2000

An Integrated Surface Water Quality Monitoring Program for the South Florida Coastal Waters FY 2000 Annual Report

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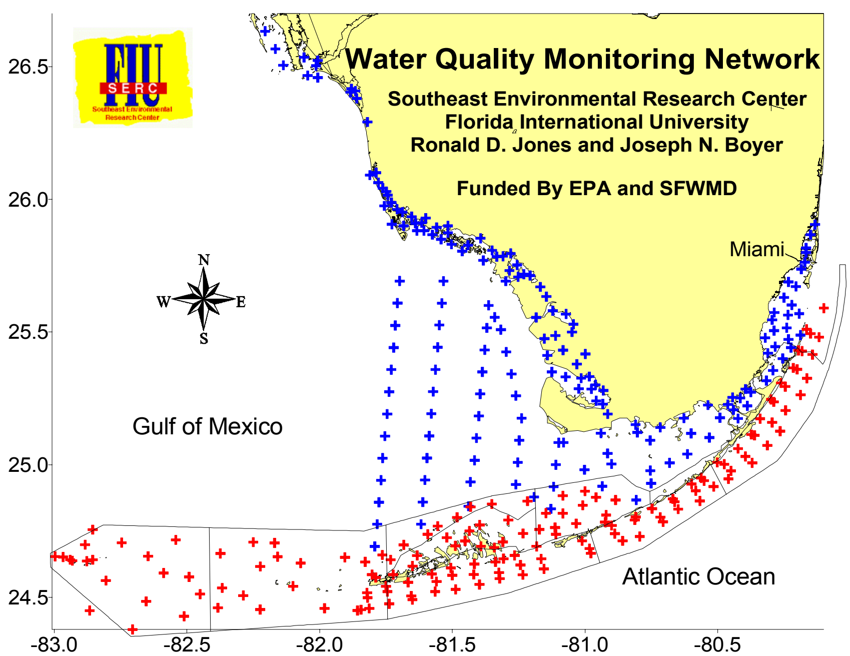
AN INTEGRATED SURFACE WATER QUALITY MONITORING PROGRAM FOR THE SOUTH FLORIDA COASTAL WATERS

FY2000 ANNUAL REPORT



Southeast Environmental Research Center
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AN INTEGRATED SURFACE WATER QUALITY MONITORING PROGRAM FOR THE SOUTH FLORIDA COASTAL WATERS

FY2000 Cumulative Report to the South Florida Water Management District (C-10244), and Everglades National Park

Which includes:

FLORIDA BAY
WHITEWATER BAY
TEN THOUSAND ISLANDS
BISCAYNE BAY
SOUTHWEST FLORIDA SHELF
CAPE ROMANO-PINE ISLAND SOUND

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EXECUTIVE SUMMARY

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 FIU’s South Florida Estuarine Water Quality Monitoring Network. This includes water quality data collected 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 monitored on a monthly basis with monitoring beginning in March 1991 at stations 1 through 24 (monitoring began at stations 14, 19, 22, and 23 in April 1991). In July 1992, stations 25 through 28 were added in Florida Bay. Monthly sampling of stations 29 through 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 Shelf was sampled quarterly beginning in spring 1995. Monthly sampling in the Cape Romano-Pine Island Sound area started January 1999.

We have begun the 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 processes which drive it. 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 goal are met.

Florida Bay

Most water quality variables during 2000 generally followed typical annual trends but there were a few exceptions. Both Central and Western Bays experienced hypersalinity during the summer months. Salinity in the Western Bay was ~ 45 during Sept.; the Central Bay got up to 48 and remained hypersaline during June – Sept. DO saturation and temperature trends were unremarkable. Ammonium (NH_4^+) concentrations continued to decline baywide but nitrate (NO_3^-) spiked in the summer in Central and Western Bays. Total phosphorus (TP) was elevated in the Eastern Bay but not in other zones. A spike in TP was seen in Dec. for all zones. Soluble reactive phosphorus (SRP) increased in all portions of the bay during 2000 but concentrations were so low that this was probably not ecologically significant. Chlorophyll *a* (CHLA) was low for all areas with the exception of a moderate phytoplankton bloom (4-12 $\mu g\ l^{-1}$) in Central Bay during March and April. Total organic carbon (TOC) concentrations remained similar to previous years as did total organic nitrogen (TON) and alkaline phosphatase activity (APA). Turbidity was low for all areas of the Bay during 2000.

Whitewater Bay-Ten Thousand Islands

The influence of freshwater input from the Everglades was very evident in this region. Large salinity variations are the norm and 2000 was much like other years. Both temperature and DO saturation followed the climactic annual cycle. Both NH_4^+ and NO_3^- concentrations remained low throughout the year in the Mangrove Rivers and Whitewater Bay. In the other zones there was a significant spike in these variables in Sept. which coincided with lowest salinity. TP in the Whitewater Bay and the Gulf Islands was elevated relative to other years and was positively correlated with salinity, implying that source of TP was not from freshwater input. Trends in SRP were unremarkable except to note relative differences between southern and northern regions. The large peaks in CHLA from the effects of Hurricane Irene (Oct. 1999) carried over to the early part of 2000. CHLA concentrations returned to normal by Feb.-Mar. 2000. Only in the Mangrove Rivers and Whitewater Bay did APA correspond with CHLA. This was due to the high P limitation in these areas. TOC and TON both showed similar interannual trends but long term declines in TON are becoming evident in the Gulf Island, Mangrove Rivers, and Inner Waterway. Turbidity remained within long term averages for all zones.

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. Temperature followed the general seasonal cycle but DO saturation was more influenced by canal releases than temperature. NH_4^+ concentrations for 2000 were low and comparable to other years (excluding hurricanes). NO_3^- continued to display spikes associated with canal releases especially in Alongshore and South Card Sound zones. Increases in TP concentrations in all areas of the Bay are beginning to become discernable. Not only are concentrations increasing but so is the variability. We can only speculate as to the cause but there is evidence from our monitoring program in the Florida Keys National Marine Sanctuary that TP is increasing over the whole region and is not fixed to a specific point source. Sharp increases in SRP during 2000 were observed which were not related to freshwater inflows. CHLA remained low in the area with the exception of Hurricane Irene effects. APA was low as well. TOC, TON, and turbidity remained relatively low and unremarkable.

Southwest Florida Shelf

Since this component of the monitoring program was sampled on a quarterly basis, there was a much smaller time series dataset to analyze. Because of this, only broad generalizations are discussed. Salinity rebounded quickly from Hurricane Irene to normal levels but continued to show broad fluctuations over the area. Water temperature followed normal seasonal cycles. The last survey of the record showed anomalously low DO saturation values for all zones. NH_4^+ concentrations were higher during 1998-99 but returned to previous levels in 2000. NO_3^- concentrations during 2000 were much higher than in previous years. The causes for this are unknown as we did not observe high concentrations in the freshwater coming out of the Everglades. As in the Florida Keys National Marine Sanctuary and Biscayne Bay, TP concentrations in the SHOAL and SHELF zones increased over the period of record. Interestingly, TP did not increase in the SHARK sites, which were most heavily influenced by freshwater inputs from the Everglades. SRP showed some spikes in 2000 but no trend was evident. CHLA showed strong seasonal variation with highest concentrations occurring in the fall/winter period. APA showed sporadic spikes in activity which were unrelated to CHLA. Trends in TOC, TON, and turbidity were unremarkable.

Cape Romano-Pine Island Sound

San Carlos Bay is located at the mouth of the Caloosahatchee River, a major managed outlet for freshwater from Lake Okeechobee. The SCB sites experienced the lowest median salinity and had the largest range in salinity as well. SCB also had highest concentrations of NO_3^-, TP, SRP, and TO). Estero Bay also exhibited lower salinities than the other areas, most probably 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, NO_3^-, and TP.

Overall, this area has significantly higher concentrations of TP, SRP, NO_3^-, and CHLA than the bulk of the TenThousand Islands stations. Much of this is due to geological changes from carbonates to silicates which facilitates transport of phosphorus and to major landuse changes from the Big Cypress National Preserve to suburban and agricultural uses. As there are only two years of data in the record; we will reserve discussion of trends until we have a significant time series.

Inland water quality sampling by Collier County was modified in 1999 to provide a more integrated picture of the connections between watershed and estuary. The combined efforts of Collier County Pollution Control and FIU show that, in many cases, nutrient concentrations are much higher in the watershed than in the estuaries. Significant watershed influences in the Faka Union Basin were observed including elevated TP, NO_3^-, NH_4^+, and lower DO. These trends were also evident for the Gordon River entering Naples Bay and Cocohatchee River at Wiggins Pass.

ACKNOWLEDGMENTS

We thank all of our many field personnel, laboratory technicians, and chemists for their diligence and perseverance in this ongoing program. This project was possible due to the continued funding of the South Florida Water Management District through the Everglades National Park (SFWMD/NPS Cooperative Agreement #C-7919, NPS/SERC Cooperative Agreement #5280-2-9017 and SFWMD/SERC Cooperative Agreement #C-10244). We also thank Rookery Bay NERR/FDEP for their field support.

This report is contribution #T-156 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 the South Florida Estuarine Water Quality Monitoring Network (Fig. 1.1). This includes water quality data collected 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 monitored on a monthly basis with monitoring beginning in March 1991 at stations 1 through 24. (Except monitoring began at stations 14, 19, 22, and 23 in April 1991). In July 1992, stations 25 through 28 were added in Florida Bay. Monthly sampling of stations 29 through 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 Shelf was sampled quarterly beginning in spring 1995; the Cape Romano-Pine Island Sound area started Jan. 1999. A summary of station locations and sampling period of record is shown in Table 1.

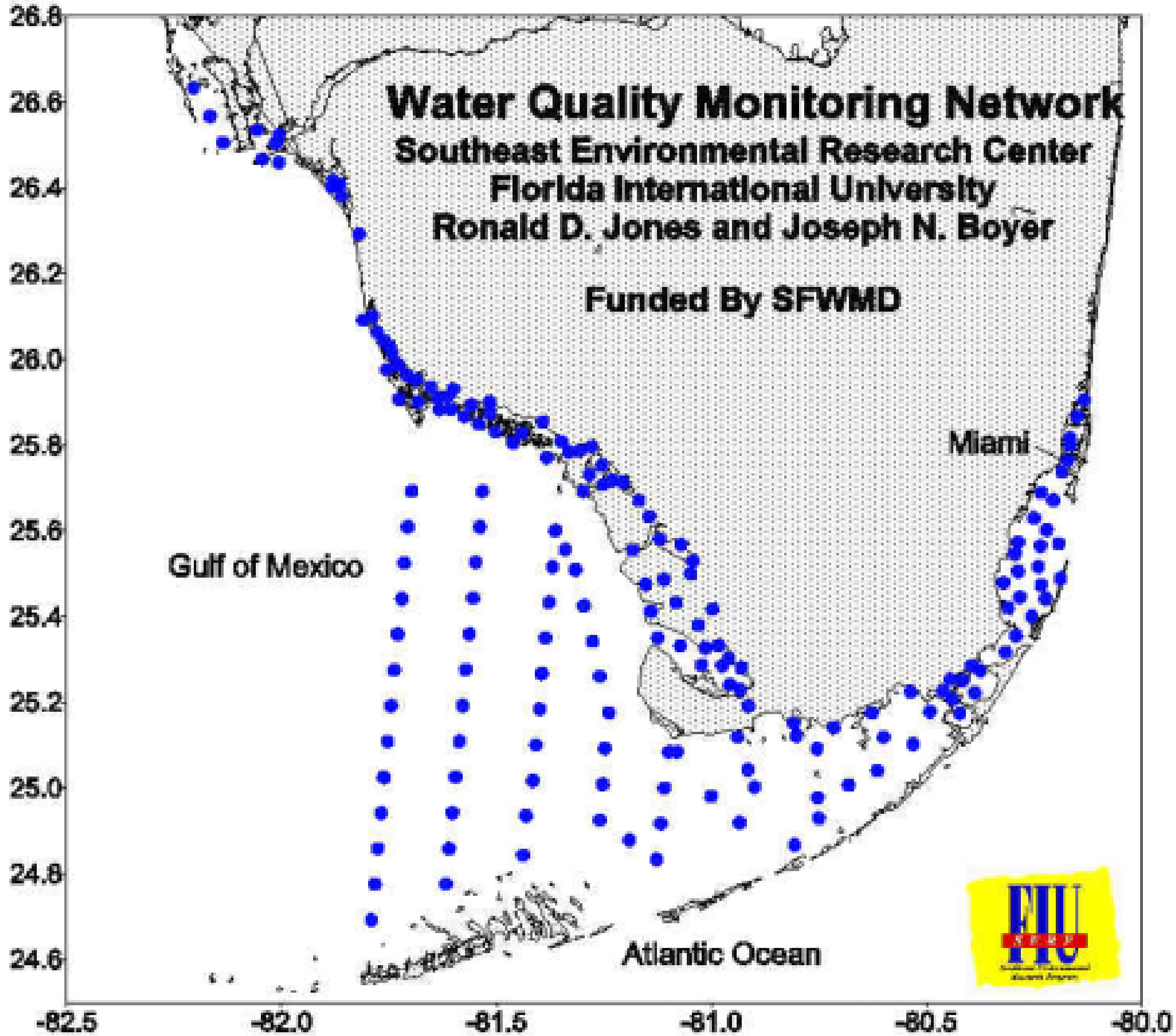


Figure 1.1. Fixed station locations for the SFWMD funded portion of the SERC water quality monitoring network.

1.2. Field and Analytical Methods

Water samples were analyzed by SERC personnel using standard methodology outlined in the Quality Assurance Project Plan (QAPP) with prior approval from SFWMD and FDEP. Salinity (ppt) and temperature (°C) were measured 10 cm below the surface and 10 cm above the bottom using a combination salinity-conductivity-temperature probe (Orion model 140). Surface and bottom dissolved oxygen (DO, mg l^{-1}) was measured using an oxygen electrode (Orion model 840), corrected for salinity and temperature.

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. Samples were filtered (25 mm glass fiber GF/F) by hand into acetone-washed and sample rinsed 60 ml HDPE bottles, which were capped and immediately placed on ice in the dark for transport. The wet filters, used for chlorophyll *a* (CHLA) analysis, were placed in 2 ml plastic centrifuge tubes to which 1.5 ml of 90% acetone was added; they were then 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. 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). The 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 each of these parameters are reported in this report 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. OVERVIEW OF WATER QUALITY OF 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 have argued that these spatially contiguous groups of stations are the result of similar loading and processing of materials, hence we call them 'zones of similar influence' (Boyer et al. 1997). 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.

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 greater than the long term average (9.2 cm mo-1) for the last 7 of 10 years (Fig 2.2). Over this period, salinity and total phosphorus (TP) concentrations declined baywide while turbidity (cloudiness of the water) increased dramatically (Boyer et al. 1999). The salinity decline in Eastern, Central and Western Florida Bay was 13.6, 11.6, and 5.6, respectively (Fig. 2.3). 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.

As mentioned previously, TP concentrations have declined baywide over the 10 year period (Fig. 2.4). The Eastern Bay has the lowest concentrations while the Central Bay is highest. 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. 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.

Turbidity in Eastern Bay increased 2-fold from 1991-98, while Central and Western Bays increased by factors of 20 and 4, respectively (Fig. 2.5). Generally, 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. Turbidity in the Central and Western Bays have increased tremendously since 1991. 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.

Chlorophyll a concentrations (CHLA), a proxy for phytoplankton biomass, were particularly dynamic and spatially heterogeneous (Fig. 2.6). In the Eastern Bay, which makes up roughly half of the surface area of Florida Bay, CHLA declined by 0.9 $\mu g\ l^{-1}$ or 63%. 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 of CHLA in the water column remained modest (~2 $\mu g\ l^{-1}$) by most estuarine standards. There were significant blooms in Central and Western Bays immediately following Hurricanes Georges (Nov. 1998) and Irene (Oct. 1999). It is important to note that these changes in turbidity and CHLA happened after the poorly-understood seagrass die-off in 1987. It is likely that the death and decomposition of large amounts of seagrass biomass can at least 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.

Ammonium (NH_4^+) levels displayed large variability over the period of record and was much higher in the Central Bay than anywhere else (Fig. 2.7). Only in Central Bay did the NH_4^+ pool increase substantially over time (3-6 fold). Trends in nitrate (NO_3^-) concentrations mirrored those of NH_4^+ and were mostly due to the biological conversion of NH_4^+ to NO_3^- via nitrification (Fig. 2.8). Total organic carbon concentrations (TOC) vary widely among the different zones and show significant intra-annual cycles (Fig. 2.9). Highest TOC levels generally occur in the Central Bay during summer as a result of evaporative concentration and restricted mixing with the rest of the Bay.

Comparison of 2000 to Overall Period of Record

Most water quality variables during 2000 generally followed typical annual trends but there were a couple exceptions. Both Central and Western Bays experienced hypersalinity during the summer months. Salinity in the Western Bay was ~ 45 during Sept.; the Central Bay got up to 48 and remained hypersaline during June – Sept. TP was elevated in the Eastern Bay but not in other zones. A spike in TP was seen in Dec. for all zones. Turbidity was low for all areas of the Bay during 2000 as was CHLA with the exception of a moderate phytoplankton bloom (4-12 µg l^{-1}) in Central Bay during March and April. NH_4^+ concentrations continued to decline baywide but NO_3^- spiked in the summer in Central and Western Bay. TOC concentrations remained similar to previous years. Soluble reactive phosphorus (SRP) increased in all portions of the bay during 2000 but concentrations were so low that this was probably not ecologically significant (Fig 2.10). Alkaline phosphatase activity remained low in all areas (Fig. 2.11) as did total organic nitrogen (Fig. 2.12). DO saturation (Fig. 2.13) and temperature trends (Fig. 2.14) were unremarkable.

