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South Florida Coastal Water Quality Monitoring Network FY2003 Cumulative Report to the South Florida Water Management District (Contract No. C-15397)

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SOUTH FLORIDA COASTAL WATER QUALITY MONITORING NETWORK

FY2003 Cumulative Report to the South Florida Water Management District (Contract No. C-15397)

Including the waters of:

FLORIDA BAY
WHITEWATER BAY
TEN THOUSAND ISLANDS
BISCAYNE BAY
SOUTHWEST FLORIDA SHELF
MARCO ISLAND
NAPLES BAY
ESTERO BAY
ROOKERY BAY
SAN CARLOS BAY
PINE ISLAND SOUND

Prepared by:

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http://serc.fiu.edu/wqmnetwork/

SOUTH FLORIDA COASTAL WATER QUALITY MONITORING NETWORK

FY2003 Cumulative Report to the South Florida Water Management District
(Contract No. C-15397)

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EXECUTIVE SUMMARY

This report summarizes the existing data from the FIU South Florida Coastal Water Quality Monitoring Network. 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.

We have continued our systematic analysis and interpretation starting with the most extensive dataset: Florida Bay. We have analyzed the data for spatial trends, temporal trends, and for freshwater loading effects. Spatial analysis can be performed on data of relatively short period of record, however, time series analysis usually requires a minimum 5 years before significant trends can be recognized over the background noise of inter-annual variability. Therefore, the type of analysis performed on each estuary is determined by the length of the record.

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.

Florida Bay

2003 was a very "average" year; most water quality variables followed typical annual trends. Due to wet spring rainfall, most of the bay did not experience any prolonged periods of hypersalinity. However, water temperatures in the bay were ~1 °C higher than the grand median. TON reversed its downward trend with a jump of 0.02 ppm baywide; TP continued its slow downward trend. DO was also lower in 2003 than the grand median for the bay. Annual

patterns in CHLA, DIN, and turbidity were unremarkable with values generally fluctuating around the median for all areas of the bay.

Whitewater Bay-Ten Thousand Islands

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. No hypersaline events were observed, as 2003 was a normal year of precipitation. Except for a small summer increase in Whitewater Bay and Gulf Islands CHLA, levels of TP and DIN were relatively unremarkable. Finally, TON and TOC continued their slow, long term downward trend in the Mangrove Rivers.

Biscayne Bay

Salinity in Biscayne Bay is strongly influenced by its large tidal exchange with the ocean. Nevertheless, canal inputs have a significant impact as evidenced by the irregular salinity fluctuations. 2003 was an unremarkable year for salinity, DIN, CHLA, and turbidity. The past years' increases in TP concentrations were reversed in 2003. This is a trend we must watch closely to see if other impacts to the Biscayne Bay's ecosystem become noticeable. TON reversed its slow decline in 2003 with a jump in concentrations of 0.045 ppm baywide. This was in direct contrast to the overall decline in TOC observed since 1997. Water temperature in Biscayne Bay jumped a full 1 °C over long term median. This change was reflected in lower DO levels during this period as a result of decreased solubility.

Southwest Florida Shelf

Since this component of the monitoring program began in 1995 and is only sampled quarterly, there is little trend data to analyze. Although these analyses are very preliminary it is possible to speculate that the clusters are formed as a function of hydrology and circulation patterns. We believe that the inshore cluster clearly shows the input 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 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

Overall, 2003 was relatively unremarkable with no variables deviating much from their grand median. TON revered its slow decline with an increase of 0.035 ppm overall. One thing to look for in the future is the possible development of an increasing trend in TP on the SHELF. As of now it is not statistically significant.

Cape Romano-Pine Island Sound

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 carbonates to silicates, which facilitates transport of phosphorus, and to major land use changes from the Big Cypress National Preserve to suburban and agricultural.

We now have five years of data in the record and can now begin to discuss trends. So far, not much is evident. The largest interannual variations seem to be driven by freshwater releases from the Caloosahatchee River. Aside from a general decline in TOC for the region, 2003 was unremarkable.

ACKNOWLEDGMENTS

We thank all of our many field personnel, laboratory technicians, and data support staff for their diligence and perseverance in this ongoing program. This project was possible due to the continued funding by the South Florida Water Management District (District Contract No. C-15397). We also thank Rookery Bay NERR/FDEP and the captain and crew of the R/V Bellows of the Florida Institute of Oceanography for their field support of the monitoring program.

This report is contribution #T-227 of the Southeast Environmental Research Center at Florida International University.

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1. PROJECT DESCRIPTION

1.1. 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 (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.

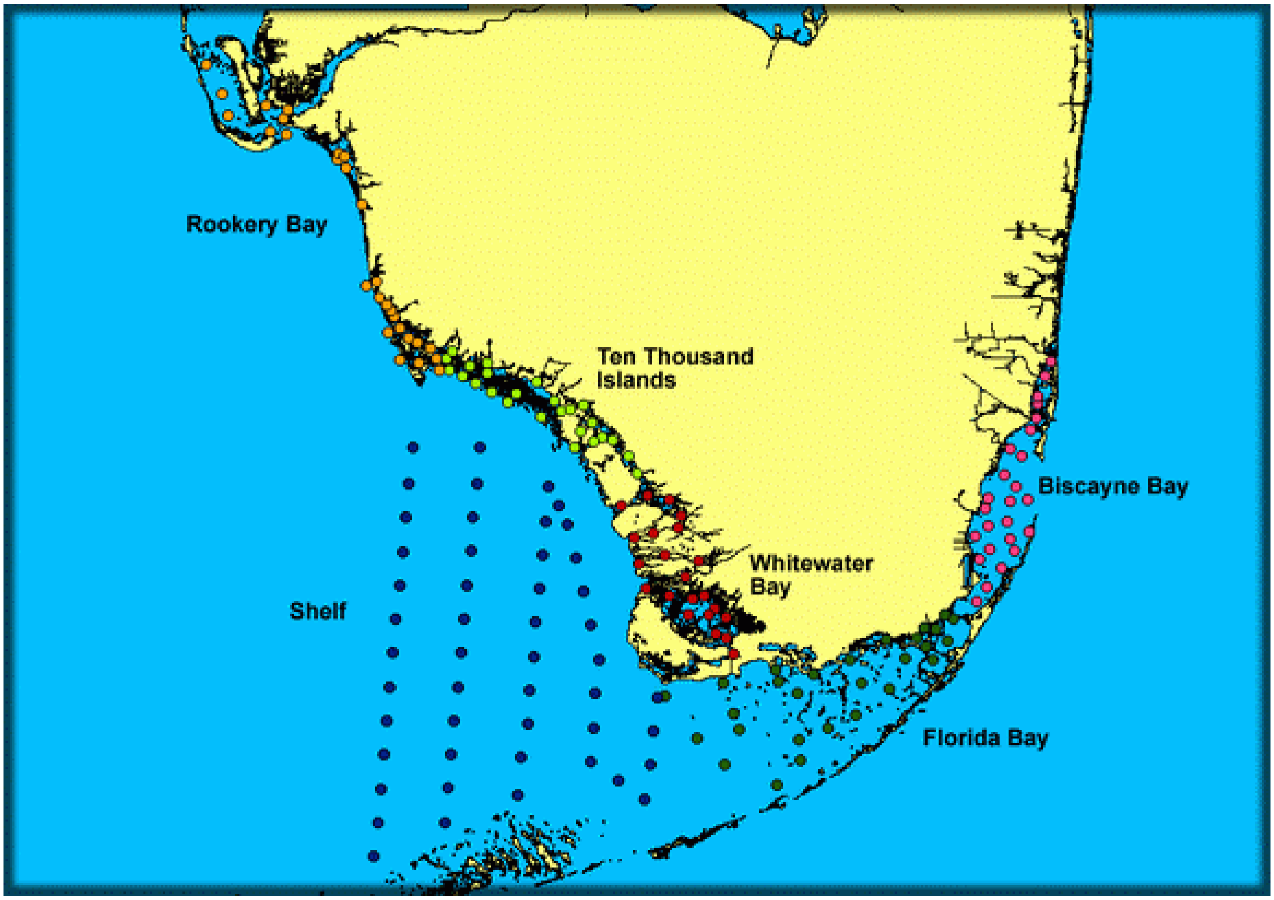

Figure 1.1. Fixed station locations for the SFWMD funded portion of the South Florida Coastal Water Quality Monitoring Network.

1.2. Field and Analytical 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^{-1}), and pH were measured 10 cm below the surface and 10 cm above the bottom using a combination sonde (Hydrolab 140). 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_2-free air. TN was measured using an ANTEK 7000N Nitrogen Analyzer using O_2 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^{-1}). 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 (NO_X^-), nitrite (NO_2^-), ammonium (NH_4^+), and silicate ($Si(OH)_4$) by flow injection analysis (Alpkem model RFA 300). Filters for CHLA content (µg l^{-1}) were allowed to extract for a minimum of 2 days at -20° 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 (NO_3^-) was calculated as NO_X^- - NO_2^-. Dissolved inorganic nitrogen (DIN) was calculated as NO_X^- + NH_4^+. Total organic nitrogen (TON) was defined as TN - DIN. Concentrations for all of these water quality variables are reported in units of milligrams per liter (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.

1.3. References

APHA. 1999. Standard Methods for the Examination of Water and Wastewater.

EPA Methods for Chemical Analysis of Water and Wastes, Revised March 1983.

Frankovich, T. A., and R. D. Jones. 1998. A rapid, precise, and sensitive method for the determination of total nitrogen in natural waters. *Marine Chemistry* **60**: 227-234.

Hashimoto, Kitao, and Keiichiro. 1985. Relationship between alkaline phosphatase activity and orthophosphate in the present Tokyo Bay. *Environ. Sci. Health* **A20**: 781-908)

Solorzano, L., and J. H. Sharp. 1980. Determination of total dissolved phosphorus and particulate phosphorus in natural waters. *Limnol. Oceanogr*. **25**: 754-758.

2. STATE OF WATER QUALITY IN FLORIDA BAY

Overall Period of Record

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. 2.1). 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.

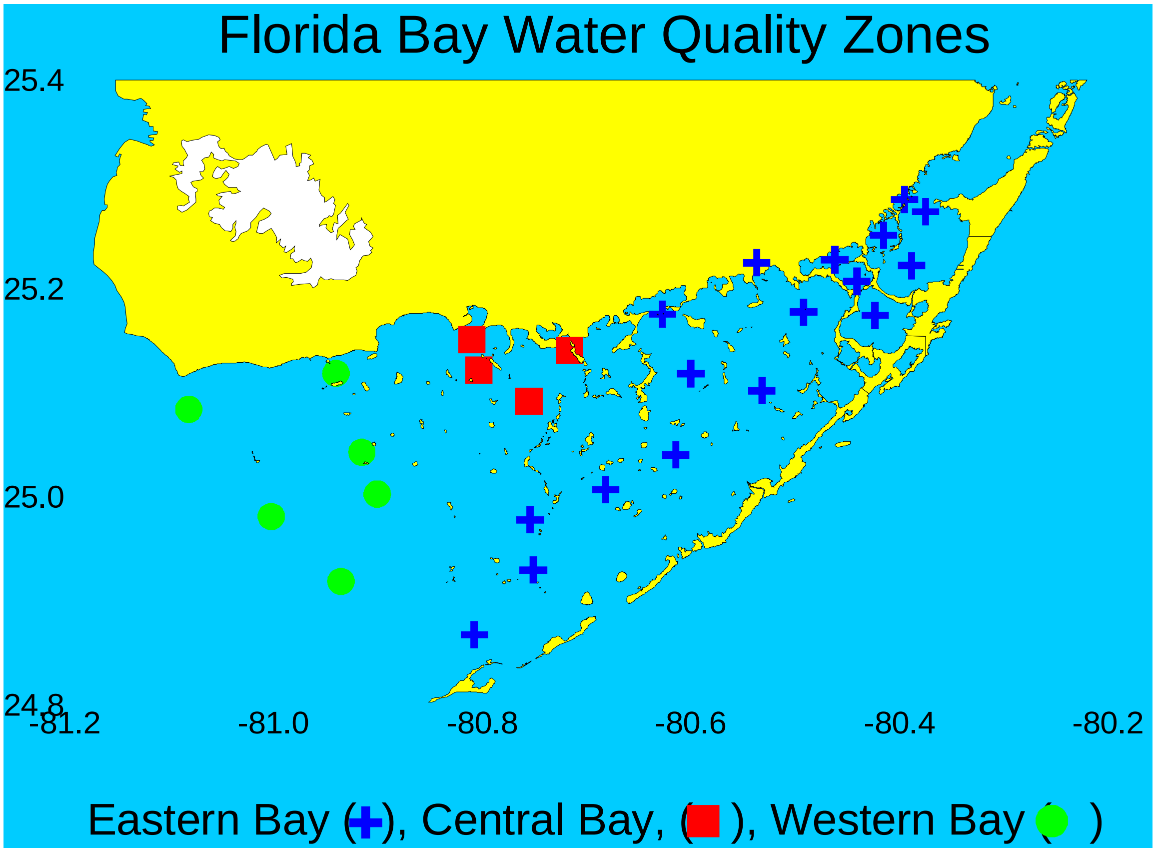

Figure 2.1. Zones of similar water quality in Florida Bay

Climactic changes occurring over the data collection period of record had major effects on the health of the bay. Precipitation rebounded from the drought during the late 80's being equal to or greater than the long term average (142 cm yr^{-1}) for 9 of the last 13 years (Fig 2.2.). 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. 2.3). 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 smaller.

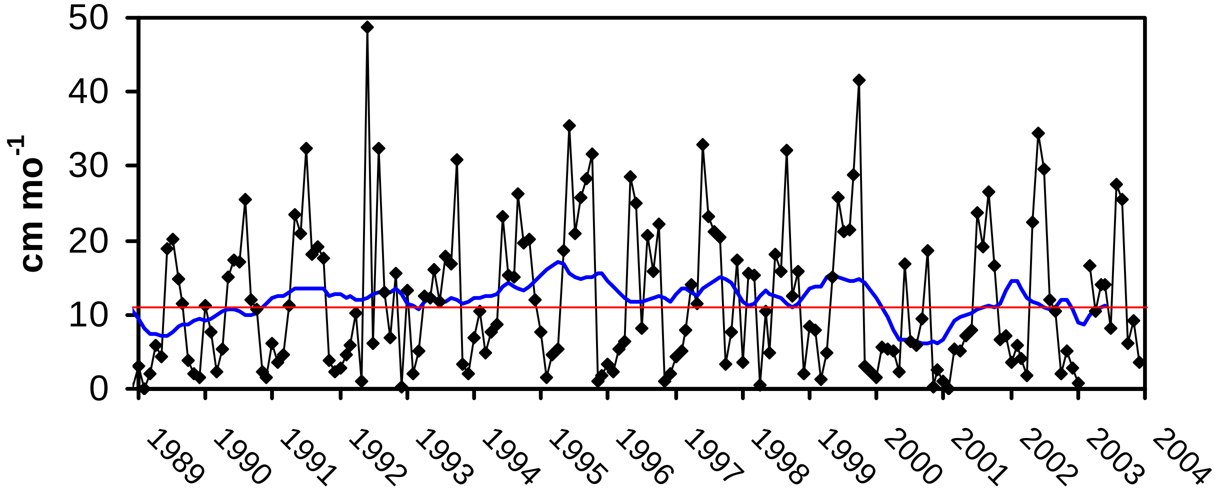

Figure 2.2. Monthly rainfall in the Florida Bay area. The red line is long term average; the blue line is 12 month moving average.

Chlorophyll *a* concentrations (CHLA), a proxy for phytoplankton biomass, were particularly dynamic and spatially heterogeneous (Fig. 2.4). 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 µg l^{-1} or 63%. Most of this decline occurred over a few months in the spring/summer of 1994 and has remained relatively stable. 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 µg 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 all throughout 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 13 year period of record (Fig. 2.5). As with salinity, most of these declines occurred in the early 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. 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. It is 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 dissolved inorganic nitrogen assemblage (DIN) is made up of ammonium (NH_4^+), nitrate (NO_3^-), and nitrate (NO_2^-). The Western Bay is lowest in DIN; phytoplankton in this region may be limited by N availability on a regular basis (Fig. 2.6). DIN in the Eastern Bay is a little higher and is mostly in the form of NO_3^- while highest levels are found in the Central Bay as NH_4^+.

Turbidity in the Central and Western Bays have increased greatly since 1991 (Fig. 2.7). 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.

2003 Alone

2003 was a very "average" year; most water quality variables followed typical annual trends. Due to wet spring rainfall, most of the bay did not experience any prolonged periods of hypersalinity. However, water temperatures in the bay were ~1 °C higher than the grand median. TON reversed its downward trend with a jump of 0.02 ppm baywide; TP continued its slow downward trend. DO was also lower in 2003 than the grand median for the bay. Annual patterns in CHLA, DIN, and turbidity were unremarkable with values generally fluctuating around the median for all areas of the bay.

Data, Graphs, and Figures

All data for the period of record are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm
Monthly time series graphs for all measured variables for each station are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/FB.htm
Contour maps showing spatial distributions of all measured variables (quarterly) are available at:
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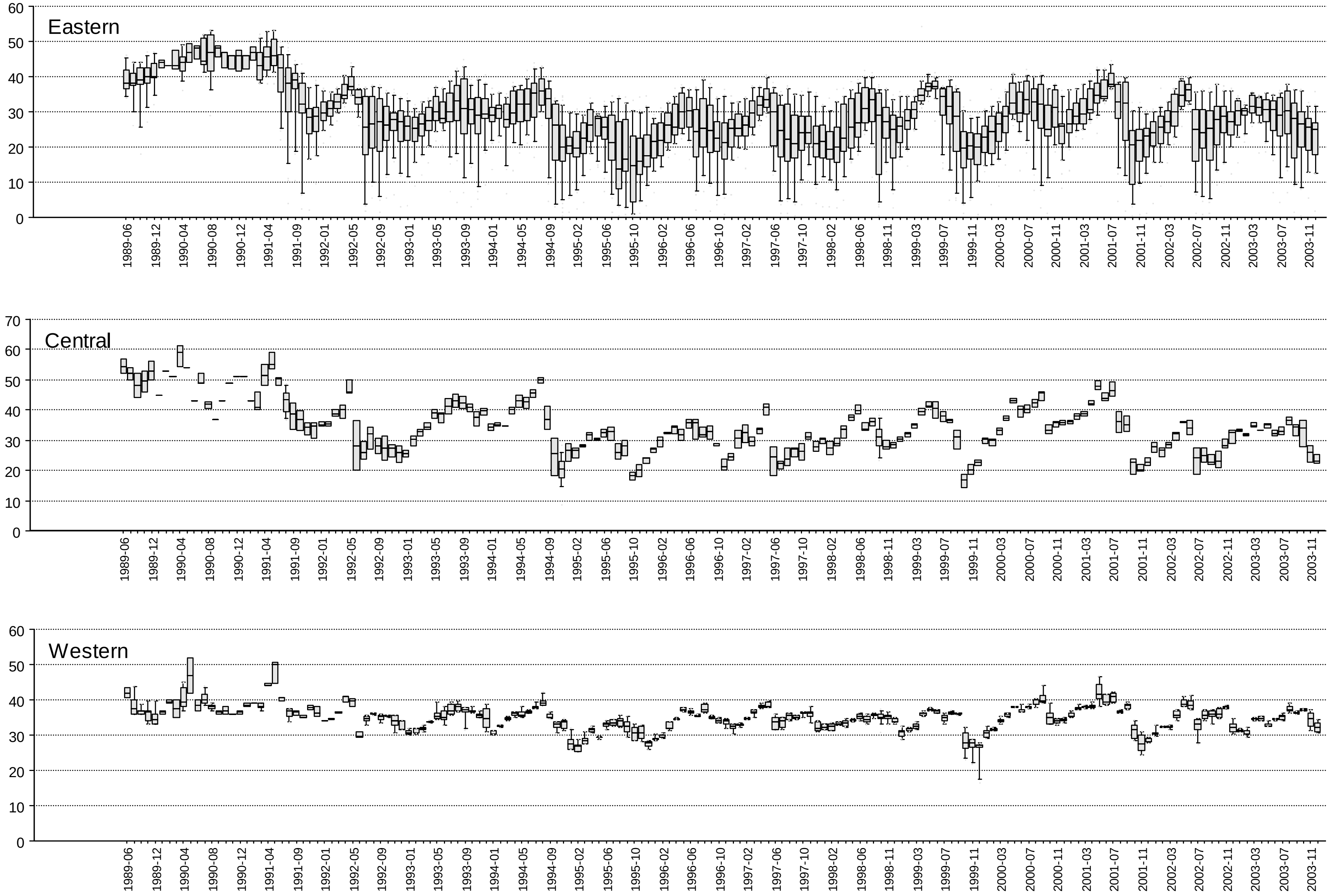

Figure 2.3. Monthly median and range of salinity in the three Florida Bay zones.

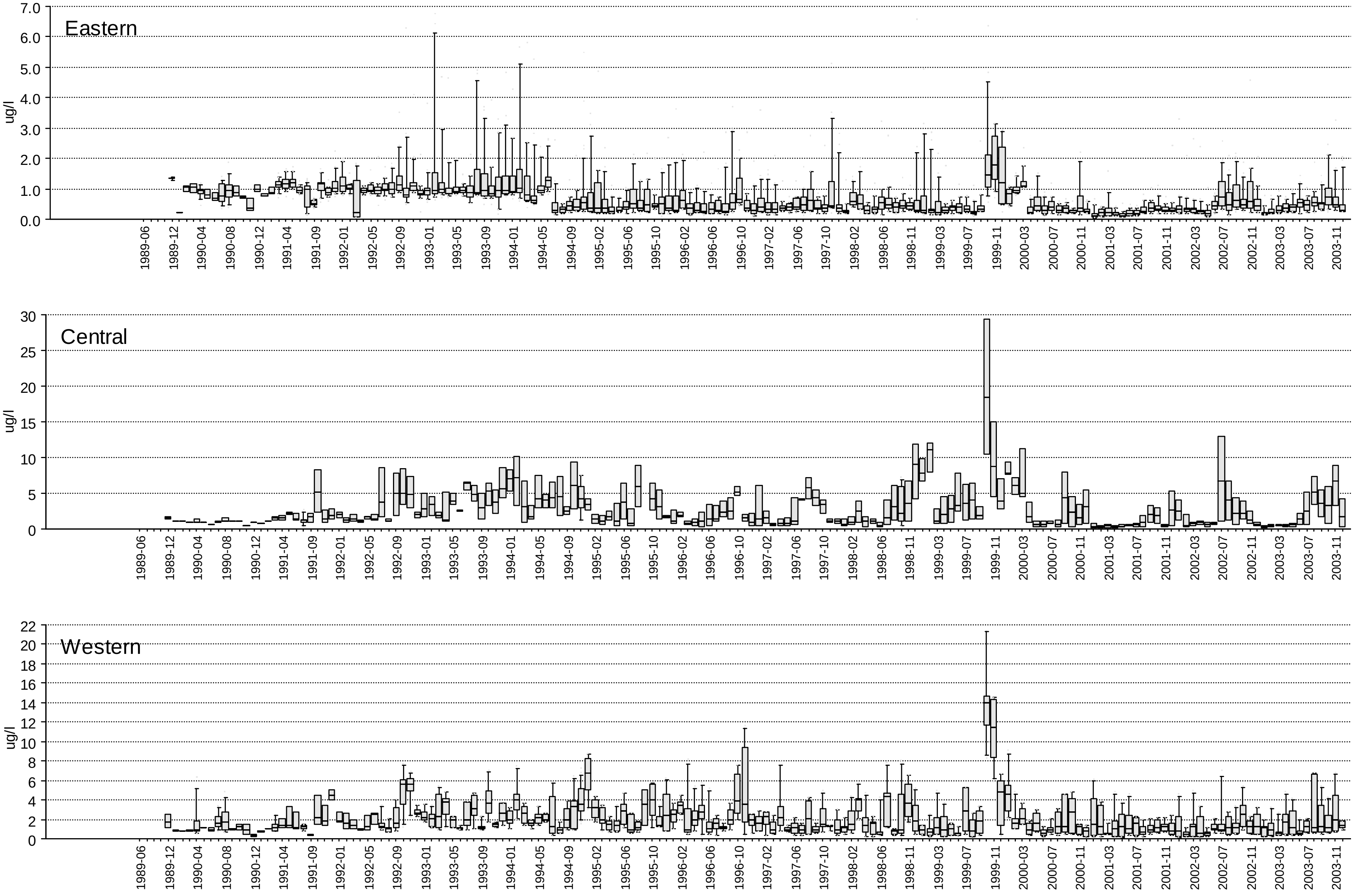

Figure 2.4. Monthly median and range of CHLA in the three Florida Bay zones.

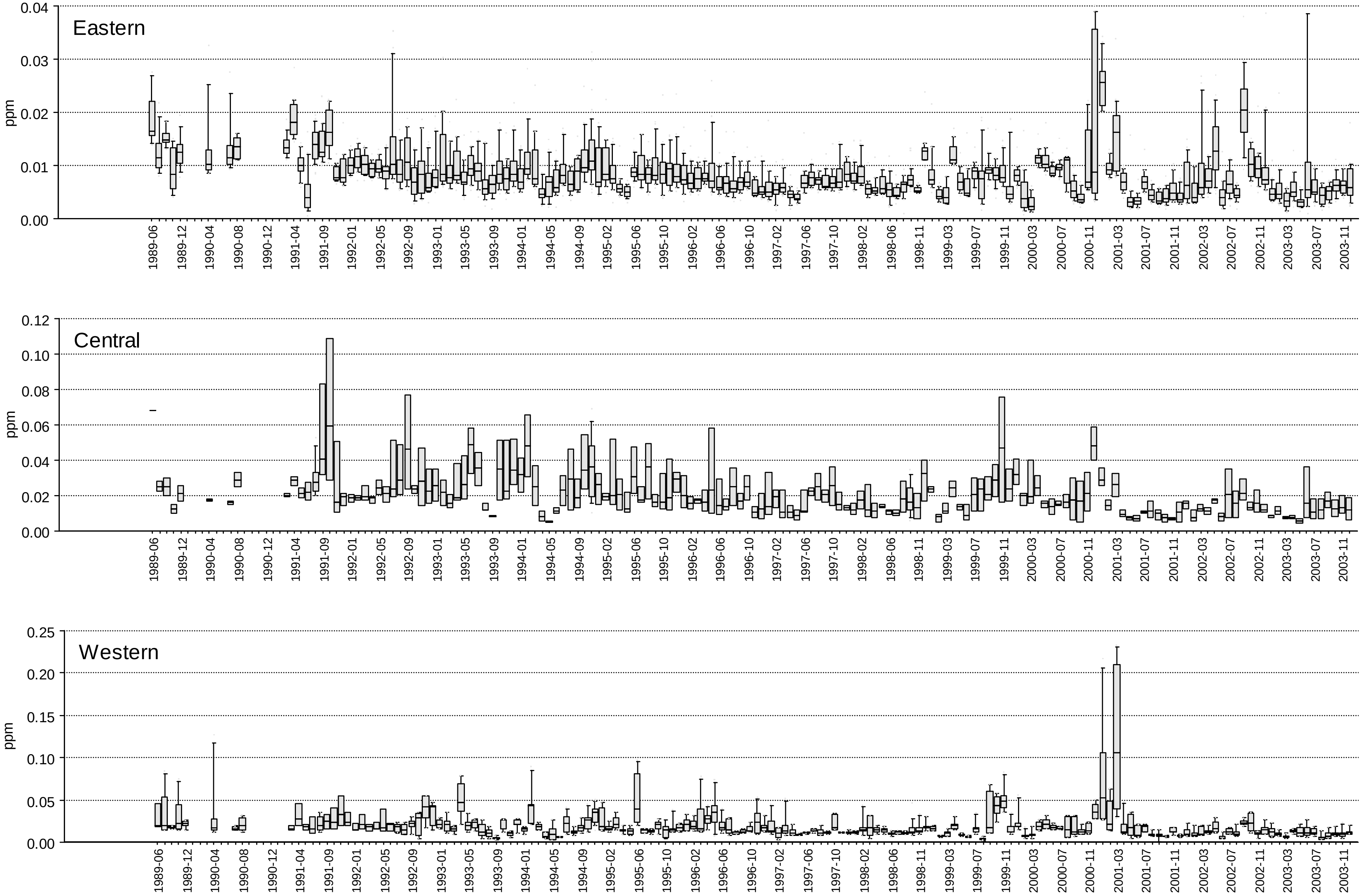

Figure 2.5. Monthly median and range of TP in the three Florida Bay zones.

