494	Mar 91 - Dec 07	1-202
Joe Bay	10	FB	25 13.468	-80 32.195	Mar 91 - Dec 07	1-202
Little Madeira Bay	11	FB	25 10.510	-80 37.615	Mar 91 - Dec 07	1-202
Terrapin Bay	12	FB	25 08.422	-80 42.967	Mar 91 - Dec 07	1-202
Whipray Basin	13	FB	25 05.485	-80 45.287	Mar 91 - Dec 07	1-202
Garfield Bight	14	FB	25 09.029	-80 48.553	Apr 91 - Dec 07	2-202
Rankin Lake	15	FB	25 07.283	-80 48.173	Mar 91 - Dec 07	1-202
Murray Key	16	FB	25 07.096	-80 56.379	Mar 91 - Dec 07	1-202
Johnson Key Basin	17	FB	25 02.548	-80 54.889	Mar 91 - Dec 07	1-202
Rabbit Key Basin	18	FB	25 00.145	-80 54.006	Mar 91 - Dec 07	1-202
Twin Key Basin	19	FB	24 58.660	-80 45.211	Apr 91 - Dec 07	2-202
Peterson Keys	20	FB	24 55.770	-80 45.028	Mar 91 - Dec 07	1-202
Porpoise Lake	21	FB	25 00.396	-80 40.876	Mar 91 - Dec 07	1-202
Captain Key	22	FB	25 02.405	-80 36.843	Apr 91 - Dec 07	2-202
Park Key	23	FB	25 07.078	-80 35.983	Apr 91 - Dec 07	2-202
Butternut Key	24	FB	25 06.105	-80 31.884	Mar 91 - Dec 07	1-202
East Cape	25	FB	25 05.022	-81 04.835	July 92 - Dec 07	17-202
Oxfoot Bank	26	FB	24 58.844	-81 00.098	July 92 - Dec 07	17-202
Sprigger Bank	27	FB	24 55.116	-80 56.092	July 92 - Dec 07	17-202
Old Dan Bank	28	FB	24 52.032	-80 48.429	July 92 - Dec 07	17-202
First Bay	29	WWB	25 33.272	-81 11.020	Sept 92 - Dec 07	19-202
Third Bay	30	WWB	25 34.810	-81 07.256	Sept 92 - Dec 07	19-202
Big Lostmans Bay	31	WWB	25 34.055	-81 04.288	Sept 92 - Dec 07	19-199
Cabbage Island	32	WWB	25 31.764	-81 02.603	Sept 92 - Dec 07	19-202
Broad River Bay	33	WWB	25 29.984	-81 02.939	Sept 92 - Dec 07	19-202
Middle Broad River	34	WWB	25 29.163	-81 06.669	Sept 92 - Dec 07	19-202
Broad River Mouth	35	WWB	25 28.501	-81 09.176	Sept 92 - Dec 07	19-202
Harney River Mouth	36	WWB	25 24.701	-81 08.487	Sept 92 - Dec 07	19-202
Harney Rivers Junction	37	WWB	25 25.901	-81 04.943	Sept 92 - Dec 07	19-202
Tarpon Bay	38	WWB	25 25.037	-80 59.906	Sept 92 - Dec 07	19-202
Gunboat Island	39	WWB	25 22.735	-81 01.844	Sept 92 - Dec 07	19-202
Ponce de Leon Bay	40	WWB	25 20.983	-81 07.474	Sept 92 - Dec 07	19-202
Oyster Bay	41	WWB	25 19.869	-81 04.360	Sept 92 - Dec 07	19-202
North Marker 36	42	WWB	25 19.560	-81 00.873	Sept 92 - Dec 07	19-202
West Marker 34	43	WWB	25 17.168	-81 01.419	Sept 92 - Dec 07	19-202
Watson River Chickee	44	WWB	25 19.912	-80 59.022	Sept 92 - Dec 07	19-202
North River Mouth	45	WWB	25 18.054	-80 57.620	Sept 92 - Dec 07	19-199