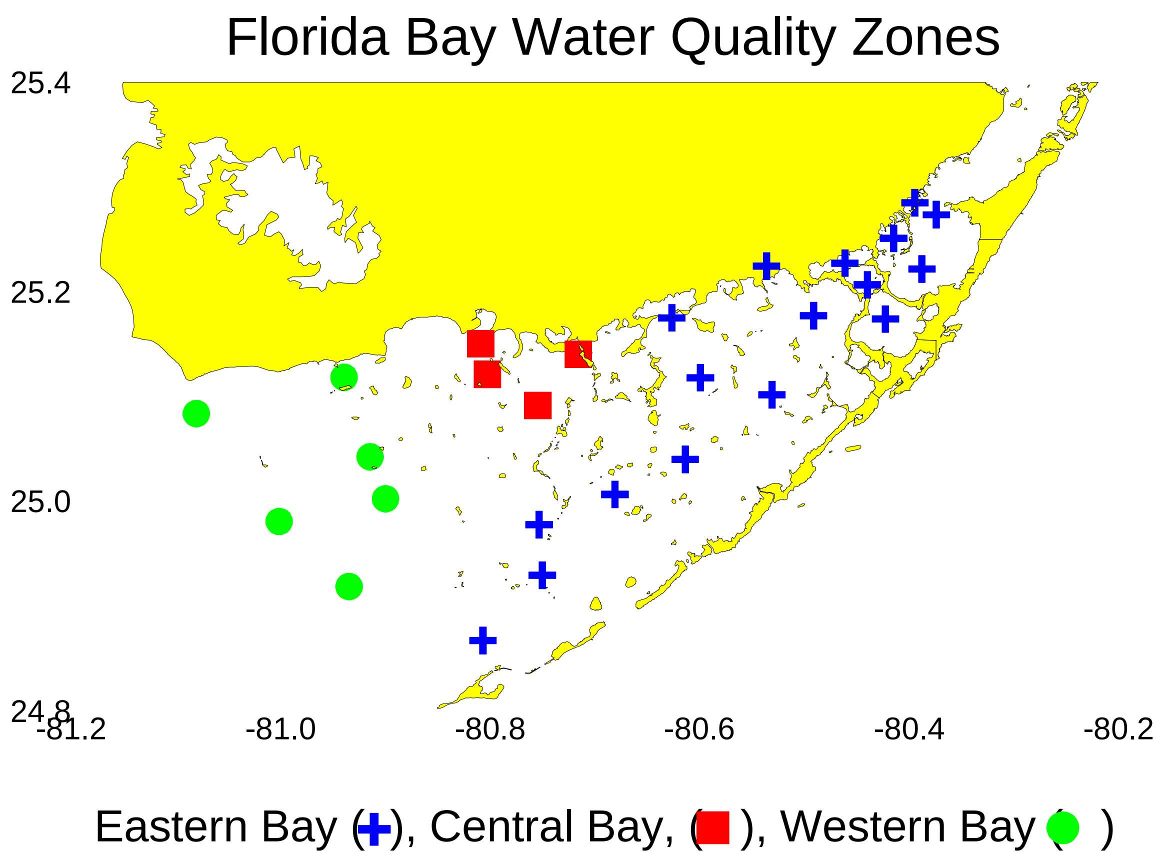


Figure 2.1. Zones of similar water quality in Florida Bay

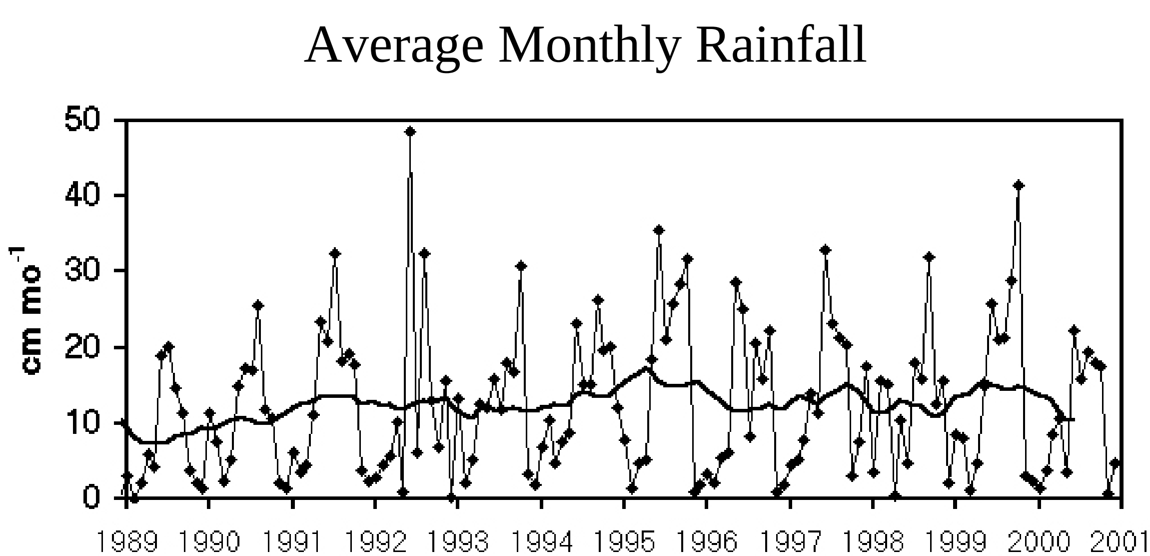


Figure 2.2. Monthly average rainfall in the Florida Bay area.

Median Salinity

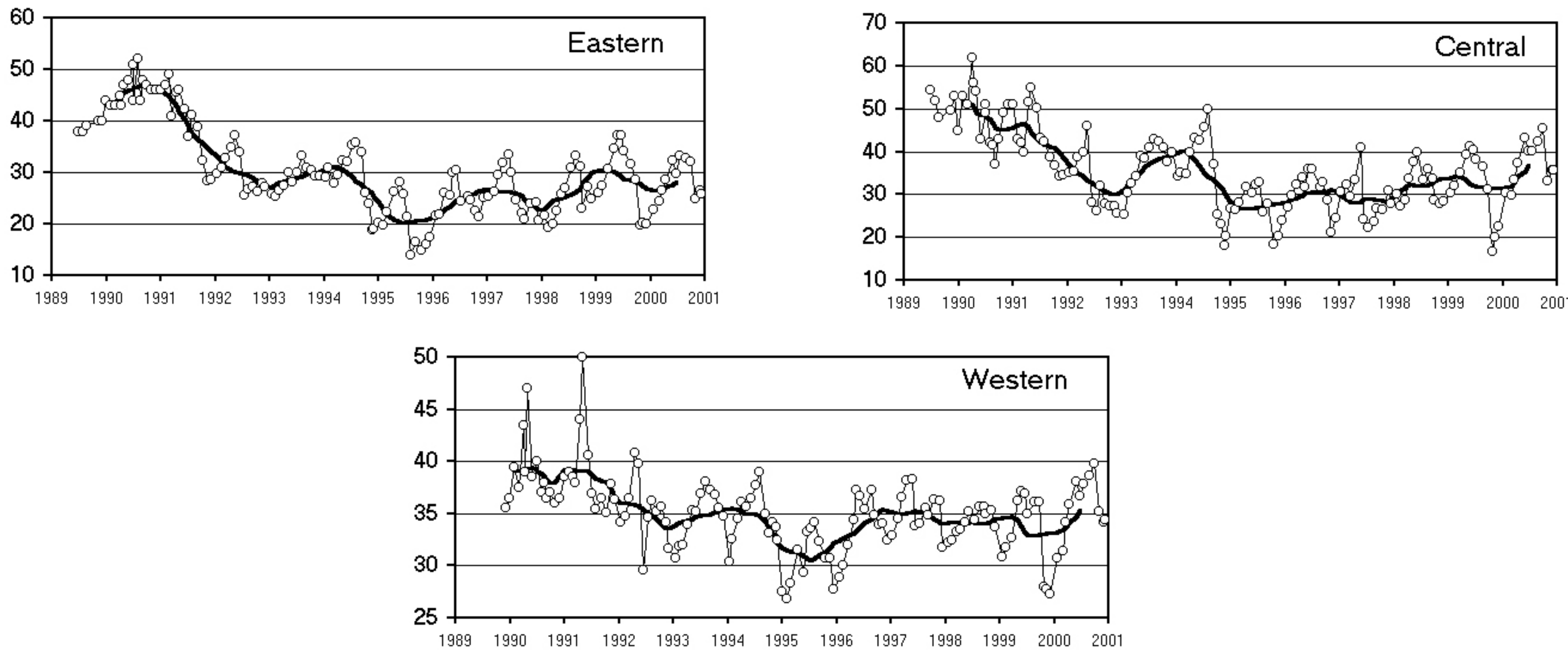


Figure 2.3. Monthly median salinity in the three Florida Bay zones.

Median Total Phosphorus

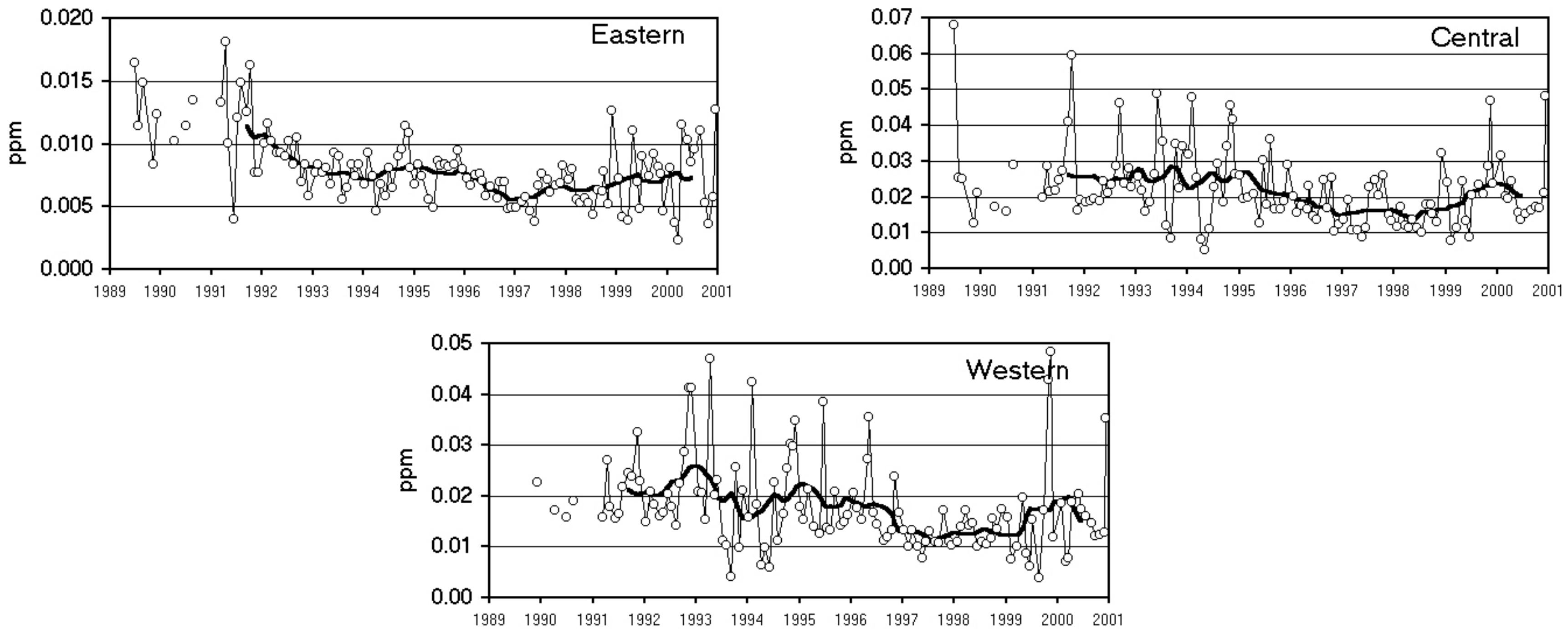


Figure 2.4. Monthly median total phosphorus concentrations in the three Florida Bay zones.

Median Turbidity

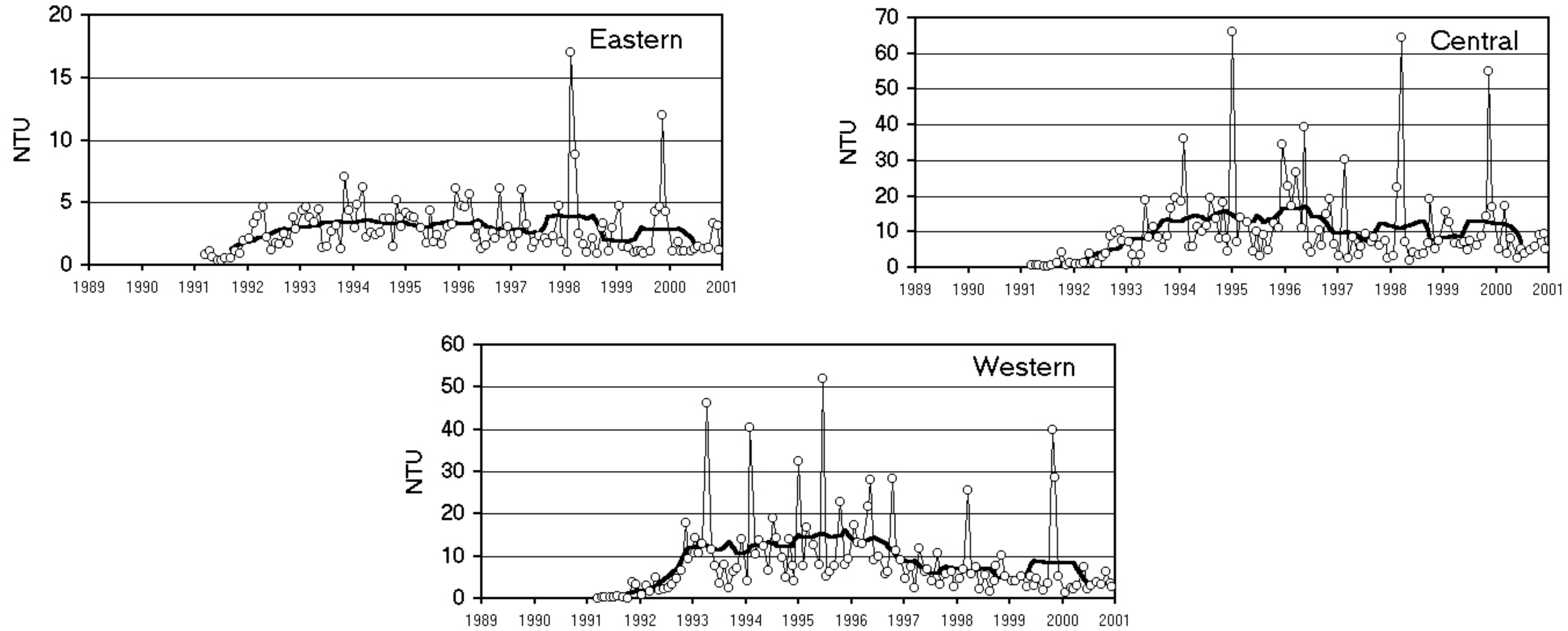


Figure 2.5. Monthly median turbidity in the three Florida Bay zones.

Median Chlorophyll *a*

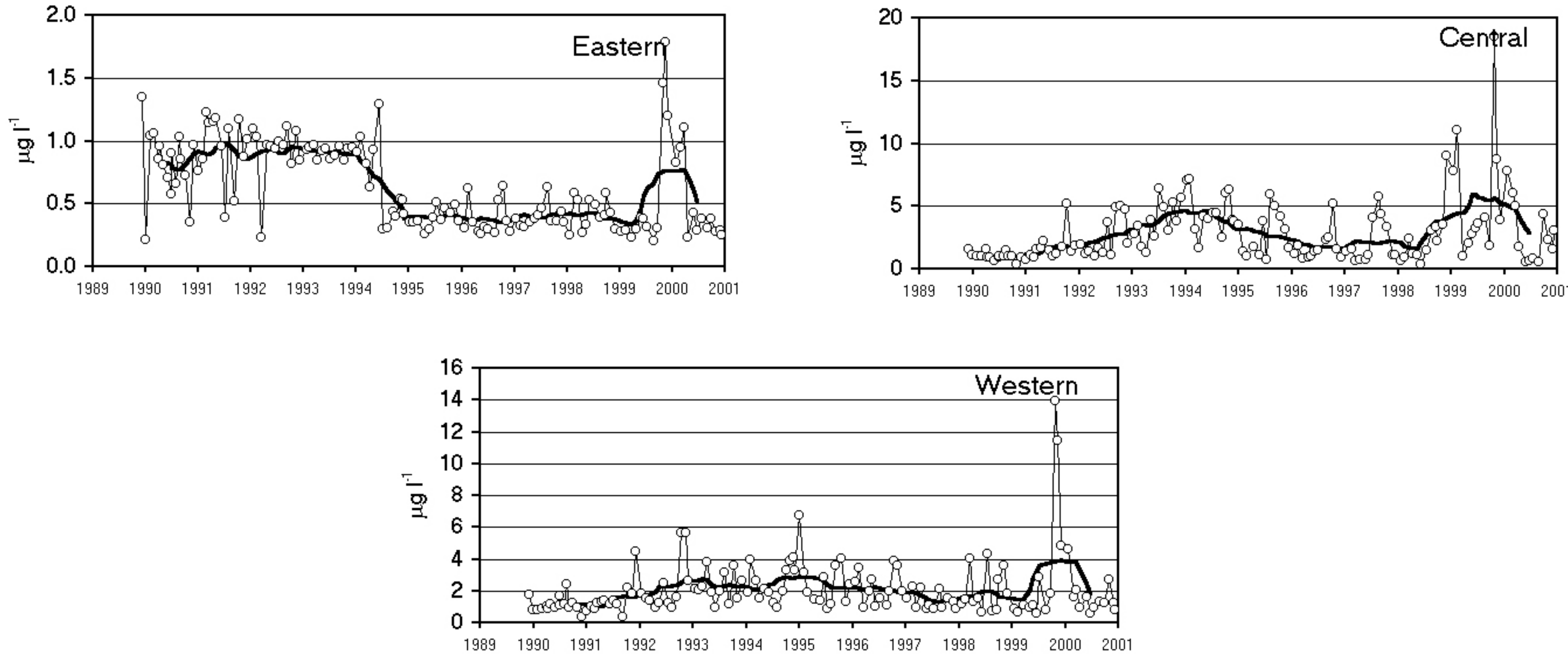


Figure 2.6. Monthly median chlorophyll *a* concentrations in the three Florida Bay zones.

Median Ammonium

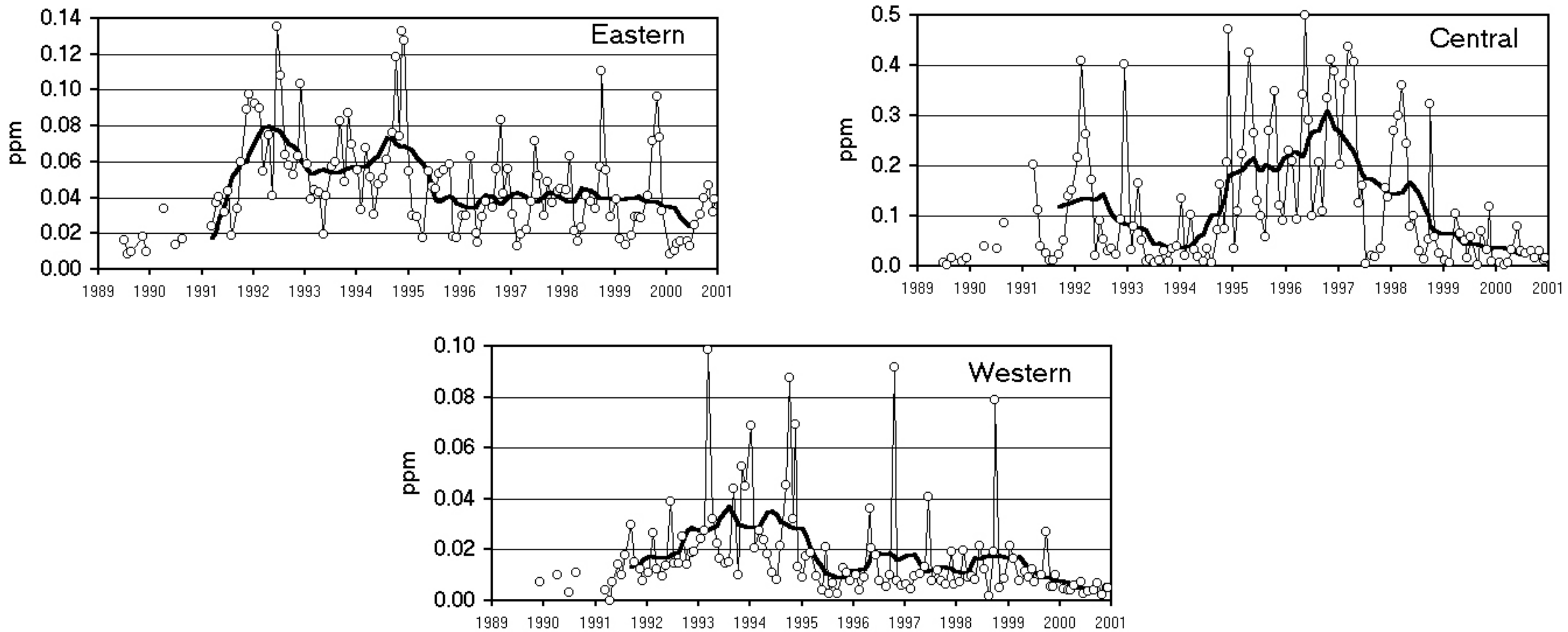


Figure 2.7. Monthly median ammonium in the three Florida Bay zones.