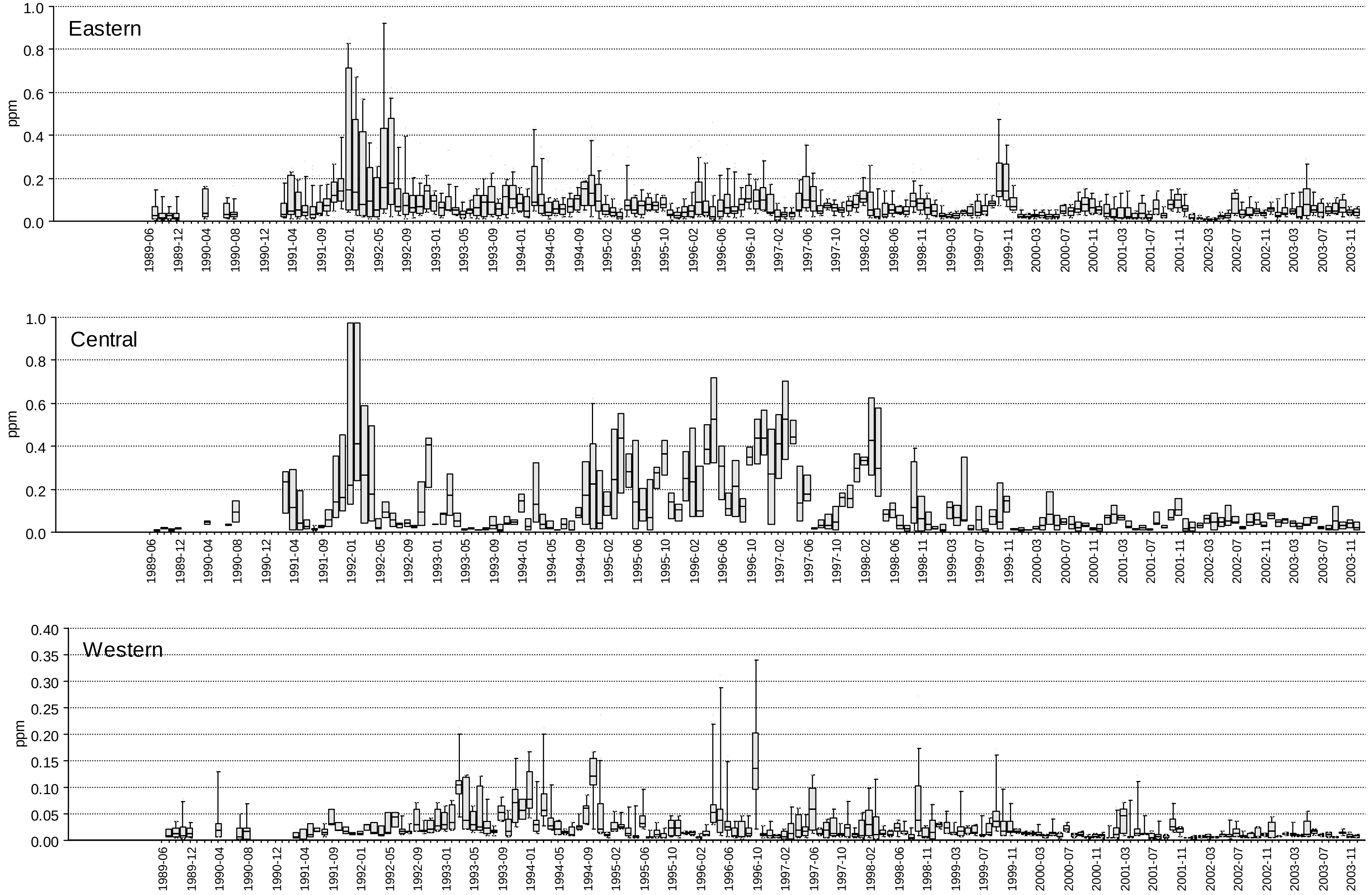

Figure 2.6. Monthly median and range of DIN in the three Florida Bay zones.

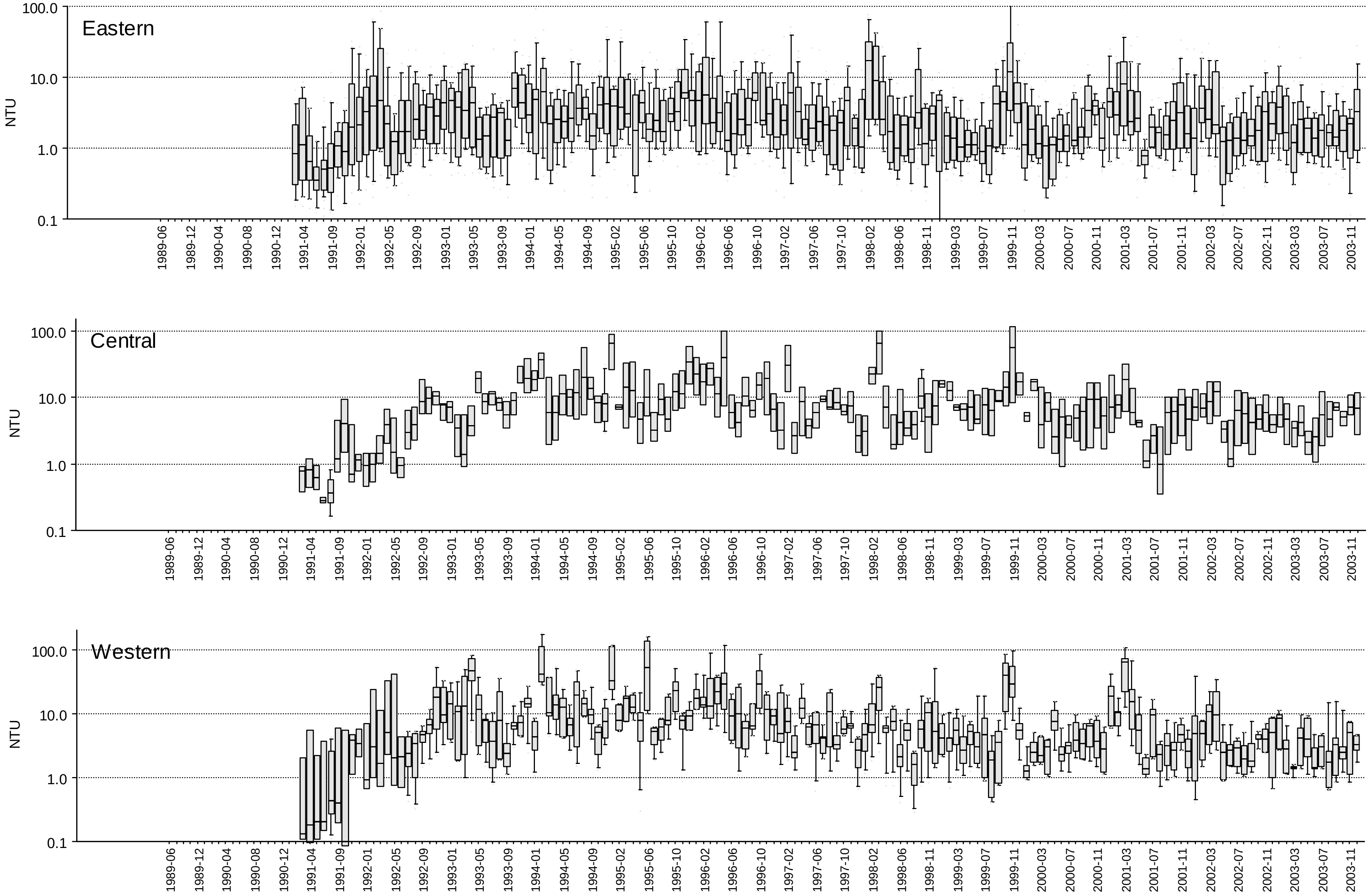

Figure 2.7. Monthly median and range of turbidity in the three Florida Bay zones.

3. STATE OF WATER QUALITY IN WHITEWATER BAY - TEN THOUSAND ISLANDS COMPLEX

Overall Period of Record

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. 3.1). 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.

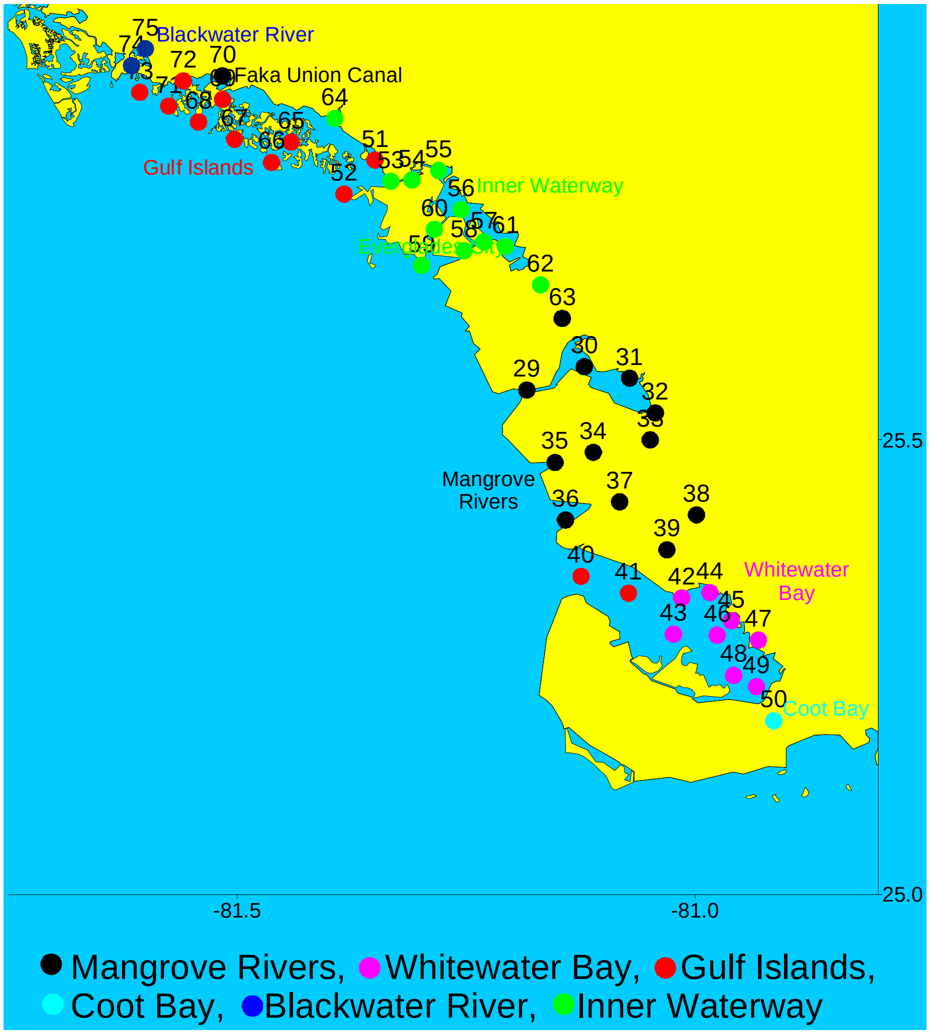

Figure 3.1. Zones of similar water quality in Whitewater Bay-Ten Thousand Islands complex

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. 3.2). 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 (Fig 3.3). 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 (Fig. 3.4). The spatial distribution of DIN was generally opposite to that of TP (Fig. 3.5). 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 (Fig. 3.6). 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.

2003 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. No hypersaline events were observed, as 2003 was a normal year of precipitation. Except for a small summer increase in Whitewater Bay and Gulf Islands CHLA, levels of TP and DIN were relatively unremarkable. Finally, TON and TOC continued their slow, long term downward trend in the Mangrove Rivers.

Data, Graphs, and Figures

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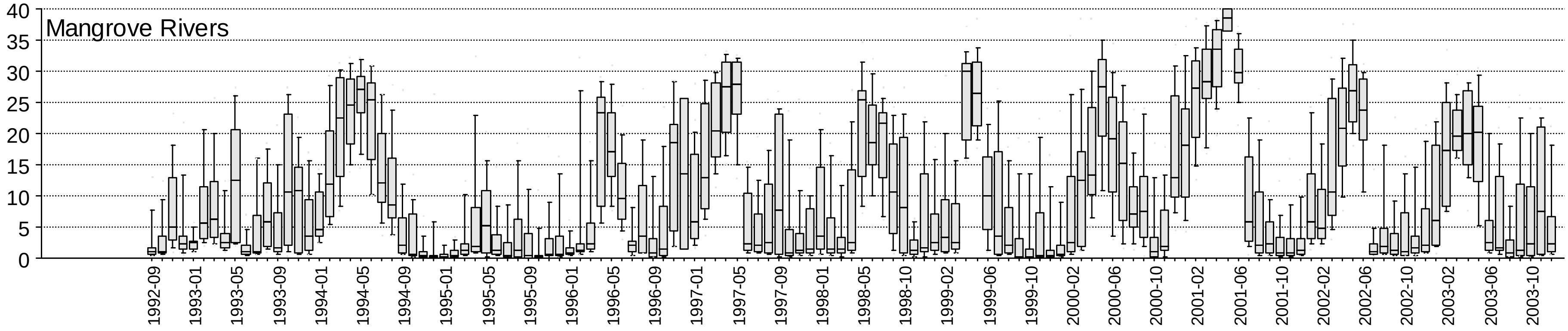

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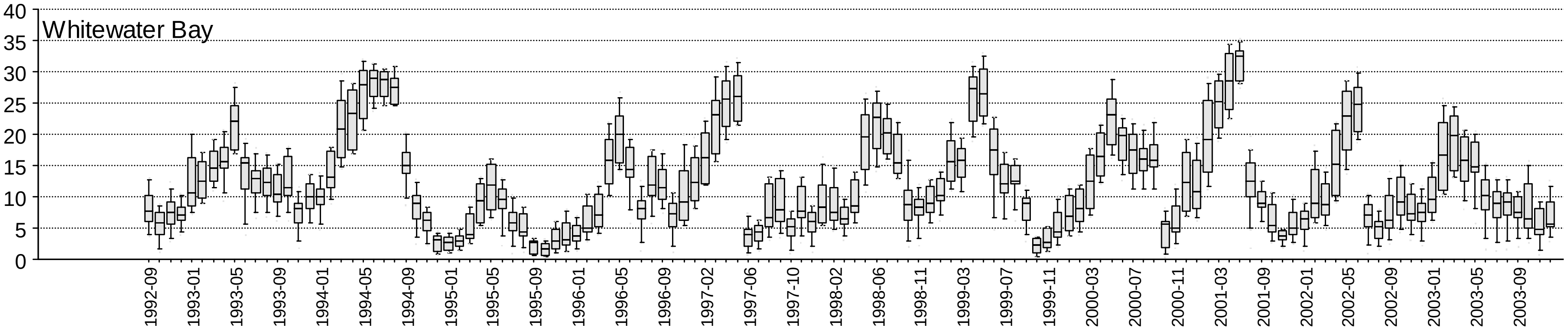

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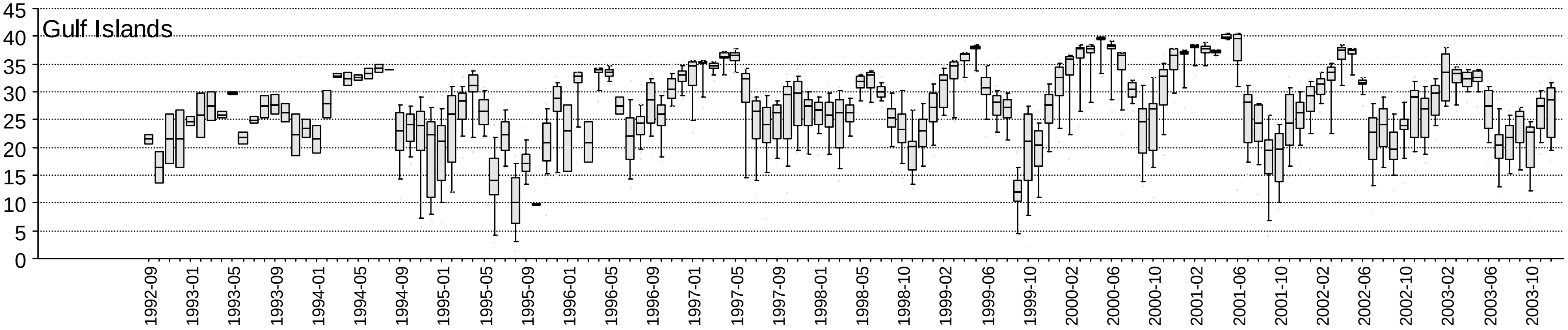

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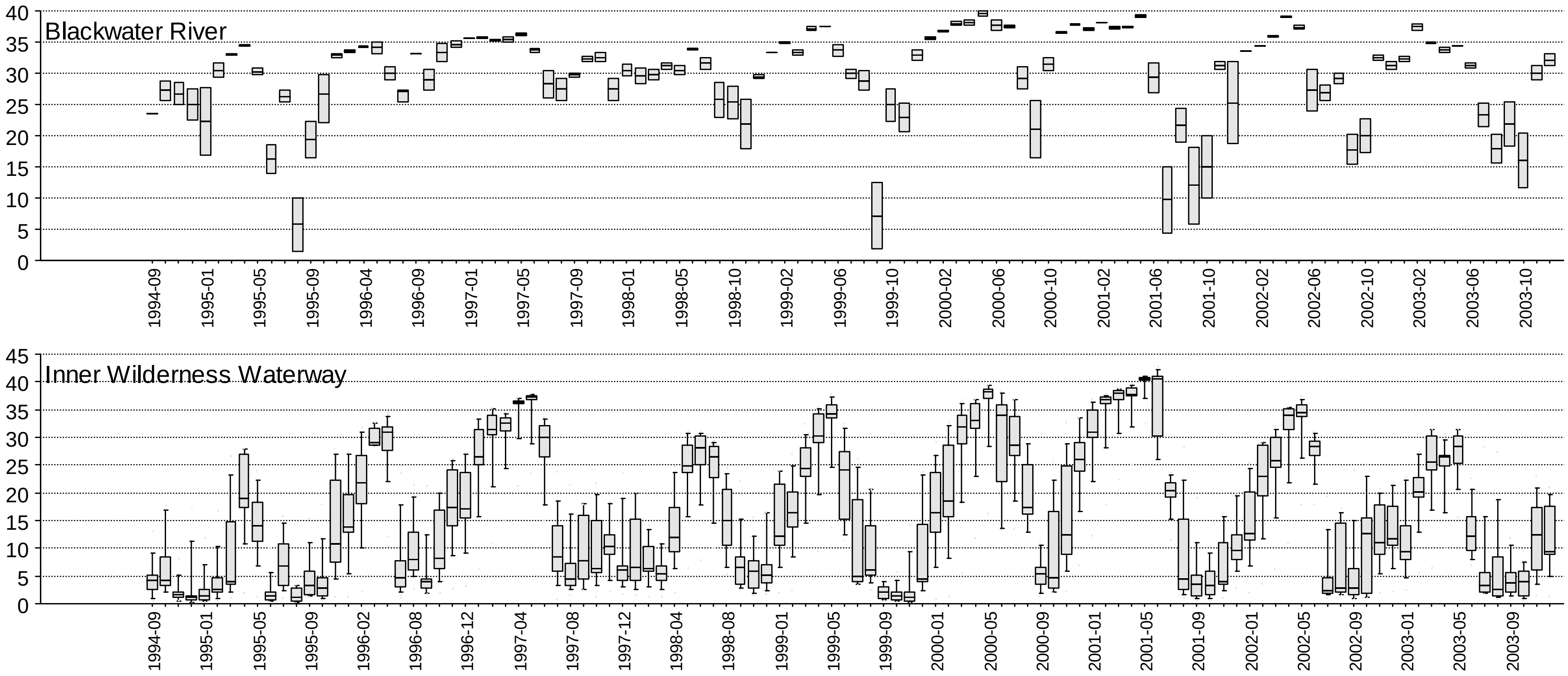
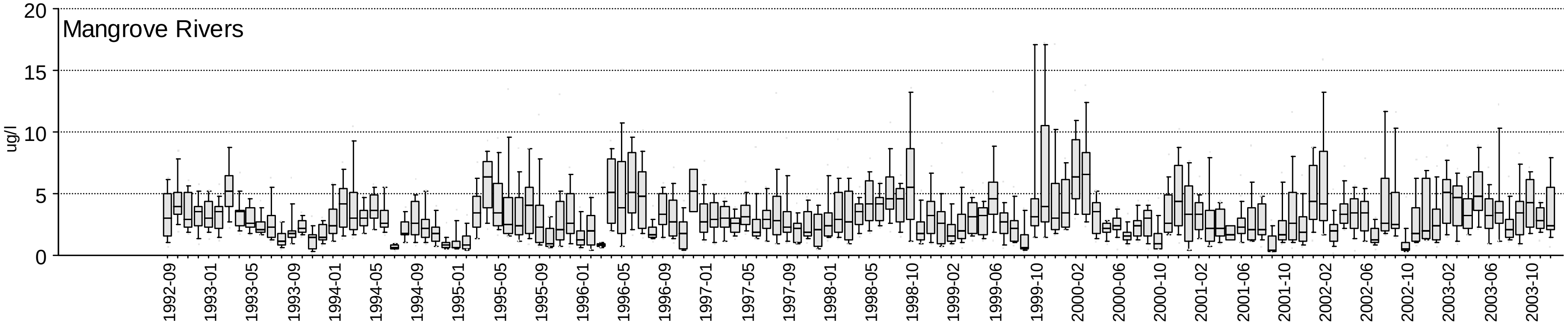


Figure 3.2. Monthly median and range of salinity in the five WWB-TTI zones.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2000-06
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2001-10
2002-02
2002-06
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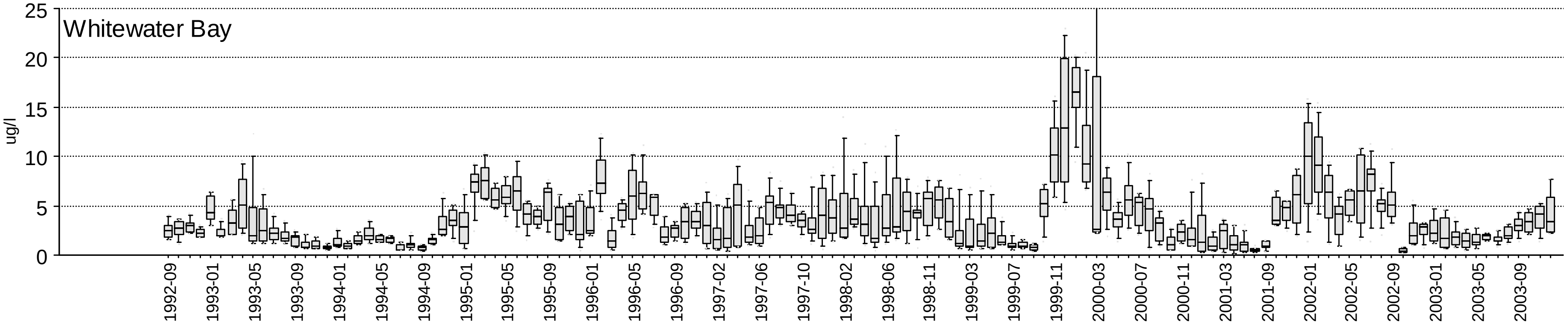
2003-06
2003-10


Whitewater Bay
ug/l
25
20
15
10
5
0
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
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1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-02
1997-06
1997-10
1998-02
1998-06
1998-11
1999-03
1999-07
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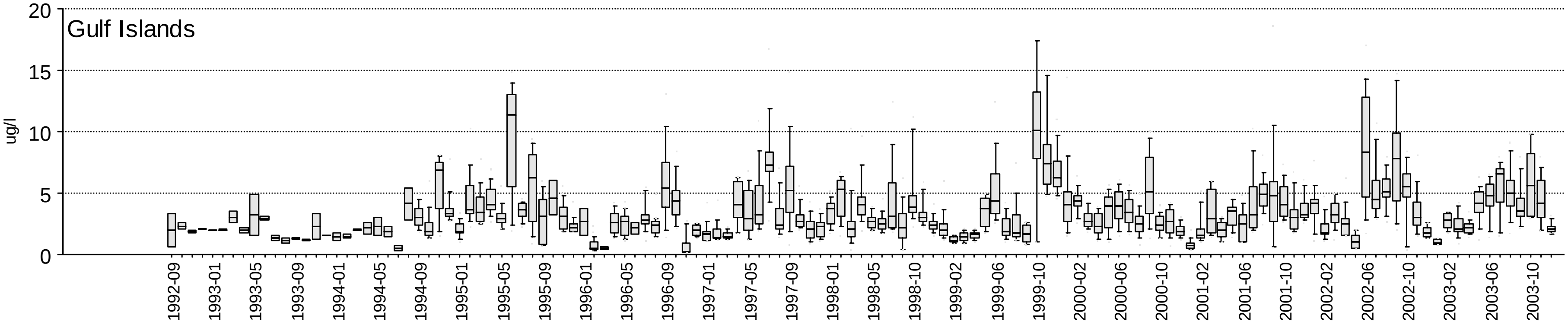
2003-05
2003-09


Gulf Islands
ug/l
20
15
10
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1993-01
1993-05
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1995-05
1995-09
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1996-09
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1997-09
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1999-02
1999-06
1999-10
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2003-10

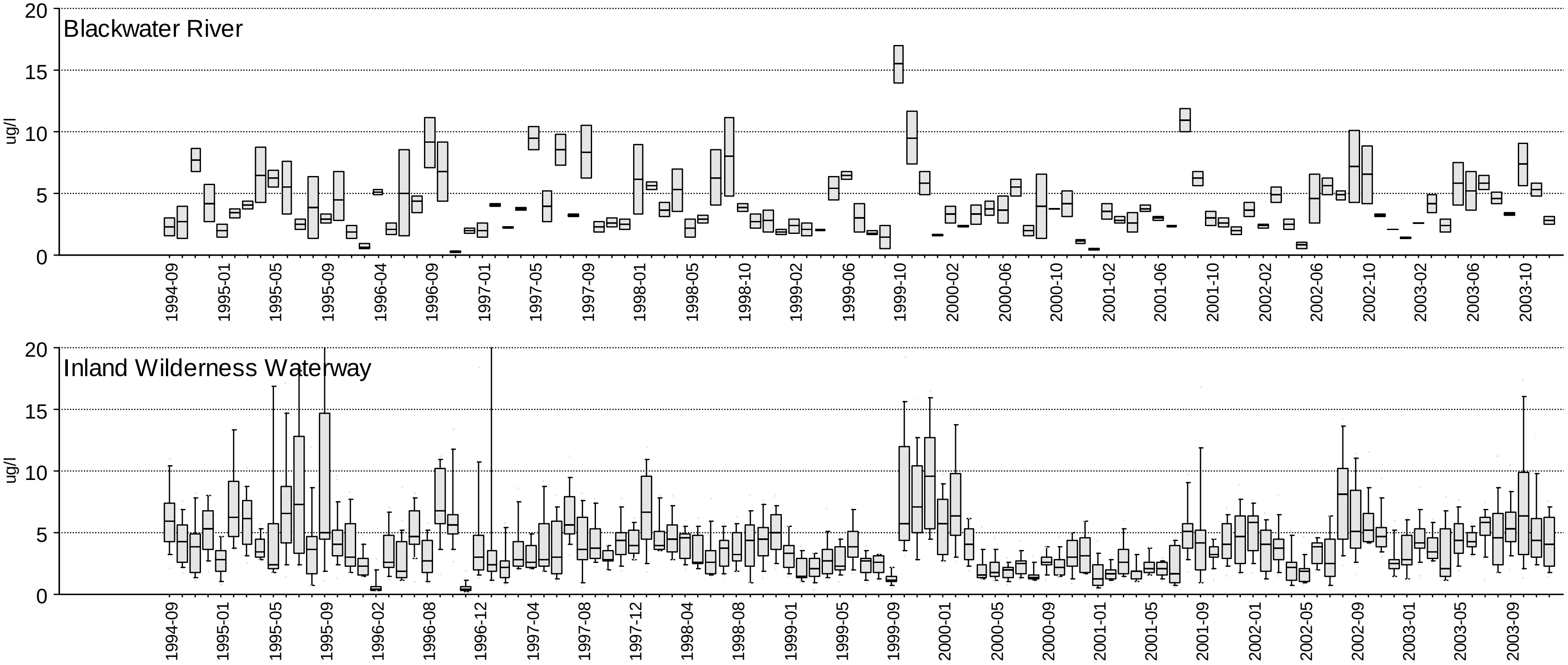
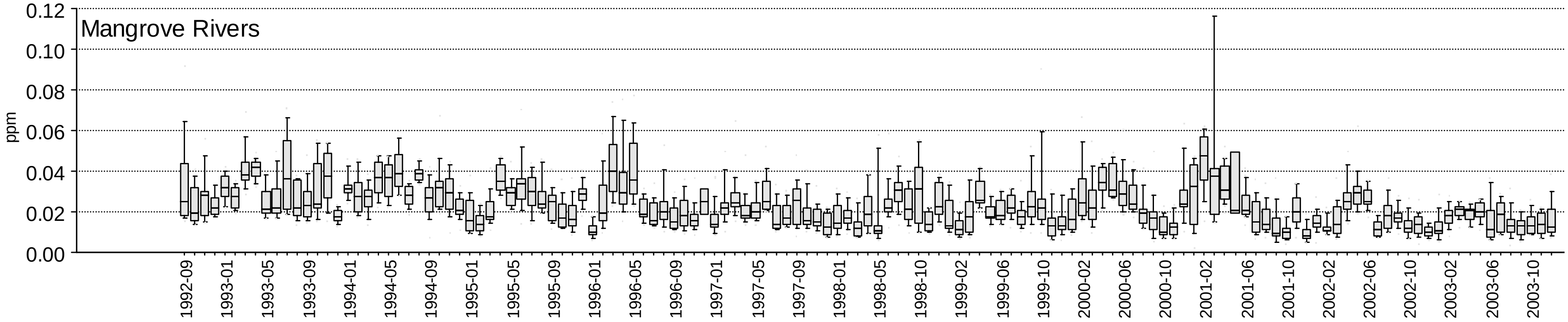


Figure 3.3. Monthly median and range of chlorophyll *a* in the five WWB-TTI zones.