Station Name	Site	Area	Latitude	Longitude	Record	Surveys
Midway Keys	46	WWB	25 17.102	-80 58.548	Sept 92 - Dec 07	19-199
Roberts River Mouth	47	WWB	25 16.779	-80 55.846	Sept 92 - Dec 07	19-202
West Marker 18	48	WWB	25 14.448	-80 57.476	Sept 92 - Dec 07	19-202
Southeast Marker 12	49	WWB	25 13.704	-80 55.980	Sept 92 - Dec 07	19-202
Coot Bay	50	WWB	25 11.452	-80 54.848	Sept 92 - Sept 07	19-199
Chokoloskee	51	TTI	25 48.450	-81 20.970	Sept 94 - Sept 07	43-199
Rabbit Key Pass	52	TTI	25 46.200	-81 23.000	Sept 94 - Dec 07	43-202
Lopez Bay	53	TTI	25 47.050	-81 19.930	Sept 94 - Dec 07	43-202
Lopez River	54	TTI	25 47.130	-81 18.550	Sept 94 - Dec 07	43-202
Sunday Bay	55	TTI	25 47.760	-81 16.800	Sept 94 - Dec 07	43-202
Huston Bay	56	TTI	25 45.180	-81 15.330	Sept 94 - Dec 07	43-202
Upper Chatham River	57	TTI	25 43.050	-81 13.830	Sept 94 - Dec 07	43-202
Watson Place	58	TTI	25 42.470	-81 15.130	Sept 94 - Dec 07	43-202
Gun Rock Point	59	TTI	25 41.500	-81 17.920	Sept 94 - Dec 07	43-202
Huston River	60	TTI	25 43.880	-81 17.080	Sept 94 - Dec 07	43-199
Chevalier Bay	61	TTI	25 42.750	-81 12.420	Sept 94 - Dec 07	43-202
Alligator Bay	62	TTI	25 40.210	-81 10.120	Sept 94 - Sept 07	43-199
Lostmans Five Bay	63	TTI	25 38.000	-81 08.700	Sept 94 - Dec 07	43-202
Barron River	64	TTI	25 51.196	-81 23.602	Sept 94 - Dec 07	43-202
Indian Key Pass	65	TTI	25 49.631	-81 26.465	Sept 94 - Dec 07	43-202
Indian Key	66	TTI	25 48.290	-81 27.750	Sept 94 - Dec 07	43-202
West Pass	67	TTI	25 49.820	-81 30.170	Sept 94 - Dec 07	43-202
Panther Key	68	TTI	25 50.960	-81 32.530	Sept 94 - Sept 07	43-199
Faka Union Pass	69	TTI	25 52.450	-81 30.960	Sept 94 - Dec 07	43-202
Faka Union Bay	70	TTI	25 54.000	-81 30.960	Sept 94 - Dec 07	43-202
White Horse Key	71	TTI	25 52.007	-81 34.489	Sept 94 - Dec 07	43-202
Dismal Key	72	TTI	25 53.668	-81 33.532	Sept 94 - Dec 07	43-202
Long Rock	73	TTI	25 52.920	-81 36.380	Sept 94 - Sept 07	43-199
Shell Key	74	TTI	25 54.670	-81 36.920	Sept 94 - Dec 07	43-202
Blackwater River	75	TTI	25 55.788	-81 36.019	Sept 94 - Dec 07	43-202
Convoy Point	101	BB	25 28.700	-80 19.250	Sept 93 - Dec 07	31-202
Black Point	102	BB	25 32.750	-80 17.680	Sept 93 - Dec 07	31-202
Near Black Ledge	103	BB	25 34.400	-80 17.200	Sept 93 - Sept 07	31-199
BNP Marker C	104	BB	25 36.100	-80 13.250	Sept 93 - Sept 07	31-202
Biscayne Channel	105	BB	25 39.252	-80 11.202	Sept 93 - Sept 07	31-63
White Marker	106	BB	25 38.052	-80 07.800	Sept 93 - Sept 07	31-63
Fowey Rocks	107	BB	25 35.400	-80 06.000	Sept 93 - Sept 07	31-63
Marker G-1B	108	BB	25 34.150	-80 11.550	Sept 93 - Dec 07	31-202
North Midbay	109	BB	25 33.850	-80 14.100	Sept 93 - Sept 07	31-199
Fender Point	110	BB	25 30.300	-80 17.250	Sept 93 - Dec 07	31-202
Featherbed Bank	111	BB	25 30.950	-80 14.400	Sept 93 - Dec 07	31-202
Sands Cut	112	BB	25 29.300	-80 11.300	Sept 93 - Dec 07	31-202
Elliott Key	113	BB	25 26.500	-80 13.400	Sept 93 - Sept 07	31-199
Caesar Creek	114	BB	25 23.100	-80 11.502	Sept 93 - May 96	31-63
Adams Key	115	BB	25 24.252	-80 14.448	Sept 93 - May 96	31-63
Rubicon Keys	116	BB	25 24.000	-80 15.300	Sept 93 - Sept 07	31-199
Totten Key	117	BB	25 23.100	-80 15.900	Sept 93 - May 96	31-63
Broad Creek	118	BB	25 20.898	-80 15.300	Sept 93 - May 96	31-63
Pumpkin Key	119	BB	25 19.098	-80 18.198	Sept 93 - May 96	31-63