Median Nitrate

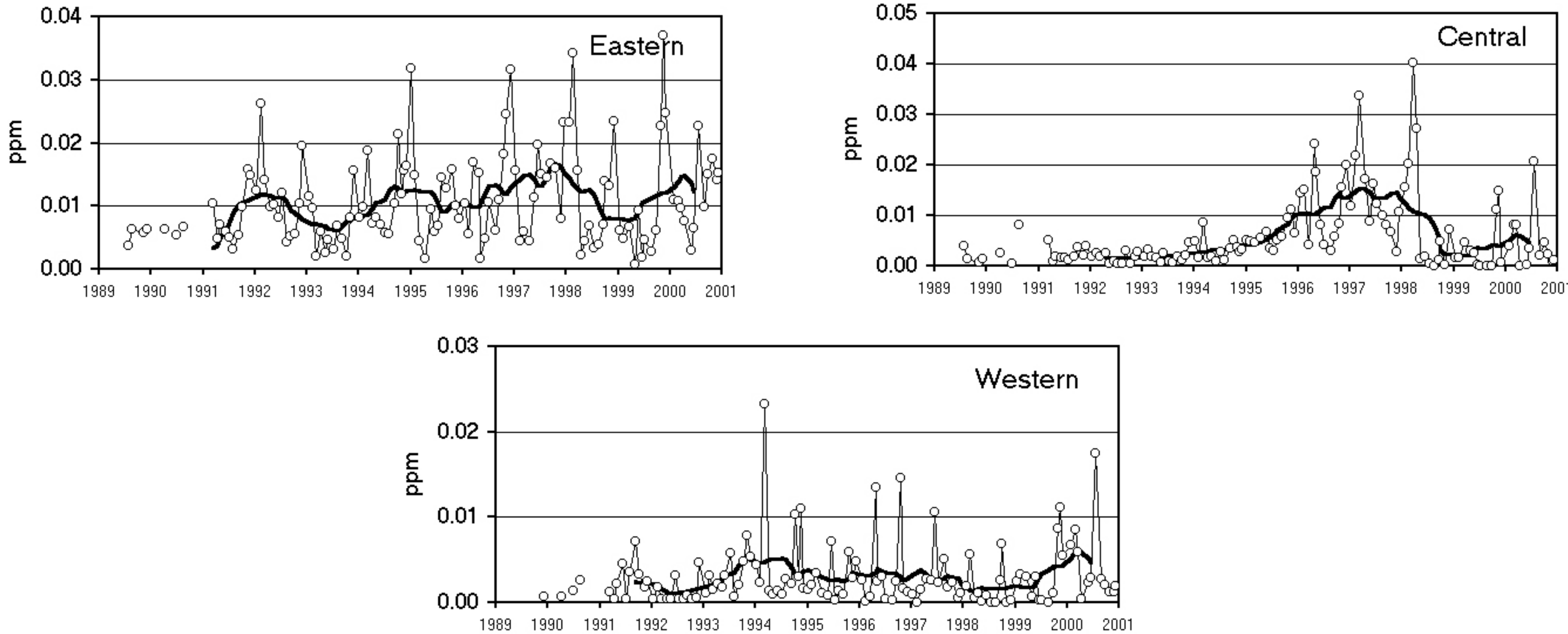


Figure 2.8. Monthly median nitrate concentrations in the three Florida Bay zones.

Median Total Organic Carbon

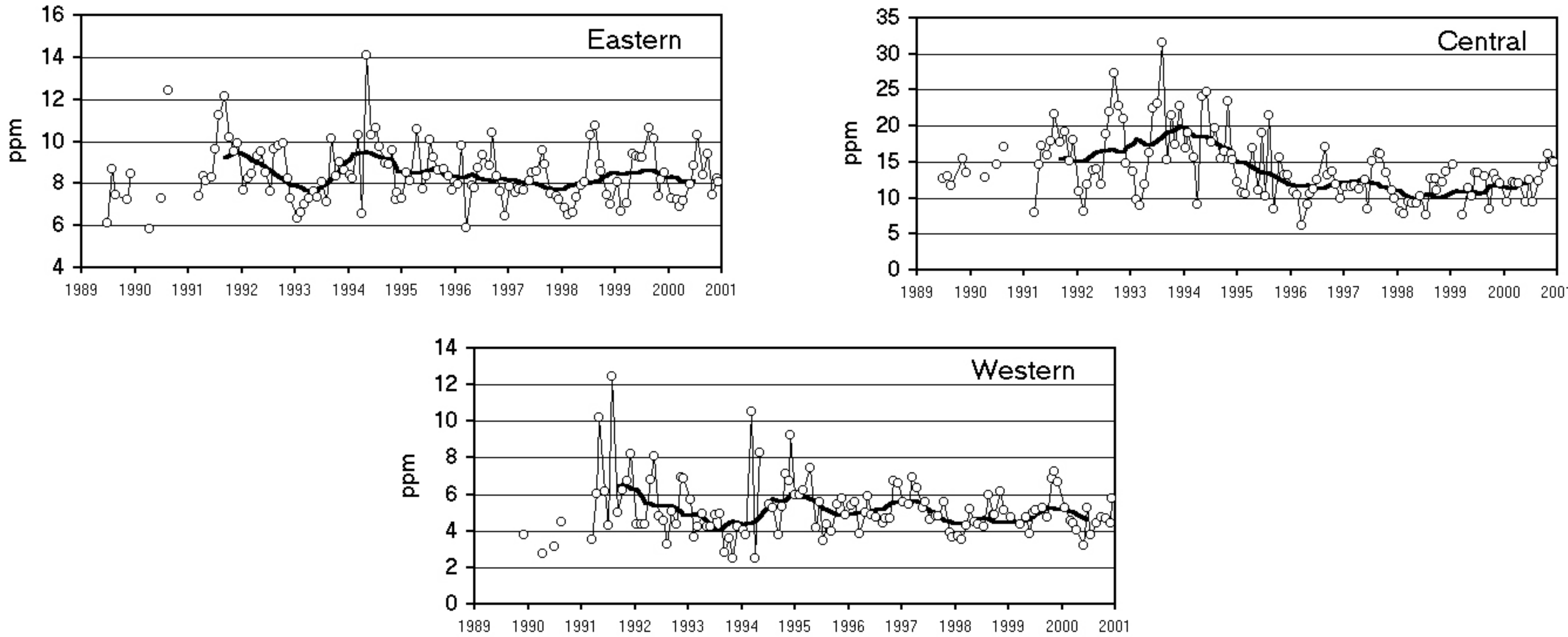


Figure 2.9. Monthly median total organic carbon concentrations in the three Florida Bay zones.

Median Soluble Reactive Phosphorus

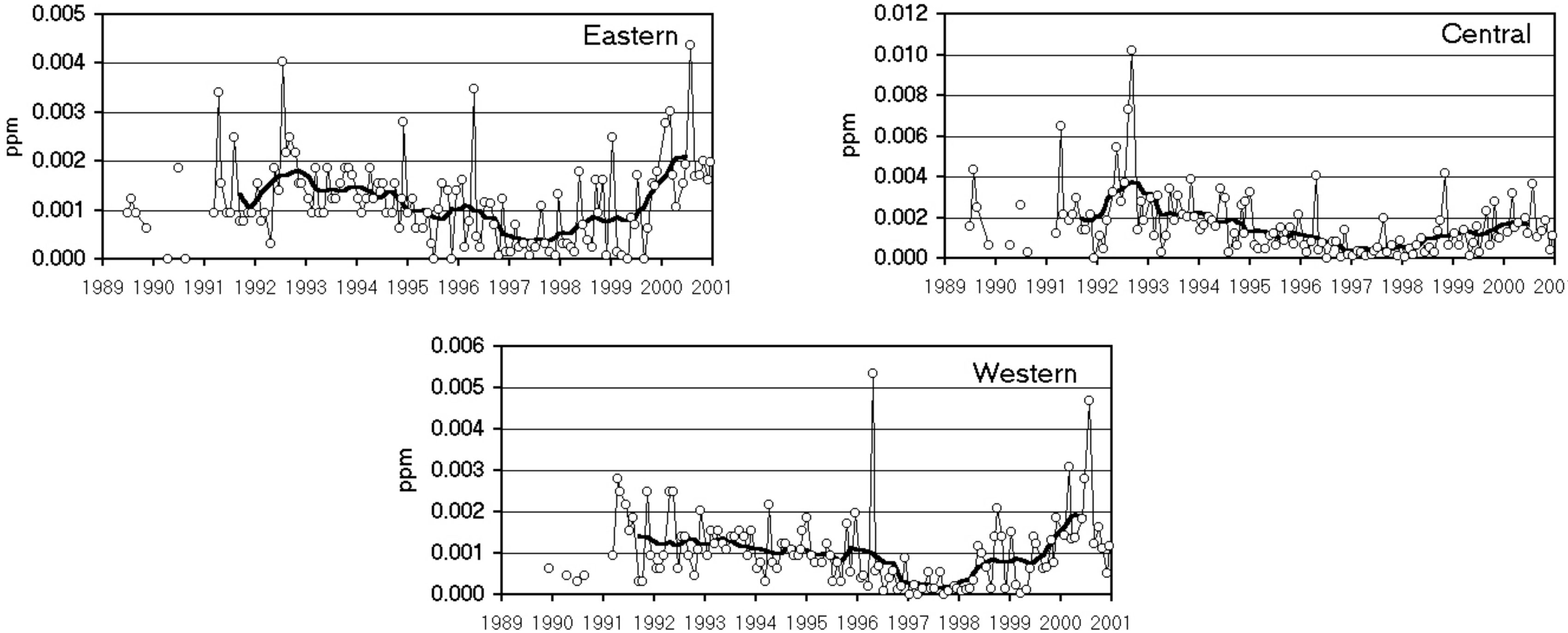
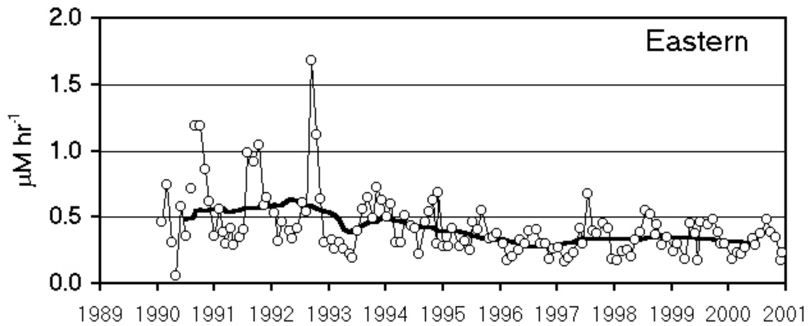
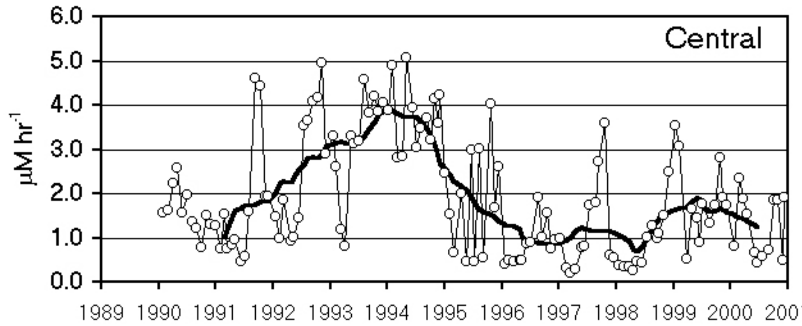


Figure 2.10. Monthly median soluble reactive phosphorus concentrations in the three Florida Bay zones.

Median Alkaline Phosphatase Activity





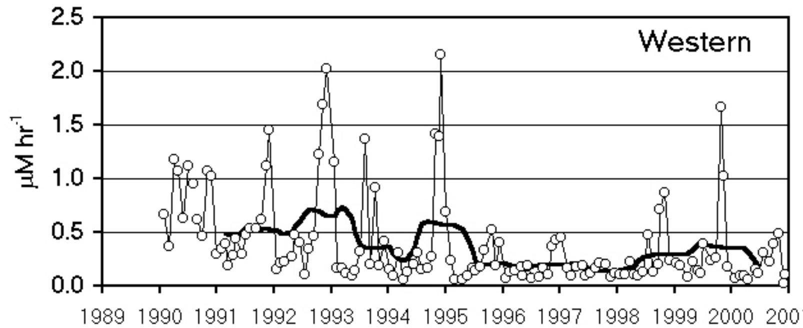


Figure 2.11. Monthly median alkaline phosphatase activity in the three Florida Bay zones.

Median Total Organic Nitrogen

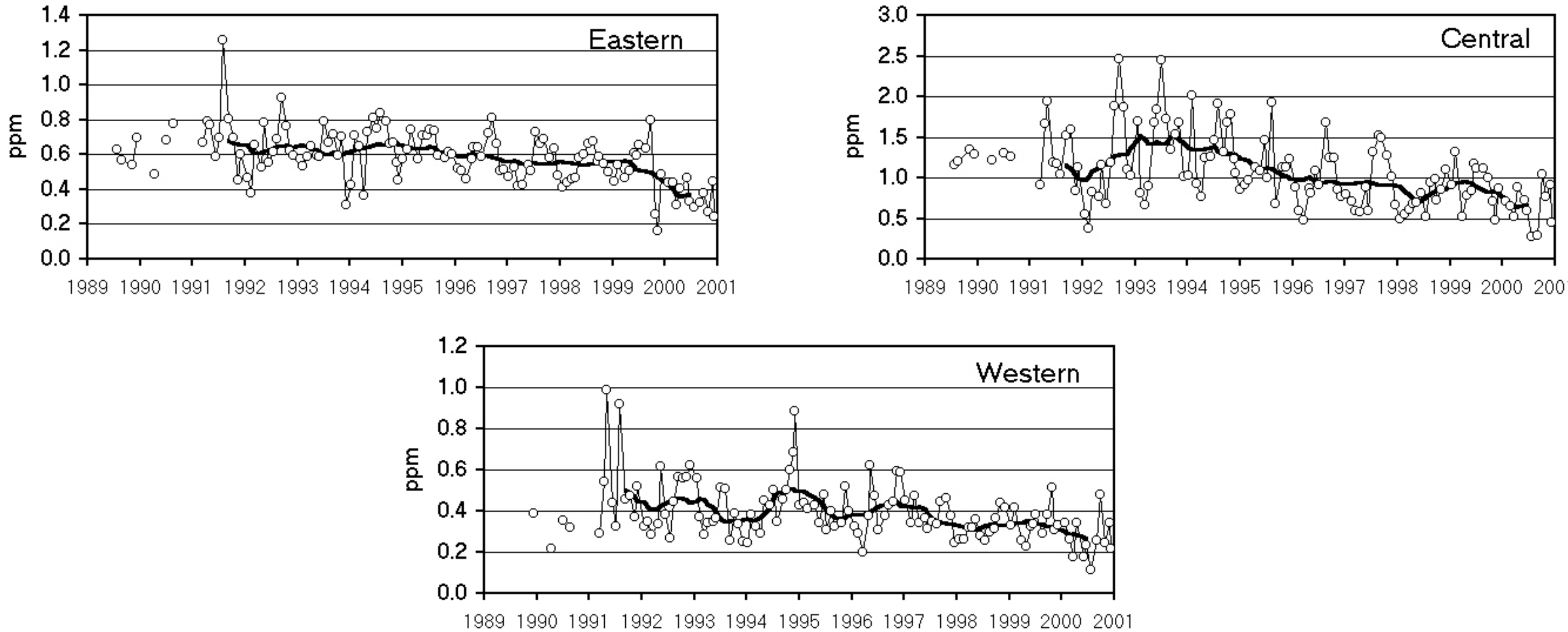


Figure 2.12. Monthly median total organic nitrogen concentrations in the three Florida Bay zones.

Median DO Saturation

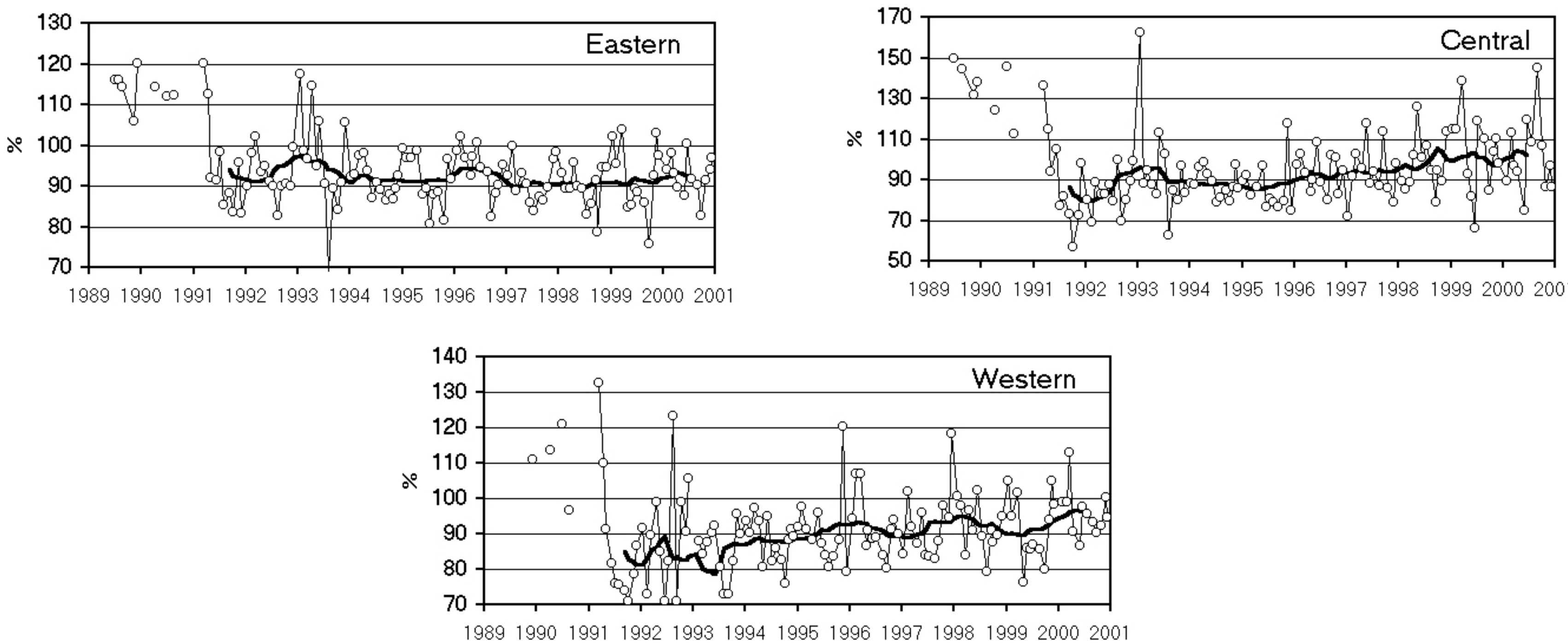


Figure 2.13. Monthly median DO saturation in the three Florida Bay zones.