Mangrove Rivers
ppm
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
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2000-06
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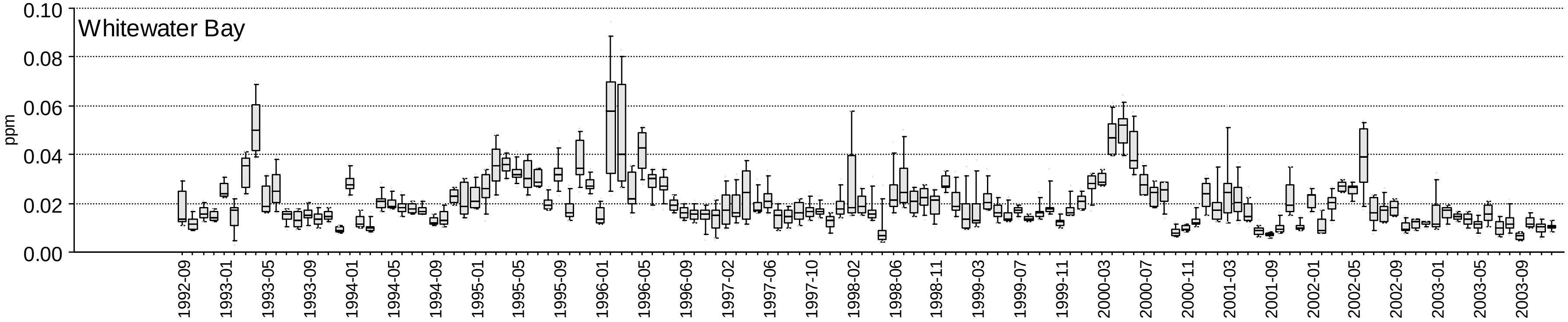
2001-02
2001-06
2001-10
2002-02
2002-06
2002-10
2003-02
2003-06
2003-10


Whitewater Bay
ppm
0.10
0.08
0.06
0.04
0.02
0.00
1992-09
1993-01
1993-05
1993-09
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1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
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1997-02
1997-06
1997-10
1998-02
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1998-11
1999-03
1999-07
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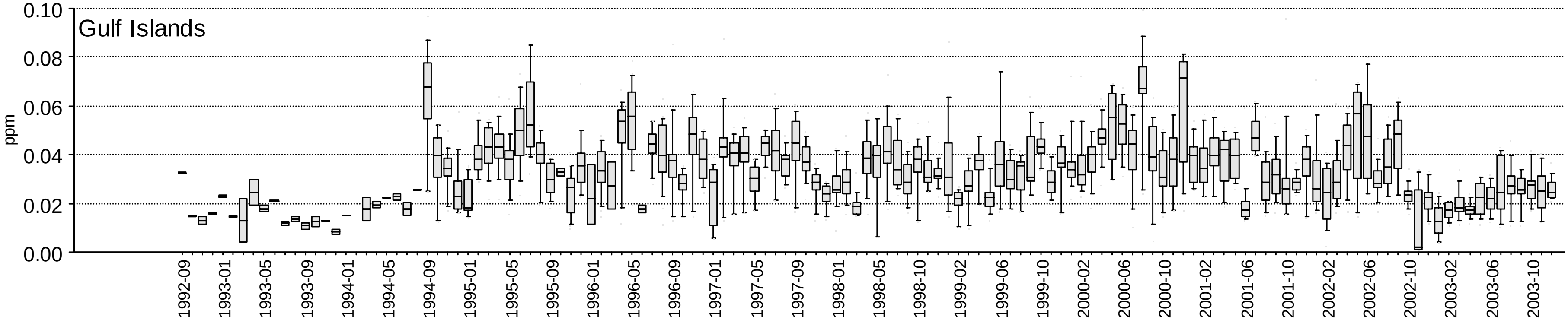
2002-05
2002-09
2003-01
2003-05
2003-09


Gulf Islands
ppm
0.10
0.08
0.06
0.04
0.02
0.00
1992-09
1993-01
1993-05
1993-09
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1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
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1999-02
1999-06
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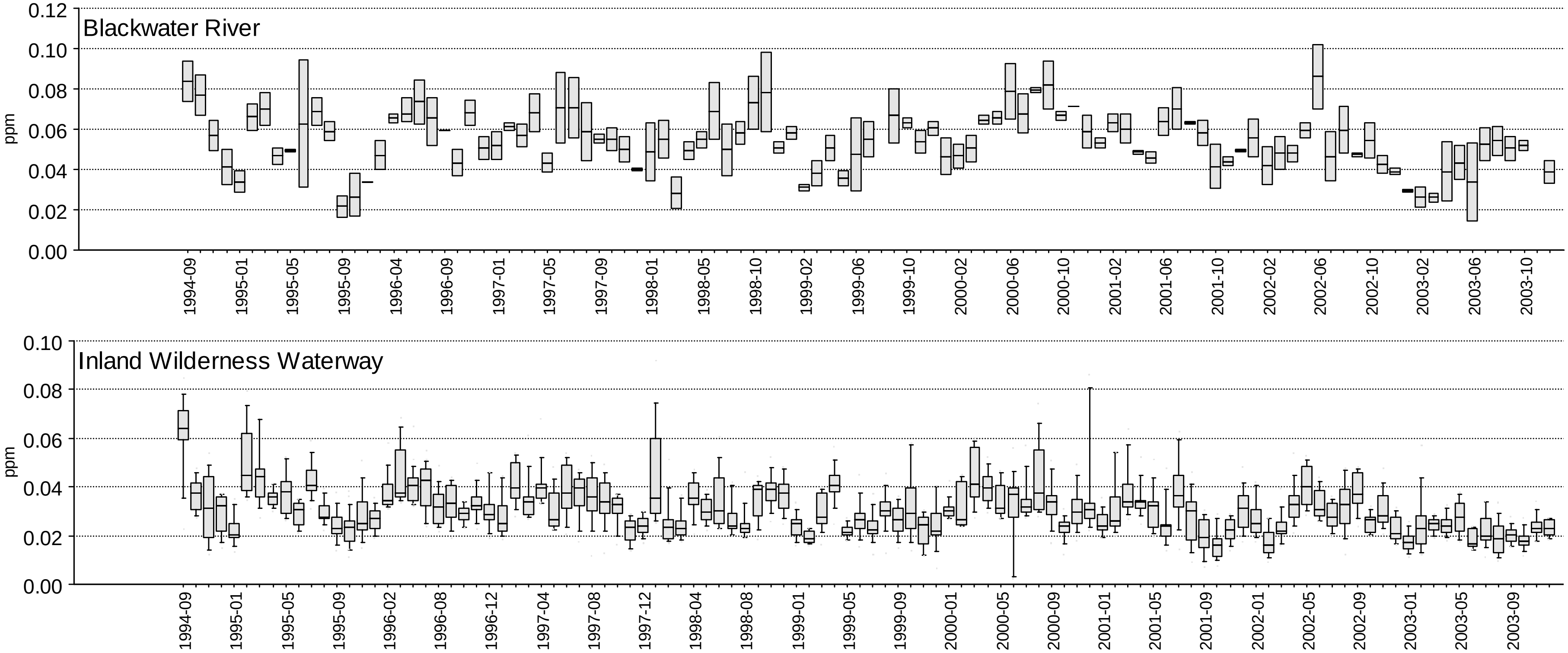
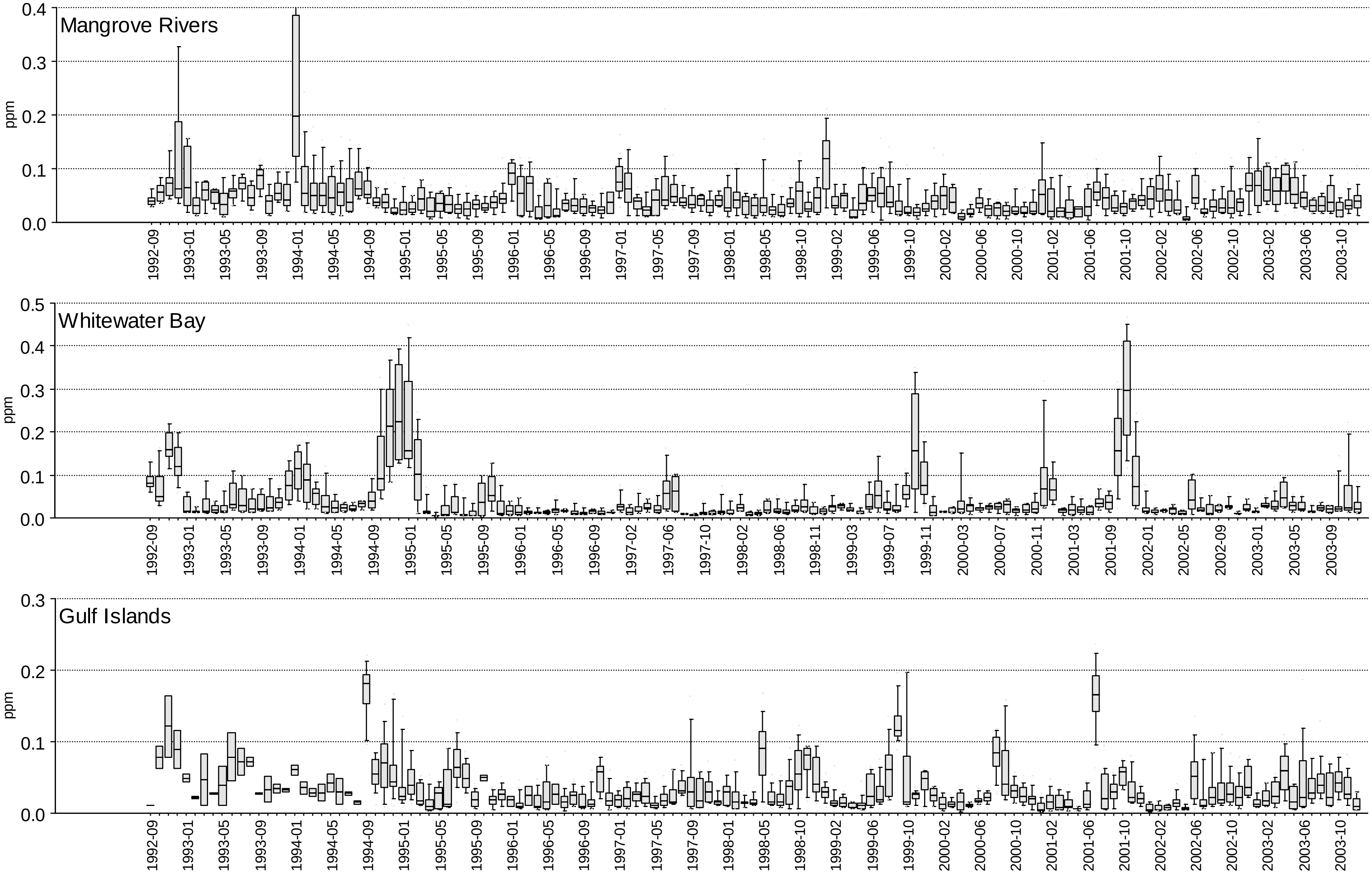


Figure 3.4. Monthly median and range of total phosphorus in the five WWB-TTI zones.


Mangrove Rivers
ppm
0.4
0.3
0.2
0.1
0.0
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-02
2001-06
2001-10
2002-02
2002-06
2002-10
2003-02
2003-06
2003-10
Whitewater Bay
ppm
0.5
0.4
0.3
0.2
0.1
0.0
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-02
1997-06
1997-10
1998-02
1998-06
1998-11
1999-03
1999-07
1999-11
2000-03
2000-07
2000-11
2001-03
2001-09
2002-01
2002-05
2002-09
2003-01
2003-05
2003-09
Gulf Islands
ppm
0.3
0.2
0.1
0.0
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
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1999-02
1999-06
1999-10
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2003-10

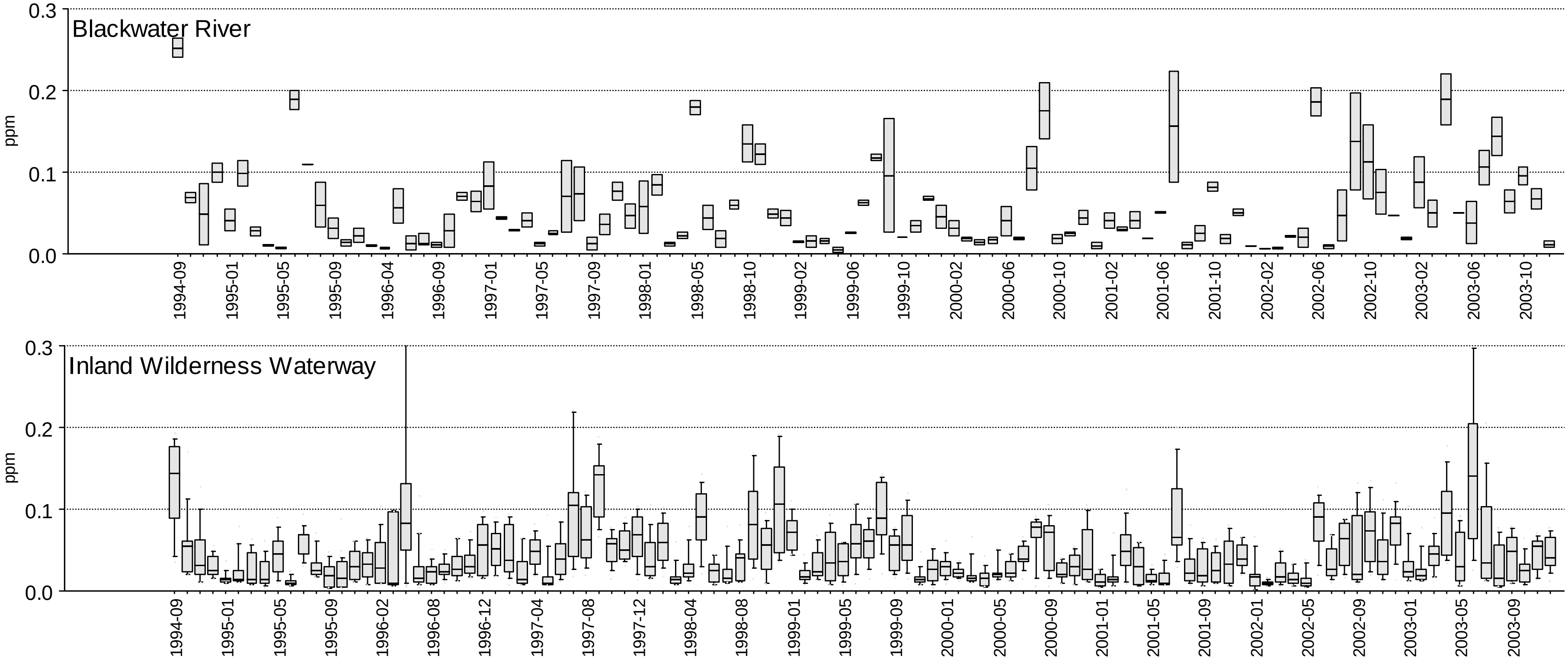
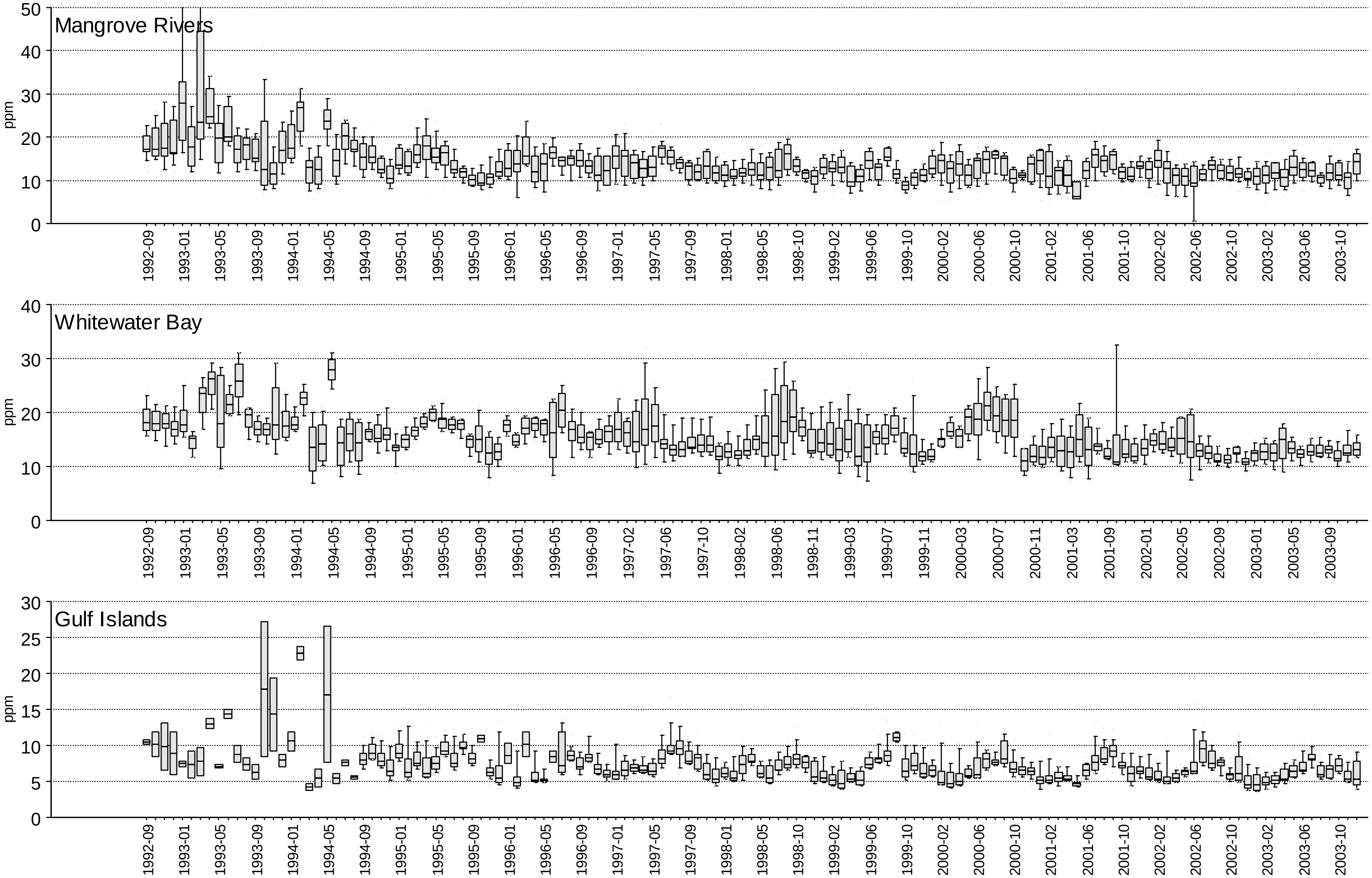


Figure 3.5. Monthly median and range of dissolved inorganic nitrogen in the five zones.


Mangrove Rivers
ppm
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10
20
30
40
50
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1993-05
1993-09
1994-01
1994-05
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1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-02
2001-06
2001-10
2002-02
2002-06
2002-10
2003-02
2003-06
2003-10
Whitewater Bay
ppm
0
10
20
30
40
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-02
1997-06
1997-10
1998-02
1998-06
1998-11
1999-03
1999-07
1999-11
2000-03
2000-07
2000-11
2001-03
2001-09
2002-01
2002-05
2002-09
2003-01
2003-05
2003-09
Gulf Islands
ppm
0
5
10
15
20
25
30
1992-09
1993-01
1993-05
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
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1999-02
1999-06
1999-10
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2003-02
2003-06
2003-10

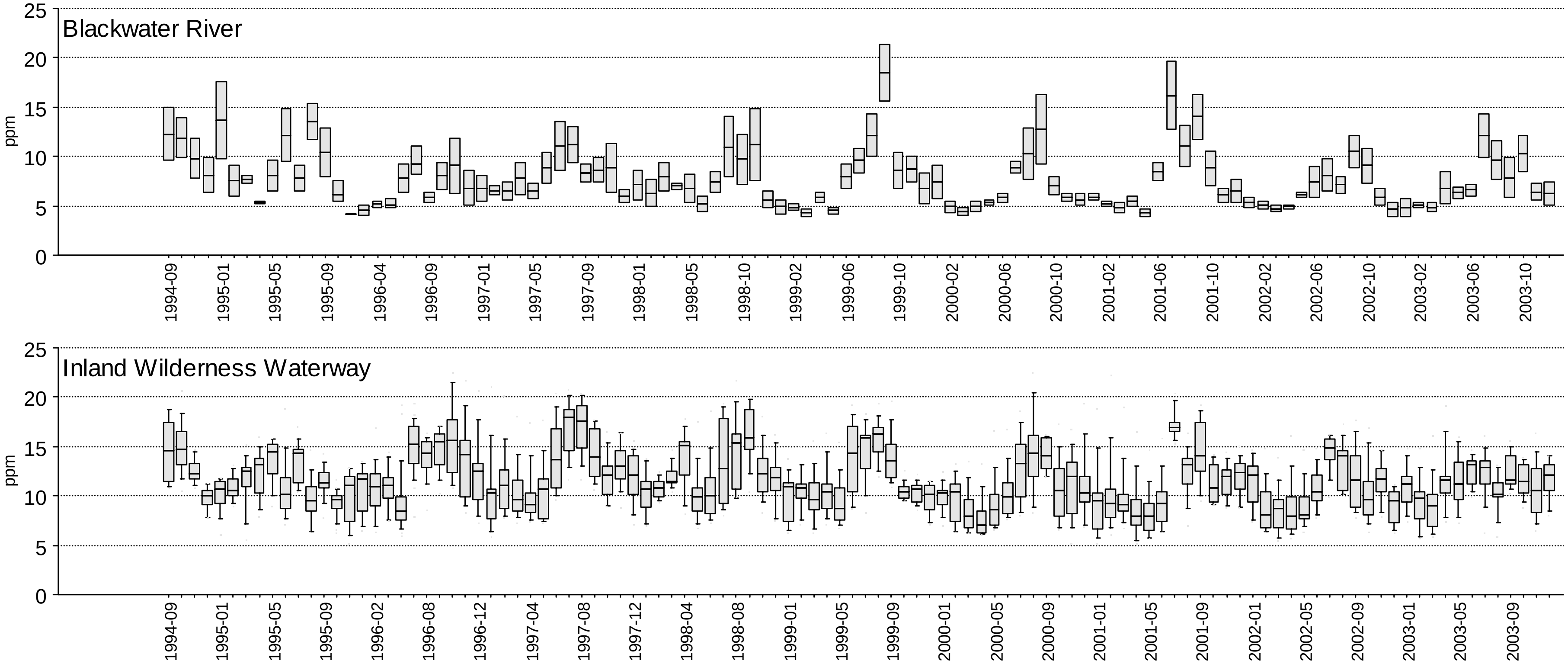


Figure 3.6. Monthly median and range of total organic carbon in the five WWB-TTI zones.

4. STATE OF WATER QUALITY IN BISCAYNE BAY

<u>Overall Period of Record</u>

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. 4.1). 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).

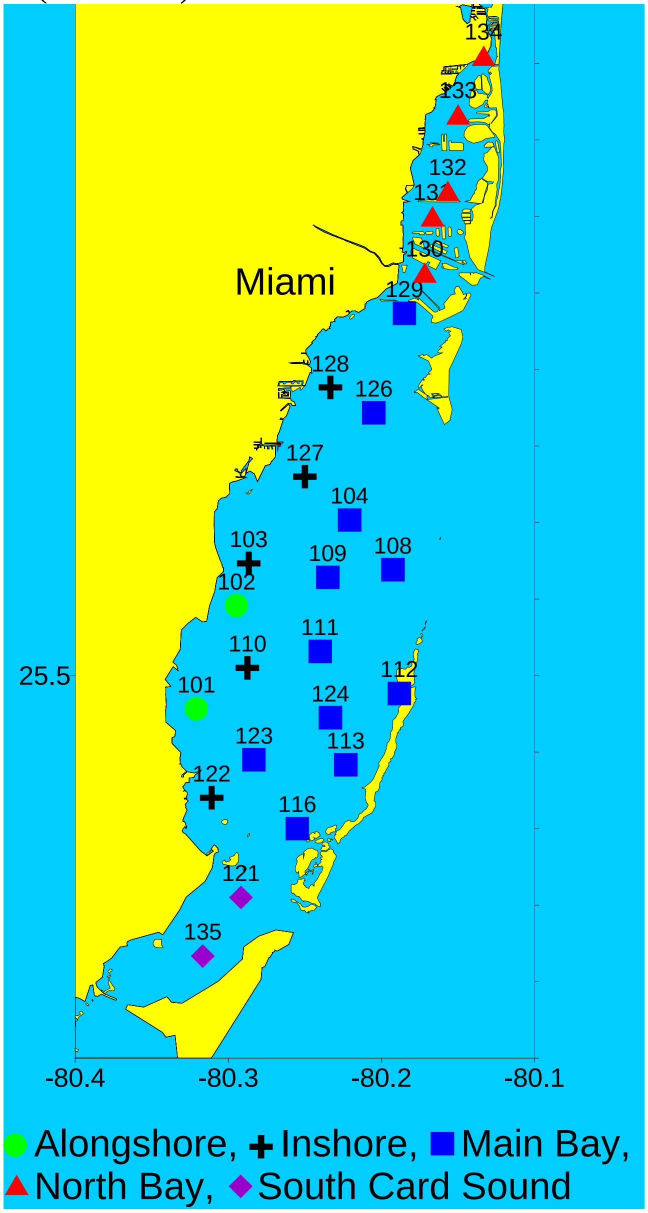


Figure 4.1. Zones of similar water quality in Biscayne Bay.

As mentioned previously, 10 stations were selected for their status as being either redundant (as in some of the Main Bay stations) or as outliers (Turkey Point and the ocean channel sites) and redistributed throughout the Bay to provide us with more complete coverage. For purposes of this report, the stations added to the area north of the Rickenbacker Causeway are defined, a priori, as a distinct cluster, North Bay (NBAY).

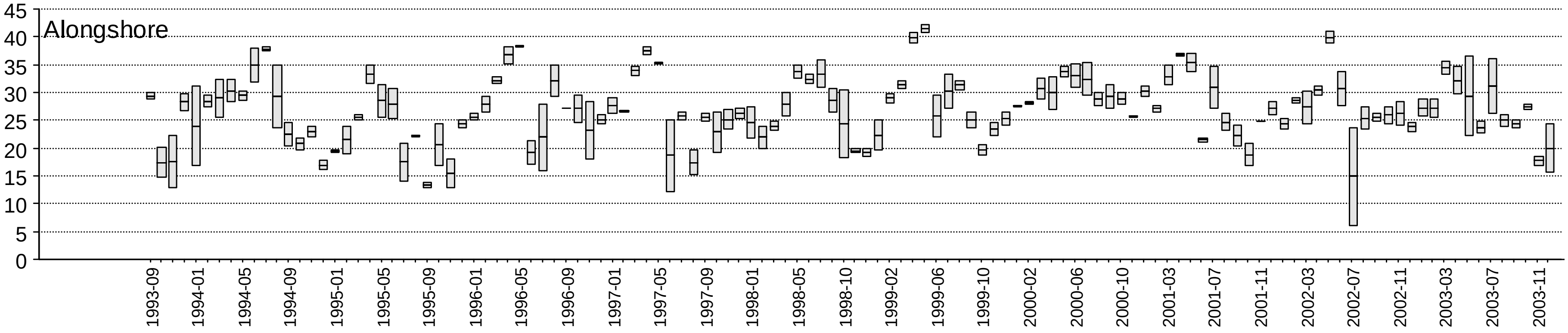
There was a gradient of increasing salinity with distance from the west coast of the Bay (AS <IS <MAIN clusters Fig. 4.2). Opposite to the salinity gradient, highest concentrations of CHLA, DIN, and TP were observed near the coast (Fig. 4.3, 4.4, & 4.5). These type of gradients are indicative of anthropogenic 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).

2003 Alone

Salinity in Biscayne Bay is strongly influenced by its large tidal exchange with the ocean. Nevertheless, canal inputs have a significant impact as evidenced by the irregular salinity fluctuations. 2003 was an unremarkable year for salinity, DIN, CHLA, and turbidity. The past years' increases in TP concentrations were reversed in 2003. This is a trend we must watch closely to see if other impacts to the Biscayne Bay's ecosystem become noticeable. TON reversed its slow decline in 2003 with a jump in concentrations of 0.045 ppm baywide. This was in direct contrast to the overall decline in TOC observed since 1997. Water temperature in Biscayne Bay jumped a full 1 °C over long term median. This change was reflected in lower DO levels during this period as a result of decreased solubility.