Station Name	Site	Area	Latitude	Longitude	Record	Surveys
Card Bank, G-17	120	BB	25 18.852	-80 20.598	Sept 93 - May 96	31-63
North Card Sound	121	BB	25 21.300	-80 17.500	Sept 93 - Dec 07	31-202
West Arsenicker	122	BB	25 25.210	-80 18.650	Sept 93 - Dec 07	31-202
Pelican Bank	123	BB	25 26.700	-80 17.000	Sept 93 - Dec 07	31-202
South Midbay	124	BB	25 28.350	-80 14.000	Sept 93 - Sept 07	31-199
Turkey Point	125	BB	25 28.200	-80 16.998	Sept 93 - May 96	31-63
BNP Marker B	126	BB	25 40.300	-80 12.300	June 96 - Sept 07	64-199
Shoal Point	127	BB	25 37.800	-80 15.000	June 96 - Dec 07	64-202
Matheson Beach	128	BB	25 41.300	-80 14.000	June 96 - Dec 07	64-202
Marker G-71	129	BB	25 44.200	-80 11.100	June 96 - Dec 07	64-202
South Dodge Island	130	BB	25 45.800	-80 10.300	June 96 - Dec 07	64-202
North Venetian Basin	131	BB	25 48.000	-80 10.000	June 96 - Dec 07	64-202
North I-195 Basin	132	BB	25 49.000	-80 10.000	June 96 - Dec 07	64-199
North Normandy Isle	133	BB	25 52.000	-80 09.000	June 96 - Dec 07	64-202
Oleta River Park	134	BB	25 54.300	-80 08.000	June 96 - Dec 07	64-202
South Card Sound	135	BB	25 19.000	-80 19.000	June 96 - Dec 07	64-202
Off Lower Harbor Keys	351	SHELF	24 41.500	-81 47.500	May 95 - Sept 07	1-49
	352	SHELF	24 46.550	-81 46.980	May 95 - Sept 07	1-49
	353	SHELF	24 51.500	-81 46.600	May 95 - Sept 07	1-49
	354	SHELF	24 56.480	-81 46.120	May 95 - Sept 07	1-49
	355	SHELF	25 01.480	-81 45.750	May 95 - Sept 07	1-49
	356	SHELF	25 06.460	-81 45.230	May 95 - Sept 07	1-49
	357	SHELF	25 11.470	-81 44.720	May 95 - Sept 07	1-49
	358	SHELF	25 16.480	-81 44.290	May 95 - Sept 07	1-49
	359	SHELF	25 21.500	-81 43.800	May 95 - Sept 07	1-49
	360	SHELF	25 26.470	-81 43.260	May 95 - Sept 07	1-49
	361	SHELF	25 31.480	-81 42.900	May 95 - Sept 07	1-49
	362	SHELF	25 36.520	-81 42.400	May 95 - Sept 07	1-49
Off Cape Romano	363	SHELF	25 41.520	-81 41.900	May 95 - Sept 07	1-49
	364	SHELF	25 41.500	-81 32.000	May 95 - Sept 07	1-49
	365	SHELF	25 36.510	-81 32.360	May 95 - Sept 07	1-49
	366	SHELF	25 31.560	-81 32.930	May 95 - Sept 07	1-49
	367	SHELF	25 26.550	-81 33.300	May 95 - Sept 07	1-49
	368	SHELF	25 21.510	-81 33.800	May 95 - Sept 07	1-49
	369	SHELF	25 16.530	-81 34.320	May 95 - Sept 07	1-49
	370	SHELF	25 11.510	-81 34.750	May 95 - Sept 07	1-49
	371	SHELF	25 06.500	-81 35.210	May 95 - Sept 07	1-49
	372	SHELF	25 01.500	-81 35.720	May 95 - Sept 07	1-49
	373	SHELF	24 56.530	-81 36.180	May 95 - Sept 07	1-49
	374	SHELF	24 51.530	-81 36.650	May 95 - Sept 07	1-49
Off Johnson Key	375	SHELF	24 46.540	-81 37.070	May 95 - Sept 07	1-49
Harbor Key Bank	376	SHELF	24 50.600	-81 26.300	May 95 - Sept 07	1-49
	377	SHELF	24 56.100	-81 25.900	May 95 - Sept 07	1-49
	378	SHELF	25 01.000	-81 24.950	May 95 - Sept 07	1-49
	379	SHELF	25 06.000	-81 24.530	May 95 - Sept 07	1-49
	380	SHELF	25 11.000	-81 24.000	May 95 - Sept 07	1-49
	381	SHELF	25 16.000	-81 23.700	May 95 - Sept 07	1-49
	382	SHELF	25 21.000	-81 23.200	May 95 - Sept 07	1-49
	383	SHELF	25 25.950	-81 22.670	May 95 - Sept 07	1-49

Station Name	Site	Area	Latitude	Longitude	Record	Surveys
	384	SHELF	25 30.930	-81 22.200	May 95 - Sept 07	1-49
	385	SHELF	25 36.010	-81 21.790	May 95 - Sept 07	1-49
	386	SHELF	25 33.330	-81 20.430	May 95 - Sept 07	1-49
	387	SHELF	25 30.530	-81 19.010	May 95 - Sept 07	1-49
	388	SHELF	25 25.500	-81 17.820	May 95 - Sept 07	1-49
	389	SHELF	25 20.500	-81 16.620	May 95 - Sept 07	1-49
	390	SHELF	25 15.600	-81 15.610	May 95 - Sept 07	1-49
	391	SHELF	25 10.500	-81 14.320	May 95 - Sept 07	1-49
	392	SHELF	25 05.500	-81 14.900	May 95 - Sept 07	1-49
	393	SHELF	25 00.500	-81 15.200	May 95 - Sept 07	1-49
	394	SHELF	24 55.500	-81 15.600	May 95 - Sept 07	1-49
Off Bluefish Bank	395	SHELF	24 52.700	-81 11.500	May 95 - Sept 07	1-49
Off Bullard Bank	396	SHELF	24 50.000	-81 07.700	May 95 - Sept 07	1-49
	397	SHELF	24 55.000	-81 07.100	May 95 - Sept 07	1-49
	398	SHELF	25 00.000	-81 06.600	May 95 - Sept 07	1-49
Off East Cape	399	SHELF	25 05.000	-81 05.960	May 95 - Sept 07	1-49
Coon Key Pass, G3	451	ROOK	25 54.626	-81 38.309	Jan 99 - Dec 07	97-202
Coon Key Light	452	ROOK	25 52.918	-81 37.954	Jan 99 - Dec 07	97-202
Fred Key, G5	453	ROOK	25 53.978	-81 41.027	Jan 99 - Dec 07	97-202
Caxambas Pass, R4	454	ROOK	25 54.360	-81 43.733	Jan 99 - Dec 07	97-202
Capri Pass, R2A	455	ROOK	25 59.285	-81 43.740	Jan 99 - Dec 07	97-202
Rt. 951 Bridge, R26	456	ROOK	25 57.737	-81 42.524	Jan 99 - Dec 07	97-202
Big Marco River, R24	457	ROOK	25 57.122	-81 41.243	Jan 99 - Dec 07	97-202
Goodland Bridge, G15	458	ROOK	25 56.080	-81 39.204	Jan 99 - Dec 07	97-202
Johnson Bay	459	ROOK	25 59.291	-81 43.748	Jan 99 - Dec 07	97-202
Hall Bay	460	ROOK	26 00.941	-81 44.566	Jan 99 - Dec 07	97-202
Rookery Bay	461	ROOK	26 01.755	-81 44.888	Jan 99 - Dec 07	97-202
First National	462	ROOK	26 02.441	-81 45.955	Jan 99 - Dec 07	97-202
Kewaydin Channel, G55	463	ROOK	26 03.611	-81 46.713	Jan 99 - Dec 07	97-202
Dollar Bay, G73	464	ROOK	26 06.000	-81 47.213	Jan 99 - Dec 07	97-202
Outer Gordon Pass, G1	465	ROOK	26 05.480	-81 48.686	Jan 99 - Dec 07	97-202
New Pass	466	ROOK	26 22.692	-81 51.508	Jan 99 - Dec 07	97-202
Wiggins Pass Bridge	467	ROOK	26 17.441	-81 49.105	Jan 99 - Dec 07	97-202
Big Carlos Pass Bridge	468	ROOK	26 24.146	-81 52.850	Jan 99 - Dec 07	97-202
Coon Key, R2A	469	ROOK	26 25.422	-81 52.400	Jan 99 - Dec 07	97-202
Central Estero Bay, R2	470	ROOK	26 24.459	-81 51.885	Jan 99 - Dec 07	97-202
Point Ybel, R8	471	ROOK	26 27.492	-82 00.444	Jan 99 - Dec 07	97-202
San Carlos Bay, R4	472	ROOK	26 28.013	-82 02.723	Jan 99 - Dec 07	97-202
Kitchel Key, G13	473	ROOK	26 30.070	-82 00.789	Jan 99 - Dec 07	97-202
Shell Point	474	ROOK	26 31.368	-82 00.417	Jan 99 - Dec 07	97-202
Reckems Point	475	ROOK	26 32.108	-82 03.548	Jan 99 - Dec 07	97-202
Sanibel	476	ROOK	26 30.472	-82 09.113	Jan 99 - Dec 07	97-202
Pine Island Sound	477	ROOK	26 33.702	-82 09.934	Jan 99 - Dec 07	97-202
Cayo Costa	478	ROOK	26 38.150	-82 12.517	Jan 99 - Dec 07	97-202
Fakahatchee Bay	479	ROOK	26 01.542	-81 43.992	Jan 99 - Dec 07	131-202