Median Temperature

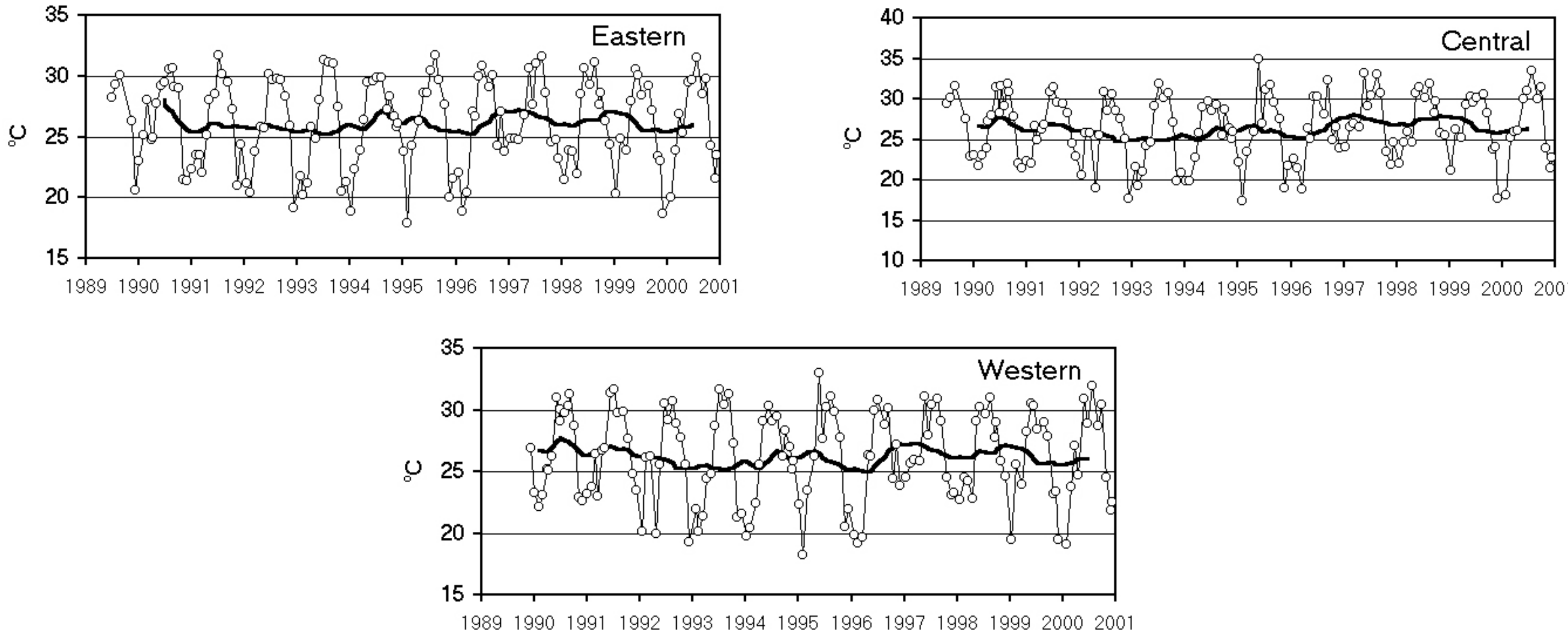


Figure 2.14. Monthly median temperature in the three Florida Bay zones.

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

Using the same statistical approach as above, the TTI-WWB complex was partitioned into 6 distinct zones of similar 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 situated 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.

Marked differences in physical, chemical, and biological characteristics among zones were illustrated by this technique. The general spatial trend is one of relatively high APA, TON, and TOC in the south declining northward along the coast (Fig. 3.2) while salinity, turbidity, TP, and SRP increased (Fig. 3.3). The net effect is the formation of a gradient with strong phosphorus limitation occurring in the southern region shifting to a more balanced N:P ratio in the northern area around the Blackwater River.

We believe these gradients are the result of coastal geomorphology and watershed characteristics in the region (Boyer and Jones in prep.). 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 an 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 salinity and P. There is much 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.

<u>Comparison of 2000 to Overall Period of Record</u>

The influence of freshwater input from the Everglades is very evident in this region (Fig. 3.4). Large salinity variations are the norm and 2000 was much like other years. Both temperatue (Fig 3.5) and DO saturation (Fig. 3.6) were unremarkable. Both NH_4^+ and NO_3^- concentrations remained low throughout the year in the Mangrove Rivers and Whitewater Bay (Fig. 3.7 and 3.8). In the other zones there was a significant spike in these variables in Sept. which coincided with lowest salinity. TP in the Whitewater Bay and the Gulf Islands was elevated relative to other years (Fig. 3.9) and was positively correlated with salinity, implying that source of TP was not from freshwater input. Trends in SRP were unremarkable except to note relative differences between southern and northern regions (Fig. 3.10). The large peaks in CHLA from effects of Hurricane Irene (Oct. 1999) carried over to the early part of 2000 (Fig. 3.11). CHLA concentrations returned to normal by Feb.-Mar. 2000. Only in the Mangrove Rivers and Whitewater Bay did APA correspond with CHLA (Fig. 3.12). This is due to the high P limitation in these areas. TOC and TON both showed similar interannual trends (Fig. 3.13 and 3.14) but long term declines in TON are becoming evident in the Gulf Island, Mangrove Rivers, and Inner Waterway. Finally, turbidity has remained within long term averages for the zones (Fig. 3.15).

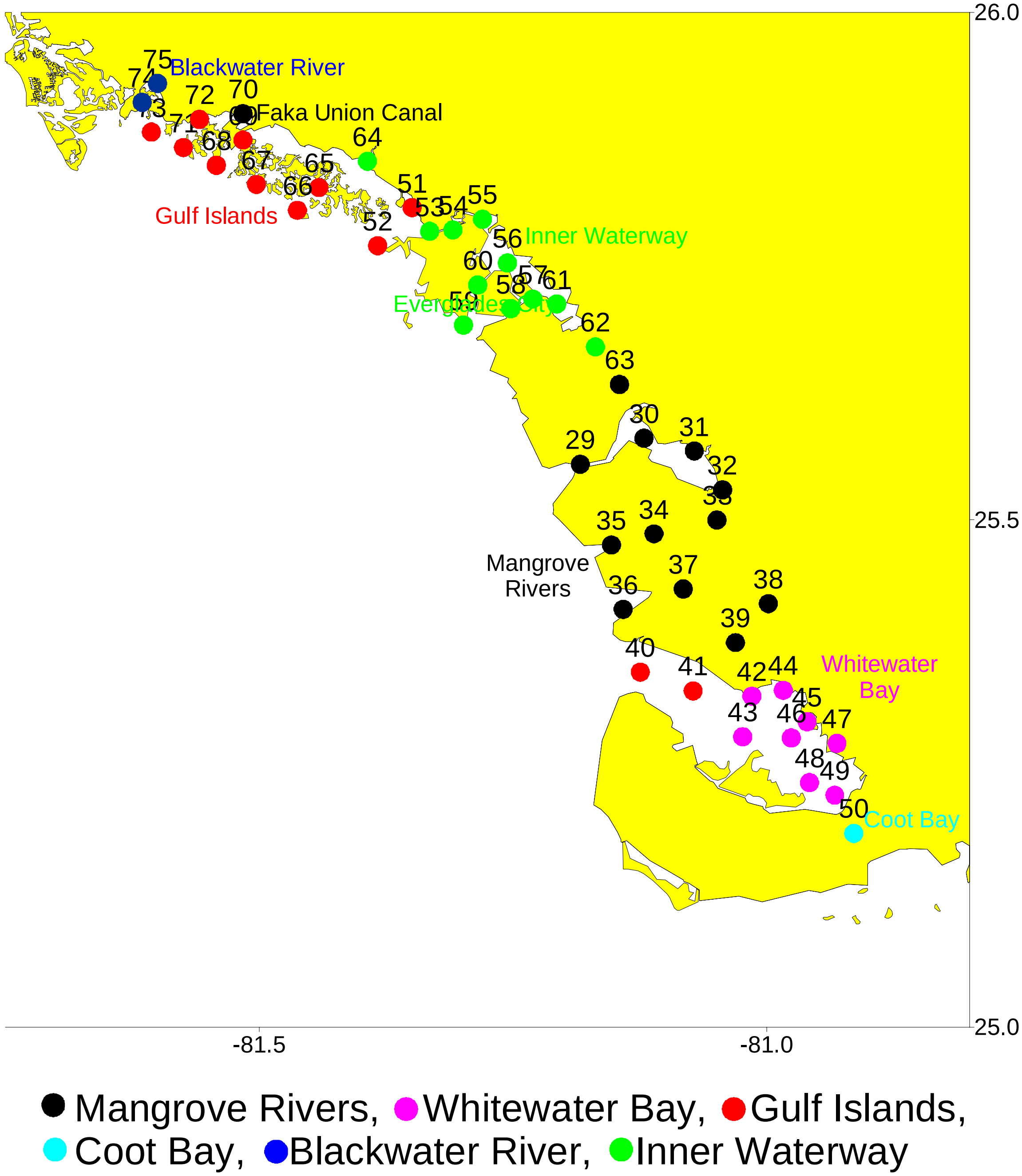


Figure 3.1. Zones of similar water quality in Whitewater Bay-Ten Thousand Islands complex:

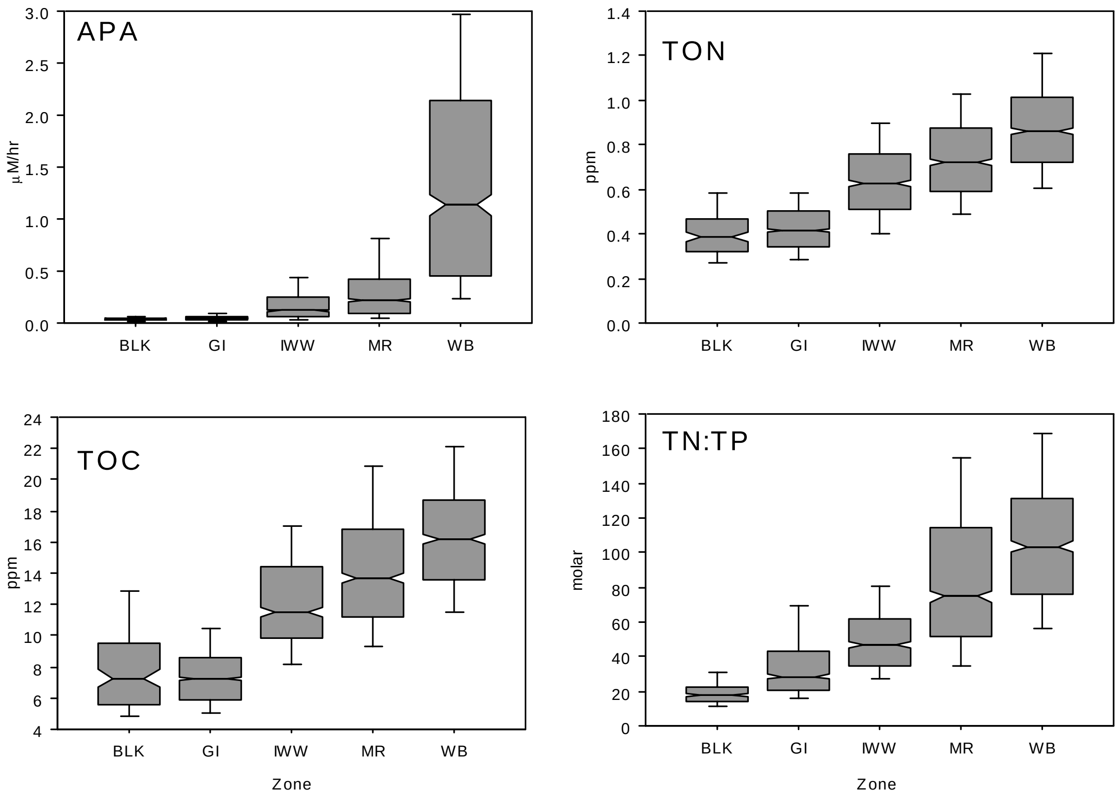


Figure 3.2. Box-and-whisker plots of alkaline phosphatase activity (APA), total organic nitrogen (TON), total organic carbon (TOC), and the total nitrogen:total phosphorus ratio (TN:TP) for the zones. A significant decreasing trend in all variables is observed with northward direction.

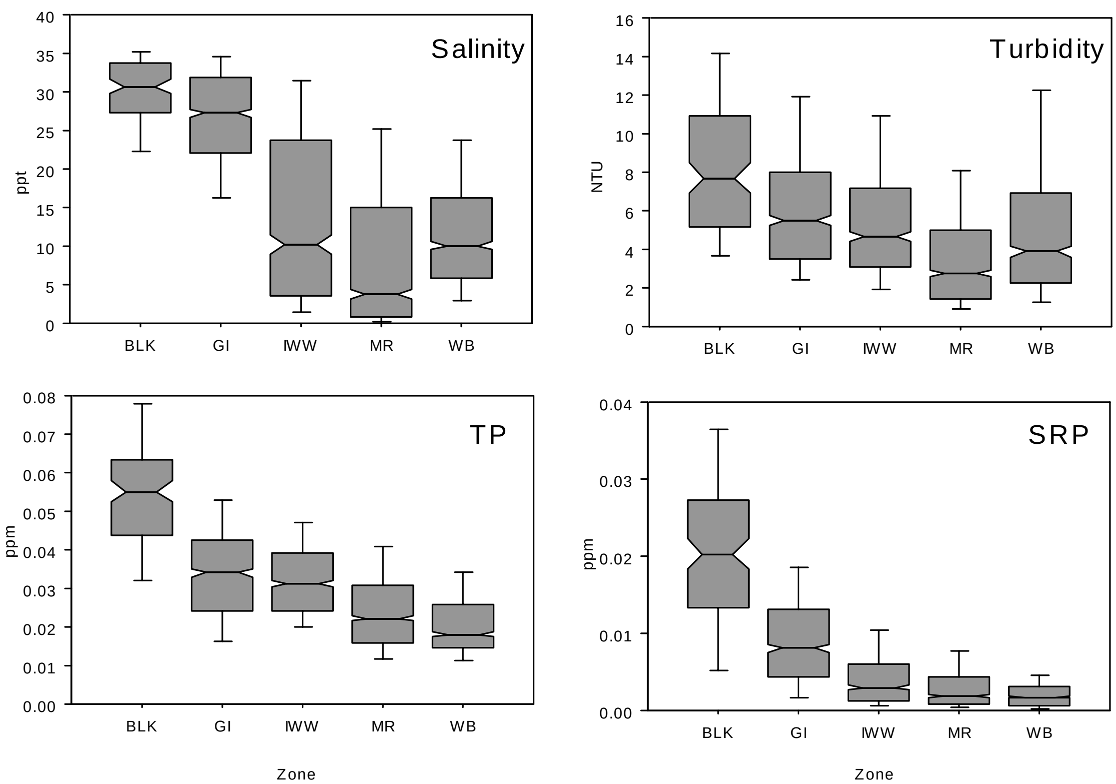


Figure 3.3. Box-and-whisker plots of salinity, turbidity, total phosphorus (TP), and soluble reactive phosphorus (SRP) for the zones. A significant increasing trend in all variables is observed with northward direction.

Median Salinity

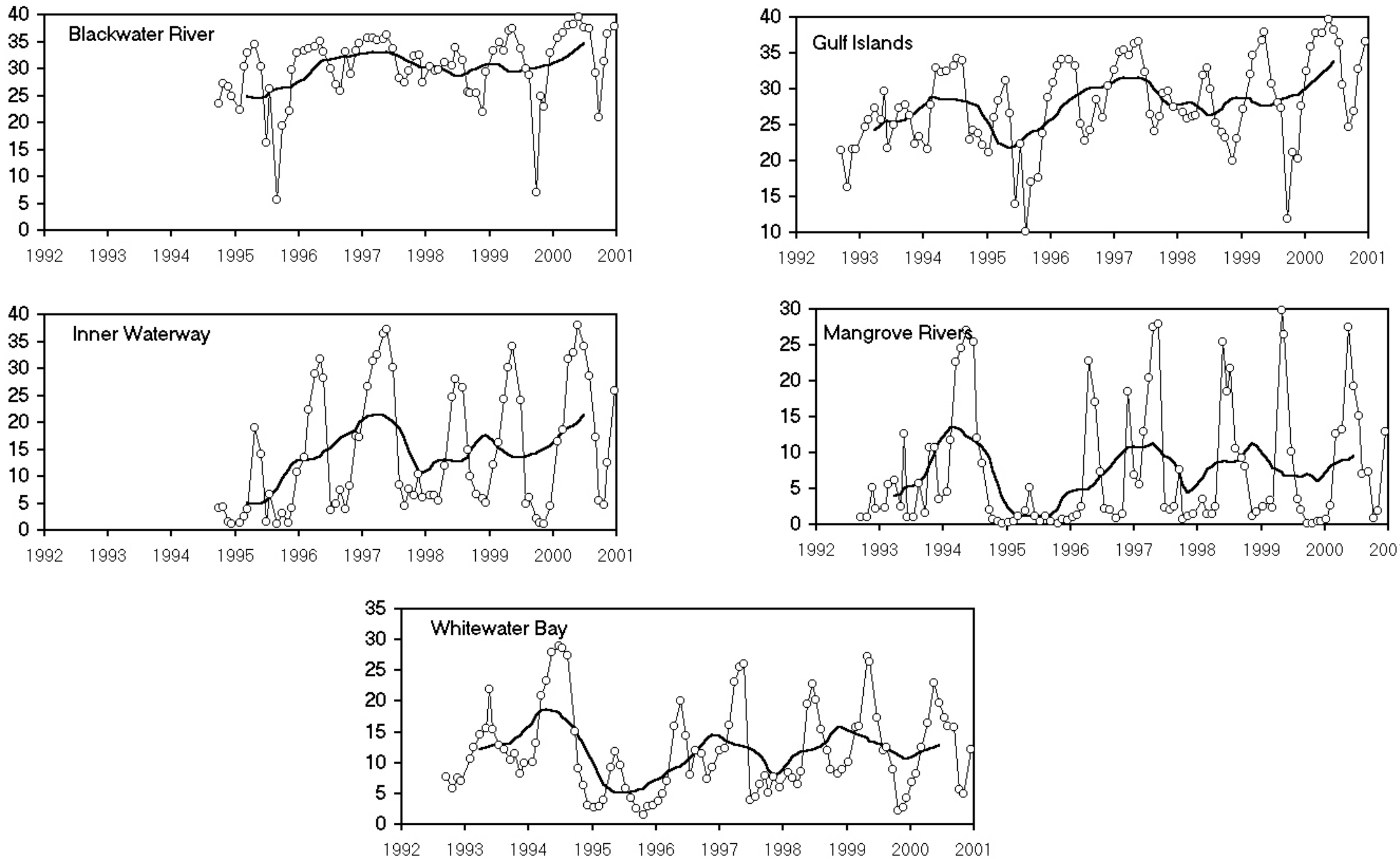


Figure 3.4. Monthly median salinity in WB-TTI zones.

Median Temperature

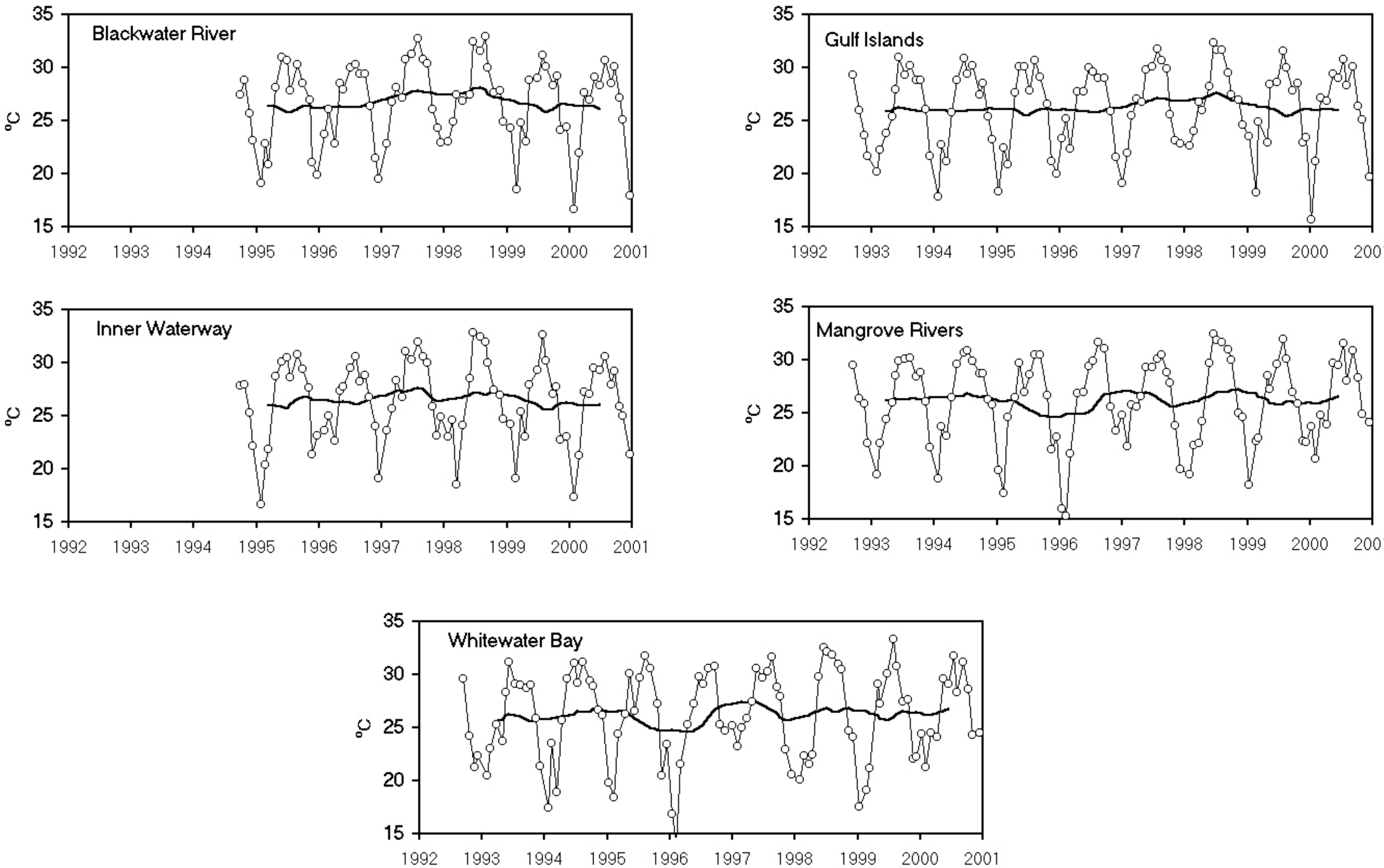


Figure 3.5. Monthly median temperature in the WB-TTI zones.