Data, Graphs, and Figures

All data for the period of record are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm
Monthly time series graphs for all measured variables for each station are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/BB.htm
Contour maps showing spatial distributions of all measured variables (quarterly) are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm


Alongshore
0
5
10
15
20
25
30
35
40
45
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-03
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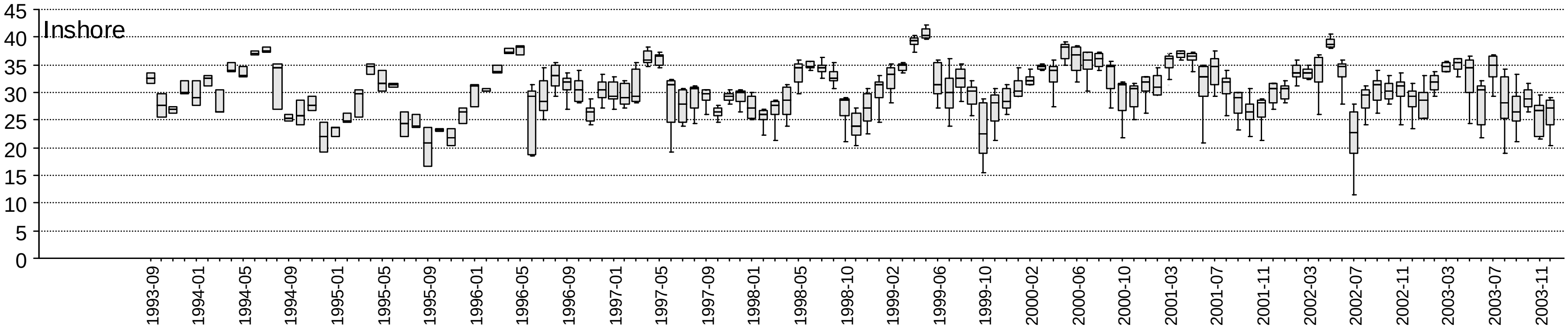
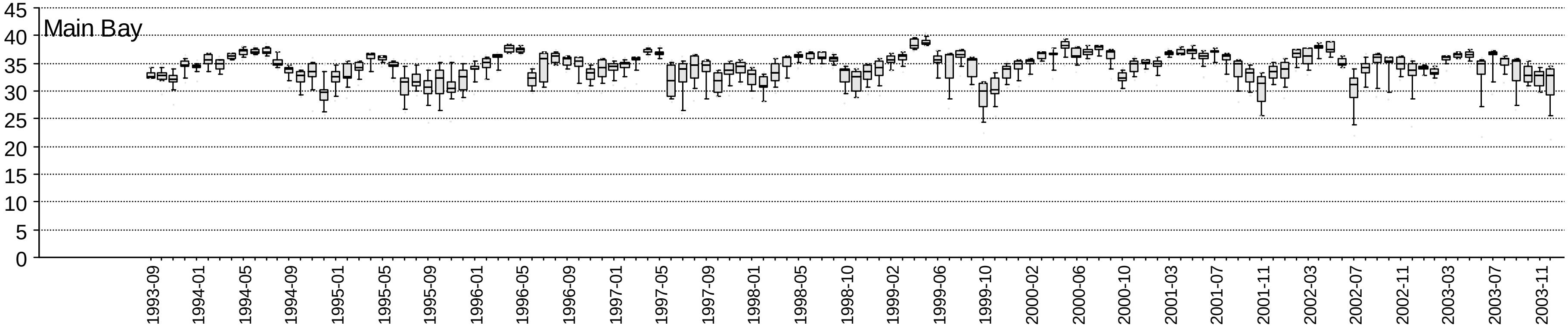
2001-11
2002-03
2002-07
2002-11
2003-03
2003-07
2003-11


Inshore
0
5
10
15
20
25
30
35
40
45
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-03
2001-07
2001-11
2002-03
2002-07
2002-11
2003-03
2003-07
2003-11


Main Bay
0
5
10
15
20
25
30
35
40
45
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-03
2001-07
2001-11
2002-03
2002-07
2002-11
2003-03
2003-07
2003-11

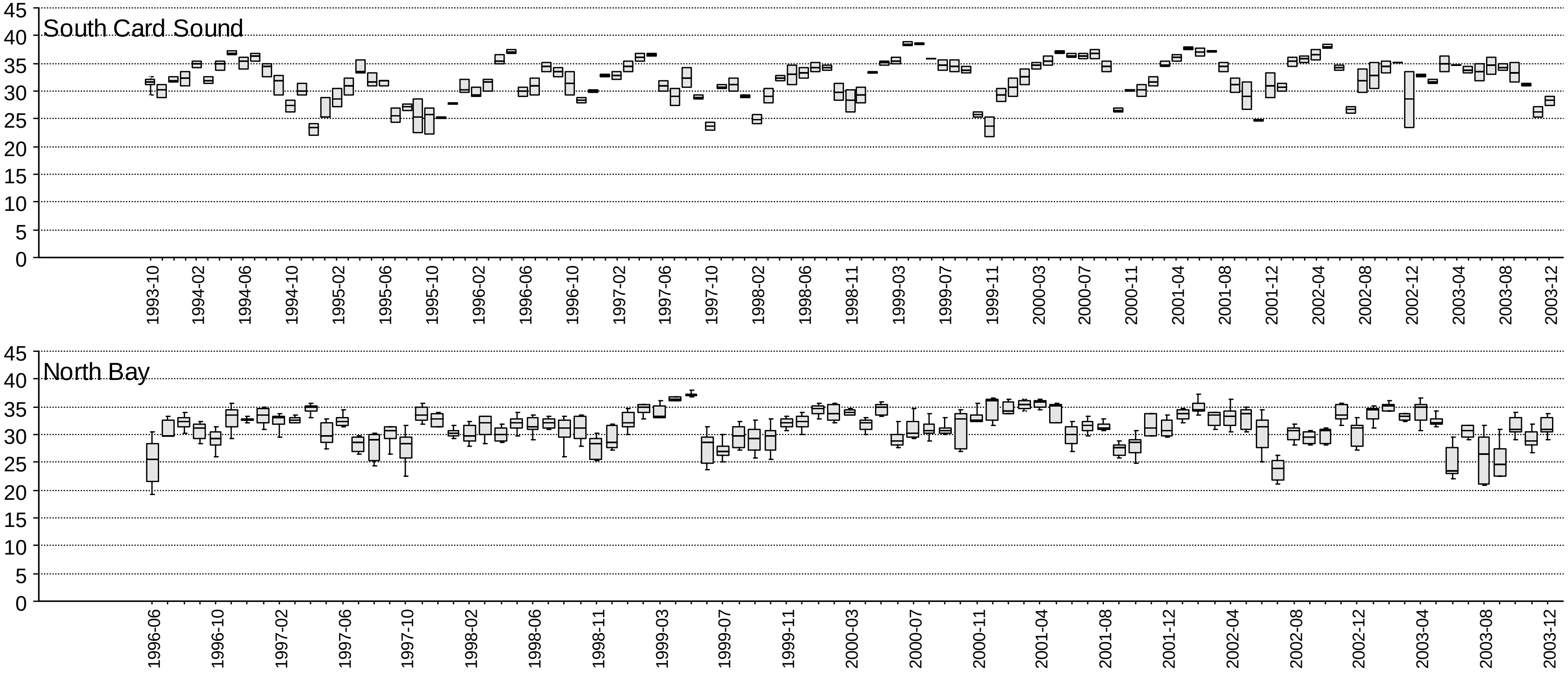
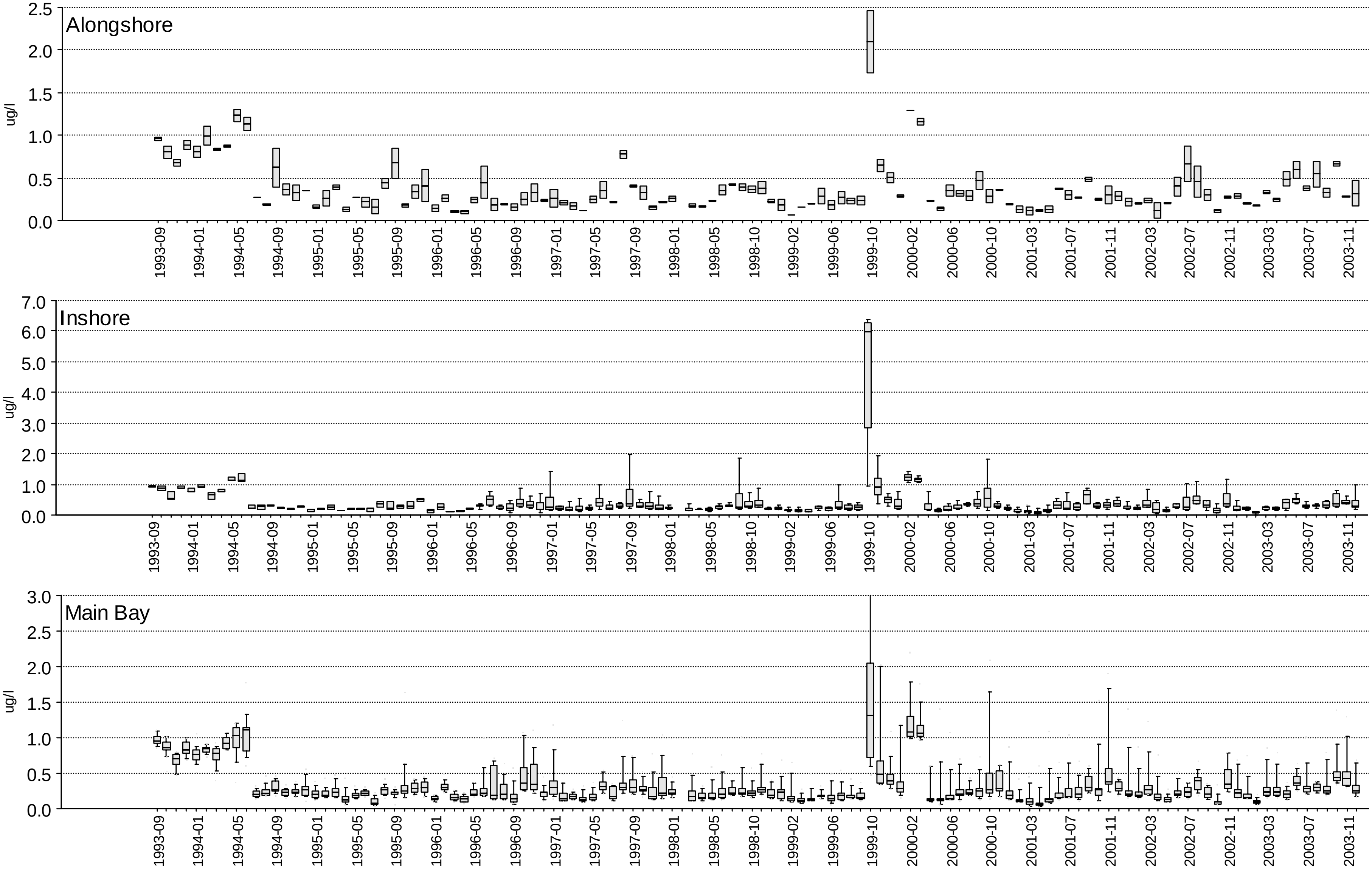


Figure 4.2. Monthly median and range of salinity in the five Biscayne Bay zones.


Alongshore
ug/l
0.0
0.5
1.0
1.5
2.0
2.5
Inshore
ug/l
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Main Bay
ug/l
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
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2002-03
2002-07
2002-11
2003-03
2003-07
2003-11

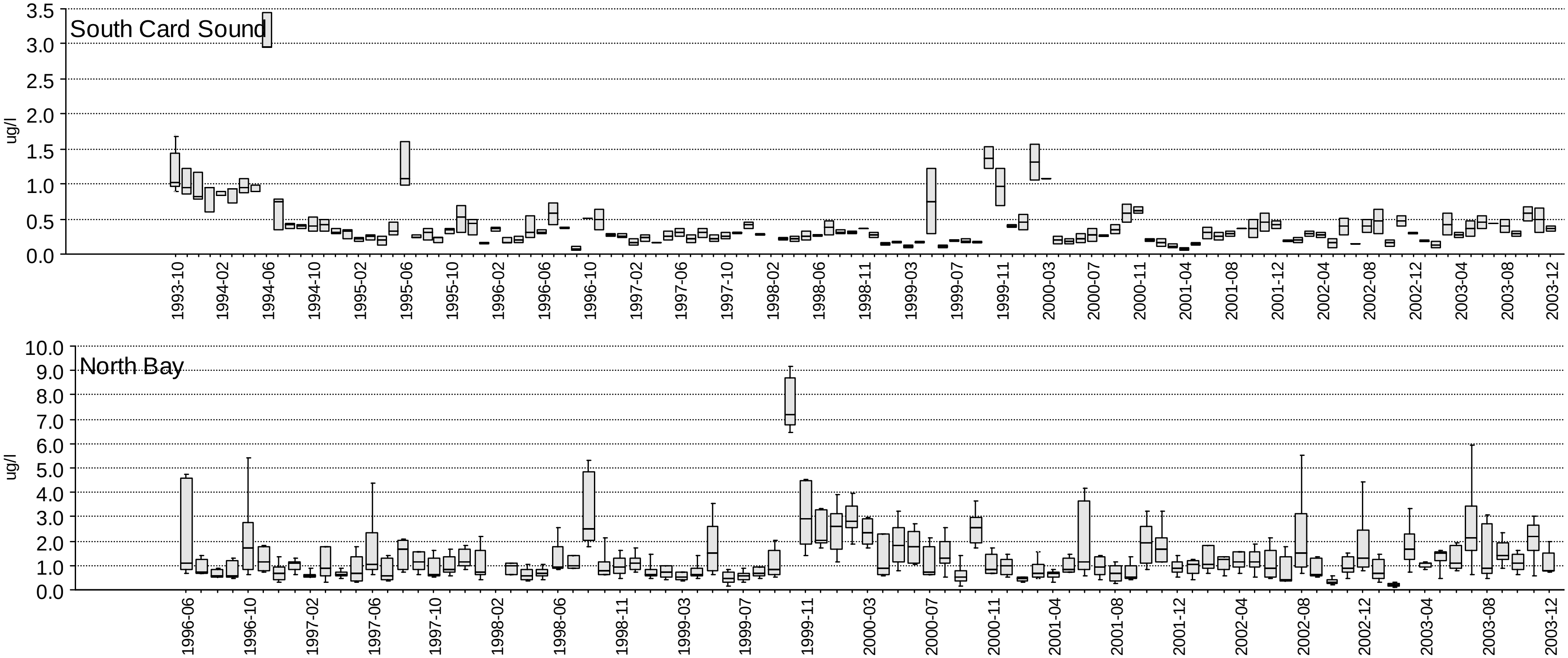
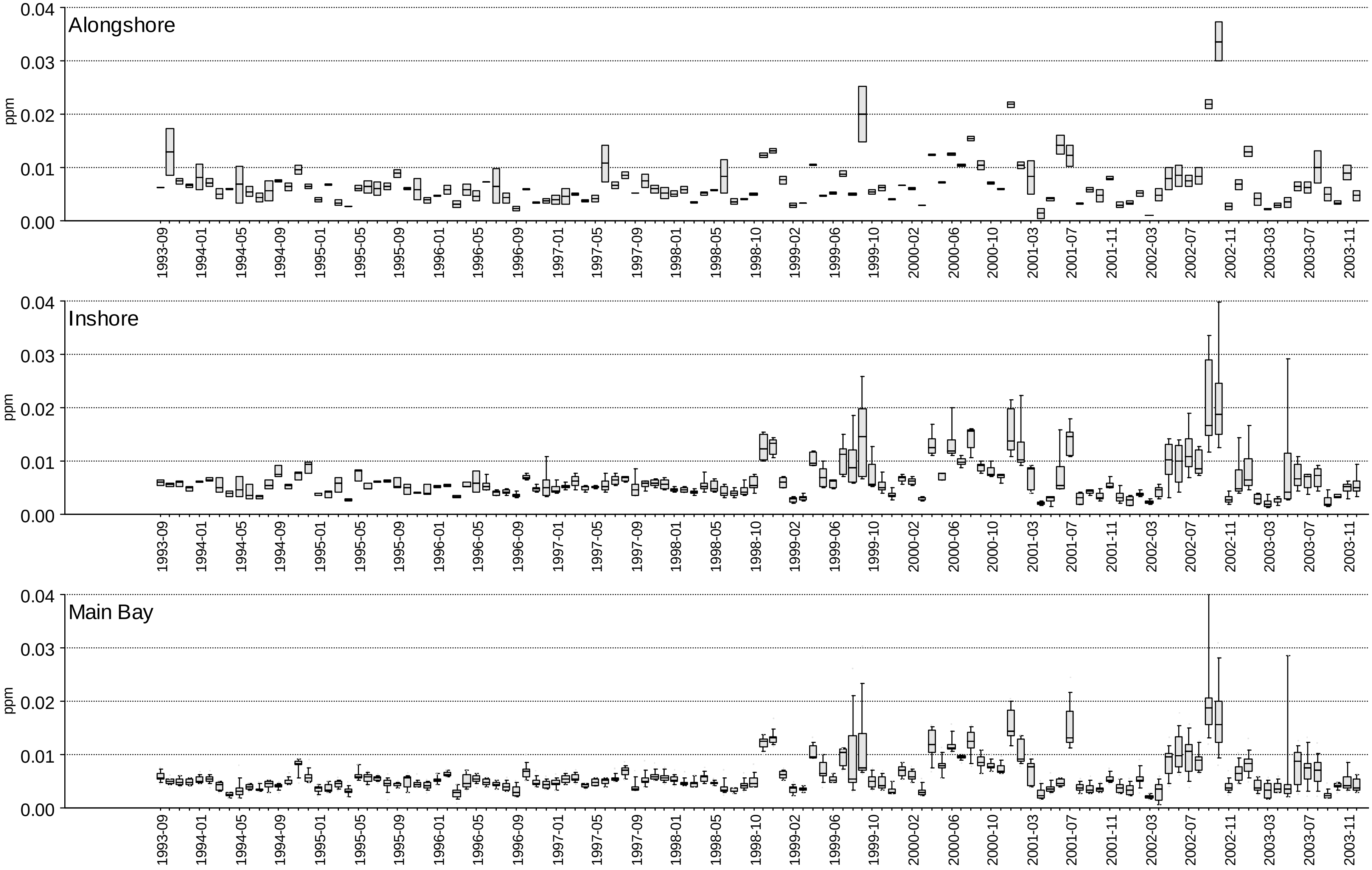


Figure 4.3. Monthly median and range of chlorophyll *a* in the five Biscayne Bay zones.


Alongshore
Inshore
Main Bay
ppm
0.00
0.01
0.02
0.03
0.04
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
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2002-03
2002-07
2002-11
2003-03
2003-07
2003-11

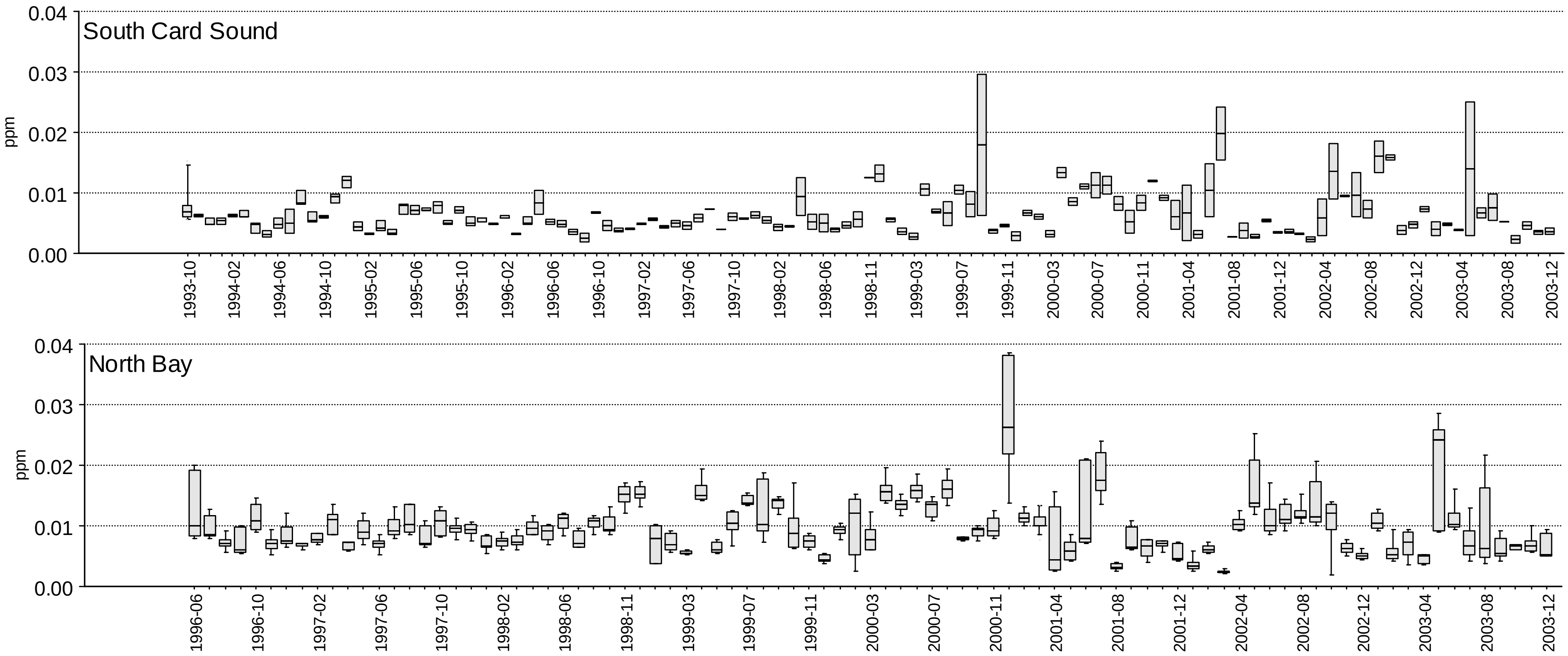
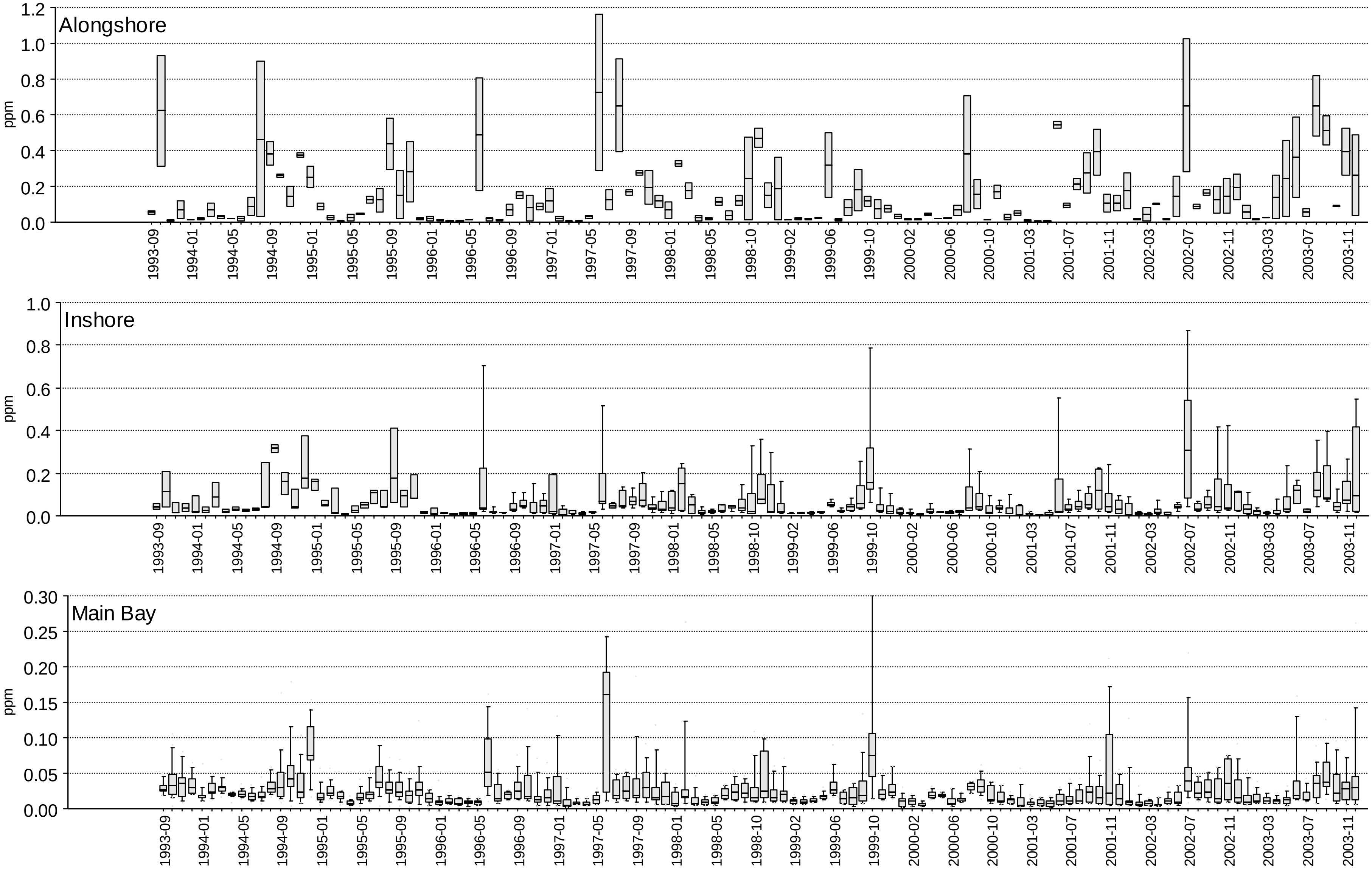


Figure 4.4. Monthly median and range of total phosphorus in the five Biscayne Bay zones.



Alongshore
ppm
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-03
2001-07
2001-11
2002-03
2002-07
2002-11
2003-03
2003-07
2003-11
Inshore
ppm
1.0
0.8
0.6
0.4
0.2
0.0
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
2000-02
2000-06
2000-10
2001-03
2001-07
2001-11
2002-03
2002-07
2002-11
2003-03
2003-07
2003-11
Main Bay
ppm
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
1998-05
1998-10
1999-02
1999-06
1999-10
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2002-07
2002-11
2003-03
2003-07
2003-11

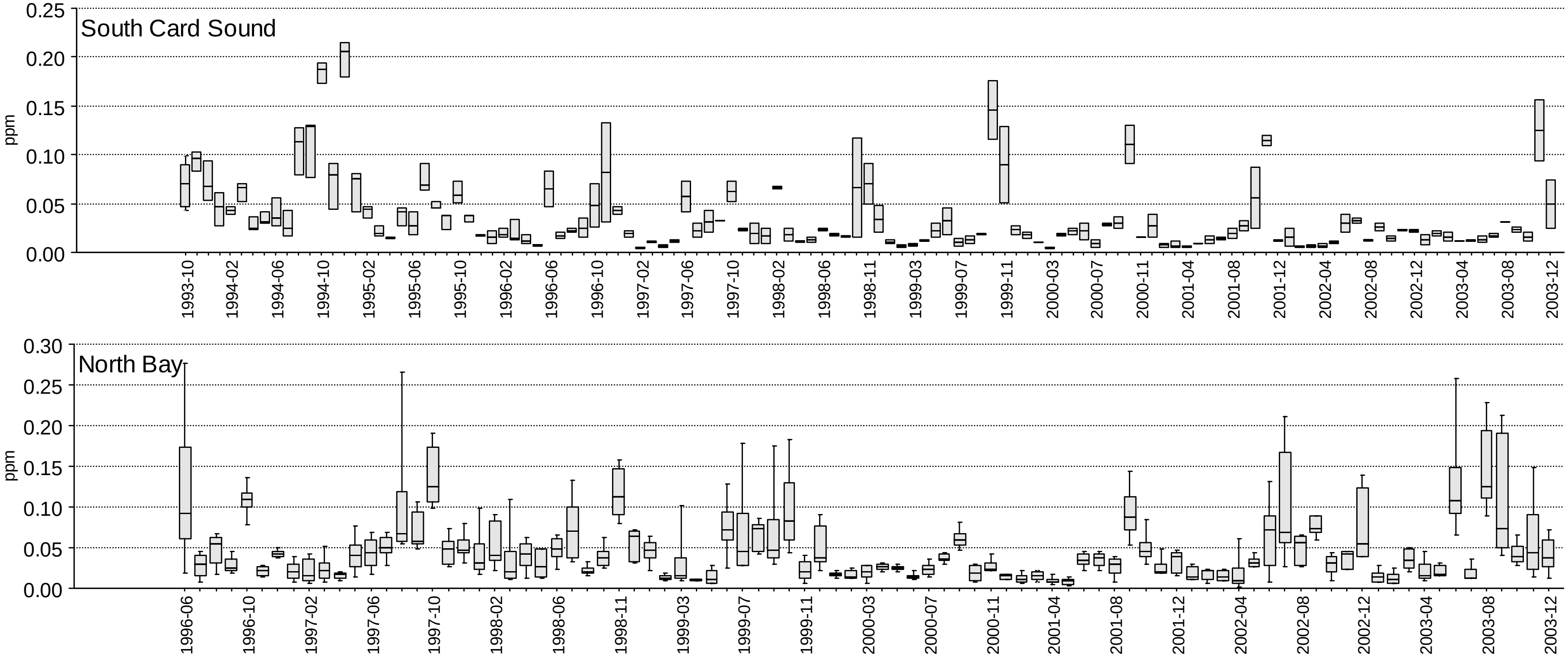
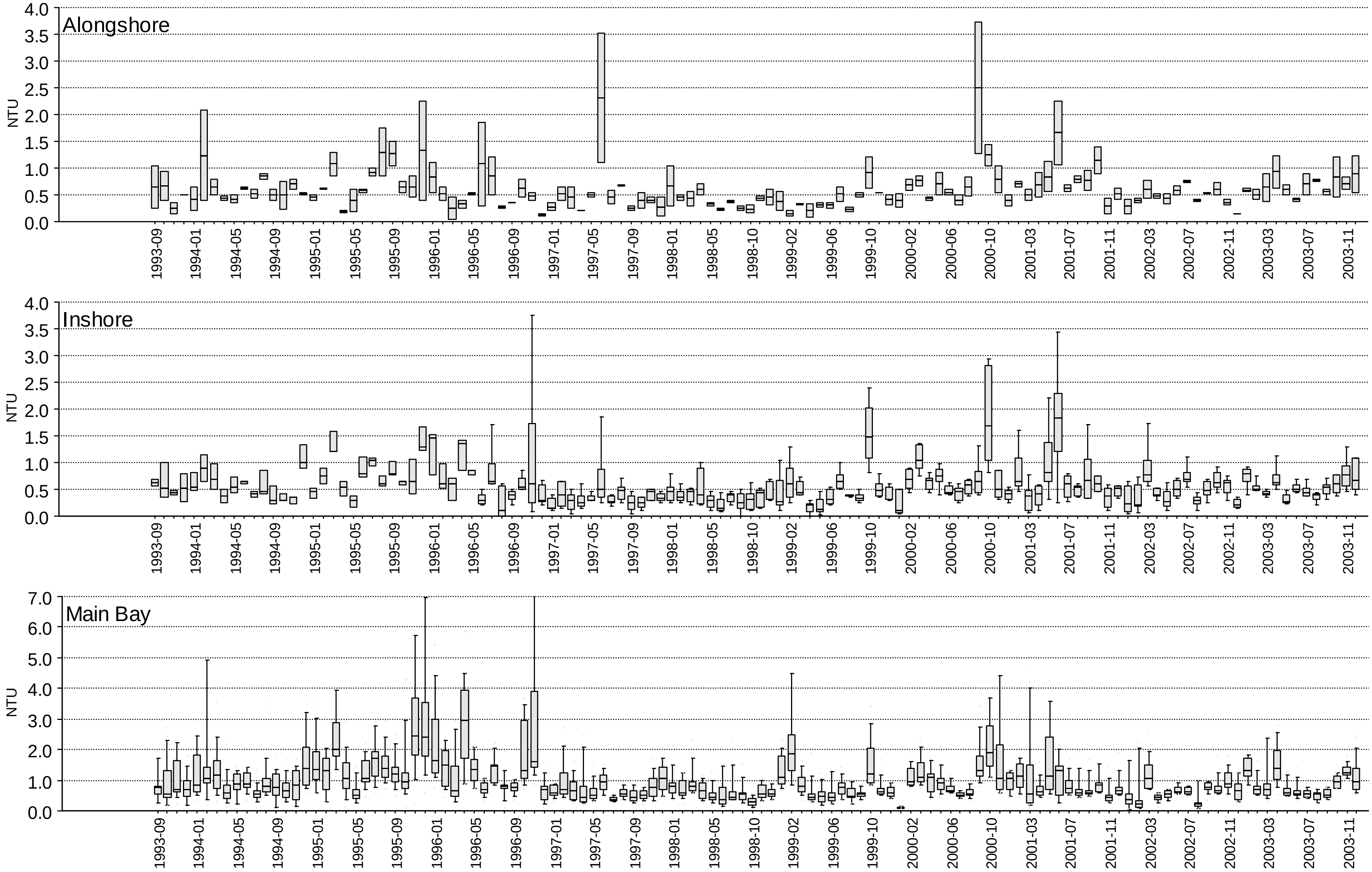


Figure 4.5. Monthly median and range of dissolved inorganic N in the Biscayne Bay zones.