**Table 9.2.** Statistical summary of Florida Bay water quality variables by zone.

Variable	Zone	Median	Min.	Max.	<i>n</i>
Alkaline Phosphatase Activity ( $\mu\text{M hr}^{-1}$ )	FBC	1.14	0.01	6.90	755
	FBE	0.35	0.01	6.11	3369
	FBW	0.16	0.01	4.93	1095
Chlorophyll <i>a</i> ( $\mu\text{g l}^{-1}$ )	FBC	1.55	0.11	35.61	782
	FBE	0.51	0.00	11.35	3495
	FBW	1.34	0.10	22.08	1146
Surface Dissolved Oxygen ( $\text{mg l}^{-1}$ )	FBC	6.4	2.4	12.3	785
	FBE	6.6	0.4	15.2	3499
	FBW	6.3	3.0	11.5	1159
Bottom Dissolved Oxygen ( $\text{mg l}^{-1}$ )	FBC	6.3	0.4	12.2	754
	FBE	6.6	1.4	15.0	3384
	FBW	6.3	3.0	11.1	1086
Ammonium (ppm)	FBC	0.035	0.000	1.681	774
	FBE	0.036	0.000	1.149	3487
	FBW	0.008	0.000	0.342	1140
Nitrite (ppm)	FBC	0.002	0.000	0.111	779
	FBE	0.002	0.000	0.041	3489
	FBW	0.001	0.000	0.025	1140
Nitrate (ppm)	FBC	0.003	0.000	0.080	777
	FBE	0.008	0.000	0.154	3479
	FBW	0.002	0.000	0.101	1135
pH	FBC	8.255	7.394	8.850	224
	FBE	8.135	7.535	9.115	1008
	FBW	8.168	7.780	8.775	336
Surface Salinity	FBC	34.00	8.70	63.00	794
	FBE	29.30	0.10	54.30	3535
	FBW	35.10	16.50	52.00	1173
Bottom Salinity	FBC	33.60	11.90	63.00	750
	FBE	29.20	0.10	54.30	3347
	FBW	34.98	16.60	51.00	1086
Silicate (ppm)	FBC	0.835	0.000	5.731	180
	FBE	0.275	0.000	4.604	810
	FBW	0.476	0.000	5.089	270
Soluble Reactive Phosphorus (ppm)	FBC	0.001	0.000	0.026	777
	FBE	0.001	0.000	0.020	3469
	FBW	0.001	0.000	0.058	1133
Surface Temperature ( $^{\circ}\text{C}$ )	FBC	26.6	13.0	36.7	790
	FBE	26.6	14.2	34.5	3516
	FBW	26.5	14.1	36.0	1167
Bottom Temperature ( $^{\circ}\text{C}$ )	FBC	26.5	13.2	35.3	758
	FBE	26.5	14.2	34.6	3394
	FBW	26.3	13.9	34.7	1092
Total Nitrogen (ppm)	FBC	0.906	0.117	4.408	779
	FBE	0.568	0.060	3.142	3488
	FBW	0.341	0.067	1.691	1141

Variable	Zone	Median	Min.	Max.	<i>n</i>
Total Organic Carbon (ppm)	FBC	12.176	3.585	42.872	774
	FBE	8.188	0.000	58.043	3477
	FBW	4.653	1.199	27.370	1134
Total Organic Nitrogen (ppm)	FBC	0.756	0.106	4.355	772
	FBE	0.501	0.000	3.098	3475
	FBW	0.322	0.046	1.680	1134
Total Phosphorus (ppm)	FBC	0.016	0.002	0.131	778
	FBE	0.007	0.001	0.099	3489
	FBW	0.014	0.000	0.232	1142
Turbidity (NTU)	FBC	5.45	0.12	134.85	763
	FBE	2.20	0.00	172.95	3417
	FBW	4.66	0.07	178.55	1097