Median DO Saturation

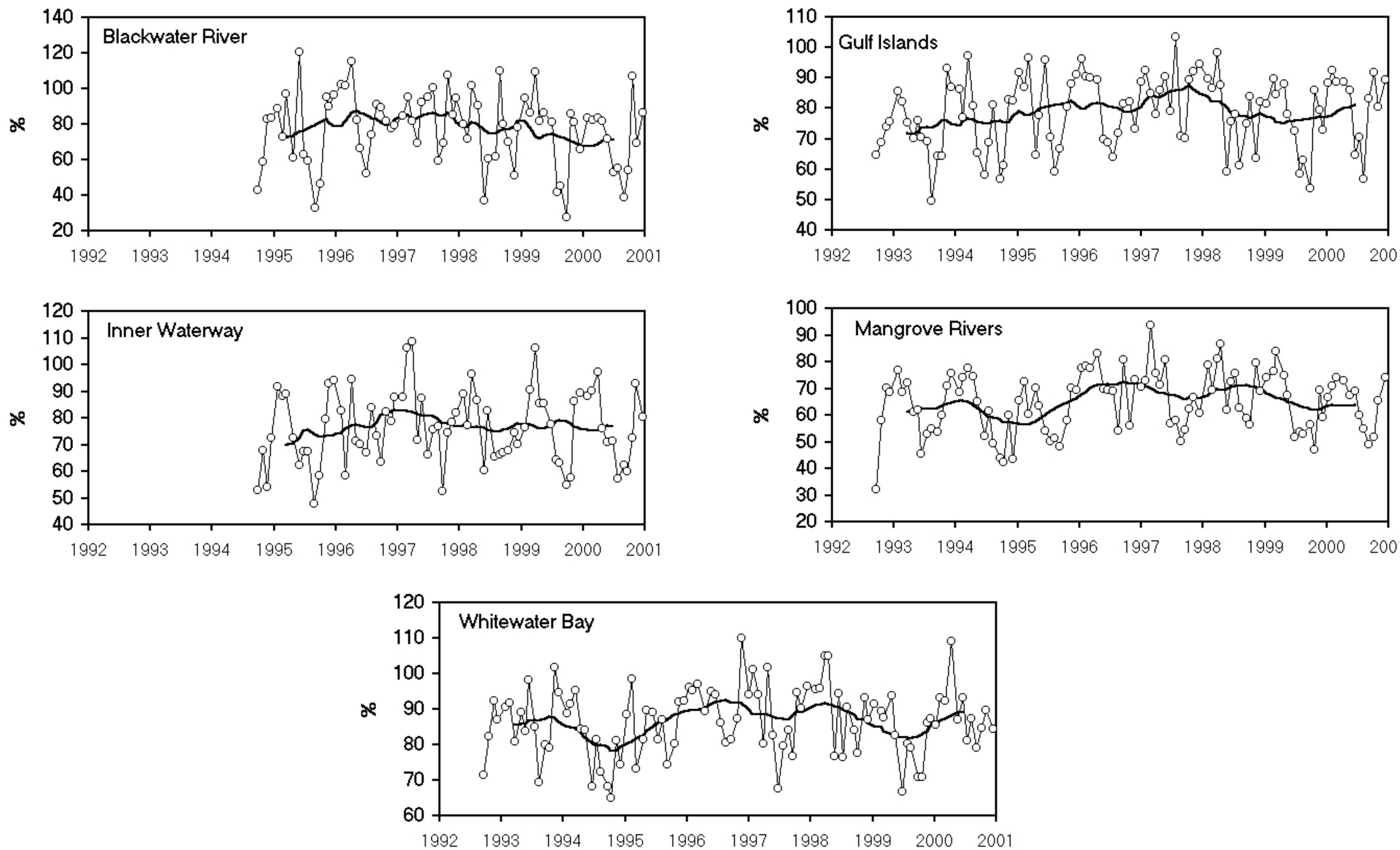


Figure 3.6. Monthly median DO saturation in the WB-TTI zones.

Median Ammonium

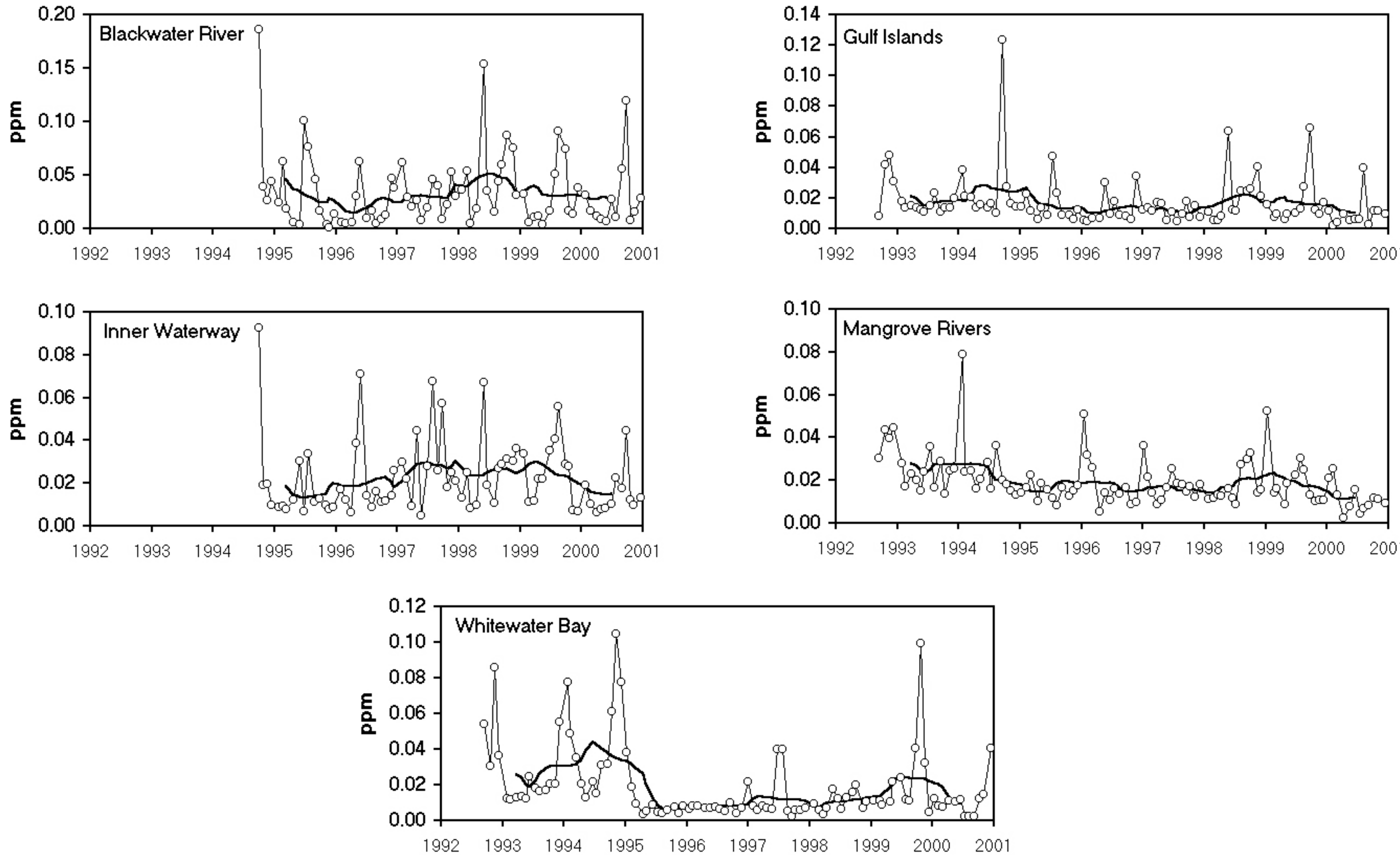


Figure 3.7. Monthly median ammonium concentrations in the WB-TTI zones.

Median Nitrate

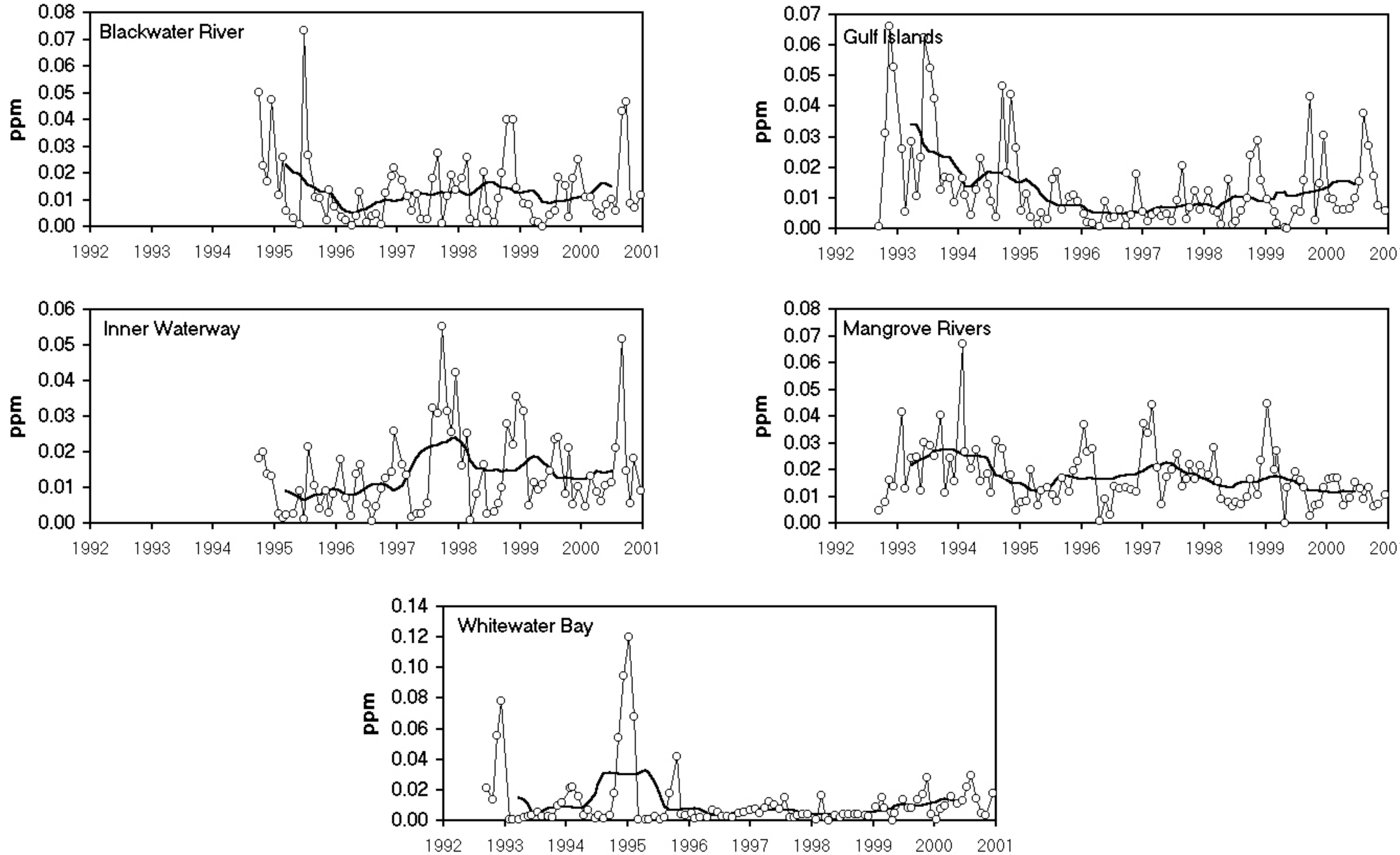


Figure 3.8. Monthly median nitrate concentrations in the WB-TTI zones.

Median Total Phosphorus

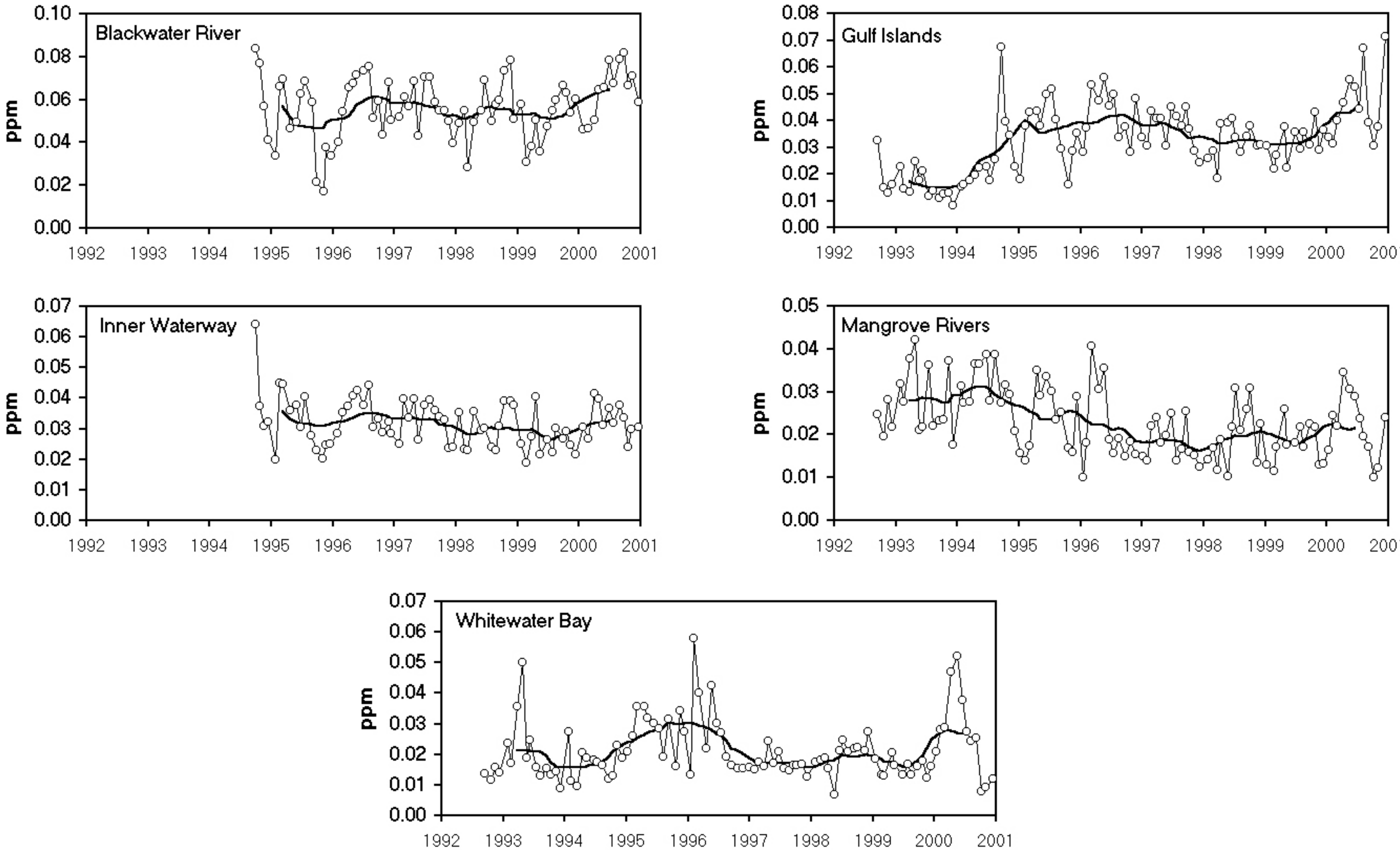


Figure 3.9. Monthly median total phosphorus concentrations in the WB-TTI zones.

Median Soluble Reactive Phosphorus

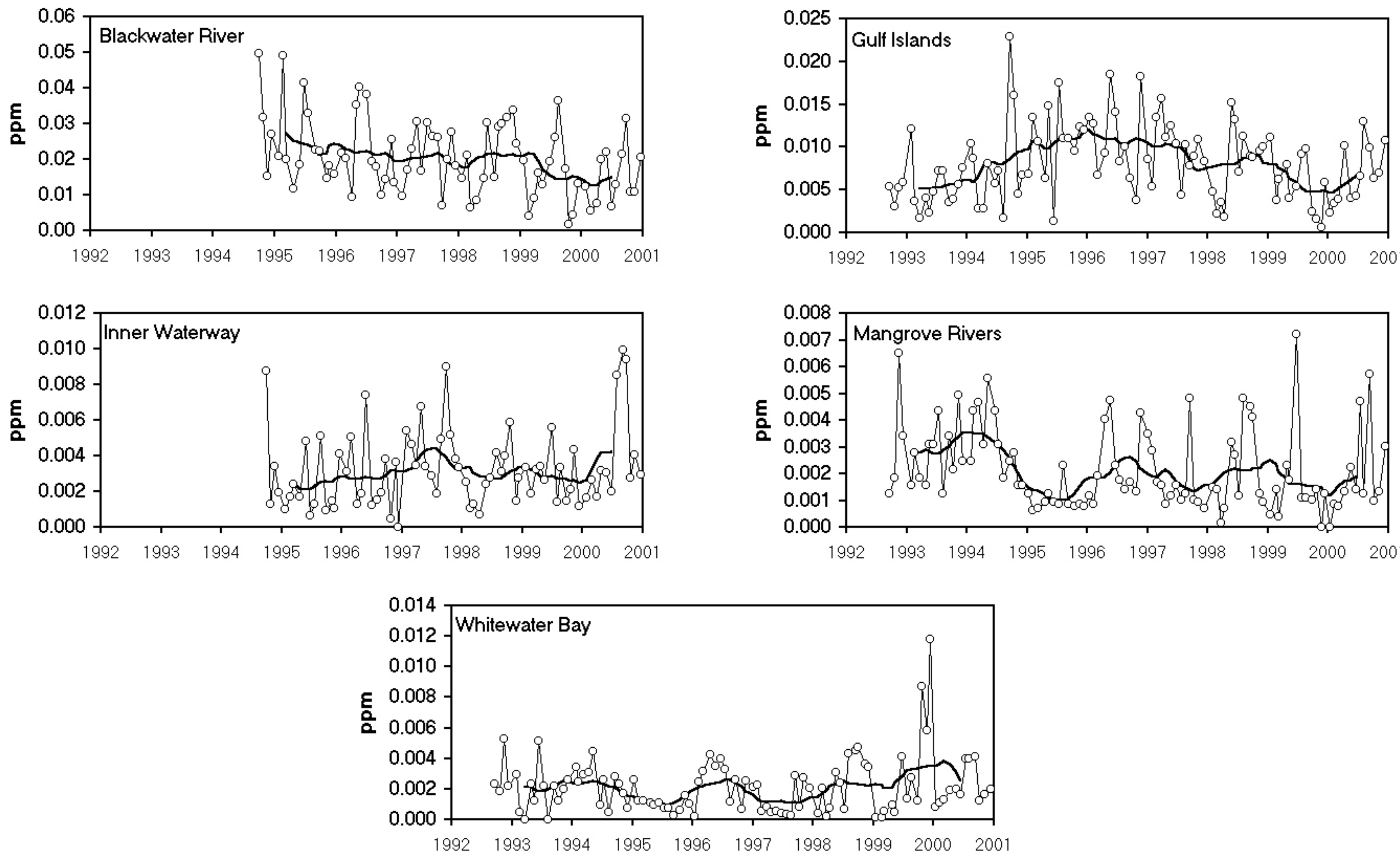


Figure 3.10. Monthly median soluble reactive phosphorus concentrations in the WB-TTI zones.