Alongshore
Inshore
Main Bay
NTU
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
5.0
6.0
7.0
1993-09
1994-01
1994-05
1994-09
1995-01
1995-05
1995-09
1996-01
1996-05
1996-09
1997-01
1997-05
1997-09
1998-01
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1999-06
1999-10
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2003-11

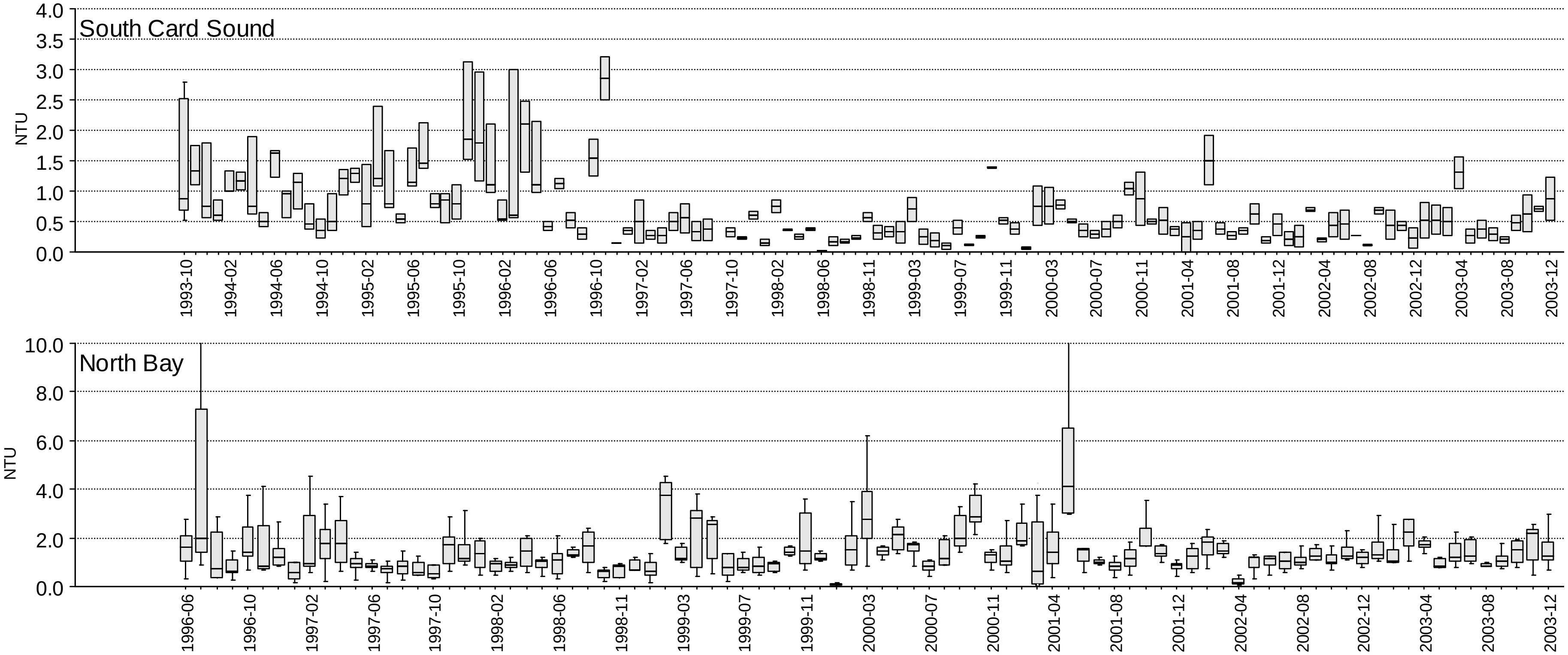


Figure 4.6. Monthly median and range of turbidity in the five Biscayne Bay zones.

5. STATE OF WATER QUALITY ON THE SOUTHWEST FLORIDA SHELF

Overall Period of Record

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. 5.1). 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.

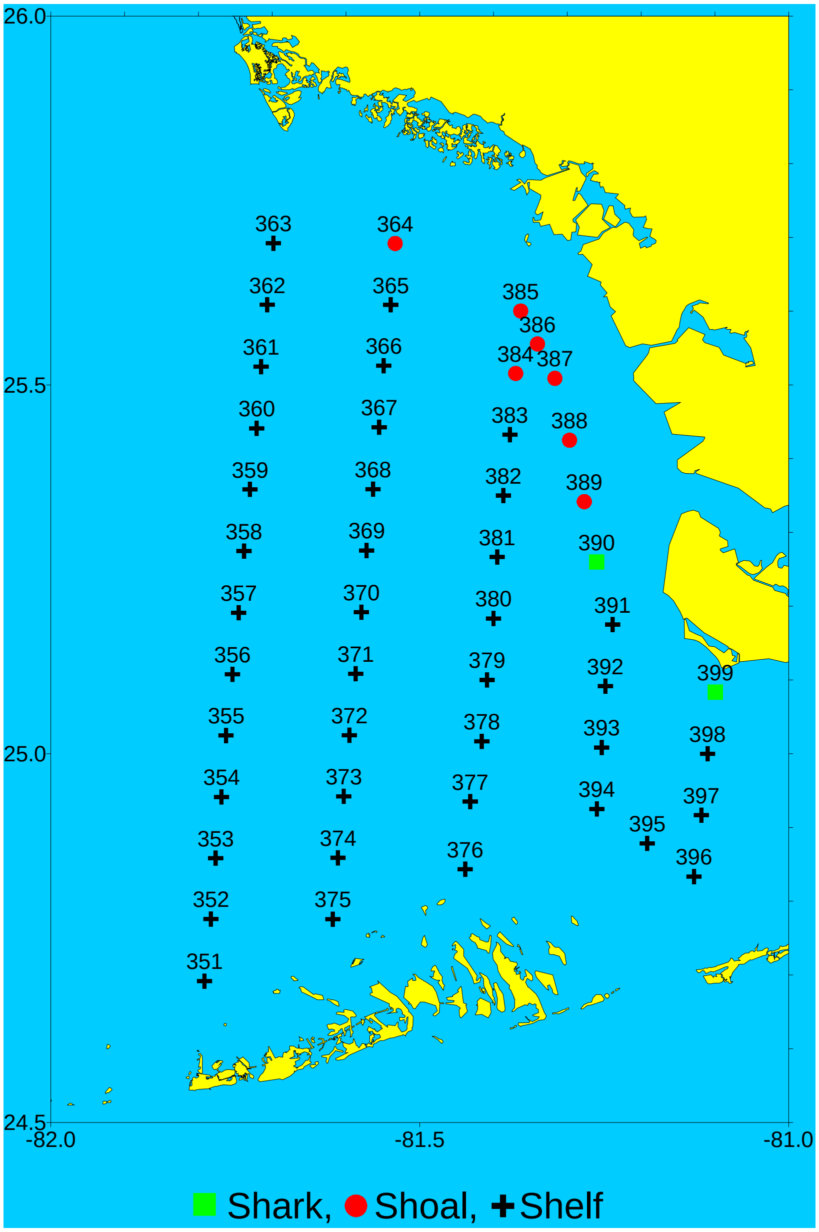


Figure 5.1. Zones of similar water quality on the SW Shelf.

Salinity was lowest in the SHARK zone as a result of the Shark River, Everglades influence (Fig. 5.2). There is a decreasing concentration gradient of SHARK > SHOAL > SHELF for CHLA, TP, and TOC (Fig. 5.3, 5.4, & 5.6). It is clear that the SHARK stations have higher DIN concentrations while the SHOAL and SHELF stations were similar (Fig. 5.5).

Although these analyses are very preliminary (only 38 sampling events) it is possible to speculate that the clusters are formed as a function of hydrology and circulation patterns. We believe that the SHARK stations clearly show the input 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 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. This is a preliminary analysis and will be repeated after a few more years of data have been collected.

2003 Alone

Since this component of the monitoring program began in 1995 and is only sampled quarterly, there is less trend data to analyze than for other regions. Overall, 2003 was relatively unremarkable with no variables deviating much from their grand median. TON revered its slow decline with an increase of 0.035 ppm overall. One thing to look for in the future is the possible development of an increasing trend in TP on the SHELF. As of now it is not statistically significant.

Data, Graphs, and Figures

All data for the period of record are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm
Monthly time series graphs for all measured variables for each station are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/Shelf.htm
Contour maps showing spatial distributions of all measured variables (quarterly) are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm

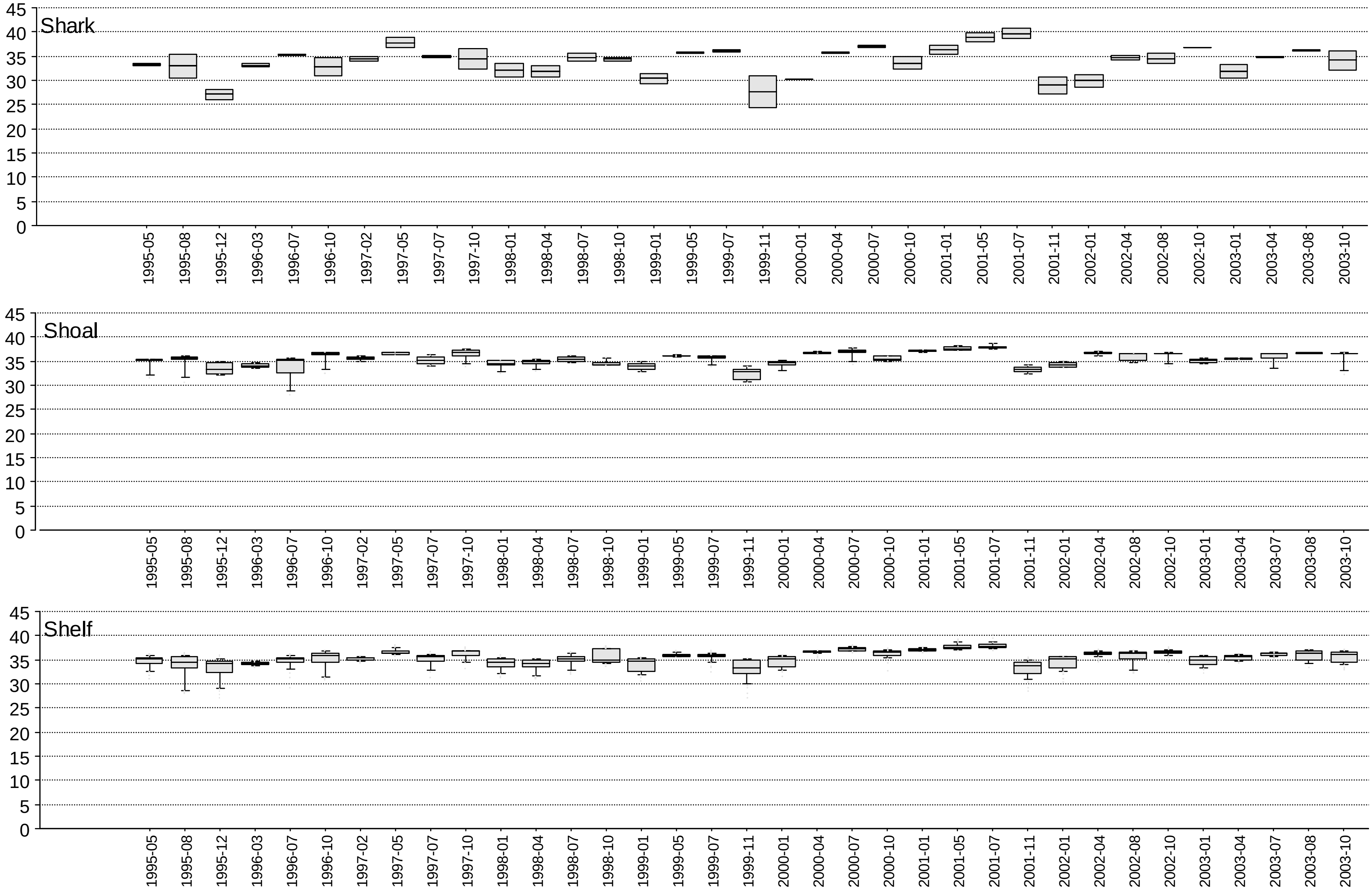


Figure 5.2. Quarterly median and range of salinity in the three SW Shelf zones.

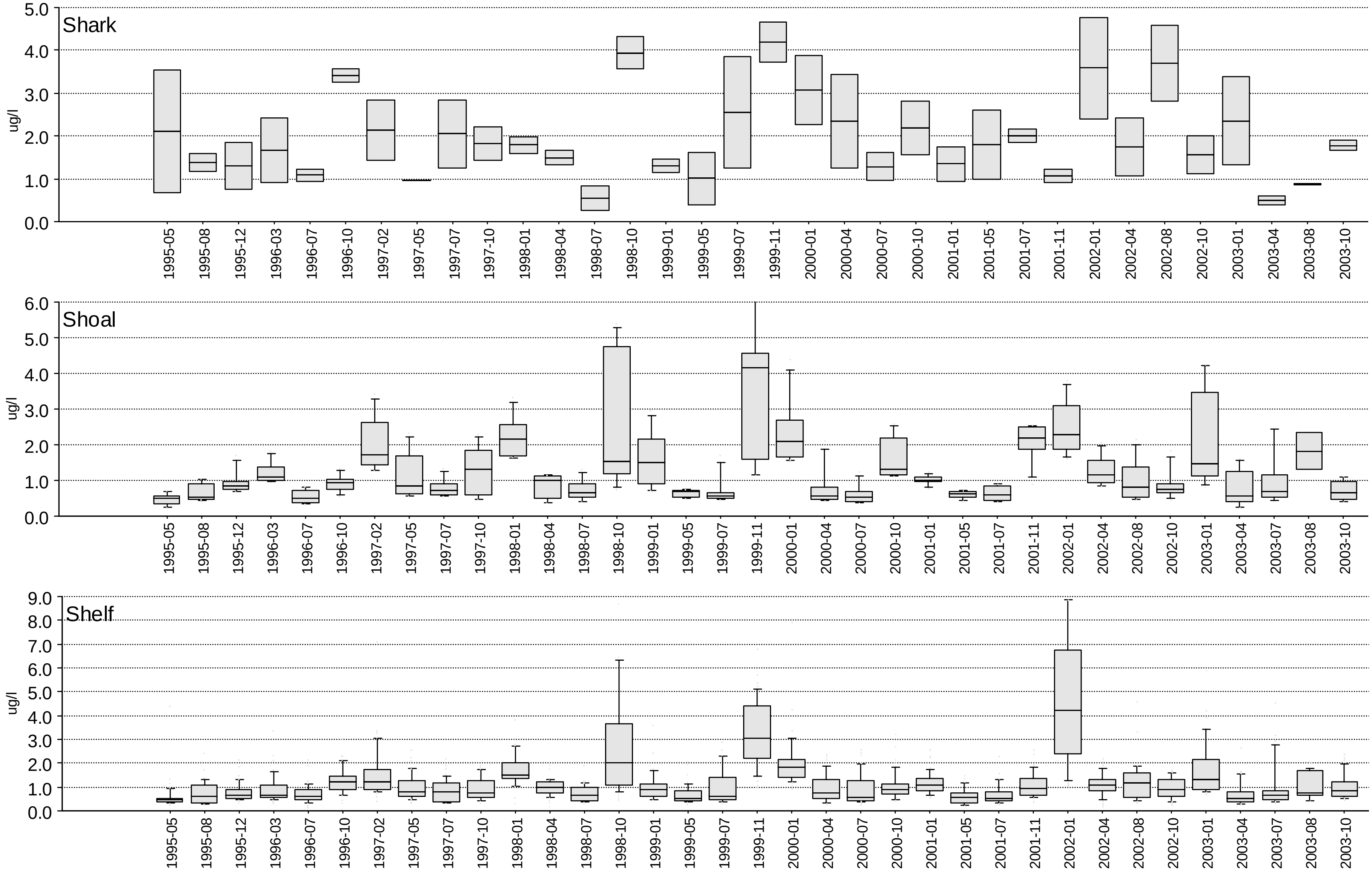


Figure 5.3. Quarterly median and range of chlorophyll *a* in the three SW Shelf zones.

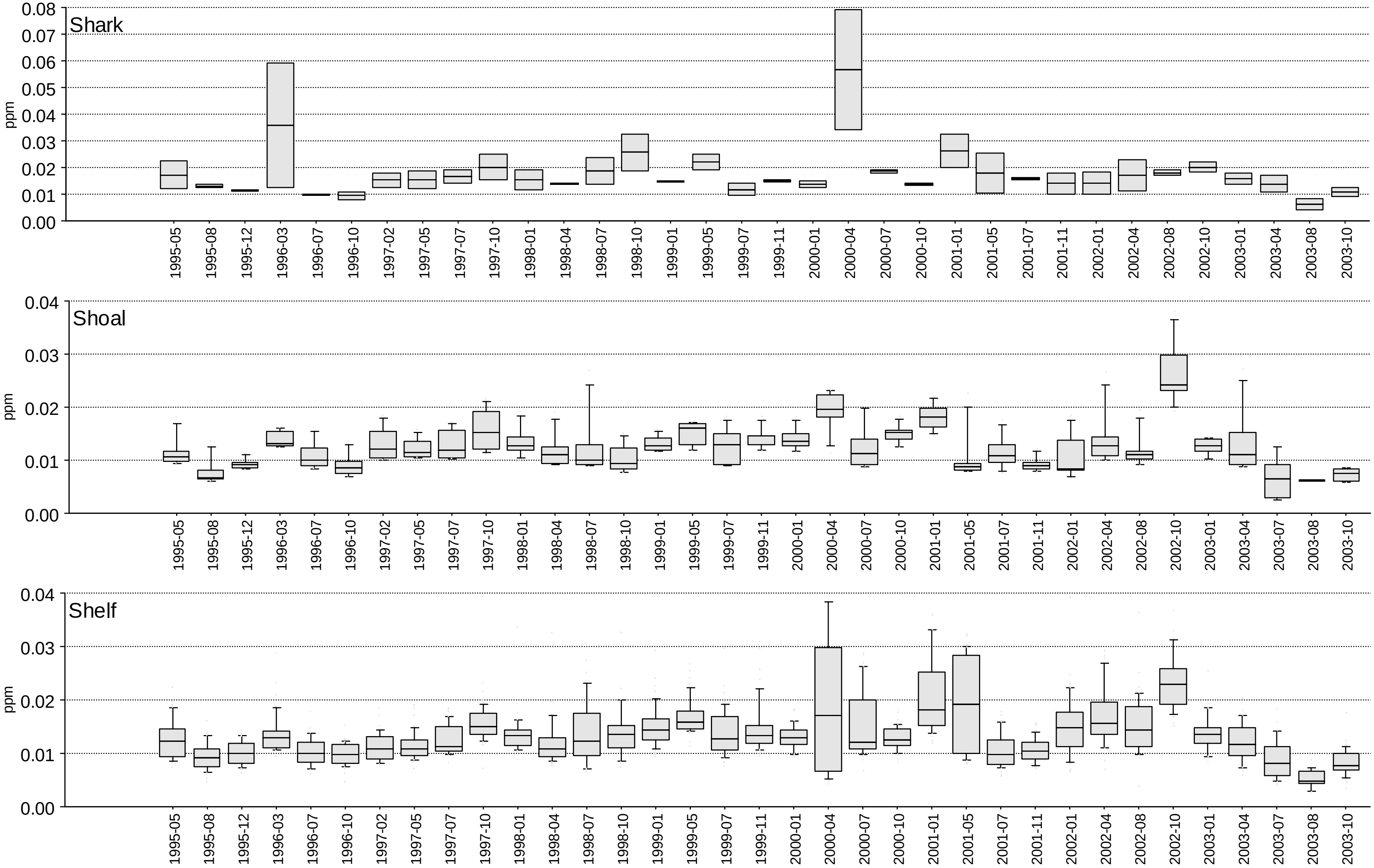


Figure 5.4. Quarterly median and range of total phosphorus in the three SW Shelf zones.

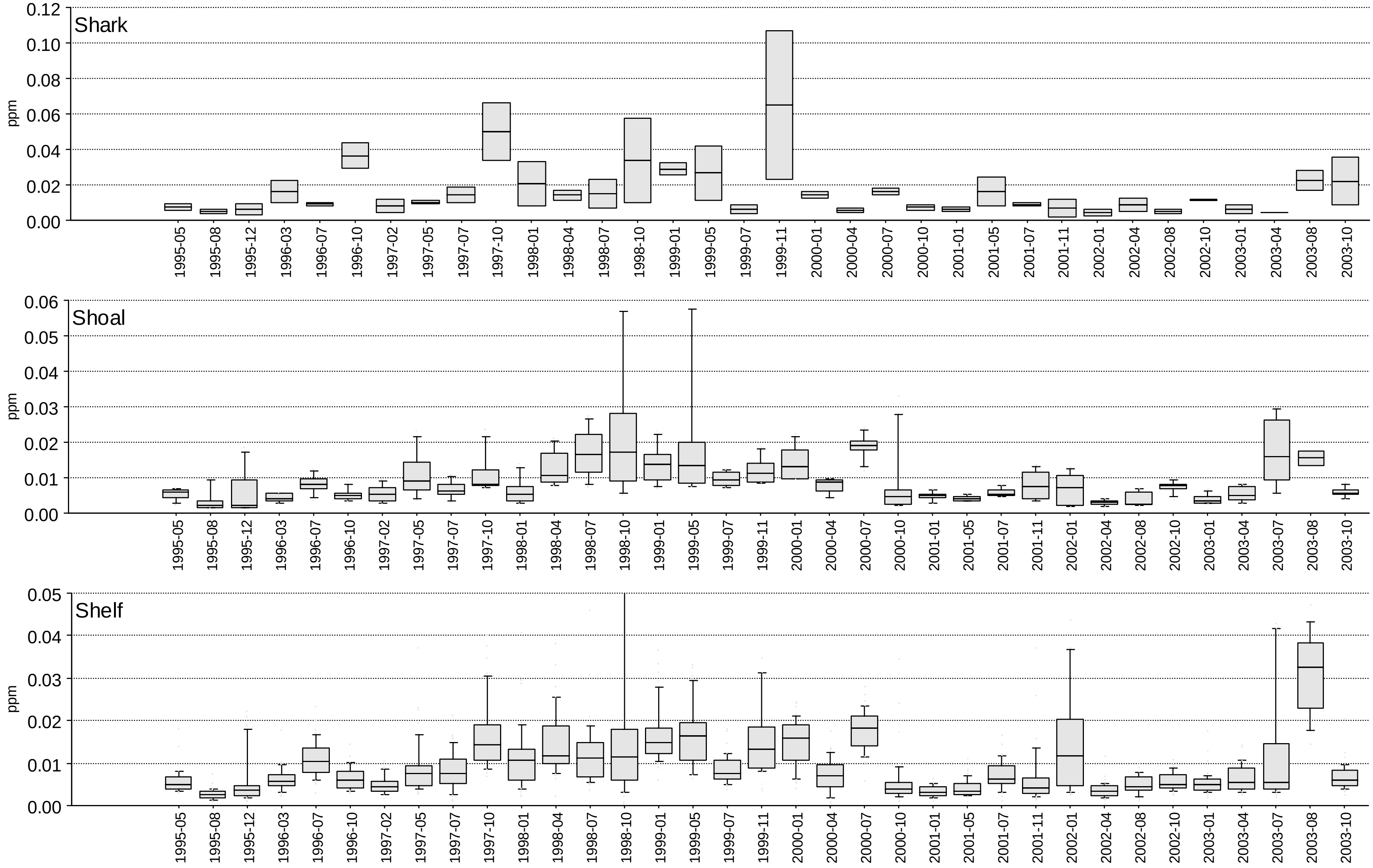


Figure 5.5. Quarterly median and range of dissolved inorganic N in the three SW Shelf zones.

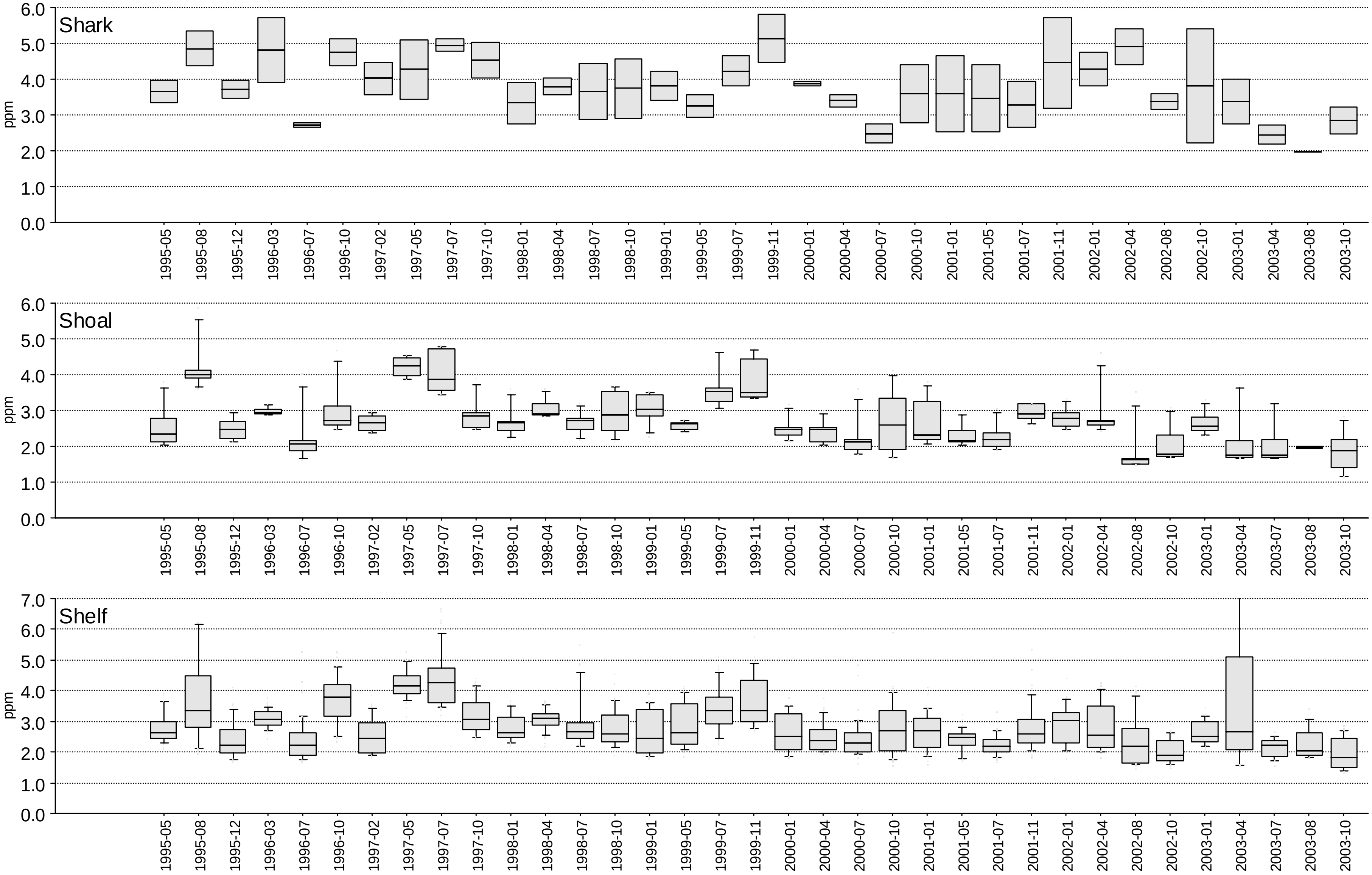


Figure 5.6. Quarterly median and range of total organic carbon in the three SW Shelf zones.

6. STATE OF WATER QUALITY IN THE CAPE ROMANO - PINE ISLAND SOUND AREA

Overall Period of Record

Sampling in this area began Jan. 1999, therefore we now have five years of data available for analysis. However, until we perform a full spatial analysis, we will use generally accepted geomorphological characteristics to group the stations (Fig. 6.1). 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.

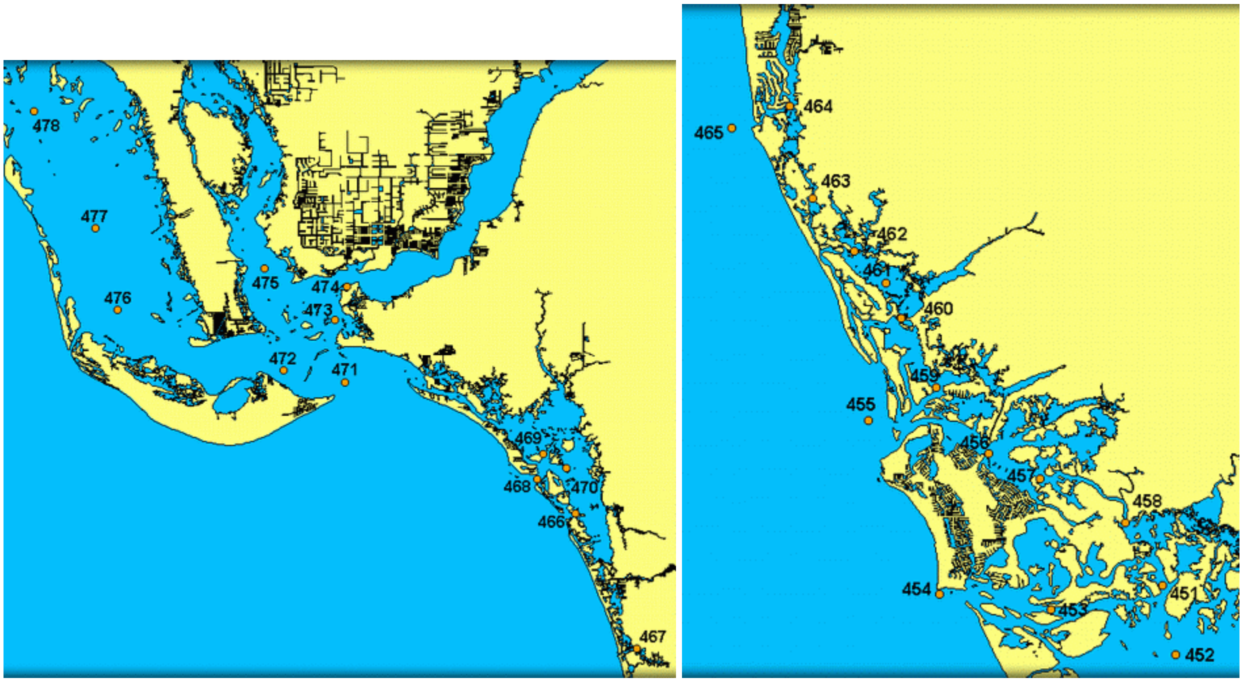


Figure 6.1. Map of station locations in Cape Romano-Pine Island Sound area.