**Table 9.3.** Statistical summary of Whitewater Bay-Ten Thousand Islands water quality variables by zone.

Variable	Zone	Median	Min.	Max.	<i>n</i>
Alkaline Phosphatase Activity ( $\mu\text{M hr}^{-1}$ )	BLK	0.04	0.02	0.28	285
	GI	0.05		3.23	1764
	IWW	0.10	0.00	8.31	1570
	MR	0.22	0.00	3.70	2111
	WWB	1.26	0.00	5.96	1334
Chlorophyll <i>a</i> ( $\mu\text{g l}^{-1}$ )	BLK	3.23	0.25	17.02	294
	GI	2.85	0.12	23.78	1810
	IWW	3.55	0.19	45.11	1614
	MR	2.76	0.15	28.76	2163
	WWB	2.92	0.11	29.78	1359
Surface Dissolved Oxygen ( $\text{mg l}^{-1}$ )	BLK	5.3	0.3	10.3	294
	GI	5.8	1.4	12.1	1808
	IWW	6.0	1.8	11.8	1614
	MR	5.2	0.4	13.9	2152
	WWB	6.9	2.2	24.4	1352
Bottom Dissolved Oxygen ( $\text{mg l}^{-1}$ )	BLK	5.1	0.1	9.8	294
	GI	5.7	0.2	11.8	1808
	IWW	5.9	1.1	11.9	1614
	MR	5.1	0.4	12.3	2151
	WWB	6.9	0.4	24.4	1352
Ammonium (ppm)	BLK	0.021	0.001	0.195	294
	GI	0.011	0.000	0.183	1810
	IWW	0.017	0.000	0.314	1614
	MR	0.018	0.000	0.402	2163
	WWB	0.014	0.000	0.408	1360
Nitrite (ppm)	BLK	0.003	0.000	0.017	294
	GI	0.002	0.000	0.033	1810
	IWW	0.002	0.000	0.036	1614
	MR	0.002	0.000	0.024	2163
	WWB	0.002	0.000	0.086	1360
Nitrate (ppm)	BLK	0.009	0.000	0.080	294
	GI	0.008	0.000	0.135	1810
	IWW	0.010	0.000	0.133	1614
	MR	0.015	0.000	0.142	2163
	WWB	0.006	0.000	0.268	1360
pH	BLK	7.793	7.170	8.530	112
	GI	7.880	6.920	8.765	670
	IWW	7.820	7.240	8.825	616
	MR	7.705	6.970	8.595	717
	WWB	8.180	7.510	8.810	440
Surface Salinity	BLK	32.0	1.4	39.9	294
	GI	28.9	1.3	40.7	1810
	IWW	15.7	0.1	42.8	1614
	MR	6.2	0.0	40.5	2160
	WWB	11.5	0.3	35.4	1360

Variable	Zone	Median	Min.	Max.	<i>n</i>
Bottom Salinity	BLK	32.4	1.4	39.9	294
	GI	29.5	1.0	40.7	1808
	IWW	17.6	0.2	53.6	1614
	MR	7.3	0.0	40.5	2148
	WWB	11.8	0.3	34.9	1352
Silicate (ppm)	BLK	1.733	0.000	4.493	84
	GI	1.491	0.000	4.705	505
	IWW	1.744	0.000	4.688	461
	MR	2.081	0.000	6.400	568
	WWB	1.422	0.002	4.880	352
Soluble Reactive Phosphorus (ppm)	BLK	0.017	0.002	0.066	294
	GI	0.006	0.000	0.044	1805
	IWW	0.003	0.000	0.033	1614
	MR	0.002	0.000	0.034	2160
	WWB	0.002	0.000	0.026	1357
Surface Temperature (°C)	BLK	27.0	15.9	38.4	294
	GI	26.7	13.7	37.2	1808
	IWW	27.0	15.1	37.5	1614
	MR	26.7	13.6	34.4	2152
	WWB	26.7	12.3	34.4	1352
Bottom Temperature (°C)	BLK	26.9	15.9	35.9	294
	GI	26.6	14.1	37.2	1808
	IWW	27.0	15.2	33.3	1614
	MR	26.5	13.6	33.3	2151
	WWB	26.6	11.8	33.5	1352
Total Nitrogen (ppm)	BLK	0.395	0.066	1.380	293
	GI	0.384	0.059	1.955	1808
	IWW	0.519	0.048	2.031	1614
	MR	0.596	0.038	3.046	2163
	WWB	0.714	0.057	2.588	1360
Total Organic Carbon (ppm)	BLK	6.316	2.897	21.385	293
	GI	6.465	1.482	27.170	1801
	IWW	10.929	2.112	23.348	1608
	MR	12.743	0.458	64.008	2162
	WWB	14.586	0.300	39.373	1358
Total Organic Nitrogen (ppm)	BLK	0.344	0.044	1.313	293
	GI	0.353	0.055	1.896	1808
	IWW	0.476	0.021	2.011	1614
	MR	0.555	0.021	2.989	2163
	WWB	0.675	0.000	2.535	1360
Total Phosphorus (ppm)	BLK	0.053	0.014	0.237	287
	GI	0.033	0.001	0.204	1802
	IWW	0.029	0.002	0.207	1612
	MR	0.021	0.001	0.125	2161
	WWB	0.018	0.003	0.094	1360