Median Chlorophyll *a*

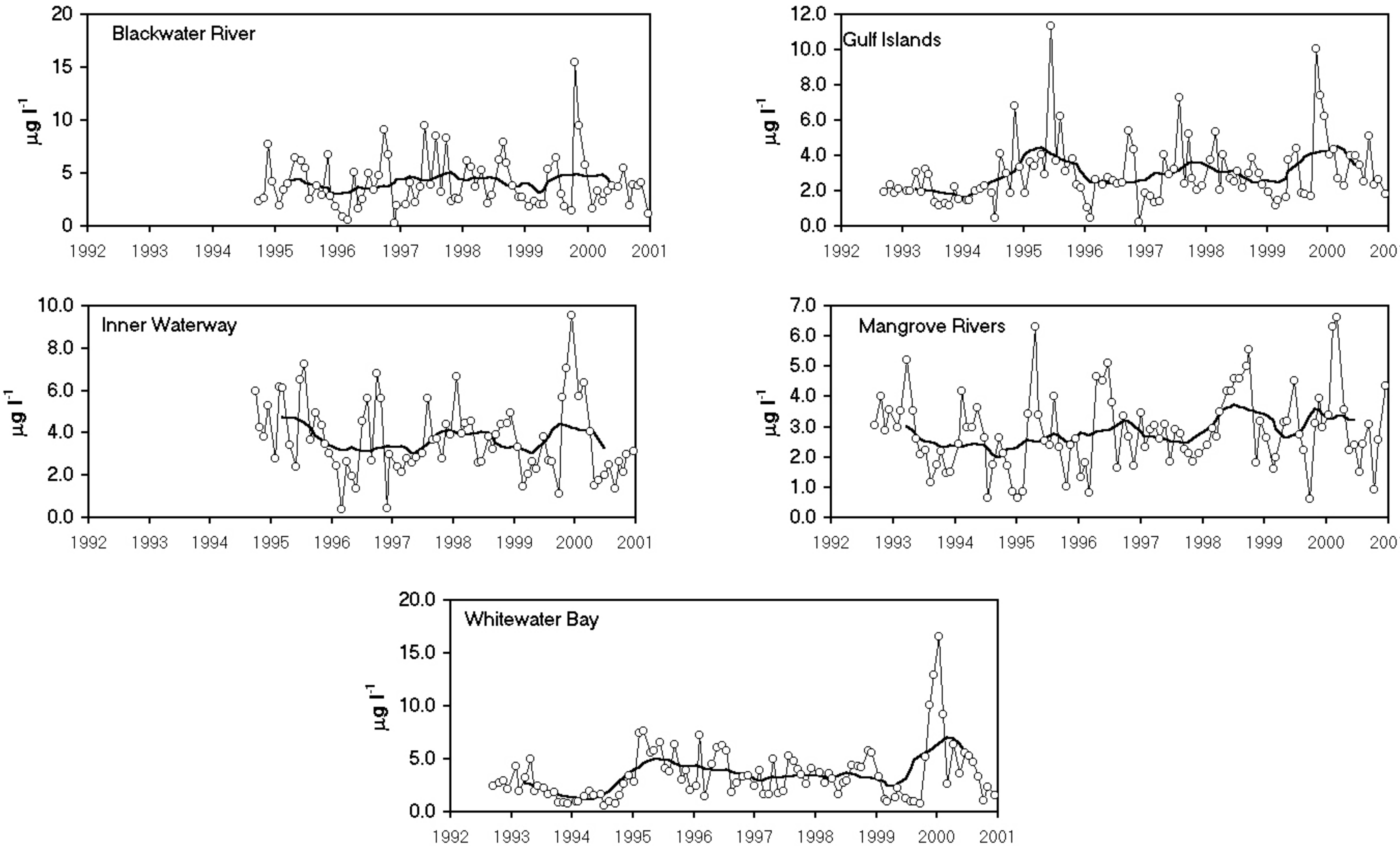


Figure 3.11. Monthly median chlorophyll *a* concentrations in the WB-TTI zones.

Median Alkaline Phosphatase Activity

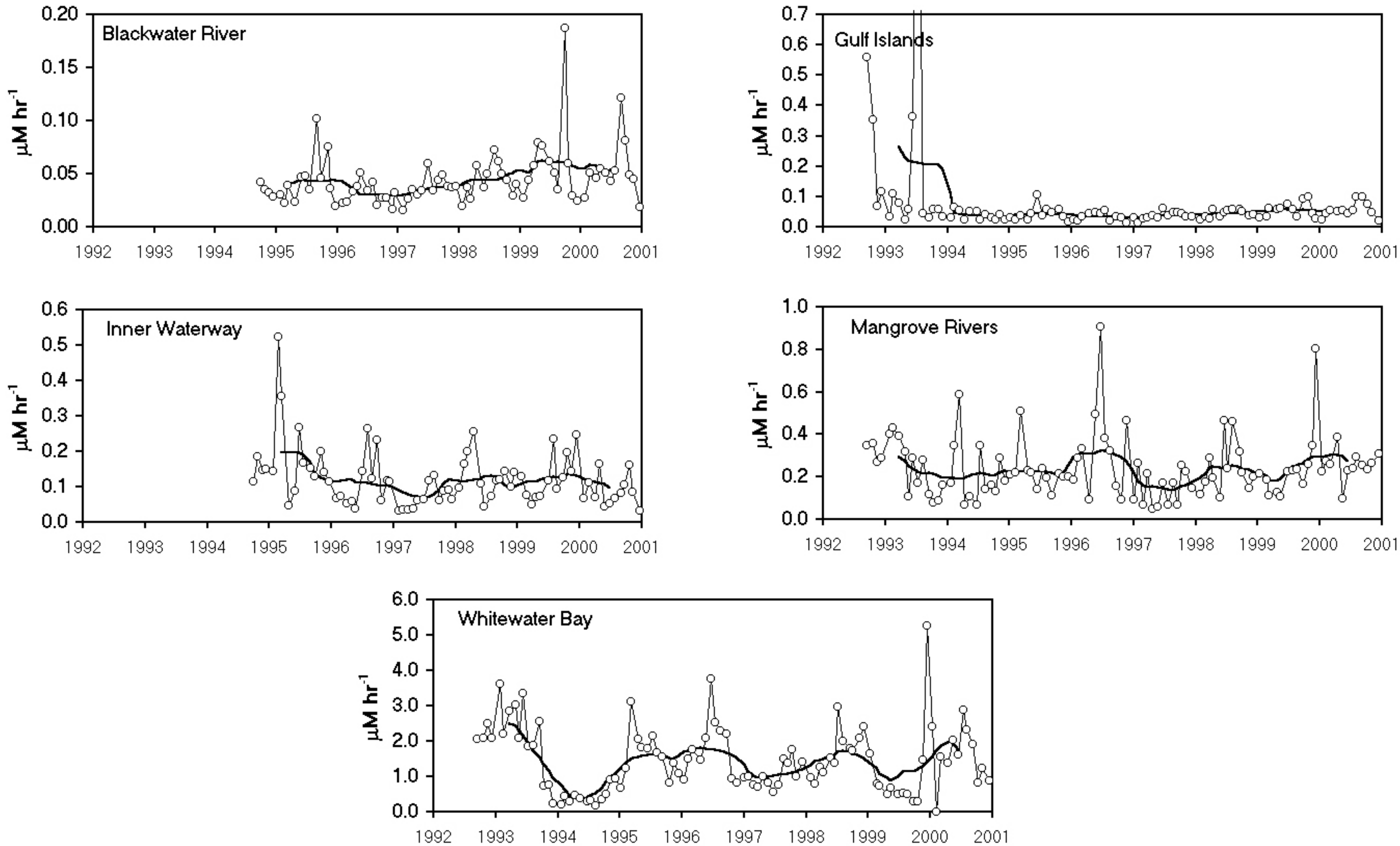


Figure 3.12. Monthly median alkaline phosphatase activity in the WB-TTI zones.

Median Total Organic Carbon

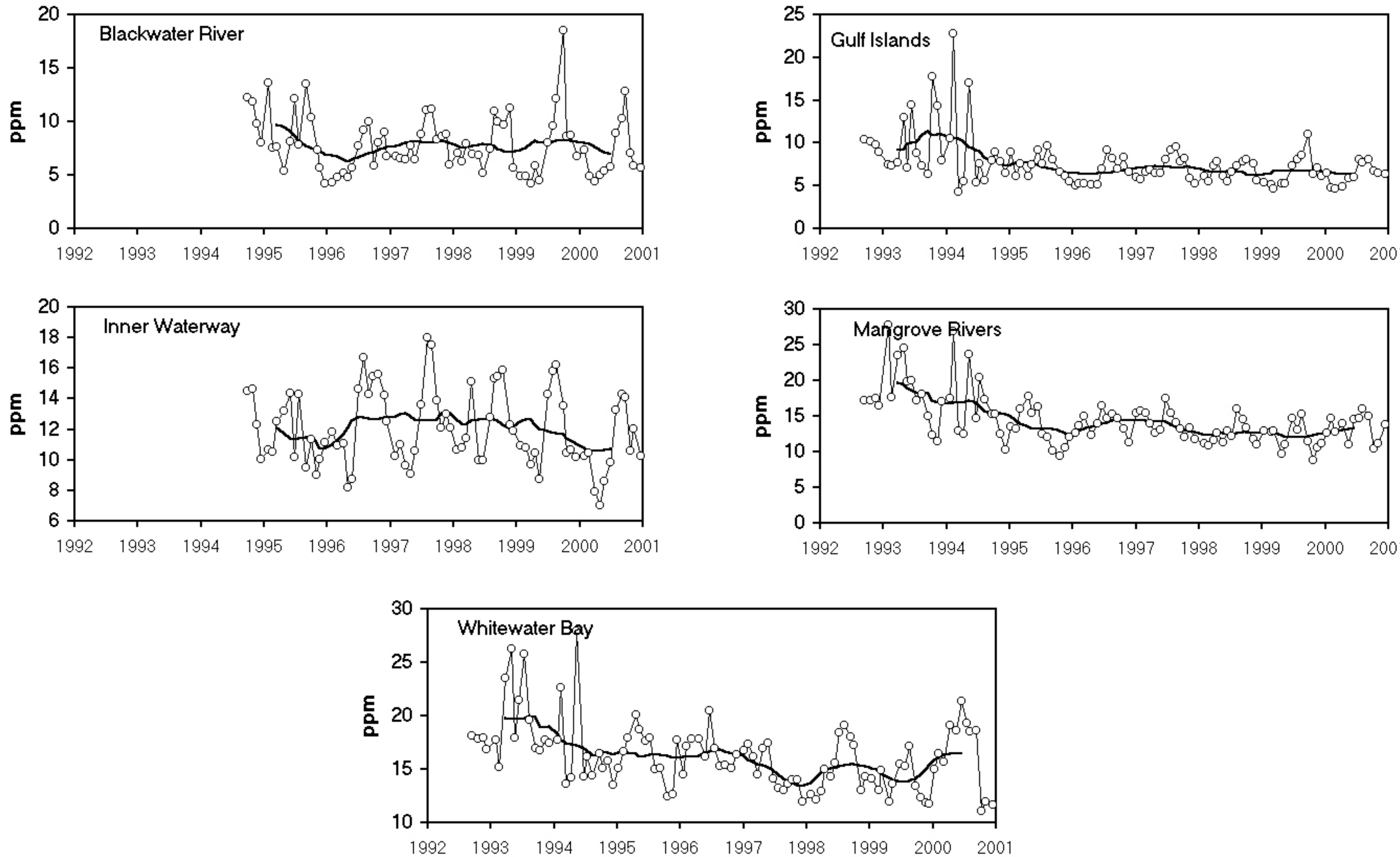


Figure 3.13. Monthly median total organic carbon concentrations in the WB-TTI zones.

Median Total Organic Nitrogen

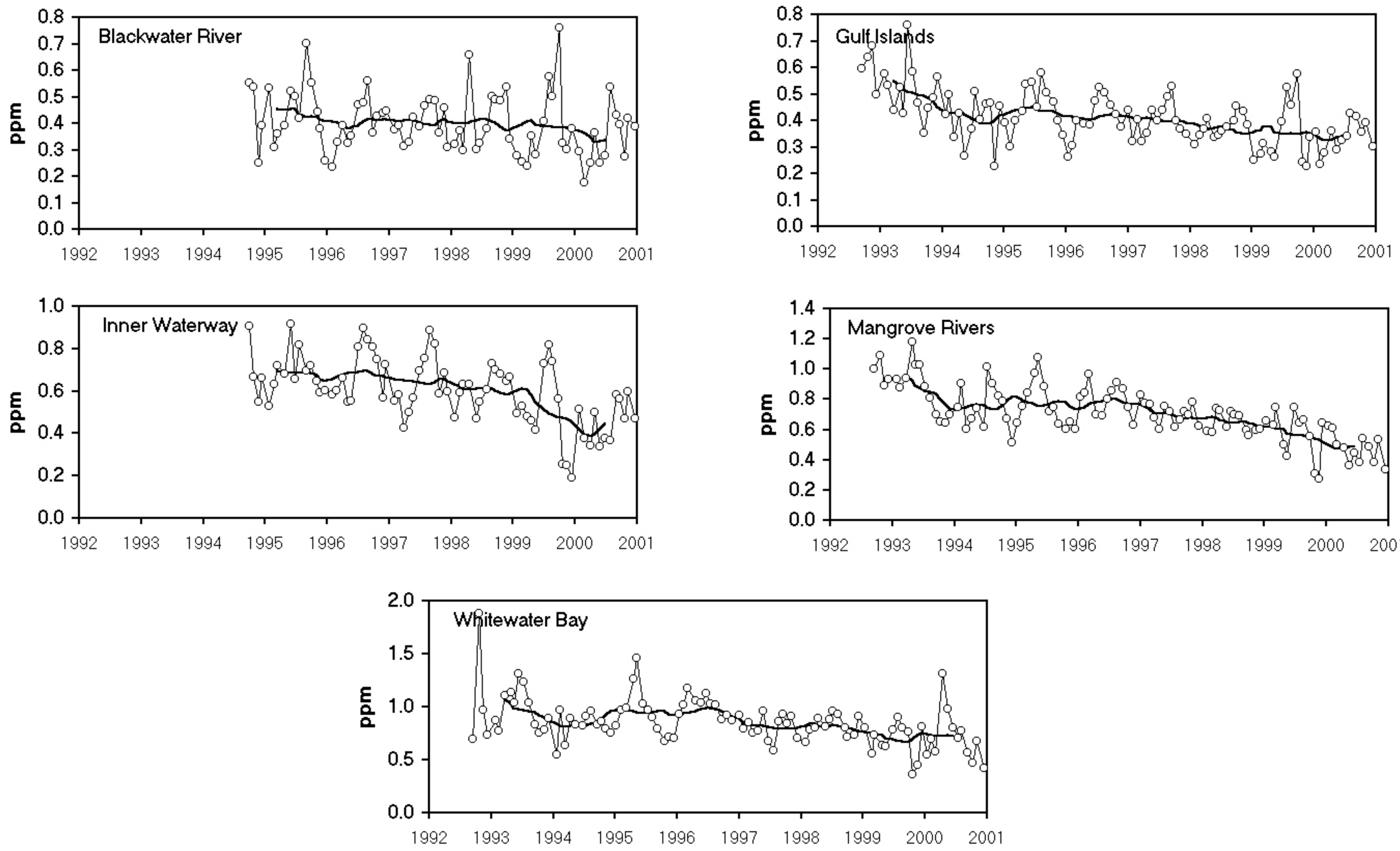


Figure 3.14. Monthly median total organic nitrogen in the WB-TTI zones.

Median Turbidity

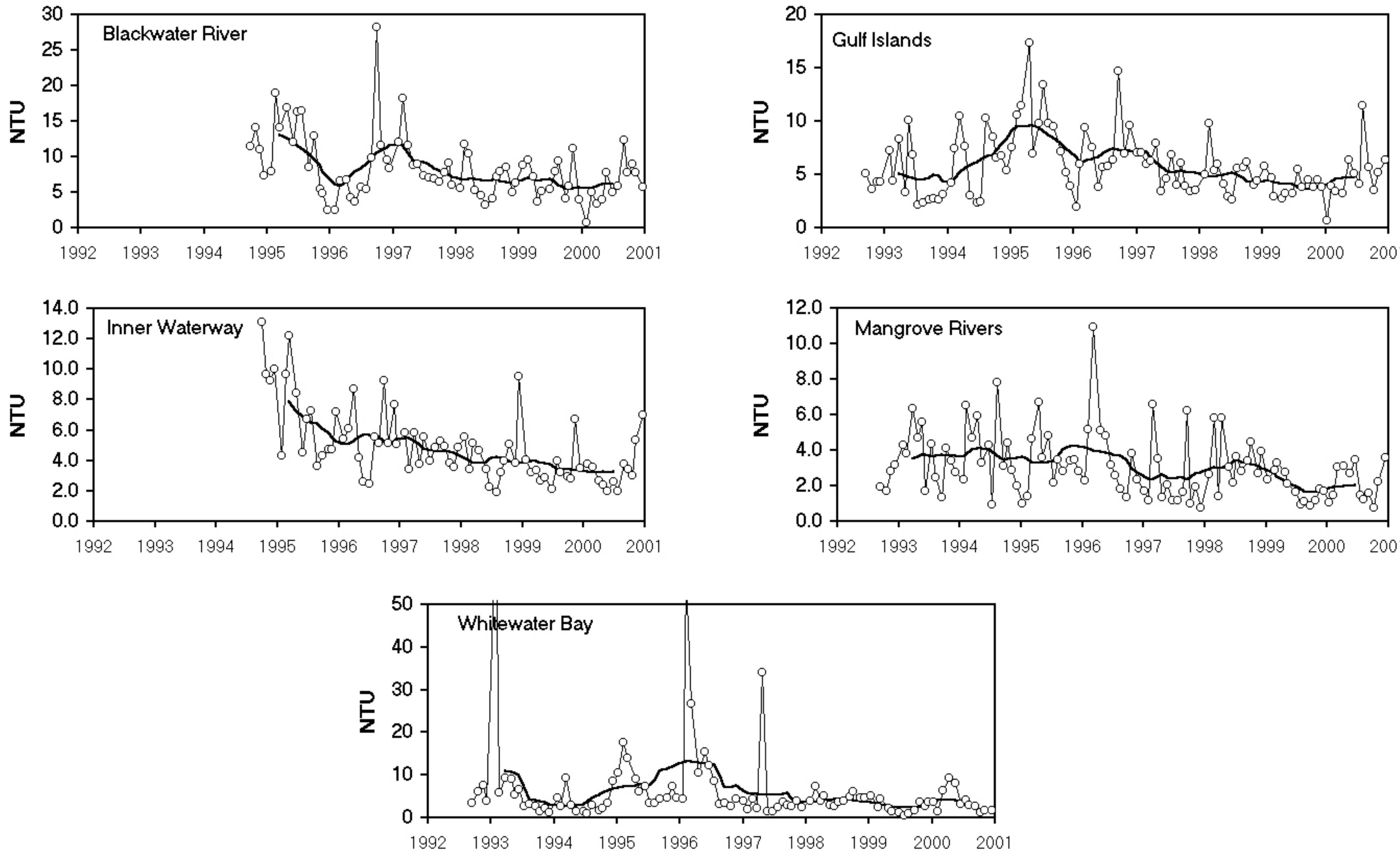


Figure 3.15. Monthly median turbidity in the WB-TTI zones.