All zones experienced low salinity during the beginning of the wet season with the opening of the Caloosahatchee structure (Fig. 6.2). CHLA is elevated in this area (Fig. 6.3) 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 (Fig. 6.4, 6.5 & 6.6). 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.

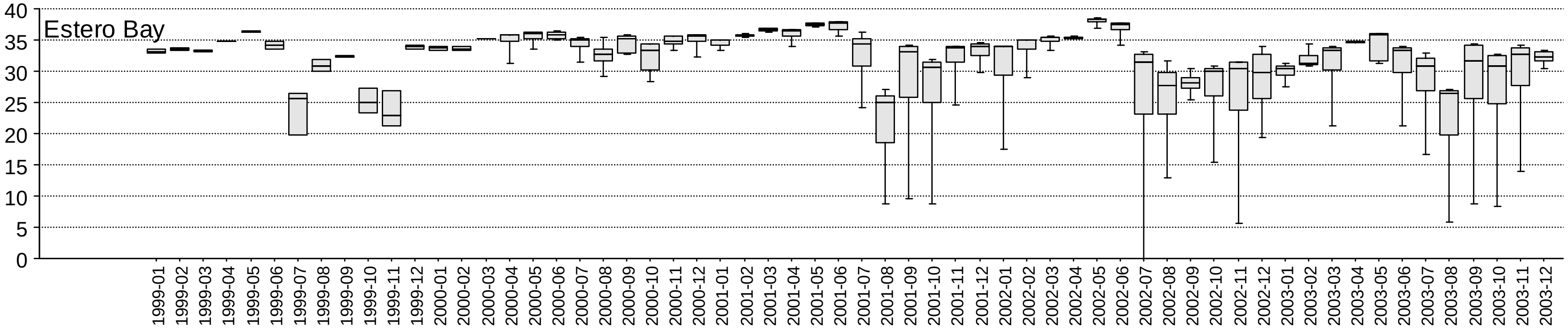
Overall, this area has significantly higher concentrations of CHLA, TP, and DIN than the bulk of the Ten Thousand Islands stations. Much of this is due to geological changes from carbonates to silicates, which facilitates transport of phosphorus, and to major land use changes from the Big Cypress National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

2003 Alone

We now have five years of data in the record and can now begin to discuss trends. So far, not much is evident. The largest interannual variations seem to be driven by freshwater releases from the Caloosahatchee River. Aside from a general decline in TOC for the region, 2003 was unremarkable.

Data, Graphs, and Figures

All data for the period of record are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/DataDL.htm
Monthly time series graphs for all measured variables for each station are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/RB.htm
Contour maps showing spatial distributions of all measured variables (quarterly) are available at:
http://serc.fiu.edu/wqmnetwork/SFWMD-CD/ContourMaps.htm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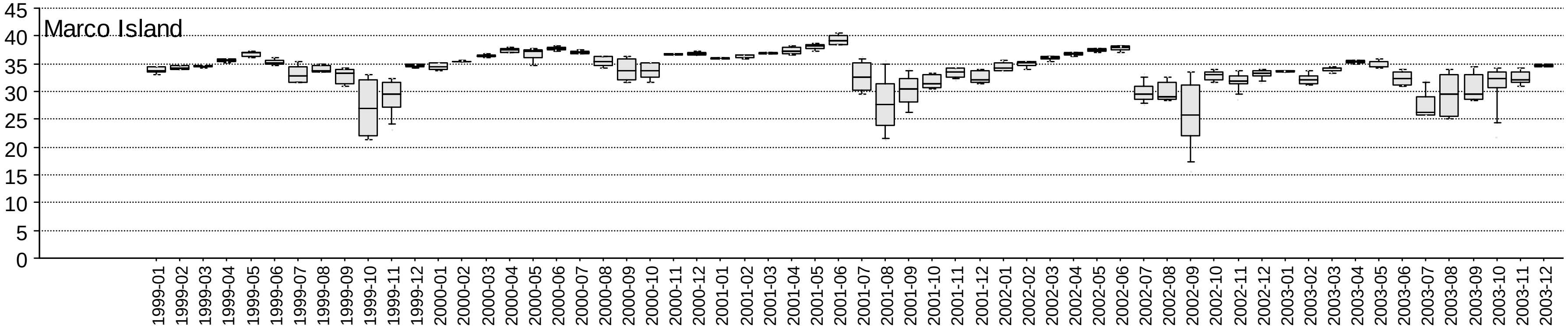
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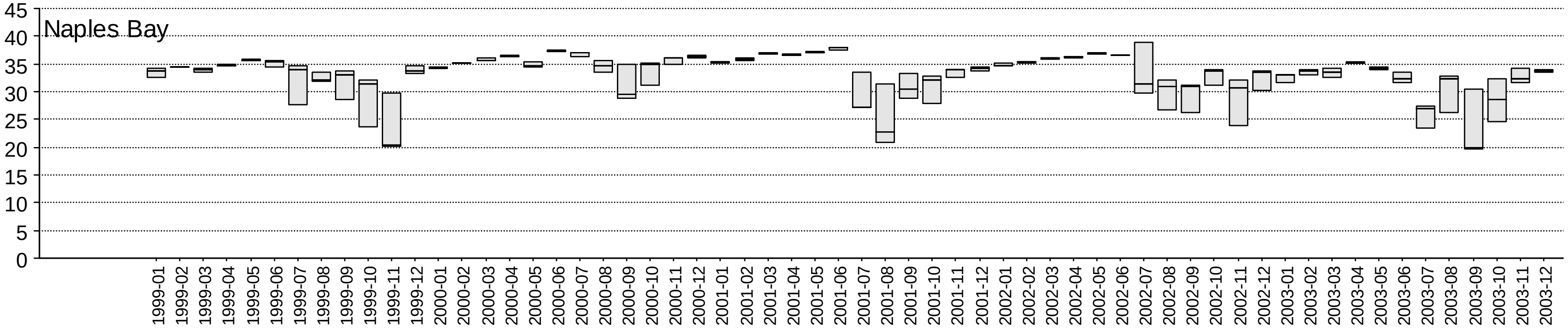
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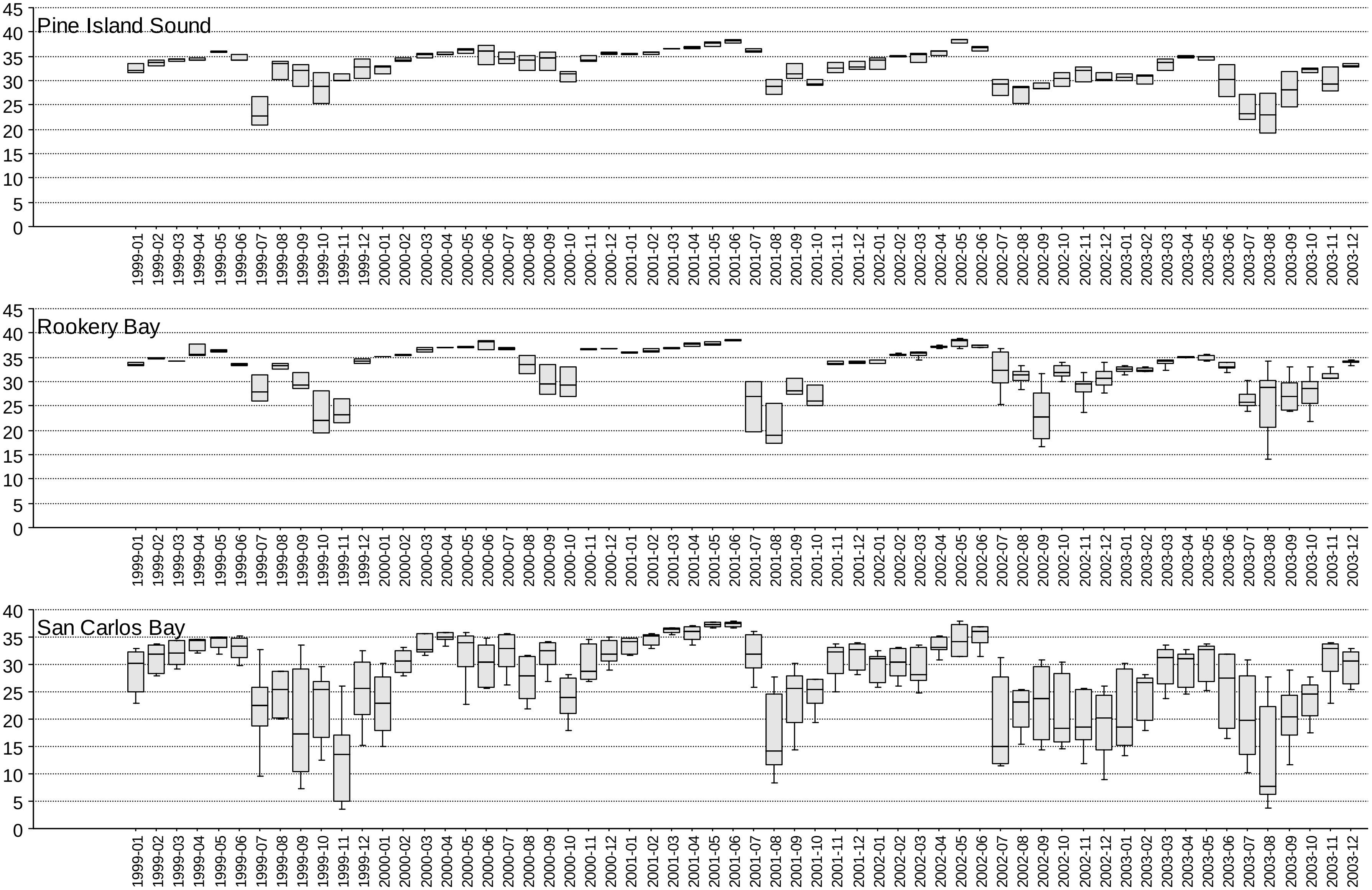
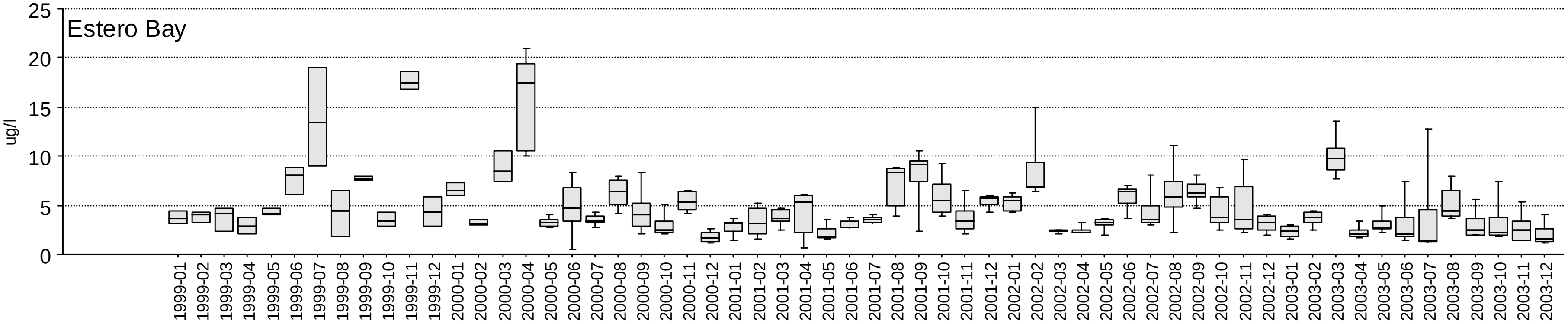


Figure 6.2. Monthly median and range of salinity in the Cape Romano-PIS area.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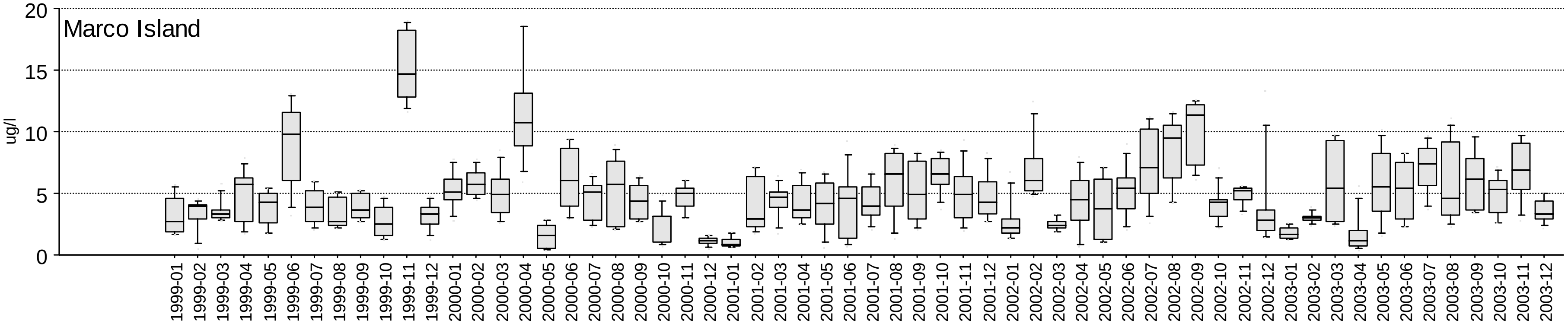
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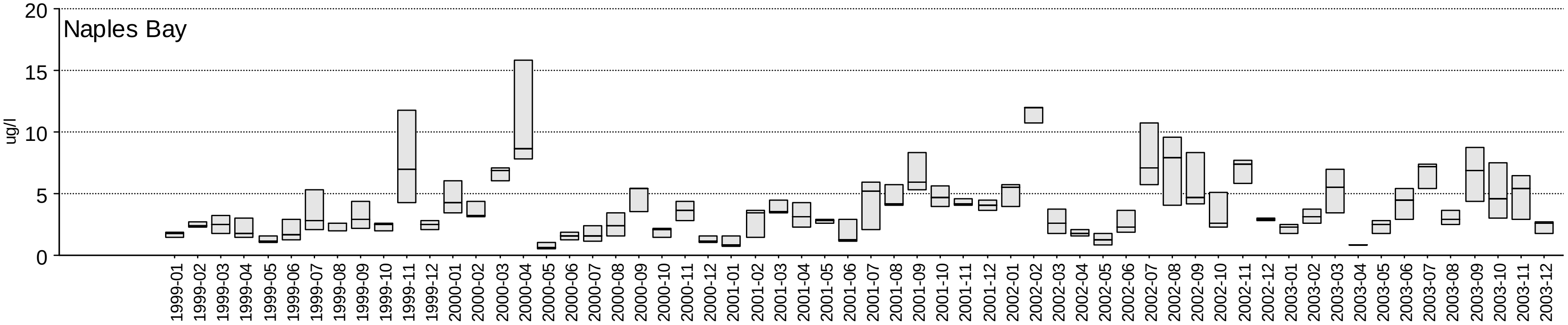
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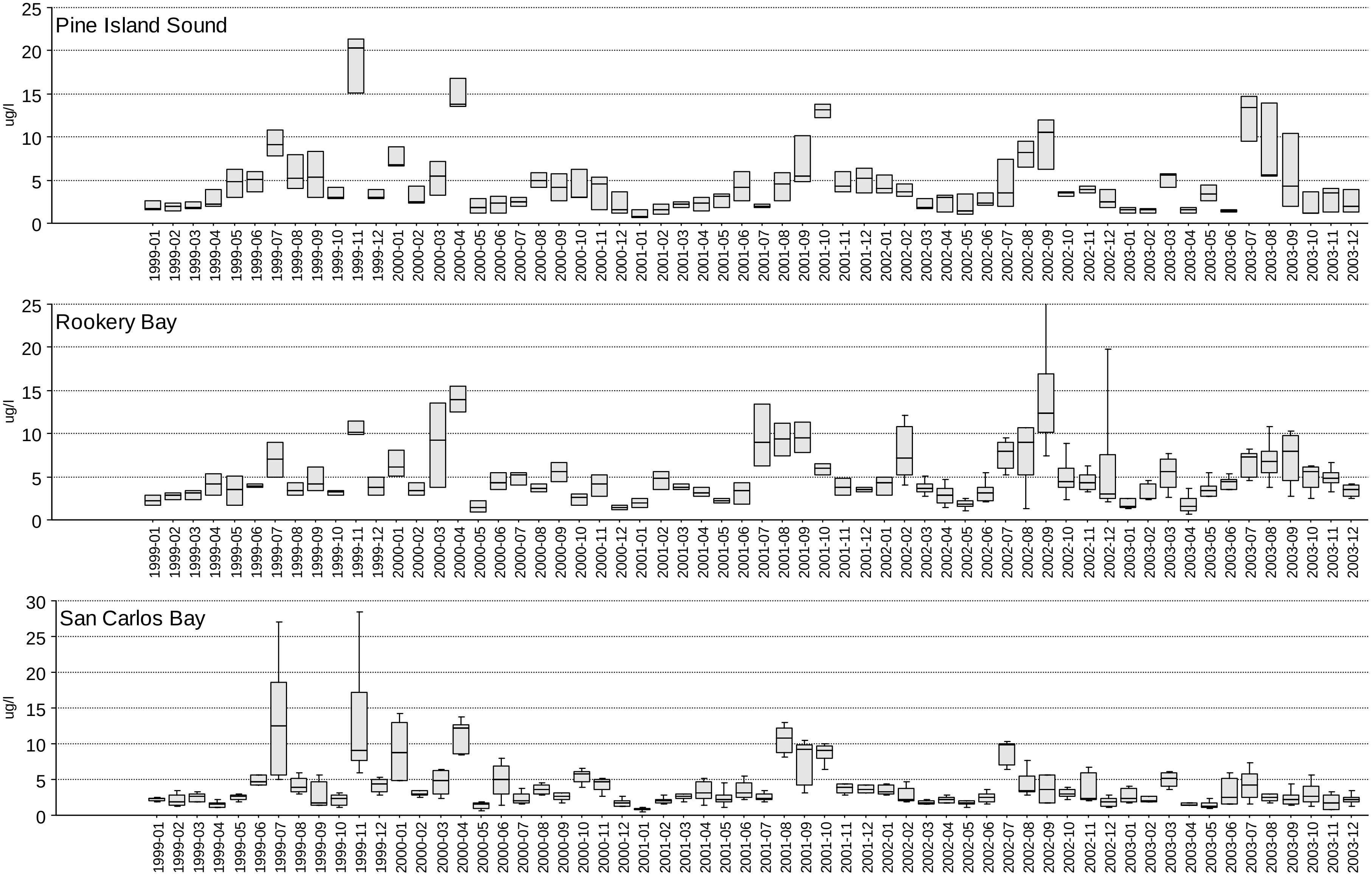
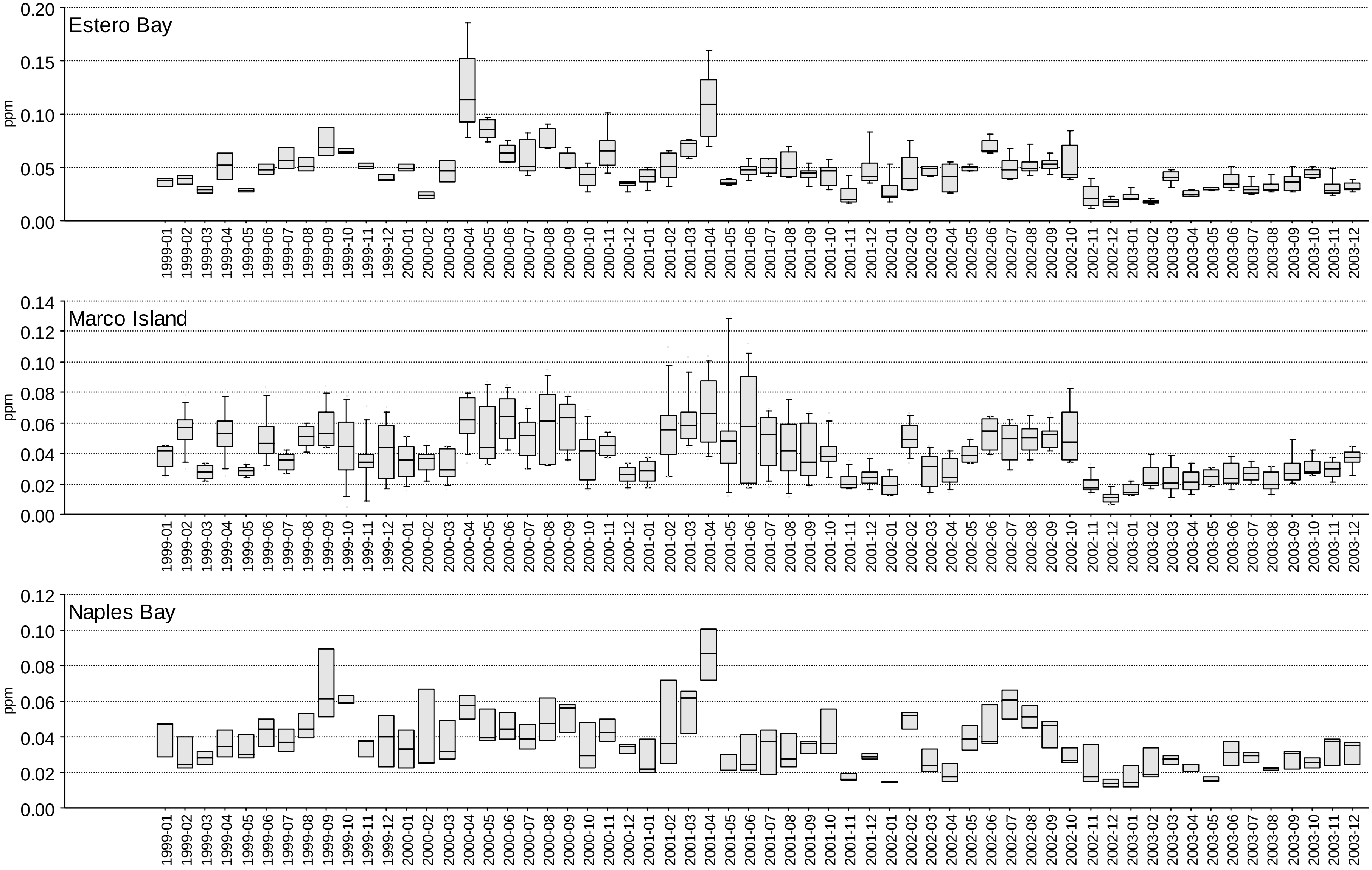


Figure 6.3. Monthly median and range of chlorophyll *a* in the Cape Romano-PIS area.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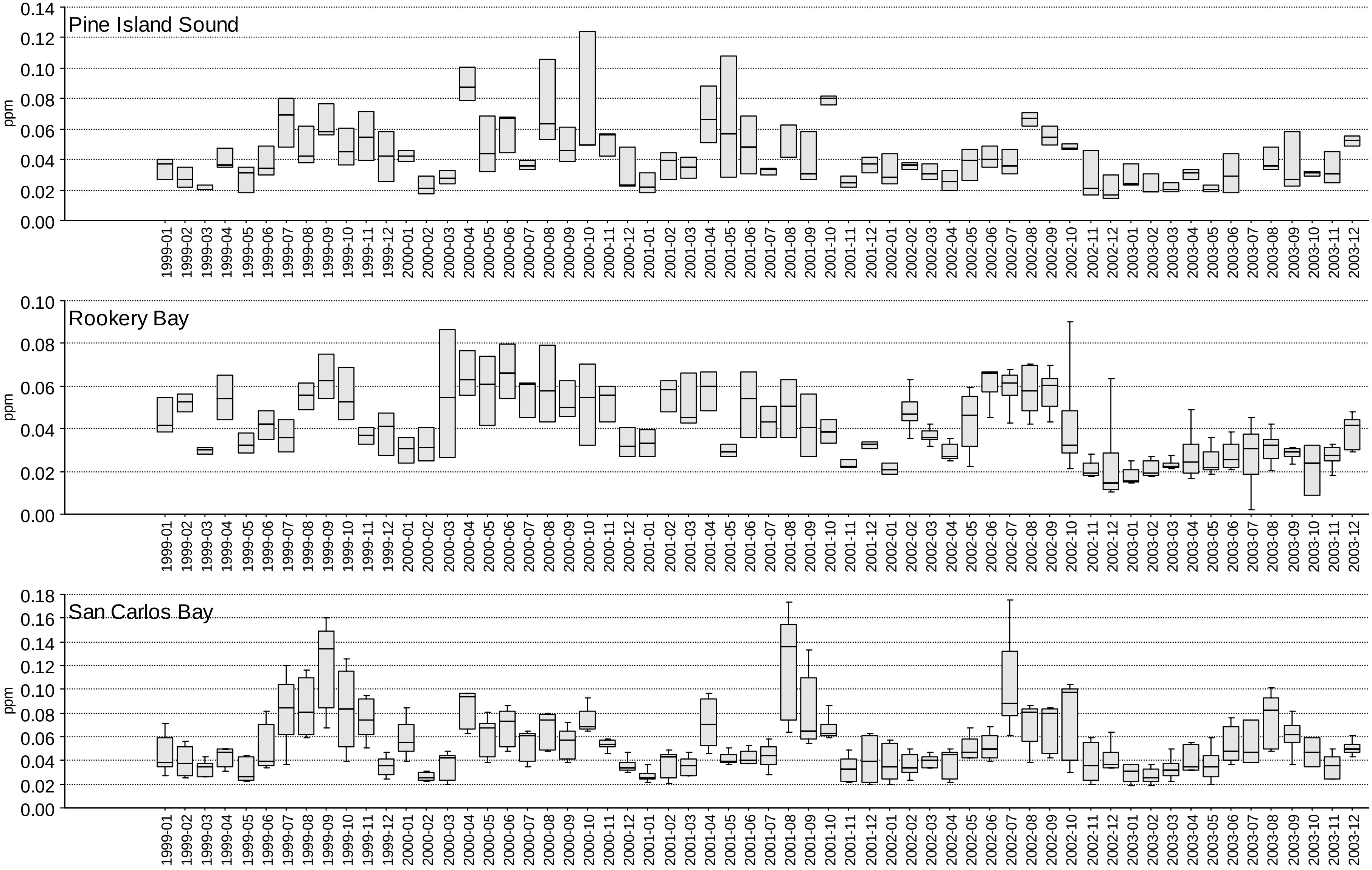
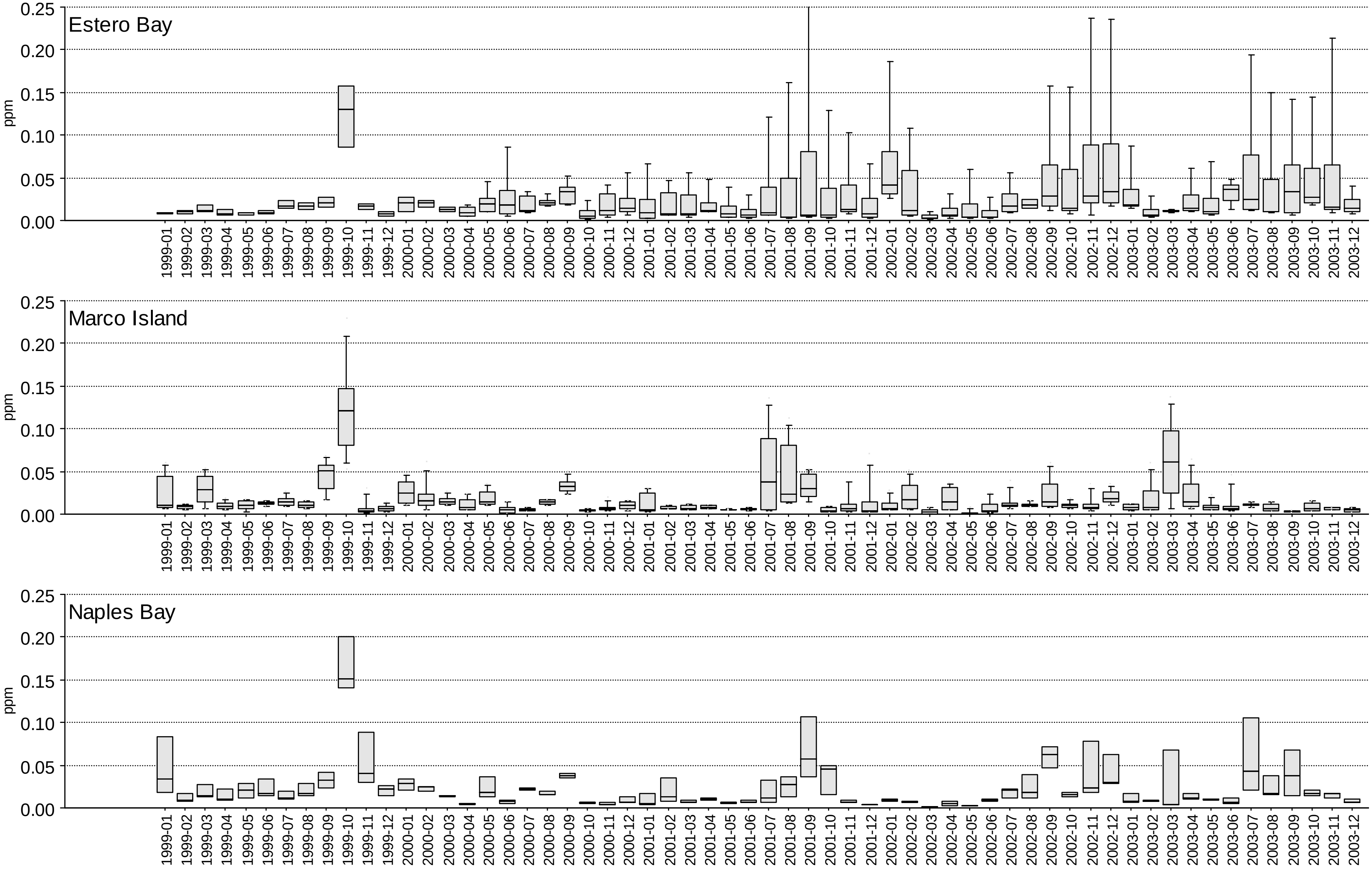