Variable	Zone	Median	Min.	Max.	<i>n</i>
Turbidity (NTU)	BLK	7.30	0.49	40.50	293
	GI	5.05	0.09	68.00	1809
	IWW	4.41	0.06	66.60	1614
	MR	2.80	0.09	58.65	2163
	WWB	3.48	0.21	107.81	1360

**Table 9.4.** Statistical summary of Biscayne Bay water quality variables by zone.

Variable	Zone	Median	Min.	Max.	<i>n</i>
Alkaline Phosphatase Activity ( $\mu\text{M hr}^{-1}$ )	AS	0.327	0.091	3.209	312
	IS	0.193	0.013	3.378	713
	MAIN	0.111	0.008	2.720	1781
	NBAY	0.117	0.008	1.475	613
	SCARD	0.142	0.022	2.949	345
Chlorophyll <i>a</i> ( $\mu\text{g l}^{-1}$ )	AS	0.30	0.03	2.46	314
	IS	0.28	0.02	6.37	719
	MAIN	0.24	0.00	5.89	1792
	NBAY	1.06	0.12	9.18	620
	SCARD	0.32	0.06	7.21	347
Surface Dissolved Oxygen ( $\text{mg l}^{-1}$ )	AS	6.9	3.1	11.6	316
	IS	6.6	3.5	11.5	728
	MAIN	6.3	2.8	10.2	1813
	NBAY	6.2	3.0	10.2	630
	SCARD	6.4	4.0	9.1	351
Bottom Dissolved Oxygen ( $\text{mg l}^{-1}$ )	AS	7.1	3.0	12.9	316
	IS	6.7	2.6	11.8	728
	MAIN	6.4	2.8	10.6	1813
	NBAY	6.2	3.2	10.4	630
	SCARD	6.5	3.3	9.5	351
Ammonium (ppm)	AS	0.018	0.001	0.228	318
	IS	0.013	0.000	0.148	729
	MAIN	0.009	0.000	0.120	1815
	NBAY	0.014	0.000	0.220	630
	SCARD	0.011	0.000	0.121	351
Nitrite (ppm)	AS	0.004	0.000	0.048	318
	IS	0.002	0.000	0.043	729
	MAIN	0.001	0.000	0.019	1815
	NBAY	0.002	0.000	0.068	630
	SCARD	0.002	0.000	0.019	351
Nitrate (ppm)	AS	0.046	0.000	1.173	318
	IS	0.012	0.000	0.732	728
	MAIN	0.004	0.000	0.633	1815
	NBAY	0.016	0.000	0.174	630
	SCARD	0.006	0.000	0.129	351
pH	AS	8.157	7.180	8.800	112
	IS	8.120	7.280	8.820	280
	MAIN	8.115	7.095	8.900	614
	NBAY	8.050	7.225	8.815	280
	SCARD	8.090	7.125	8.825	112
Surface Salinity	AS	27.1	6.2	44.1	318
	IS	31.4	11.5	43.8	729
	MAIN	35.3	21.2	41.4	1814
	NBAY	32.1	16.2	38.9	630
	SCARD	33.1	21.0	40.8	351



Variable	Zone	Median	Min.	Max.	<i>n</i>
Bottom Salinity	AS	28.0	7.2	44.1	318
	IS	32.0	11.5	43.9	729
	MAIN	35.5	24.2	41.5	1813
	NBAY	33.4	24.7	39.0	630
	SCARD	33.5	20.9	40.9	351
Silicate (ppm)	AS	0.181	0.000	1.972	84
	IS	0.074	0.000	1.268	210
	MAIN	0.025	0.000	0.720	462
	NBAY	0.194	0.001	1.287	210
	SCARD	0.031	0.000	1.552	84
Soluble Reactive Phosphorus (ppm)	AS	0.001	0.000	0.010	317
	IS	0.001	0.000	0.009	725
	MAIN	0.001	0.000	0.009	1808
	NBAY	0.001	0.000	0.021	626
	SCARD	0.001	0.000	0.008	349
Surface Temperature (°C)	AS	26.7	10.2	33.0	318
	IS	26.3	14.2	33.3	729
	MAIN	26.3	13.5	32.8	1814
	NBAY	26.0	14.3	32.5	630
	SCARD	26.3	15.9	33.0	351
Bottom Temperature (°C)	AS	26.7	10.3	33.2	318
	IS	26.3	14.2	33.4	729
	MAIN	26.3	13.5	32.7	1814
	NBAY	25.8	14.5	32.9	630
	SCARD	26.6	15.8	33.8	351
Total Nitrogen (ppm)	AS	0.445	0.101	1.560	318
	IS	0.313	0.031	1.026	726
	MAIN	0.215	0.000	1.313	1815
	NBAY	0.248	0.047	1.011	626
	SCARD	0.301	0.055	1.325	350
Total Organic Carbon (ppm)	AS	4.477	1.379	9.330	318
	IS	3.590	1.463	9.415	728
	MAIN	2.542	0.326	11.982	1815
	NBAY	3.261	1.128	10.690	629
	SCARD	3.801	1.684	11.050	350
Total Organic Nitrogen (ppm)	AS	0.325	0.000	1.010	318
	IS	0.261	0.014	0.877	726
	MAIN	0.192	0.000	1.288	1815
	NBAY	0.201	0.032	0.983	626
	SCARD	0.273	0.030	1.229	350
Total Phosphorus (ppm)	AS	0.006	0.000	0.052	318
	IS	0.005	0.001	0.059	727
	MAIN	0.005	0.000	0.049	1815
	NBAY	0.009	0.002	0.058	629
	SCARD	0.006	0.002	0.030	351
Turbidity (NTU)	AS	0.50	0.05	11.53	318
	IS	0.47	0.00	5.09	728
	MAIN	0.75	0.00	19.00	1813
	NBAY	1.18	0.01	22.35	630
	SCARD	0.55	0.00	5.17	351