4. OVERVIEW OF WATER QUALITY OF BISCAYNE BAY

Biscayne Bay was partitioned into 6 distinct zones using the above statistical analysis. The first cluster was composed of 2 stations closest to the shore in the south Bay (Fig. 4.1); they were 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). 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).

It is clear that there is a gradient of increased salinity with decreased nutrient concentration with distance from the west coast of the Bay (Fig. 4.2). For AS, IS, and MAIN clusters, highest concentrations of NO_3^-, NO_2^-, NH_4^+, and TP were observed in the AS stations (Fig. 4.3). NBAY showed NH_4 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 ZSI. SCARD had relatively high NH_4 concentration 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. APA as well as TON and TOC concentrations were highest in AS > IS > MAIN, denoting a freshwater source. It is interesting to note the northwards decreasing gradient of TON and TOC along the coast. Concentrations of SRP were so low so as be undetectable in many instances. The relationship between SRP and CHLA was very weak and may have been influenced by other factors yet determined. This is a preliminary analysis and will be repeated after more data collection.

<u>Comparison of 2000 to Overall Period of Record</u>

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 (Fig. 4.4). Temperature follows the general seasonal cycle (Fig. 4.5) but DO saturation is more influenced by canal releases than temperature (Fig. 4.6). NH_4^+ concentrations for 2000 were low (Fig. 4.7) but comparable to other years (excluding hurricanes). NO_3^- continues to display spikes associated with canal releases especially in Alongshore and South Card Sound zones (Fig. 4.8).

Increases in TP concentrations in all areas of the Bay are beginning to become discernable (Fig. 4.9). Not only are concentrations increasing but so is the variability. We can only speculate as to the cause but there is evidence from the monitoring program in the Florida Keys National Marine Sanctuary that TP is increasing over the whole region and is not tied to a specific point source (http:///serc.fiu.edu/wqmnetwork). Sharp increases in SRP during 2000 were observed which were not related to freshwater inflows (Fig. 4.10). CHLA remains low in the area with the exception of Hurricane Irene effects (Fig. 4.11). APA is low as well (Fig. 4.12). TOC, TON, and turbidity remain relatively low and unremarkable (Fig. 4.13, 4.14, and 4.15).

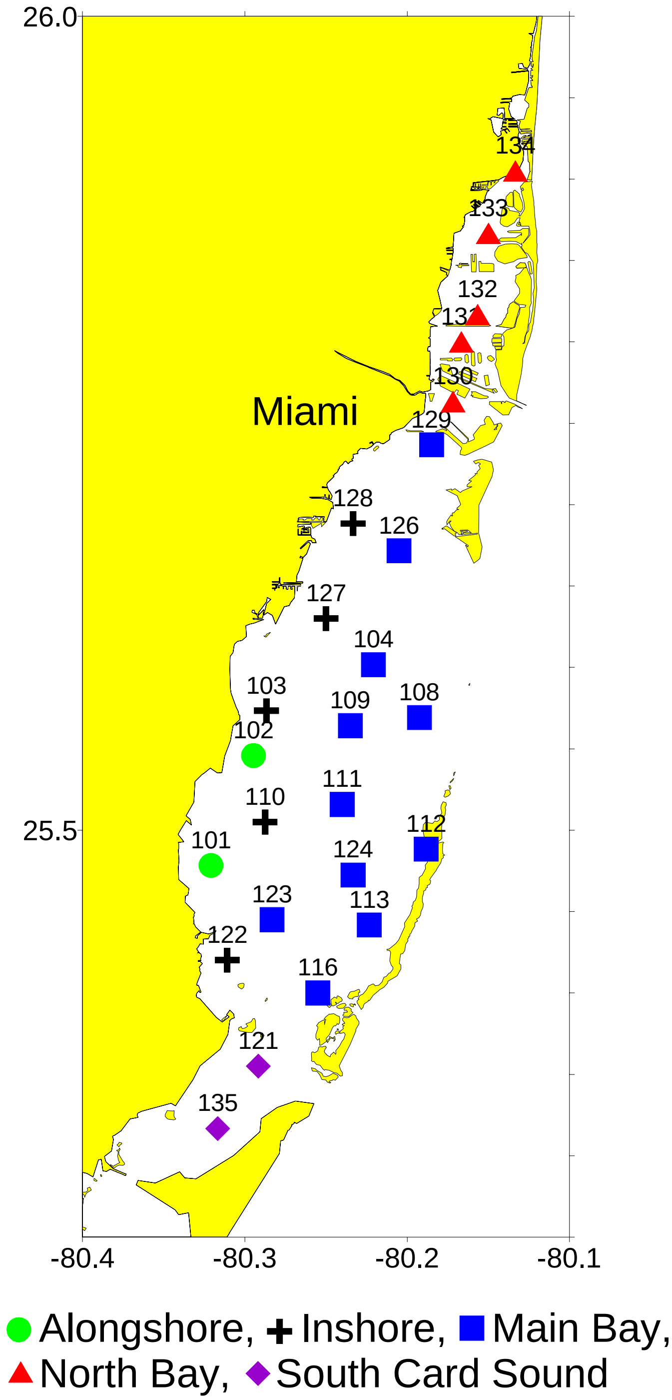


Figure 4.1. Zones of similar water quality in Biscayne Bay.

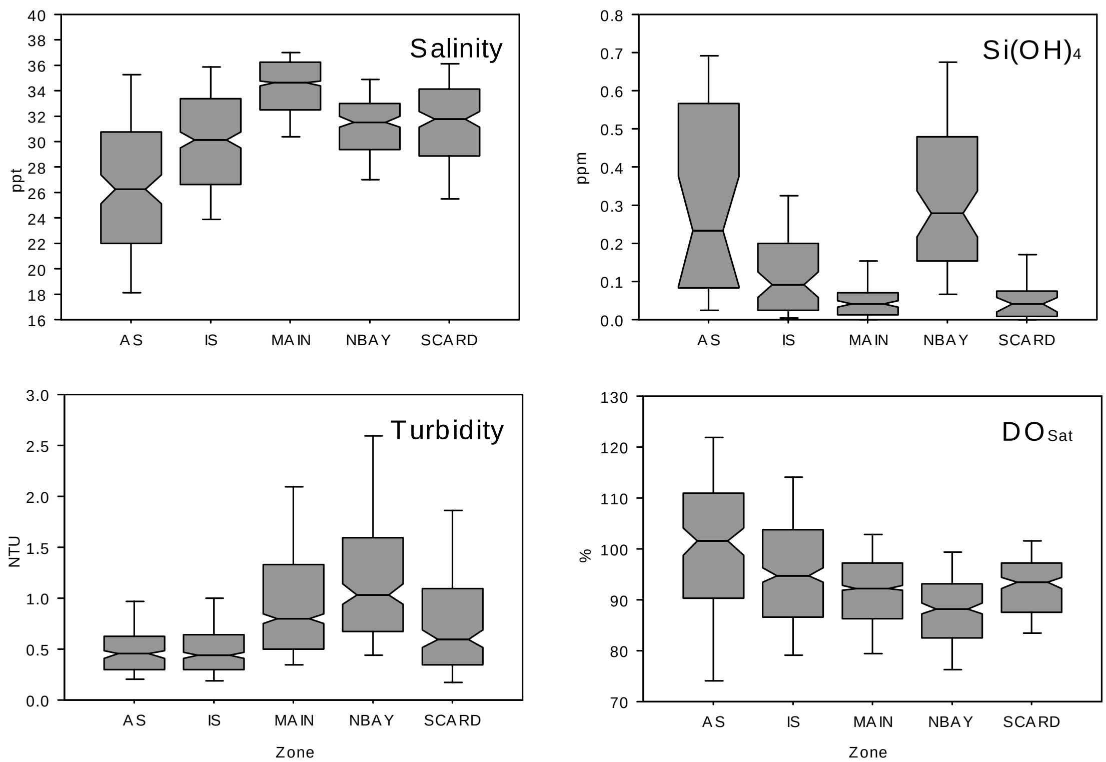


Figure 4.2. Box-and-whisker plots of salinity, silicate ($Si(OH)_4$), turbidity, and dissolved oxygen saturation (DO_{sat}) by zone. A significant increasing trend in salinity and turbidity is observed with distance offshore with concomitant decline in $Si(OH)_4$and DO_{sat}.

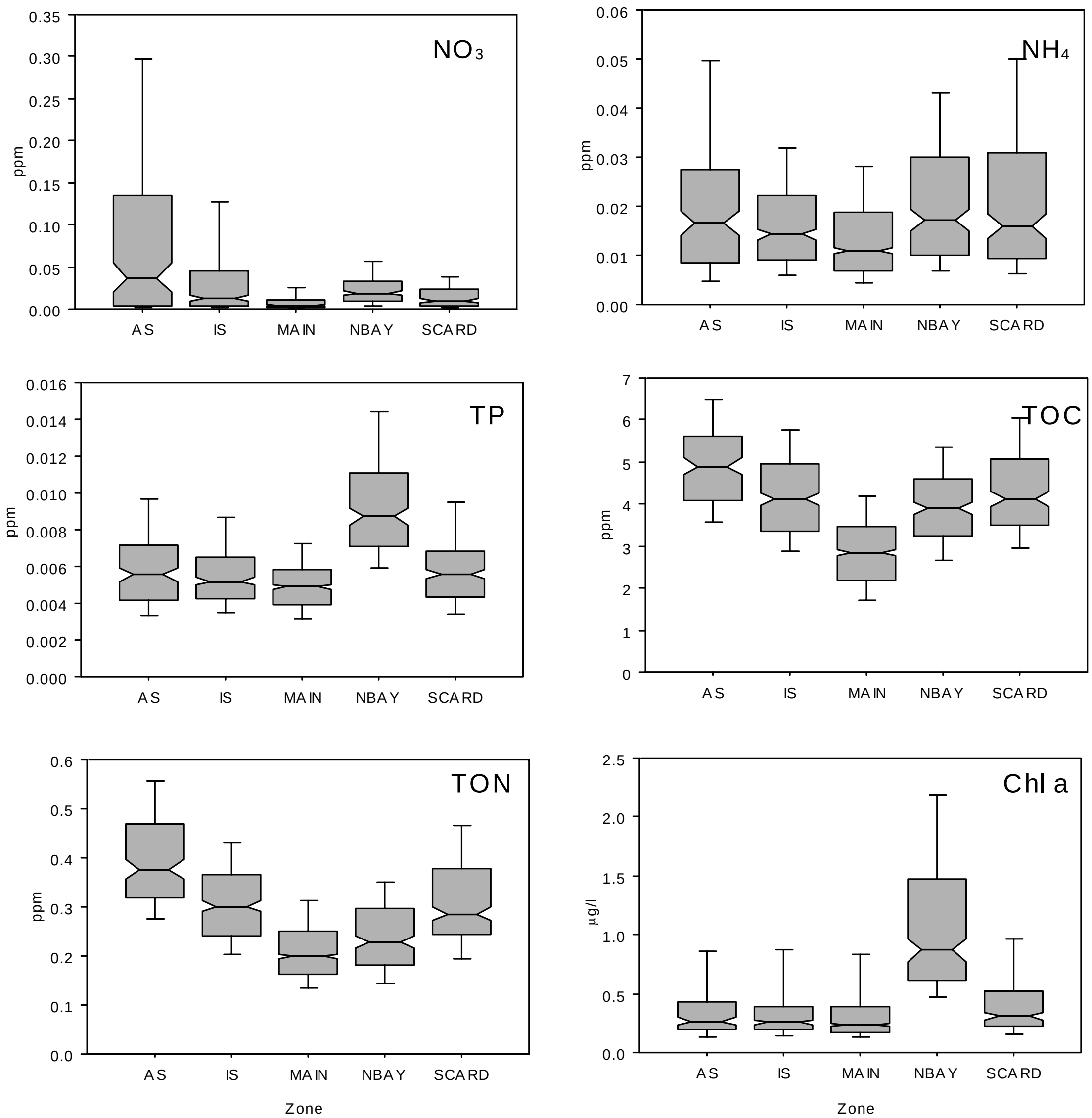


Figure 4.3. Box-and-whisker plots of nitrate (NO3), ammonia (NH4), total phosphorus (TP), total organic carbon (TOC), total organic nitrogen (TON), and chlorophyll *a* (CHLA) for the zones. A significant decreasing trend in these variables (except CHLA) is observed with distance offshore.

Median Salinity

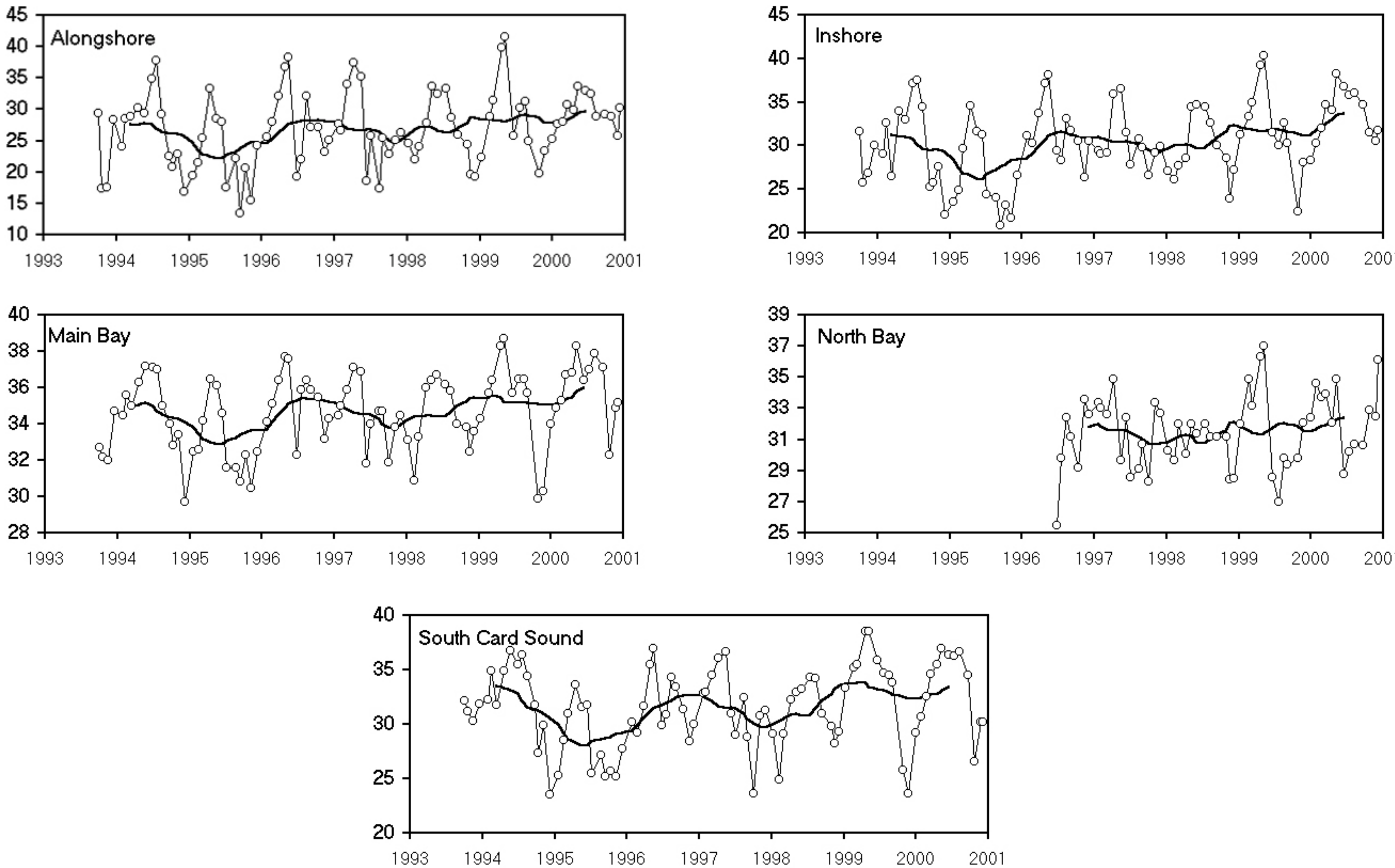


Figure 4.4. Monthly median salinity in the Biscayne Bay zones.

Median Temperature

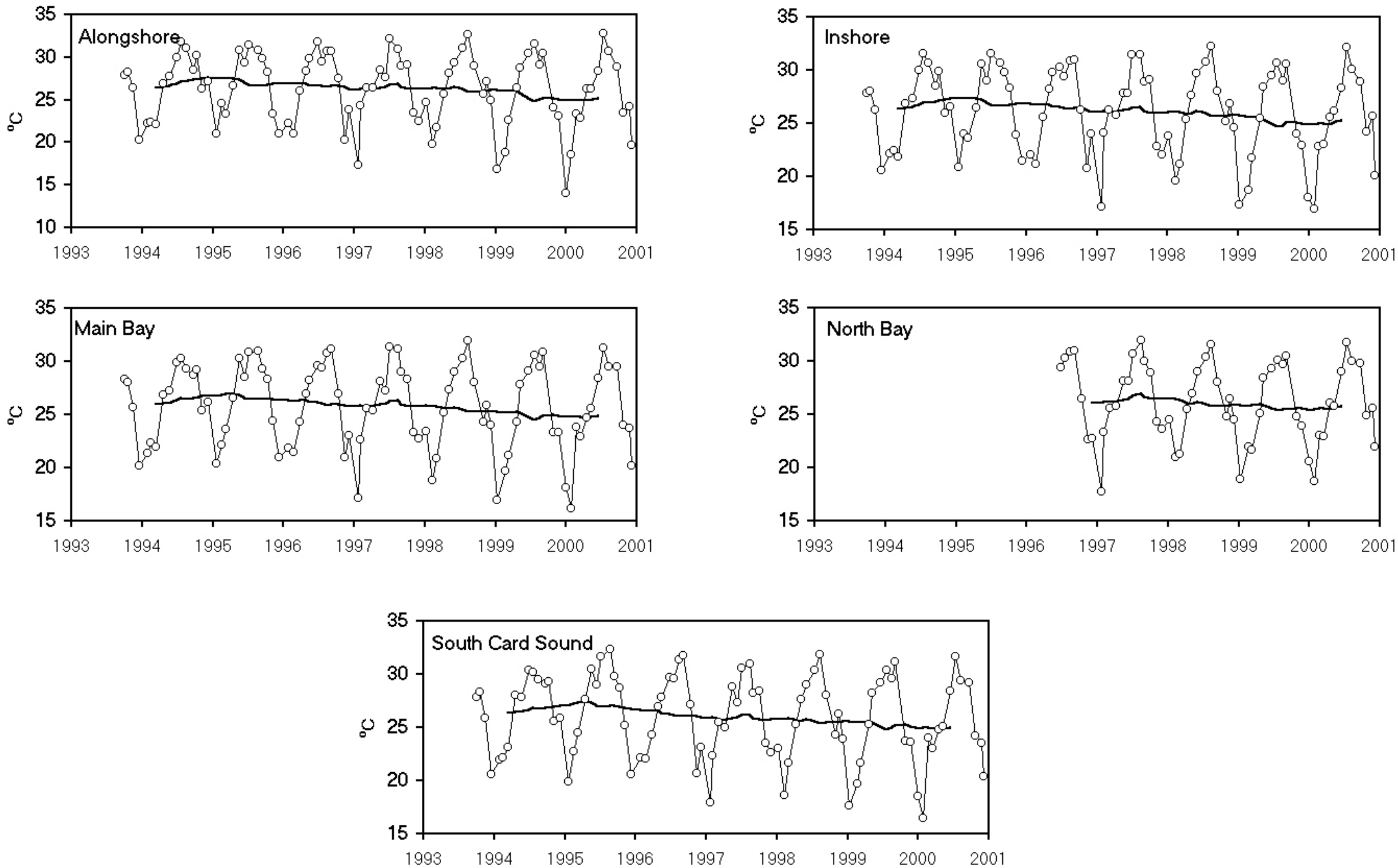


Figure 4.5. Monthly median temperature in the Biscayne Bay zones.