Figure 6.4. Monthly median and range of total phosphorus in the Cape Romano-PIS area.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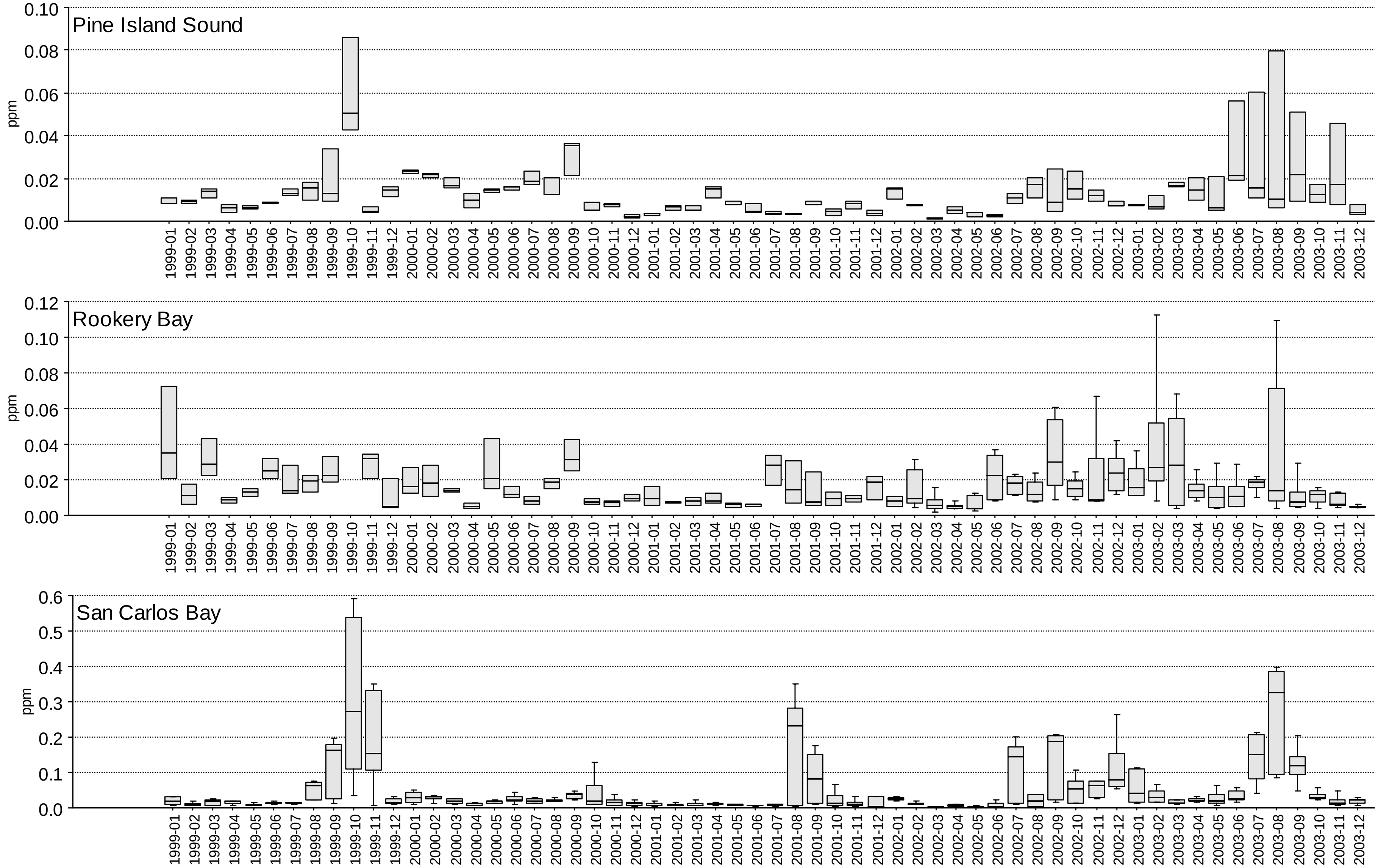
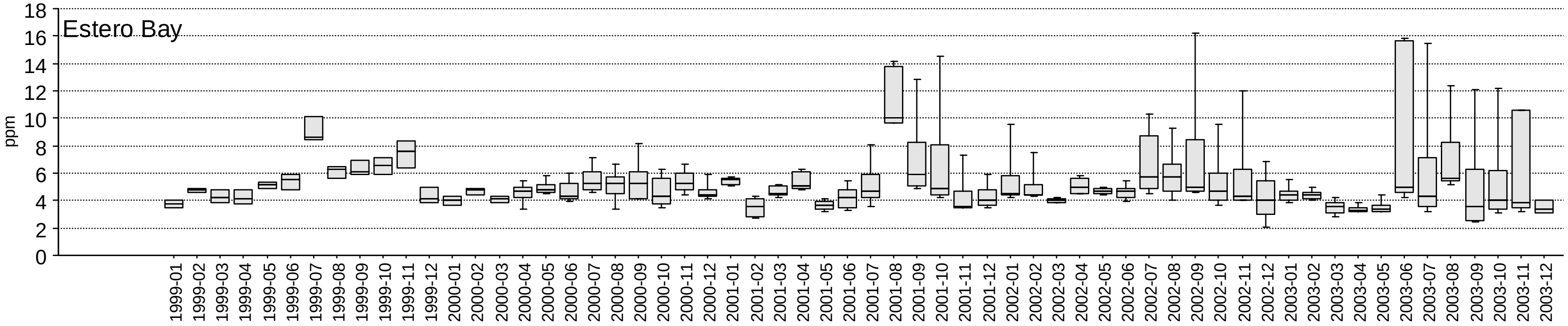


Figure 6.5. Monthly median and range of DIN in the Cape Romano-PIS area.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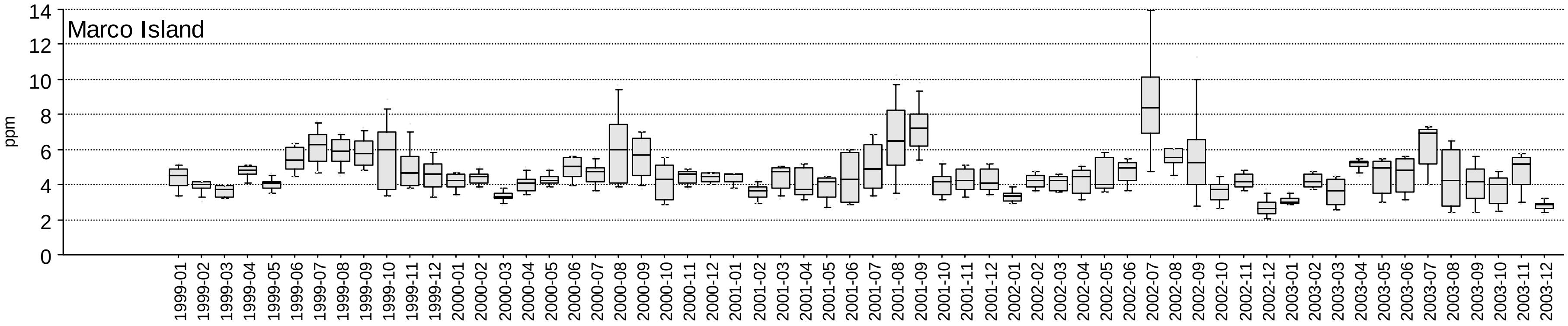
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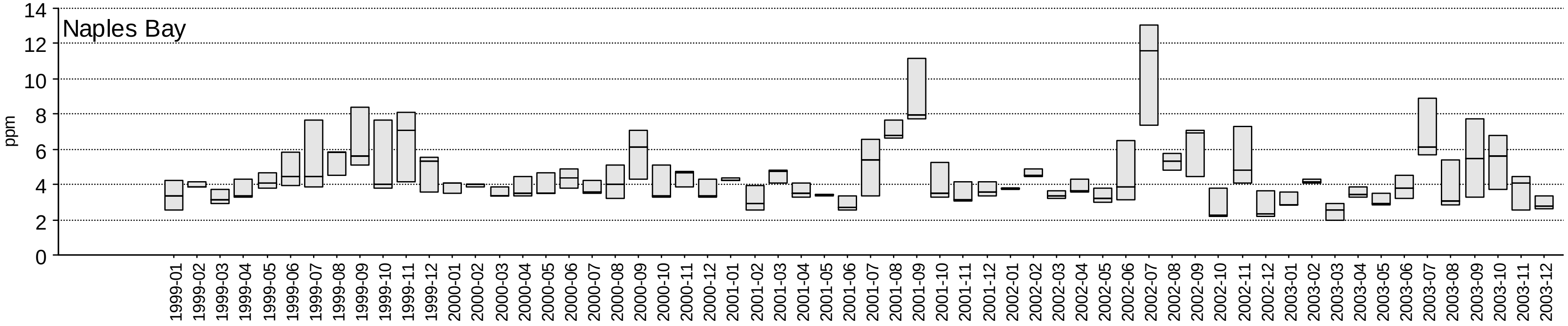
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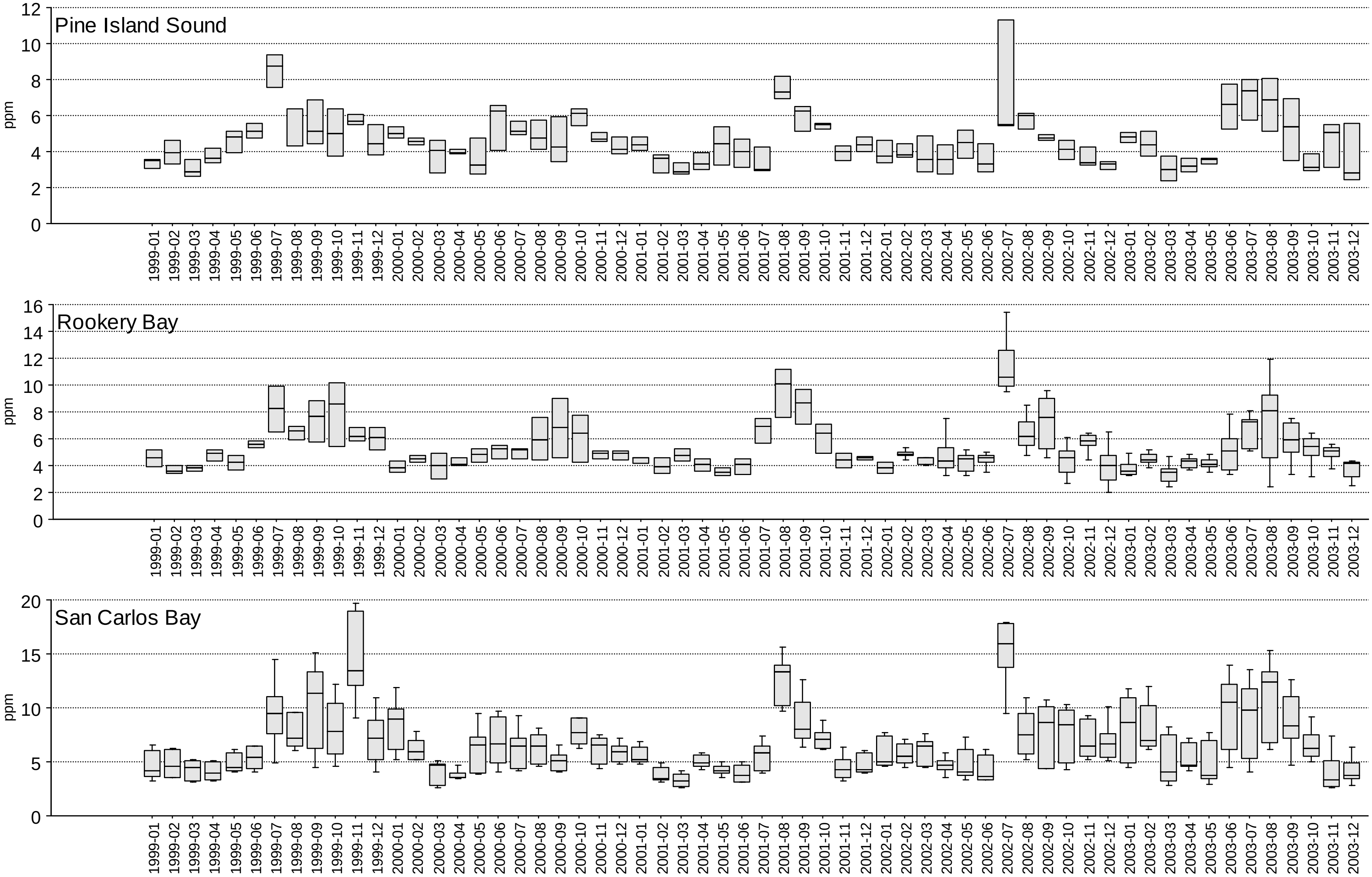

Figure 6.6. Monthly median and range of total organic carbon in the Cape Romano-PIS area.

7. PUBLICATIONS DERIVED FROM THIS PROJECT

FOURQUREAN, J. W., R. D. JONES, AND J. C. ZIEMAN. 1993. Processes influencing water column nutrient characteristics and phosphorus limitation of phytoplankton biomass in Florida Bay, FL, USA: Inferences from spatial distributions. *Estuarine, Coastal and Shelf Science* 36:295-314.

BOYER, J. N., J. W. FOURQUREAN, AND R. D. JONES. 1997. Spatial characterization of water quality in Florida Bay and Whitewater Bay by principal component and cluster analyses: Zones of similar influence (ZSI). *Estuaries* 20:743-758.

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BOYER, J. N. AND R. D. JONES. 2000. Trends in water quality of Florida Bay (1989-1999). State of Florida Bay. NPS - Everglades National Park Report.

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HU, C., F. E. MULLER-KARGER, Z.-P. LEE, K. L. CARDER, B. ROBERTS, J. J. WALSH, R. H. WEISBERG, R. HE, E. JOHNS, T. LEE, N. KURING, J. PATCH, J. IVEY, P. G. COBLE, C. HEIL, G. A. VARGO, R. G. ZEPP, K. STEIDINGER, G. MCRAE, J. BOYER, R. JONES, G. KIRKPATRICK, E. MUELLER, R. PIERCE, J. CULTER, B. KELLER, J. HUNT. 2002. The 2002 "black water" event off SW Florida as detected by satellites. *EOS* 83: 281, 285.

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SCULLEY, N. M., N. MAIE, S. K. DAILEY, J. N. BOYER, AND R. JAFFÉ. 2004. Photochemical and microbial transformation of plant derived dissolved organic matter in the Florida Everglades. *Limnology and Oceanography*. In press.

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CHILDERS, D. L., J. N. BOYER, S. E. DAVIS, C. J. MADDEN, D. T. RUDNICK, AND F. H. SKLAR. (in review) Nutrient concentration patterns in the oligotrophic “upside-down” estuaries of the Florida Everglades. *Limnology and Oceanography*

DAILEY, S. K., AND J. N. BOYER. (in prep.) Nutrient, dissolved organic matter, and microbial coupling in the Shark River Estuary, FL. *Estuaries*.

BOYER, J. N., S. K. DAILEY, R. JAFFÉ, N. MAIE. (in prep.) Biological availability of organic nitrogen along an oligotrophic marsh/mangrove/estuary ecotone in South Florida, USA. *Aquatic Microbial Ecology*.

KELBLE, C. R., P. B. ORTNER, G. L. HITCHCOCK, AND J. N. BOYER. (in prep.) A re-examination of the light environment of Florida Bay. *Estuaries*.

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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 water quality variables by zone.

Table 9.1. List of fixed station location and sampling period of record.

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
Card Sound Bridge	1	FB	25 16.413	-80 22.475	Mar 91 - Dec 03	1-154
Middle Key	2	FB	25 17.102	-80 23.702	Mar 91 - Dec 03	1-154
Manatee Bay	3	FB	25 15.062	-80 24.910	Mar 91 - Dec 03	1-154
Barnes Sound	4	FB	25 13.304	-80 23.299	Mar 91 - Dec 03	1-154
Blackwater Sound	5	FB	25 10.443	-80 25.385	Mar 91 - Dec 03	1-154
Little Blackwater Sound	6	FB	25 12.401	-80 26.424	Mar 91 - Dec 03	1-154
Highway Creek	7	FB	25 15.216	-80 26.649	Mar 91 - Dec 03	1-154
Long Sound	8	FB	25 13.642	-80 27.700	Mar 91 - Dec 03	1-154
Duck Key	9	FB	25 10.624	-80 29.494	Mar 91 - Dec 03	1-154
Joe Bay	10	FB	25 13.468	-80 32.195	Mar 91 - Dec 03	1-154
Little Madeira Bay	11	FB	25 10.510	-80 37.615	Mar 91 - Dec 03	1-154
Terrapin Bay	12	FB	25 08.422	-80 42.967	Mar 91 - Dec 03	1-154
Whipray Basin	13	FB	25 05.485	-80 45.287	Mar 91 - Dec 03	1-154
Garfield Bight	14	FB	25 09.029	-80 48.553	Apr 91 - Dec 03	2-154
Rankin Lake	15	FB	25 07.283	-80 48.173	Mar 91 - Dec 03	1-154
Murray Key	16	FB	25 07.096	-80 56.379	Mar 91 - Dec 03	1-154
Johnson Key Basin	17	FB	25 02.548	-80 54.889	Mar 91 - Dec 03	1-154
Rabbit Key Basin	18	FB	25 00.145	-80 54.006	Mar 91 - Dec 03	1-154
Twin Key Basin	19	FB	24 58.660	-80 45.211	Apr 91 - Dec 03	2-154
Peterson Keys	20	FB	24 55.770	-80 45.028	Mar 91 - Dec 03	1-154
Porpoise Lake	21	FB	25 00.396	-80 40.876	Mar 91 - Dec 03	1-154
Captain Key	22	FB	25 02.405	-80 36.843	Apr 91 - Dec 03	2-154
Park Key	23	FB	25 07.078	-80 35.983	Apr 91 - Dec 03	2-154
Butternut Key	24	FB	25 06.105	-80 31.884	Mar 91 - Dec 03	1-154
East Cape	25	FB	25 05.022	-81 04.835	July 92 - Dec 03	17-154
Oxfoot Bank	26	FB	24 58.844	-81 00.098	July 92 - Dec 03	17-154
Sprigger Bank	27	FB	24 55.116	-80 56.092	July 92 - Dec 03	17-154
Old Dan Bank	28	FB	24 52.032	-80 48.429	July 92 - Dec 03	17-154
First Bay	29	WWB	25 33.272	-81 11.020	Sept 92 - Dec 03	19-154
Third Bay	30	WWB	25 34.810	-81 07.256	Sept 92 - Dec 03	19-154
Big Lostmans Bay	31	WWB	25 34.055	-81 04.288	Sept 92 - Dec 03	19-154
Cabbage Island	32	WWB	25 31.764	-81 02.603	Sept 92 - Dec 03	19-154
Broad River Bay	33	WWB	25 29.984	-81 02.939	Sept 92 - Dec 03	19-154
Middle Broad River	34	WWB	25 29.163	-81 06.669	Sept 92 - Dec 03	19-154
Broad River Mouth	35	WWB	25 28.501	-81 09.176	Sept 92 - Dec 03	19-154
Harney River Mouth	36	WWB	25 24.701	-81 08.487	Sept 92 - Dec 03	19-154
Harney Rivers Junction	37	WWB	25 25.901	-81 04.943	Sept 92 - Dec 03	19-154
Tarpon Bay	38	WWB	25 25.037	-80 59.906	Sept 92 - Dec 03	19-154
Gunboat Island	39	WWB	25 22.735	-81 01.844	Sept 92 - Dec 03	19-154
Ponce de Leon Bay	40	WWB	25 20.983	-81 07.474	Sept 92 - Dec 03	19-154
Oyster Bay	41	WWB	25 19.869	-81 04.360	Sept 92 - Dec 03	19-154
North Marker 36	42	WWB	25 19.560	-81 00.873	Sept 92 - Dec 03	19-154
West Marker 34	43	WWB	25 17.168	-81 01.419	Sept 92 - Dec 03	19-154
Watson River Chickee	44	WWB	25 19.912	-80 59.022	Sept 92 - Dec 03	19-154
North River Mouth	45	WWB	25 18.054	-80 57.620	Sept 92 - Dec 03	19-154
Midway Keys	46	WWB	25 17.102	-80 58.548	Sept 92 - Dec 03	19-154
Roberts River Mouth	47	WWB	25 16.779	-80 55.846	Sept 92 - Dec 03	19-154
West Marker 18	48	WWB	25 14.448	-80 57.476	Sept 92 - Dec 03	19-154
Southeast Marker 12	49	WWB	25 13.704	-80 55.980	Sept 92 - Dec 03	19-154
Coot Bay	50	WWB	25 11.452	-80 54.848	Sept 92 - Dec 03	19-154

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
Chokoloskee	51	TTI	25 48.450	-81 20.970	Sept 94 - Dec 03	43-154
Rabbit Key Pass	52	TTI	25 46.200	-81 23.000	Sept 94 - Dec 03	43-154
Lopez Bay	53	TTI	25 47.050	-81 19.930	Sept 94 - Dec 03	43-154
Lopez River	54	TTI	25 47.130	-81 18.550	Sept 94 - Dec 03	43-154
Sunday Bay	55	TTI	25 47.760	-81 16.800	Sept 94 - Dec 03	43-154
Huston Bay	56	TTI	25 45.180	-81 15.330	Sept 94 - Dec 03	43-154
Upper Chatham River	57	TTI	25 43.050	-81 13.830	Sept 94 - Dec 03	43-154
Watson Place	58	TTI	25 42.470	-81 15.130	Sept 94 - Dec 03	43-154
Gun Rock Point	59	TTI	25 41.500	-81 17.920	Sept 94 - Dec 03	43-154
Huston River	60	TTI	25 43.880	-81 17.080	Sept 94 - Dec 03	43-154
Chevalier Bay	61	TTI	25 42.750	-81 12.420	Sept 94 - Dec 03	43-154
Alligator Bay	62	TTI	25 40.210	-81 10.120	Sept 94 - Dec 03	43-154
Lostmans Five Bay	63	TTI	25 38.000	-81 08.700	Sept 94 - Dec 03	43-154
Barron River	64	TTI	25 51.196	-81 23.602	Sept 94 - Dec 03	43-154
Indian Key Pass	65	TTI	25 49.631	-81 26.465	Sept 94 - Dec 03	43-154
Indian Key	66	TTI	25 48.290	-81 27.750	Sept 94 - Dec 03	43-154
West Pass	67	TTI	25 49.820	-81 30.170	Sept 94 - Dec 03	43-154
Panther Key	68	TTI	25 50.960	-81 32.530	Sept 94 - Dec 03	43-154
Faka Union Pass	69	TTI	25 52.450	-81 30.960	Sept 94 - Dec 03	43-154
Faka Union Bay	70	TTI	25 54.000	-81 30.960	Sept 94 - Dec 03	43-154
White Horse Key	71	TTI	25 52.007	-81 34.489	Sept 94 - Dec 03	43-154
Dismal Key	72	TTI	25 53.668	-81 33.532	Sept 94 - Dec 03	43-154
Long Rock	73	TTI	25 52.920	-81 36.380	Sept 94 - Dec 03	43-154
Shell Key	74	TTI	25 54.670	-81 36.920	Sept 94 - Dec 03	43-154
Blackwater River	75	TTI	25 55.788	-81 36.019	Sept 94 - Dec 03	43-154
Fakahatchee Bay	76	TTI	25 53.369	-81 28.592	Jan 02 - Dec-03	131-154
Convoy Point	101	BB	25 28.700	-80 19.250	Sept 93 - Dec 03	31-154
Black Point	102	BB	25 32.750	-80 17.680	Sept 93 - Dec 03	31-154
Near Black Ledge	103	BB	25 34.400	-80 17.200	Sept 93 - Dec 03	31-154
BNP Marker C	104	BB	25 36.100	-80 13.250	Sept 93 - Dec 03	31-154
Biscayne Channel	105	BB	25 39.252	-80 11.202	Sept 93 - May 96	31-63
White Marker	106	BB	25 38.052	-80 07.800	Sept 93 - May 96	31-63
Fowey Rocks	107	BB	25 35.400	-80 06.000	Sept 93 - May 96	31-63
Marker G-1B	108	BB	25 34.150	-80 11.550	Sept 93 - Dec 03	31-154
North Midbay	109	BB	25 33.850	-80 14.100	Sept 93 - Dec 03	31-154
Fender Point	110	BB	25 30.300	-80 17.250	Sept 93 - Dec 03	31-154
Featherbed Bank	111	BB	25 30.950	-80 14.400	Sept 93 - Dec 03	31-154
Sands Cut	112	BB	25 29.300	-80 11.300	Sept 93 - Dec 03	31-154
Elliott Key	113	BB	25 26.500	-80 13.400	Sept 93 - Dec 03	31-154
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 - Dec 03	31-154
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
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 03	31-154
West Arsenicker	122	BB	25 25.210	-80 18.650	Sept 93 - Dec 03	31-154
Pelican Bank	123	BB	25 26.700	-80 17.000	Sept 93 - Dec 03	31-154

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
South Midbay	124	BB	25 28.350	-80 14.000	Sept 93 - Dec 03	31-154
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 - Dec 03	64-154
Shoal Point	127	BB	25 37.800	-80 15.000	June 96 - Dec 03	64-154
Matheson Beach	128	BB	25 41.300	-80 14.000	June 96 - Dec 03	64-154
Marker G-71	129	BB	25 44.200	-80 11.100	June 96 - Dec 03	64-154
South Dodge Island	130	BB	25 45.800	-80 10.300	June 96 - Dec 03	64-154
North Venetian Basin	131	BB	25 48.000	-80 10.000	June 96 - Dec 03	64-154
North I-195 Basin	132	BB	25 49.000	-80 10.000	June 96 - Dec 03	64-154
North Normandy Isle	133	BB	25 52.000	-80 09.000	June 96 - Dec 03	64-154
Oleta River Park	134	BB	25 54.300	-80 08.000	June 96 - Dec 03	64-154
South Card Sound	135	BB	25 19.000	-80 19.000	June 96 - Dec 03	64-154
Lower Harbor Keys	351	SHELF	24 41.500	-81 47.500	May 95 - Dec 03	1-34
	352	SHELF	24 46.550	-81 46.980	May 95 - Dec 03	1-34
	353	SHELF	24 51.500	-81 46.600	May 95 - Dec 03	1-34
	354	SHELF	24 56.480	-81 46.120	May 95 - Dec 03	1-34
	355	SHELF	25 01.480	-81 45.750	May 95 - Dec 03	1-34
	356	SHELF	25 06.460	-81 45.230	May 95 - Dec 03	1-34
	357	SHELF	25 11.470	-81 44.720	May 95 - Dec 03	1-34
	358	SHELF	25 16.480	-81 44.290	May 95 - Dec 03	1-34
	359	SHELF	25 21.500	-81 43.800	May 95 - Dec 03	1-34
	360	SHELF	25 26.470	-81 43.260	May 95 - Dec 03	1-34
	361	SHELF	25 31.480	-81 42.900	May 95 - Dec 03	1-34
	362	SHELF	25 36.520	-81 42.400	May 95 - Dec 03	1-34
Off Cape Romano	363	SHELF	25 41.520	-81 41.900	May 95 - Dec 03	1-34
	364	SHELF	25 41.500	-81 32.000	May 95 - Dec 03	1-34
	365	SHELF	25 36.510	-81 32.360	May 95 - Dec 03	1-34
	366	SHELF	25 31.560	-81 32.930	May 95 - Dec 03	1-34
	367	SHELF	25 26.550	-81 33.300	May 95 - Dec 03	1-34
	368	SHELF	25 21.510	-81 33.800	May 95 - Dec 03	1-34
	369	SHELF	25 16.530	-81 34.320	May 95 - Dec 03	1-34
	370	SHELF	25 11.510	-81 34.750	May 95 - Dec 03	1-34
	371	SHELF	25 06.500	-81 35.210	May 95 - Dec 03	1-34
	372	SHELF	25 01.500	-81 35.720	May 95 - Dec 03	1-34
	373	SHELF	24 56.530	-81 36.180	May 95 - Dec 03	1-34
	374	SHELF	24 51.530	-81 36.650	May 95 - Dec 03	1-34
Off Johnson Key	375	SHELF	24 46.540	-81 37.070	May 95 - Dec 03	1-34
Harbor Key Bank	376	SHELF	24 50.600	-81 26.300	May 95 - Dec 03	1-34
	377	SHELF	24 56.100	-81 25.900	May 95 - Dec 03	1-34
	378	SHELF	25 01.000	-81 24.950	May 95 - Dec 03	1-34
	379	SHELF	25 06.000	-81 24.530	May 95 - Dec 03	1-34
	380	SHELF	25 11.000	-81 24.000	May 95 - Dec 03	1-34
	381	SHELF	25 16.000	-81 23.700	May 95 - Dec 03	1-34
	382	SHELF	25 21.000	-81 23.200	May 95 - Dec 03	1-34
	383	SHELF	25 25.950	-81 22.670	May 95 - Dec 03	1-34
	384	SHELF	25 30.930	-81 22.200	May 95 - Dec 03	1-34
	385	SHELF	25 36.010	-81 21.790	May 95 - Dec 03	1-34
	386	SHELF	25 33.330	-81 20.430	May 95 - Dec 03	1-34
	387	SHELF	25 30.530	-81 19.010	May 95 - Dec 03	1-34
	388	SHELF	25 25.500	-81 17.820	May 95 - Dec 03	1-34
	389	SHELF	25 20.500	-81 16.620	May 95 - Dec 03	1-34