**Table 9.5.** Statistical summary of Southwest Florida Shelf water quality variables by zone.

Variable	Zone	Median	Min.	Max.	<i>n</i>
Alkaline Phosphatase Activity ( $\mu\text{M hr}^{-1}$ )	SHARK	0.055	0.016	2.485	85
	SHELF	0.043	0.004	12.017	1677
	SHOAL	0.047	0.006	7.627	296
Chlorophyll <i>a</i> ( $\mu\text{g l}^{-1}$ )	SHARK	1.608	0.254	8.910	92
	SHELF	0.913	0.000	13.791	1825
	SHOAL	0.922	0.120	8.448	320
Surface Dissolved Oxygen ( $\text{mg l}^{-1}$ )	SHARK	6.1	2.4	8.6	91
	SHELF	6.0	1.0	12.6	1803
	SHOAL	6.0	0.9	12.8	318
Bottom Dissolved Oxygen ( $\text{mg l}^{-1}$ )	SHARK	5.4	2.8	8.6	62
	SHELF	5.8	1.7	29.9	1235
	SHOAL	5.8	2.6	9.7	219
Ammonium (ppm)	SHARK	0.006	0.001	0.049	92
	SHELF	0.004	0.000	0.129	1825
	SHOAL	0.004	0.000	0.064	320
Nitrite (ppm)	SHARK	0.001	0.000	0.006	92
	SHELF	0.000	0.000	0.008	1825
	SHOAL	0.000	0.000	0.005	320
Nitrate (ppm)	SHARK	0.002	0.000	0.072	92
	SHELF	0.001	0.000	0.078	1825
	SHOAL	0.001	0.000	0.022	320
pH	SHARK	7.918	7.565	8.265	30
	SHELF	7.895	7.395	8.780	584
	SHOAL	7.905	7.595	8.885	103
Surface Salinity	SHARK	34.6	24.4	40.7	91
	SHELF	35.4	27.0	40.1	1809
	SHOAL	35.5	27.9	38.8	318
Bottom Salinity	SHARK	34.6	26.0	40.7	62
	SHELF	35.7	24.4	40.1	1241
	SHOAL	35.7	31.0	39.2	219
Silicate (ppm)	SHARK	0.424	0.000	1.756	85
	SHELF	0.063	0.000	2.238	1738
	SHOAL	0.041	0.000	1.698	305
Soluble Reactive Phosphorus (ppm)	SHARK	0.001	0.000	0.006	92
	SHELF	0.001	0.000	0.014	1825
	SHOAL	0.001	0.000	0.008	320
Surface Temperature ( $^{\circ}\text{C}$ )	SHARK	26.4	14.8	32.1	91
	SHELF	26.7	14.7	32.7	1809
	SHOAL	26.8	15.2	32.3	318
Bottom Temperature ( $^{\circ}\text{C}$ )	SHARK	26.3	14.8	31.4	62
	SHELF	26.5	14.7	31.9	1241
	SHOAL	26.2	15.2	32.0	219
Total Nitrogen (ppm)	SHARK	0.262	0.068	0.967	91
	SHELF	0.200	0.027	1.028	1817
	SHOAL	0.207	0.023	1.043	320

Variable	Zone	Median	Min.	Max.	<i>n</i>
Total Organic Carbon (ppm)	SHARK	3.553	1.722	5.812	91
	SHELF	2.482	1.009	16.708	1822
	SHOAL	2.441	1.055	5.864	320
Total Organic Nitrogen (ppm)	SHARK	0.247	0.059	0.957	91
	SHELF	0.191	0.023	1.021	1817
	SHOAL	0.198	0.020	1.040	320
Total Phosphorus (ppm)	SHARK	0.015	0.004	0.079	92
	SHELF	0.012	0.000	0.190	1825
	SHOAL	0.012	0.003	0.038	320
Turbidity (NTU)	SHARK	5.99	0.62	66.25	88
	SHELF	2.02	0.00	45.05	1745
	SHOAL	2.64	0.19	20.70	305

**Table 9.6.** Statistical summary of Cape Romano-Pine Island Sound water quality variables by zone.

Variable	Zone	Median	Min.	Max.	<i>n</i>
Alkaline Phosphatase Activity ( $\mu\text{M hr}^{-1}$ )	COCO	0.05	0.02	0.30	77
	EST	0.05	0.01	0.22	386
	MARC	0.04	0.01	0.29	743
	NPL	0.05	0.02	0.31	279
	PIS	0.05	0.01	0.17	279
	RB	0.05	0.01	0.44	428
	SCB	0.05	0.01	0.19	465
Chlorophyll <i>a</i> ( $\mu\text{g l}^{-1}$ )	COCO	4.34	0.63	18.27	78
	EST	3.95	0.41	24.68	395
	MARC	4.37	0.38	20.85	757
	NPL	2.99	0.33	18.22	285
	PIS	3.34	0.49	28.63	285
	RB	4.00	0.67	28.30	438
	SCB	3.05	0.53	28.47	475
Surface Dissolved Oxygen ( $\text{mg l}^{-1}$ )	COCO	5.5	1.8	7.3	20
	EST	6.1	2.0	9.9	400
	MARC	6.0	2.8	14.8	765
	NPL	5.8	2.1	11.7	288
	PIS	6.4	1.0	9.8	288
	RB	5.8	1.3	12.9	431
	SCB	6.4	3.0	10.8	480
Bottom Dissolved Oxygen ( $\text{mg l}^{-1}$ )	COCO	4.9	2.6	8.0	79
	EST	6.3	2.8	10.5	400
	MARC	6.2	2.8	13.2	765
	NPL	5.9	2.3	11.5	288
	PIS	6.8	3.9	10.6	288
	RB	6.0	2.7	10.0	443
	SCB	6.6	3.1	11.1	480
Ammonium (ppm)	COCO	0.046	0.001	0.217	77
	EST	0.008	0.000	0.141	400
	MARC	0.006	0.000	0.194	764
	NPL	0.008	0.000	0.170	288
	PIS	0.005	0.000	0.173	288
	RB	0.008	0.000	0.239	442
	SCB	0.010	0.000	0.184	477
Nitrite (ppm)	COCO	0.002	0.000	0.017	78
	EST	0.001	0.000	0.014	400
	MARC	0.001	0.000	0.010	765
	NPL	0.001	0.000	0.009	288
	PIS	0.001	0.000	0.023	288
	RB	0.001	0.000	0.009	443
	SCB	0.001	0.000	0.047	480