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
	390	SHELF	25 15.600	-81 15.610	May 95 - Dec 03	1-34
	391	SHELF	25 10.500	-81 14.320	May 95 - Dec 03	1-34
	392	SHELF	25 05.500	-81 14.900	May 95 - Dec 03	1-34
	393	SHELF	25 00.500	-81 15.200	May 95 - Dec 03	1-34
	394	SHELF	24 55.500	-81 15.600	May 95 - Dec 03	1-34
Off Bluefish Bank	395	SHELF	24 52.700	-81 11.500	May 95 - Dec 03	1-34
Off Bullard Bank	396	SHELF	24 50.000	-81 07.700	May 95 - Dec 03	1-34
	397	SHELF	24 55.000	-81 07.100	May 95 - Dec 03	1-34
	398	SHELF	25 00.000	-81 06.600	May 95 - Dec 03	1-34
Off East Cape	300	SHELF	25 05.000	-81 05.960	May 95 - Dec 03	1-34
Coon Key Pass, G3	451	ROOK	25 54.626	-81 38.309	Jan 99 - Dec 03	97-154
Coon Key Light	452	ROOK	25 52.918	-81 37.954	Jan 99 - Dec 03	97-154
Fred Key, G5	453	ROOK	25 53.978	-81 41.027	Jan 99 - Dec 03	97-154
Caxambas Pass, R4	454	ROOK	25 54.360	-81 43.733	Jan 99 - Dec 03	97-154
Capri Pass, R2A	455	ROOK	25 59.285	-81 43.740	Jan 99 - Dec 03	97-154
Rt. 951 Bridge, R26	456	ROOK	25 57.737	-81 42.524	Jan 99 - Dec 03	97-154
Big Marco River, R24	457	ROOK	25 57.122	-81 41.243	Jan 99 - Dec 03	97-154
Goodland Bridge, G15	458	ROOK	25 56.080	-81 39.204	Jan 99 - Dec 03	97-154
Johnson Bay	459	ROOK	25 59.291	-81 43.748	Jan 99 - Dec 03	97-154
Hall Bay	460	ROOK	26 00.941	-81 44.566	Jan 99 - Dec 03	97-154
Rookery Bay	461	ROOK	26 01.755	-81 44.888	Jan 99 - Dec 03	97-154
First National	462	ROOK	26 02.441	-81 45.955	Jan 99 - Dec 03	97-154
Kewaydin Channel, G55	463	ROOK	26 03.611	-81 46.713	Jan 99 - Dec 03	97-154
Dollar Bay, G73	464	ROOK	26 06.000	-81 47.213	Jan 99 - Dec 03	97-154
Outer Gordon Pass, G1	465	ROOK	26 05.480	-81 48.686	Jan 99 - Dec 03	97-154
New Pass	466	ROOK	26 22.692	-81 51.508	Jan 99 - Dec 03	97-154
Wiggins Pass Bridge	467	ROOK	26 17.441	-81 49.105	Jan 99 - Dec 03	97-154
Big Carlos Pass Bridge	468	ROOK	26 24.146	-81 52.850	Jan 99 - Dec 03	97-154
Coon Key, R2A	469	ROOK	26 25.422	-81 52.400	Jan 99 - Dec 03	97-154
Central Estero Bay, R2	470	ROOK	26 24.459	-81 51.885	Jan 99 - Dec 03	97-154
Point Ybel, R8	471	ROOK	26 27.492	-82 00.444	Jan 99 - Dec 03	97-154
San Carlos Bay, R4	472	ROOK	26 28.013	-82 02.723	Jan 99 - Dec 03	97-154
Kitchel Key, G13	473	ROOK	26 30.070	-82 00.789	Jan 99 - Dec 03	97-154
Shell Point	474	ROOK	26 31.368	-82 00.417	Jan 99 - Dec 03	97-154
Reckems Point	475	ROOK	26 32.108	-82 03.548	Jan 99 - Dec 03	97-154
Sanibel	476	ROOK	26 30.472	-82 09.113	Jan 99 - Dec 03	97-154
Pine Island Sound	477	ROOK	26 33.702	-82 09.934	Jan 99 - Dec 03	97-154
Cayo Costa	478	ROOK	26 38.150	-82 12.517	Jan 99 - Dec 03	97-154

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

Variable	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity (μM hr^{-1})	All	0.36	0.01	6.44	3495
	FBC	1.48	0.01	6.44	528
	FBE	0.35	0.01	6.11	2214
	FBW	0.19	0.01	4.93	753
Chlorophyll *a* (μg l^{-1})	All	0.84	0.00	35.61	3612
	FBC	1.79	0.11	35.61	542
	FBE	0.55	0.00	11.35	2284
	FBW	1.55	0.14	22.08	786
Surface Dissolved Oxygen (mg l^{-1})	All	6.6	0.4	12.3	3633
	FBC	6.4	2.8	12.3	545
	FBE	6.7	0.4	11.7	2289
	FBW	6.3	3.0	11.5	799
Bottom Dissolved Oxygen (mg l^{-1})	All	6.5	1.4	13.4	3414
	FBC	6.3	1.5	12.2	514
	FBE	6.7	1.4	13.4	2174
	FBW	6.2	3.0	11.1	726
Ammonium (ppm)	All	0.032	0.000	1.681	3592
	FBC	0.051	0.000	1.681	535
	FBE	0.039	0.000	1.149	2277
	FBW	0.011	0.000	0.342	780
Nitrite (ppm)	All	0.002	0.000	0.111	3597
	FBC	0.002	0.000	0.111	539
	FBE	0.003	0.000	0.037	2278
	FBW	0.001	0.000	0.025	780
Nitrate (ppm)	All	0.005	0.000	0.154	3580
	FBC	0.003	0.000	0.080	537
	FBE	0.009	0.000	0.154	2268
	FBW	0.002	0.000	0.101	775
Surface Salinity	All	31.90	0.20	63.00	3691
	FBC	34.00	8.70	63.00	554
	FBE	28.90	0.20	54.30	2324
	FBW	35.00	16.50	52.00	813
Bottom Salinity	All	31.30	0.20	63.00	3376
	FBC	33.15	11.90	63.00	510
	FBE	28.40	0.20	54.30	2140
	FBW	34.70	16.60	51.00	726
Silicate (ppm)	All	0.381	0.000	4.060	648
	FBC	0.998	0.000	4.060	96
	FBE	0.278	0.000	3.426	408
	FBW	0.417	0.000	2.932	144
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.026	3570
	FBC	0.001	0.000	0.026	537
	FBE	0.001	0.000	0.016	2260
	FBW	0.001	0.000	0.010	773

Variable	Zone	Median	Min.	Max.	*n*
Surface Temperature (^{o}C)	All	26.5	13.3	36.7	3663
	FBC	26.5	13.3	36.7	550
	FBE	26.5	14.4	34.5	2306
	FBW	26.3	14.2	36.0	807
Bottom Temperature (^{o}C)	All	26.3	13.3	35.3	3434
	FBC	26.3	13.3	35.3	518
	FBE	26.5	14.4	34.6	2184
	FBW	26.1	14.4	34.7	732
Total Organic Carbon (ppm)	All	8.070	0.000	58.043	3569
	FBC	13.144	4.518	42.872	532
	FBE	8.264	0.000	58.043	2268
	FBW	4.944	1.199	20.216	769
Total Organic Nitrogen (ppm)	All	0.546	0.000	4.355	3574
	FBC	0.939	0.135	4.355	533
	FBE	0.564	0.000	3.098	2267
	FBW	0.353	0.046	1.680	774
Total Phosphorus (ppm)	All	0.010	0.000	0.232	3599
	FBC	0.018	0.004	0.131	538
	FBE	0.008	0.001	0.041	2279
	FBW	0.015	0.000	0.232	782
Turbidity (NTU)	All	3.31	0.01	178.55	3466
	FBC	6.60	0.12	134.85	523
	FBE	2.25	0.01	172.95	2206
	FBW	6.04	0.07	178.55	737

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

Variable	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity (μM hr^{-1})	All	0.13	0.00	8.31	4463
	BLK	0.04	0.02	0.28	171
	GI	0.05	0.00	3.23	1082
	IW	0.11	0.00	8.31	943
	MR	0.22	0.00	3.70	1381
	WB	1.09	0.00	5.96	886
Chlorophyll *a* (μg l^{-1})	All	2.80	0.11	45.11	4501
	BLK	3.16	0.25	17.02	174
	GI	2.73	0.12	23.78	1092
	IW	3.19	0.20	45.11	954
	MR	2.57	0.19	28.76	1394
	WB	2.71	0.11	29.78	887
Surface Dissolved Oxygen (mg l^{-1})	All	5.8	0.3	13.9	4481
	BLK	5.4	0.3	10.3	174
	GI	5.8	1.4	12.1	1090
	IW	5.8	1.8	11.8	954
	MR	5.1	0.4	13.9	1383
	WB	6.8	2.2	11.1	880
Bottom Dissolved Oxygen (mg l^{-1})	All	5.8	0.1	12.3	4480
	BLK	5.3	0.1	9.8	174
	GI	5.7	1.8	11.8	1090
	IW	5.8	1.1	11.9	954
	MR	5.1	0.4	12.3	1382
	WB	6.9	0.4	11.1	880
Ammonium (ppm)	All	0.014	0.000	0.408	4502
	BLK	0.021	0.001	0.195	174
	GI	0.011	0.000	0.183	1092
	IW	0.016	0.000	0.285	954
	MR	0.016	0.000	0.402	1394
	WB	0.012	0.000	0.408	888
Nitrite (ppm)	All	0.002	0.000	0.086	4502
	BLK	0.003	0.000	0.017	174
	GI	0.002	0.000	0.033	1092
	IW	0.003	0.000	0.036	954
	MR	0.002	0.000	0.012	1394
	WB	0.002	0.000	0.086	888
Nitrate (ppm)	All	0.010	0.000	0.268	4502
	BLK	0.008	0.000	0.080	174
	GI	0.008	0.000	0.135	1092
	IW	0.010	0.000	0.133	954
	MR	0.015	0.000	0.142	1394
	WB	0.005	0.000	0.268	888

Variable	Zone	Median	Min.	Max.	*n*
Surface Salinity	All	15.8	0.0	42.8	4499
	BLK	31.7	1.4	39.9	174
	GI	28.3	1.3	40.7	1092
	IW	13.8	0.1	42.8	954
	MR	5.1	0.0	40.5	1391
	WB	10.9	0.3	35.4	888
Bottom Salinity	All	16.9	0.0	53.6	4477
	BLK	31.6	1.4	39.9	174
	GI	28.8	1.0	40.7	1090
	IW	15.3	0.2	53.6	954
	MR	5.8	0.0	40.5	1379
	WB	11.3	0.3	34.9	880
Silicate (ppm)	All	1.614	0.000	4.880	1050
	BLK	1.488	0.000	3.657	44
	GI	1.455	0.000	4.705	265
	IW	1.584	0.000	4.688	241
	MR	2.069	0.000	4.699	308
	WB	1.381	0.002	4.880	192
Soluble Reactive Phosphorus (ppm)	All	0.003	0.000	0.066	4491
	BLK	0.017	0.002	0.066	174
	GI	0.007	0.000	0.044	1087
	IW	0.003	0.000	0.028	954
	MR	0.002	0.000	0.034	1391
	WB	0.002	0.000	0.026	885
Surface Temperature (^{o}C)	All	26.9	12.5	38.4	4481
	BLK	27.4	15.9	38.4	174
	GI	27.0	14.9	37.2	1090
	IW	27.3	15.2	37.5	954
	MR	26.5	13.6	34.4	1383
	WB	26.5	12.5	34.2	880
Bottom Temperature (^{o}C)	All	26.8	11.8	37.2	4480
	BLK	27.2	16.0	35.9	174
	GI	27.0	14.9	37.2	1090
	IW	27.2	15.2	33.3	954
	MR	26.5	13.6	33.3	1382
	WB	26.3	11.8	33.5	880
Total Organic Carbon (ppm)	All	11.608	3.634	64.008	4500
	BLK	6.992	3.805	21.385	173
	GI	6.989	3.634	27.170	1091
	IW	11.289	5.187	22.462	954
	MR	13.524	5.064	64.008	1394
	WB	15.759	6.143	39.373	888
Total Organic Nitrogen (ppm)	All	0.568	0.000	2.989	4500
	BLK	0.375	0.130	0.937	173
	GI	0.391	0.108	1.748	1091
	IW	0.568	0.021	1.566	954
	MR	0.660	0.021	2.989	1394
	WB	0.807	0.000	2.535	888

Variable	Zone	Median	Min.	Max.	*n*
Total Phosphorus (ppm)	All	0.027	0.001	0.125	4490
	BLK	0.057	0.016	0.098	170
	GI	0.035	0.004	0.112	1085
	IW	0.031	0.002	0.092	954
	MR	0.022	0.001	0.125	1393
	WB	0.018	0.003	0.094	888
Turbidity (NTU)	All	4.00	0.06	107.81	4500
	BLK	7.30	0.49	40.50	173
	GI	5.11	0.42	68.00	1091
	IW	4.30	0.06	43.60	954
	MR	2.70	0.09	58.65	1394
	WB	3.64	0.21	107.81	888

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

Variable	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity (μM hr^{-1})	All	0.135	0.008	3.209	2339
	AS	0.328	0.093	3.209	198
	IS	0.193	0.036	2.119	428
	MAIN	0.108	0.008	0.894	1154
	NBAY	0.110	0.017	1.475	328
	SCARD	0.141	0.041	0.942	231
Chlorophyll *a* (μg l^{-1})	All	0.28	0.00	9.18	2317
	AS	0.27	0.04	2.46	196
	IS	0.26	0.03	6.37	424
	MAIN	0.23	0.00	5.89	1143
	NBAY	0.91	0.16	9.18	325
	SCARD	0.30	0.06	3.61	229
Surface Dissolved Oxygen (mg l^{-1})	All	6.4	2.8	11.6	2339
	AS	7.2	3.1	11.6	196
	IS	6.7	4.0	11.5	428
	MAIN	6.3	2.8	10.2	1154
	NBAY	6.2	3.0	10.2	330
	SCARD	6.4	4.0	9.0	231
Bottom Dissolved Oxygen (mg l^{-1})	All	6.5	2.8	12.9	2339
	AS	7.4	3.7	12.9	196
	IS	6.8	3.9	11.8	428
	MAIN	6.3	2.8	10.6	1154
	NBAY	6.2	3.2	10.4	330
	SCARD	6.4	3.3	9.5	231
Ammonium (ppm)	All	0.011	0.000	0.228	2343
	AS	0.015	0.001	0.228	198
	IS	0.012	0.000	0.095	429
	MAIN	0.010	0.000	0.083	1155
	NBAY	0.014	0.000	0.114	330
	SCARD	0.014	0.000	0.121	231
Nitrite (ppm)	All	0.002	0.000	0.060	2343
	AS	0.003	0.000	0.032	198
	IS	0.002	0.000	0.021	429
	MAIN	0.001	0.000	0.010	1155
	NBAY	0.002	0.000	0.060	330
	SCARD	0.002	0.000	0.019	231
Nitrate (ppm)	All	0.007	0.000	1.082	2343
	AS	0.035	0.000	1.082	198
	IS	0.012	0.000	0.672	429
	MAIN	0.004	0.000	0.295	1155
	NBAY	0.015	0.000	0.174	330
	SCARD	0.009	0.000	0.129	231

Variable	Zone	Median	Min.	Max.	*n*
Surface Salinity	All	33.3	12.3	42.3	2343
	AS	27.0	12.3	42.3	198
	IS	30.8	15.1	42.2	429
	MAIN	35.0	22.5	40.4	1155
	NBAY	31.9	19.3	37.9	330
	SCARD	32.0	21.0	39.0	231
Bottom Salinity	All	33.9	3.4	42.2	2342
	AS	27.7	12.8	42.2	198
	IS	31.4	3.4	42.2	429
	MAIN	35.1	24.2	40.3	1154
	NBAY	33.3	25.2	37.9	330
	SCARD	32.8	20.9	39.0	231
Silicate (ppm)	All	0.063	0.000	1.287	550
	AS	0.174	0.000	0.851	44
	IS	0.088	0.000	0.828	110
	MAIN	0.029	0.000	0.720	242
	NBAY	0.210	0.001	1.287	110
	SCARD	0.040	0.000	0.260	44
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.021	2325
	AS	0.001	0.000	0.010	197
	IS	0.001	0.000	0.009	425
	MAIN	0.000	0.000	0.009	1148
	NBAY	0.001	0.000	0.021	326
	SCARD	0.001	0.000	0.008	229
Surface Temperature (°C)	All	26.3	10.2	33.3	2343
	AS	26.8	10.2	32.9	198
	IS	26.3	15.7	33.3	429
	MAIN	26.1	15.5	32.8	1155
	NBAY	25.8	16.5	32.5	330
	SCARD	26.3	16.4	32.5	231
Bottom Temperature (°C)	All	26.1	10.3	33.8	2343
	AS	26.7	10.3	33.2	198
	IS	26.3	15.7	33.4	429
	MAIN	26.1	15.6	32.5	1155
	NBAY	25.6	16.5	32.9	330
	SCARD	26.5	16.6	33.8	231
Total Organic Carbon (ppm)	All	3.346	0.326	9.330	2340
	AS	4.750	1.379	9.330	198
	IS	3.908	1.463	9.168	428
	MAIN	2.803	0.326	6.522	1155
	NBAY	3.614	1.451	8.208	329
	SCARD	3.988	1.968	7.572	230
Total Organic Nitrogen (ppm)	All	0.228	0.006	1.229	2342
	AS	0.356	0.006	0.825	198
	IS	0.282	0.016	0.877	428
	MAIN	0.193	0.031	1.010	1155
	NBAY	0.206	0.045	0.652	330
	SCARD	0.274	0.068	1.229	231

Variable	Zone	Median	Min.	Max.	*n*
Total Phosphorus (ppm)	All	0.006	0.000	0.038	2342
	AS	0.006	0.000	0.025	198
	IS	0.005	0.001	0.026	428
	MAIN	0.005	0.001	0.030	1155
	NBAY	0.009	0.003	0.038	330
	SCARD	0.006	0.002	0.030	231
Turbidity (NTU)	All	0.69	0.00	22.35	2341
	AS	0.50	0.05	3.73	198
	IS	0.45	0.00	3.75	428
	MAIN	0.80	0.00	19.00	1154
	NBAY	1.12	0.01	22.35	330
	SCARD	0.55	0.00	3.80	231

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

Variable	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity (μM hr^{-1})	All	0.052	0.004	12.017	1096
	SHARK	0.063	0.016	2.485	45
	SHELF	0.051	0.004	12.017	892
	SHOAL	0.052	0.012	7.627	159
Chlorophyll *a* (μg l^{-1})	All	0.905	0.000	10.463	1274
	SHARK	1.597	0.254	4.651	52
	SHELF	0.869	0.000	10.463	1040
	SHOAL	0.926	0.240	6.560	182
Surface Dissolved Oxygen (mg l^{-1})	All	6.2	2.8	12.8	1257
	SHARK	6.1	3.6	8.3	51
	SHELF	6.2	2.8	12.6	1026
	SHOAL	6.1	3.1	12.8	180
Bottom Dissolved Oxygen (mg l^{-1})	All	5.6	1.7	13.0	561
	SHARK	5.0	2.8	7.3	22
	SHELF	5.6	1.7	13.0	458
	SHOAL	5.8	2.6	9.7	81
Ammonium (ppm)	All	0.005	0.000	0.129	1274
	SHARK	0.008	0.001	0.049	52
	SHELF	0.005	0.000	0.129	1040
	SHOAL	0.005	0.000	0.064	182
Nitrite (ppm)	All	0.000	0.000	0.008	1274
	SHARK	0.001	0.000	0.006	52
	SHELF	0.000	0.000	0.008	1040
	SHOAL	0.001	0.000	0.005	182
Nitrate (ppm)	All	0.000	0.000	0.078	1274
	SHARK	0.002	0.000	0.072	52
	SHELF	0.000	0.000	0.078	1040
	SHOAL	0.001	0.000	0.022	182
Surface Salinity	All	35.5	24.4	40.7	1261
	SHARK	34.7	24.4	40.7	51
	SHELF	35.5	27.0	40.1	1030
	SHOAL	35.5	27.9	38.8	180
Bottom Salinity	All	36.0	26.0	40.7	565
	SHARK	35.5	26.0	40.7	22
	SHELF	36.1	27.8	40.1	462
	SHOAL	35.8	31.0	39.2	81
Silicate (ppm)	All	0.066	0.000	2.238	1169
	SHARK	0.399	0.000	1.199	47
	SHELF	0.067	0.000	2.238	955
	SHOAL	0.041	0.000	1.038	167
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.014	1274
	SHARK	0.001	0.000	0.006	52
	SHELF	0.001	0.000	0.014	1040
	SHOAL	0.001	0.000	0.008	182

Variable	Zone	Median	Min.	Max.	*n*
Surface Temperature (^oC)	All	26.5	14.7	32.7	1261
	SHARK	26.5	14.8	32.1	51
	SHELF	26.5	14.7	32.7	1030
	SHOAL	26.6	15.2	32.3	180
Bottom Temperature (^oC)	All	25.2	14.7	32.0	565
	SHARK	25.1	14.8	31.4	22
	SHELF	25.2	14.7	31.9	462
	SHOAL	25.4	15.2	32.0	81
Total Organic Carbon (ppm)	All	2.818	1.544	10.790	1274
	SHARK	3.929	2.221	5.812	52
	SHELF	2.793	1.544	10.790	1040
	SHOAL	2.761	1.606	5.864	182
Total Organic Nitrogen (ppm)	All	0.195	0.038	1.021	1265
	SHARK	0.270	0.065	0.957	51
	SHELF	0.192	0.038	1.021	1032
	SHOAL	0.197	0.051	0.511	182
Total Phosphorus (ppm)	All	0.012	0.000	0.190	1274
	SHARK	0.015	0.008	0.079	52
	SHELF	0.012	0.000	0.190	1040
	SHOAL	0.012	0.006	0.027	182
Turbidity (NTU)	All	2.17	0.00	66.25	1176
	SHARK	6.65	2.14	66.25	48
	SHELF	1.97	0.00	45.05	960
	SHOAL	2.95	0.21	20.70	168

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

Variable	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity (μM hr^{-1})	All	0.05	0.01	0.44	1005
	COCO	0.05	0.02	0.13	14
	EST	0.05	0.02	0.30	164
	MARC	0.04	0.01	0.29	287
	NPL	0.05	0.02	0.31	108
	PIS	0.05	0.02	0.17	108
	RB	0.04	0.02	0.44	144
	SCB	0.05	0.02	0.19	180
Chlorophyll *a* (μg l^{-1})	All	3.72	0.38	28.47	1005
	COCO	4.72	2.16	15.78	14
	EST	4.20	0.41	24.68	164
	MARC	4.22	0.38	20.85	287
	NPL	2.86	0.44	18.22	108
	PIS	3.30	0.55	21.76	108
	RB	3.76	0.75	17.68	144
	SCB	3.15	0.53	28.47	180
Surface Dissolved Oxygen (mg l^{-1})	All	6.1	1.3	11.7	977
	COCO	5.9	5.0	6.4	3
	EST	6.1	1.8	9.2	147
	MARC	6.1	2.8	9.3	287
	NPL	5.8	2.1	11.7	108
	PIS	6.4	3.7	9.1	108
	RB	5.7	1.3	9.5	144
	SCB	6.3	3.6	10.4	180
Bottom Dissolved Oxygen (mg l^{-1})	All	6.2	2.3	11.5	1006
	COCO	4.9	2.9	6.6	14
	EST	6.1	2.6	9.4	165
	MARC	6.2	2.8	9.3	287
	NPL	5.8	2.3	11.5	108
	PIS	6.5	4.2	10.1	108
	RB	5.8	2.7	8.9	144
	SCB	6.5	3.8	11.1	180
Light Extinction Coefficient (m^{-1})	All	0.372	0.008	3.859	198
	COCO	.	.	.	
	EST	0.399	0.041	1.113	31
	MARC	0.372	0.008	3.859	56
	NPL	0.318	0.021	1.473	21
	PIS	0.417	0.115	0.968	24
	RB	0.300	0.043	1.923	26
	SCB	0.399	0.035	2.559	40

Variable	Zone	Median	Min.	Max.	*n*
Ammonium (ppm)	All	0.007	0.000	0.239	1005
	COCO	0.040	0.017	0.215	13
	EST	0.007	0.000	0.217	165
	MARC	0.006	0.000	0.194	287
	NPL	0.008	0.001	0.170	108
	PIS	0.006	0.000	0.077	108
	RB	0.008	0.001	0.239	144
	SCB	0.007	0.000	0.184	180
Nitrite (ppm)	All	0.001	0.000	0.021	1005
	COCO	0.002	0.000	0.011	13
	EST	0.001	0.000	0.011	165
	MARC	0.001	0.000	0.010	287
	NPL	0.001	0.000	0.009	108
	PIS	0.001	0.000	0.004	108
	RB	0.001	0.000	0.009	144
	SCB	0.001	0.000	0.021	180
Nitrate (ppm)	All	0.003	0.000	0.405	1005
	COCO	0.015	0.002	0.112	13
	EST	0.002	0.000	0.073	165
	MARC	0.002	0.000	0.052	287
	NPL	0.002	0.000	0.056	108
	PIS	0.001	0.000	0.035	108
	RB	0.003	0.000	0.034	144
	SCB	0.005	0.000	0.405	180
Surface Salinity	All	34.5	3.6	40.7	976
	COCO	21.2	10.1	33.9	3
	EST	34.4	18.6	38.3	147
	MARC	35.4	21.9	40.7	287
	NPL	34.9	19.6	37.8	108
	PIS	34.5	25.8	38.6	108
	RB	35.0	14.2	38.9	143
	SCB	32.9	3.6	37.9	180
Bottom Salinity	All	34.3	1.6	40.6	1005
	COCO	29.5	1.6	35.7	14
	EST	34.0	8.7	37.9	165
	MARC	35.2	21.2	40.6	287
	NPL	34.8	20.1	37.9	108
	PIS	34.3	20.3	38.5	108
	RB	34.9	13.2	39.9	143
	SCB	31.8	3.6	37.9	180
Silicate (ppm)	All	0.596	0.000	4.175	334
	COCO	1.598	0.611	2.637	4
	EST	0.652	0.033	2.476	55
	MARC	0.577	0.013	2.872	95
	NPL	0.520	0.011	1.591	36
	PIS	0.387	0.000	1.404	36
	RB	0.564	0.079	1.859	48
	SCB	0.746	0.059	4.175	60

Variable	Zone	Median	Min.	Max.	*n*
Soluble Reactive Phosphorus (ppm)	All	0.004	0.000	0.098	1005
	COCO	0.018	0.001	0.041	13
	EST	0.004	0.000	0.030	165
	MARC	0.004	0.000	0.028	287
	NPL	0.004	0.000	0.034	108
	PIS	0.002	0.000	0.027	108
	RB	0.004	0.000	0.026	144
	SCB	0.008	0.000	0.098	180
Surface Temperature (^{o}C)	All	25.3	15.4	34.5	977
	COCO	31.1	21.5	32.7	3
	EST	25.8	16.8	31.7	147
	MARC	25.5	15.6	31.3	287
	NPL	25.0	15.4	31.5	108
	PIS	24.9	15.6	31.5	108
	RB	25.3	15.6	31.9	144
	SCB	25.0	16.5	34.5	180
Bottom Temperature (^{o}C)	All	25.3	15.6	32.8	1006
	COCO	25.7	19.6	32.7	14
	EST	25.6	16.9	32.8	165
	MARC	25.5	15.6	31.7	287
	NPL	25.1	16.4	31.4	108
	PIS	25.1	16.9	32.0	108
	RB	25.4	15.6	32.2	144
	SCB	25.0	17.0	31.9	180
Total Organic Carbon (ppm)	All	4.668	2.226	19.688	1006
	COCO	6.674	4.457	16.598	14
	EST	4.838	2.729	14.538	165
	MARC	4.481	2.575	10.220	287
	NPL	4.019	2.226	12.230	108
	PIS	4.487	2.425	9.607	108
	RB	4.844	2.728	12.070	144
	SCB	5.469	2.603	19.688	180
Total Organic Nitrogen (ppm)	All	0.272	0.057	0.832	1004
	COCO	0.362	0.222	0.630	13
	EST	0.299	0.104	0.769	165
	MARC	0.265	0.099	0.818	287
	NPL	0.237	0.078	0.541	108
	PIS	0.287	0.088	0.699	108
	RB	0.258	0.104	0.591	144
	SCB	0.286	0.057	0.832	179
Total Phosphorus (ppm)	All	0.044	0.000	0.186	1006
	COCO	0.049	0.032	0.072	14
	EST	0.049	0.017	0.186	165
	MARC	0.042	0.000	0.160	287
	NPL	0.037	0.012	0.106	108
	PIS	0.041	0.014	0.148	108
	RB	0.045	0.018	0.099	144
	SCB	0.049	0.019	0.173	180

Variable	Zone	Median	Min.	Max.	*n*
Turbidity (NTU)	All	3.75	0.06	38.65	1006
	COCO	5.67	0.35	8.24	14
	EST	4.41	0.13	28.75	165
	MARC	4.99	0.58	38.65	287
	NPL	2.85	0.25	27.25	108
	PIS	2.75	0.07	20.65	108
	RB	4.74	0.61	35.25	144
	SCB	2.80	0.06	11.80	180