Variable	Zone	Median	Min.	Max.	<i>n</i>
Nitrate (ppm)	COCO	0.013	0.000	0.137	78
	EST	0.003	0.000	0.126	400
	MARC	0.002	0.000	0.052	765
	NPL	0.003	0.000	0.103	288
	PIS	0.003	0.000	0.087	288
	RB	0.003	0.000	0.056	443
	SCB	0.009	0.000	0.424	480
pH	COCO	7.745	5.200	8.390	53
	EST	7.990	5.300	8.525	292
	MARC	7.982	5.150	8.560	550
	NPL	7.920	5.180	8.475	207
	PIS	8.100	5.250	8.715	207
	RB	7.870	5.180	8.565	335
	SCB	8.025	5.260	8.550	345
Surface Salinity	COCO	33.1	3.5	38.3	20
	EST	33.7	5.5	38.3	400
	MARC	34.5	21.2	40.7	765
	NPL	34.5	8.7	41.5	288
	PIS	33.7	18.3	38.6	288
	RB	34.3	14.2	40.5	430
	SCB	30.3	1.3	37.9	480
Bottom Salinity	COCO	29.6	0.0	37.1	79
	EST	33.5	2.8	38.5	400
	MARC	34.5	15.5	40.6	765
	NPL	34.3	6.8	41.4	288
	PIS	33.1	17.0	38.5	288
	RB	34.2	12.2	39.9	442
	SCB	28.4	0.6	38.0	480
Silicate (ppm)	COCO	0.825	0.166	2.940	31
	EST	0.646	0.033	2.476	128
	MARC	0.645	0.003	3.488	253
	NPL	0.546	0.006	2.466	96
	PIS	0.374	0.000	1.612	96
	RB	0.717	0.014	2.436	147
	SCB	0.821	0.045	4.175	160
Soluble Reactive Phosphorus (ppm)	COCO	0.012	0.000	0.068	78
	EST	0.006	0.000	0.060	400
	MARC	0.004	0.000	0.035	765
	NPL	0.005	0.000	0.034	288
	PIS	0.005	0.000	0.153	288
	RB	0.005	0.000	0.031	443
	SCB	0.014	0.000	0.165	477
Surface Temperature (°C)	COCO	28.7	19.8	32.7	20
	EST	25.4	15.7	32.0	400
	MARC	25.8	12.7	32.5	765
	NPL	25.8	15.4	32.0	288
	PIS	24.9	14.3	33.0	288
	RB	26.2	15.1	33.5	431
	SCB	25.1	14.9	34.5	480

Variable	Zone	Median	Min.	Max.	<i>n</i>
Bottom Temperature (°C)	COCO	26.1	17.7	32.8	79
	EST	25.6	15.7	32.2	400
	MARC	25.9	14.8	38.0	765
	NPL	25.8	15.8	32.1	288
	PIS	25.1	14.2	32.0	288
	RB	26.3	15.1	33.6	443
	SCB	25.3	15.0	33.1	480
Total Nitrogen (ppm)	COCO	0.428	0.186	1.108	79
	EST	0.273	0.092	0.982	400
	MARC	0.255	0.055	0.951	765
	NPL	0.255	0.066	0.736	288
	PIS	0.276	0.019	1.250	288
	RB	0.268	0.029	1.056	443
	SCB	0.308	0.030	1.849	479
Total Organic Carbon (ppm)	COCO	5.939	2.458	16.598	79
	EST	4.303	2.087	17.602	399
	MARC	3.987	1.443	15.172	765
	NPL	3.714	1.748	13.520	288
	PIS	4.240	1.808	13.733	288
	RB	4.498	1.495	16.720	443
	SCB	5.805	1.700	19.688	480
Total Organic Nitrogen (ppm)	COCO	0.325	0.053	1.052	77
	EST	0.250	0.033	0.769	400
	MARC	0.241	0.048	0.908	764
	NPL	0.228	0.028	0.713	288
	PIS	0.246	0.017	1.229	288
	RB	0.245	0.013	1.034	442
	SCB	0.266	0.024	1.417	476
Total Phosphorus (ppm)	COCO	0.049	0.018	0.118	79
	EST	0.043	0.012	0.186	400
	MARC	0.035	0.000	0.160	763
	NPL	0.033	0.011	0.150	287
	PIS	0.039	0.014	0.215	285
	RB	0.038	0.002	0.102	441
	SCB	0.050	0.012	0.213	475
Turbidity (NTU)	COCO	4.46	0.35	18.08	79
	EST	4.07	0.13	63.90	400
	MARC	5.02	0.39	60.30	765
	NPL	3.01	0.25	38.65	288
	PIS	2.40	0.07	20.65	288
	RB	5.01	0.61	35.25	443
	SCB	2.53	0.06	55.35	480