Median DO Saturation

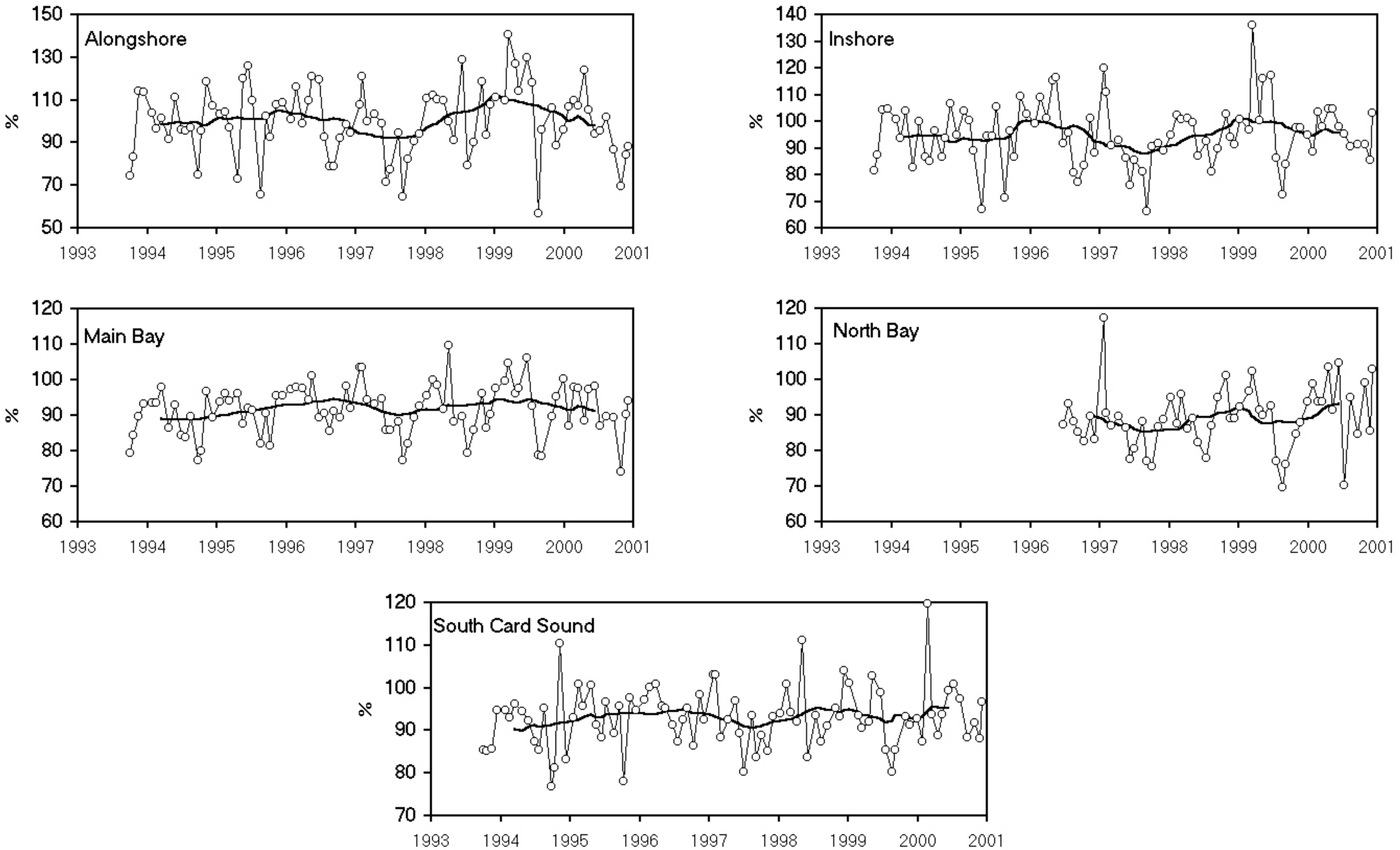


Figure 4.6. Monthly median DO saturation in the Biscayne Bay zones.

Median Ammonium

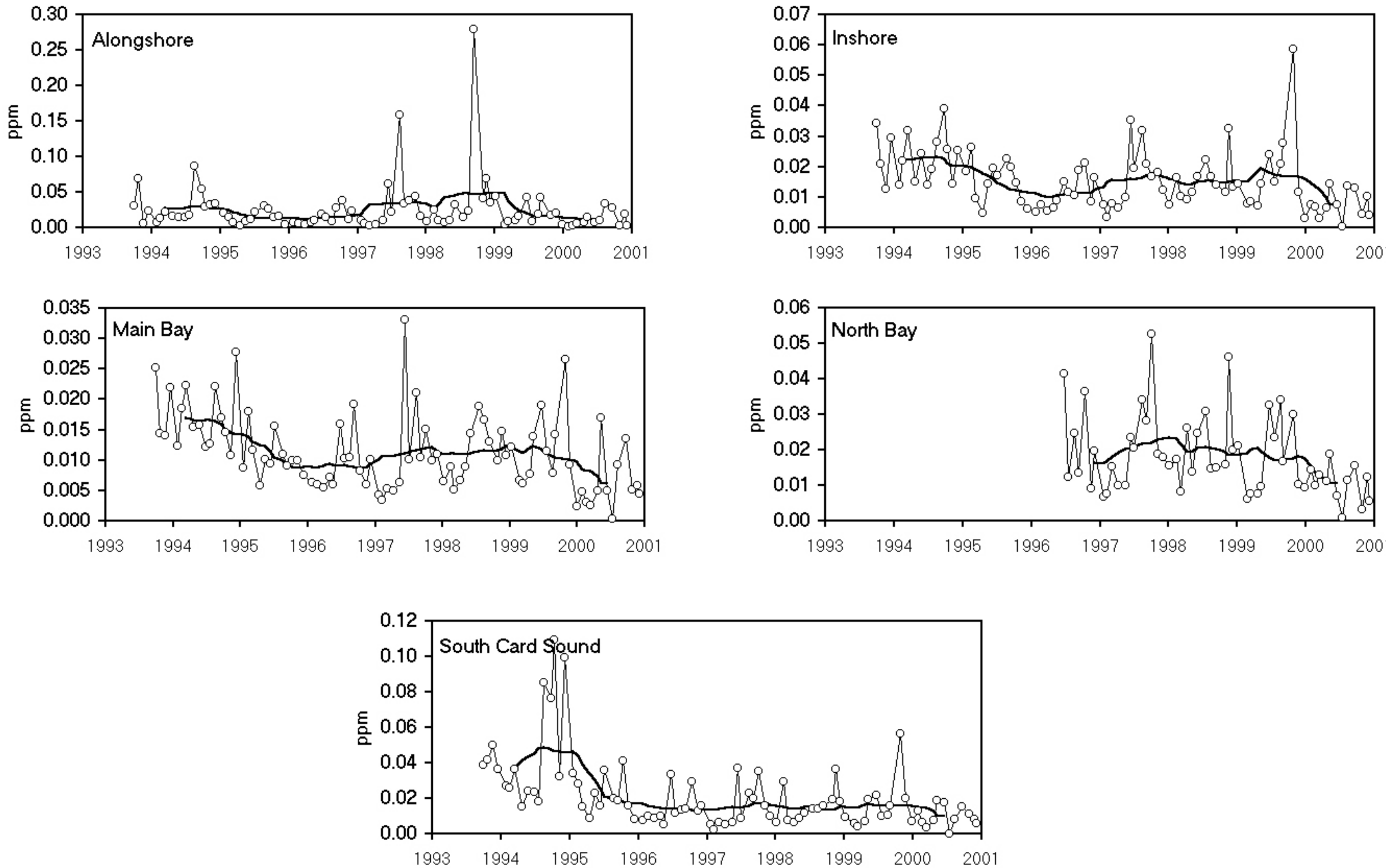


Figure 4.7. Monthly median ammonium concentrations in the Biscayne Bay zones.

Median Nitrate

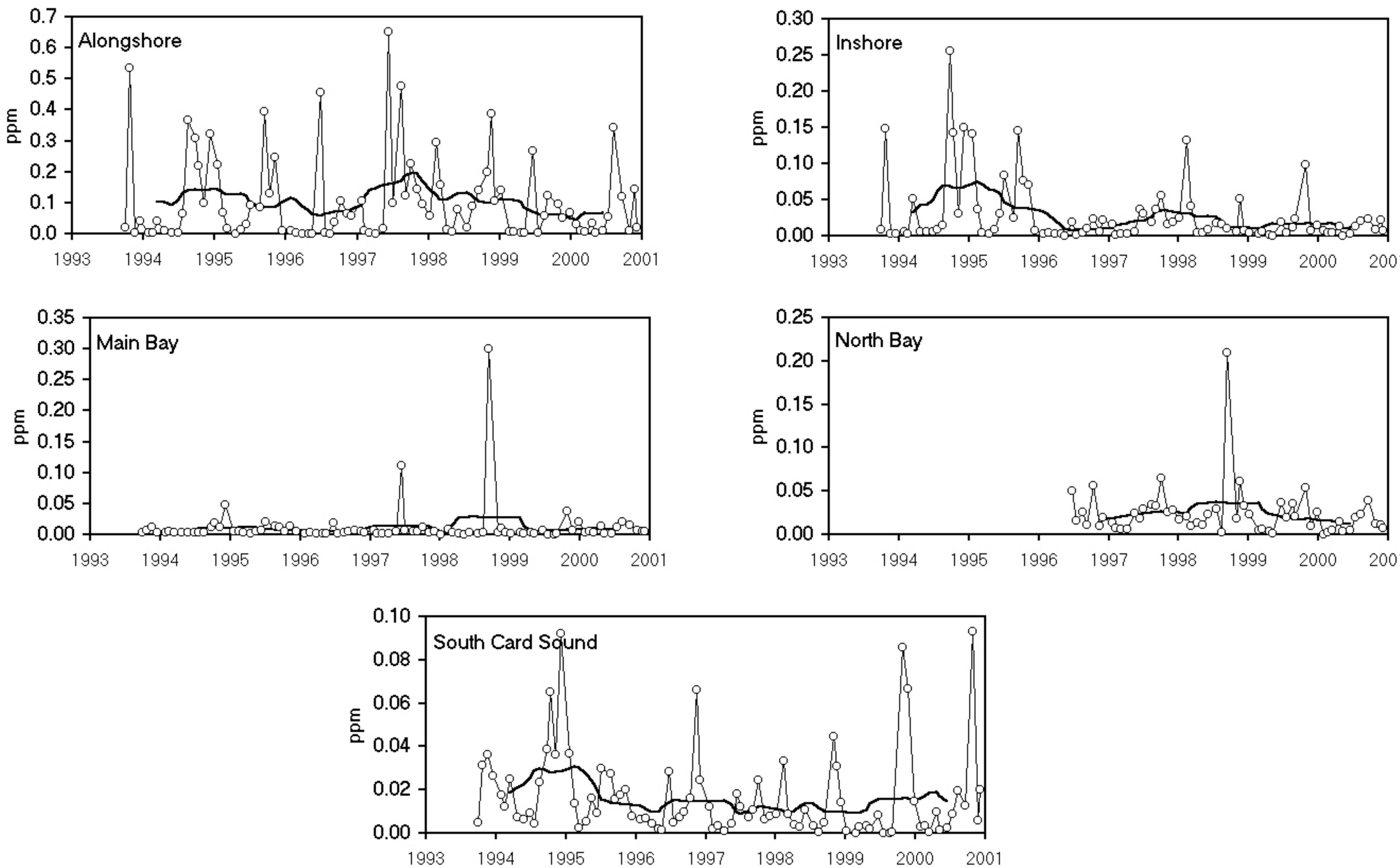


Figure 4.8. Monthly median nitrate concentrations in the Biscayne Bay zones.

Median Total Phosphorus

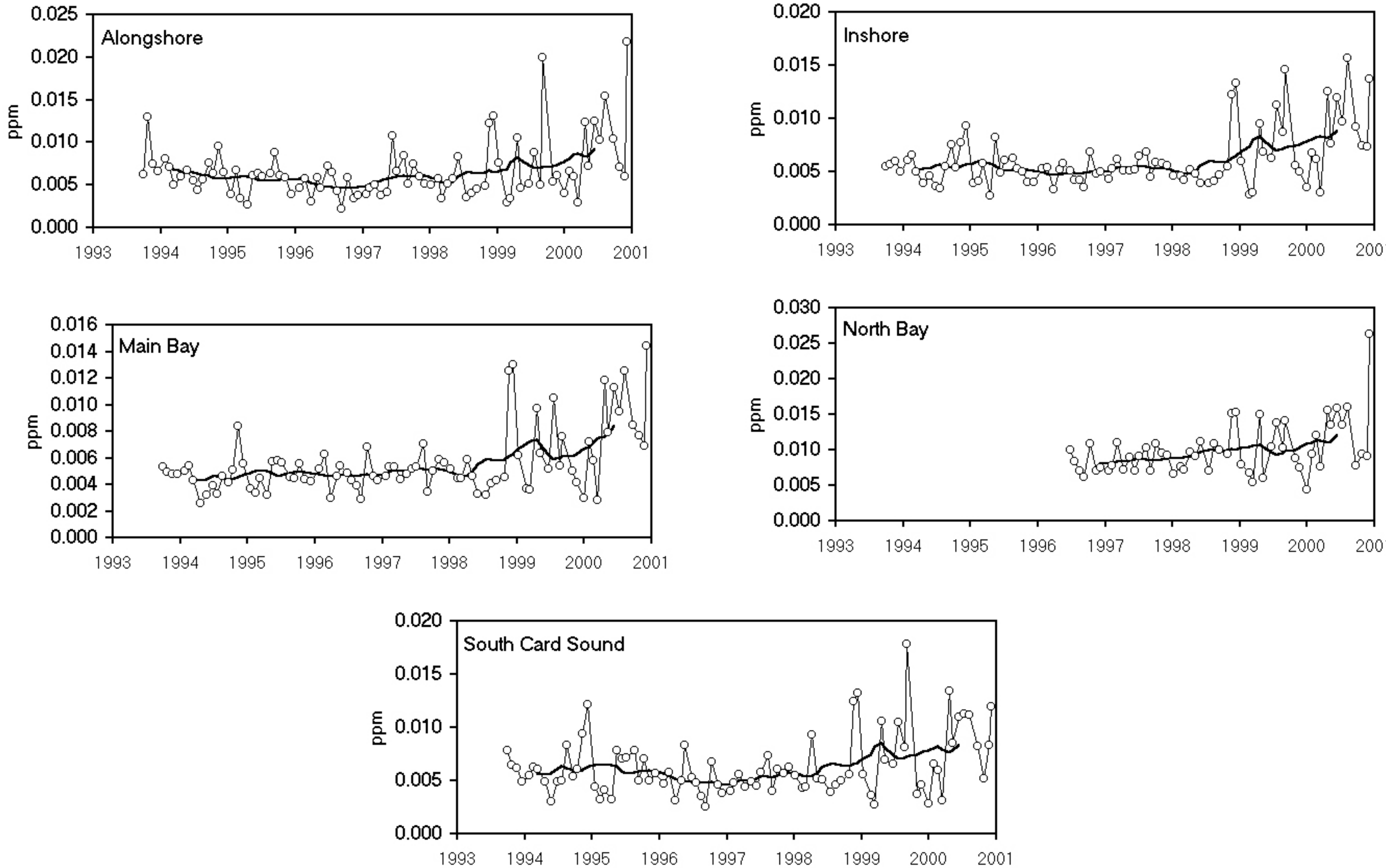


Figure 4.9. Monthly median total phosphorus concentrations in the Biscayne Bay zones.

Median Soluble Reactive Phosphorus

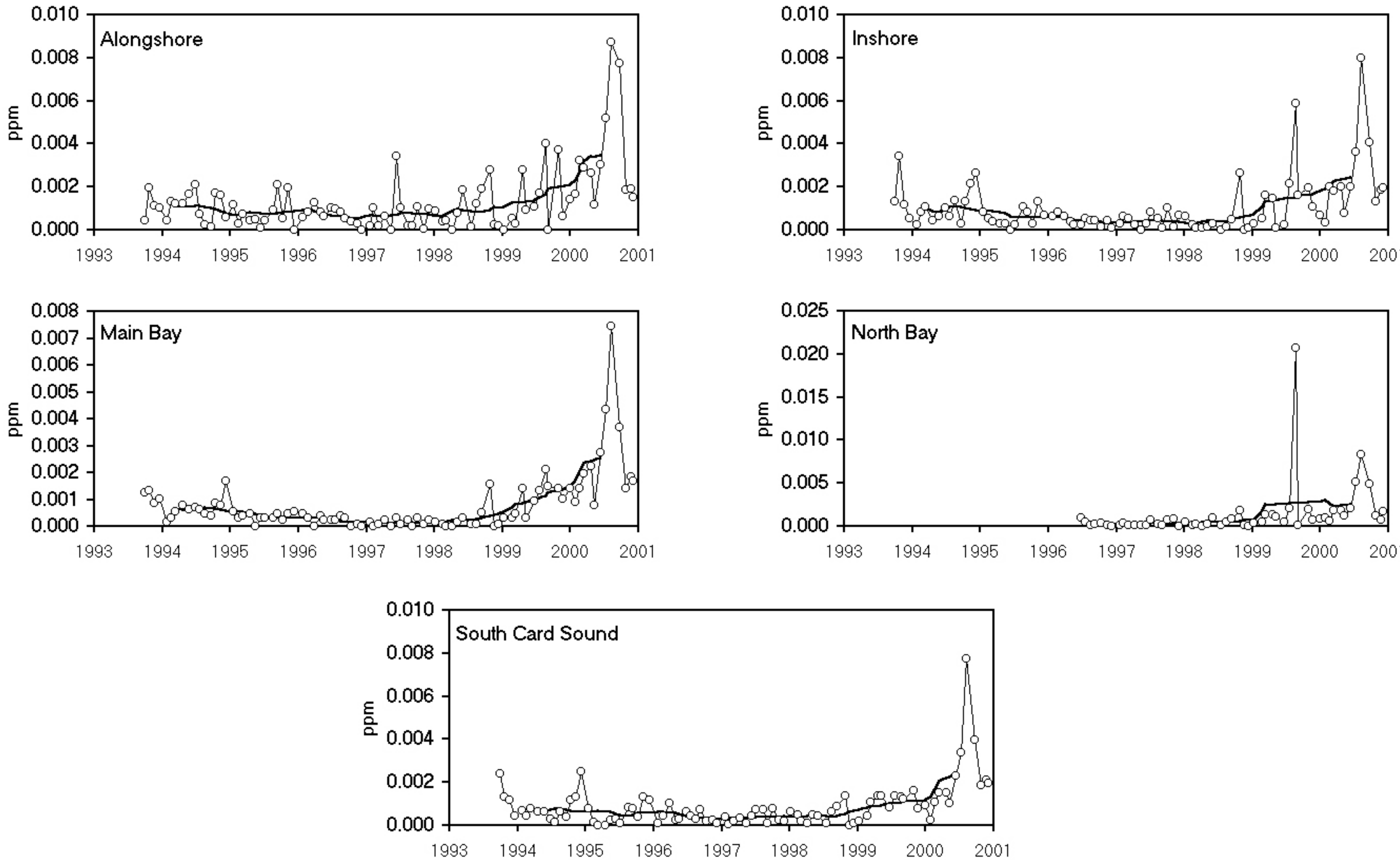


Figure 4.10. Monthly median soluble reactive phosphorus concentrations in the Biscayne Bay zones.

Median Chlorophyll *a*

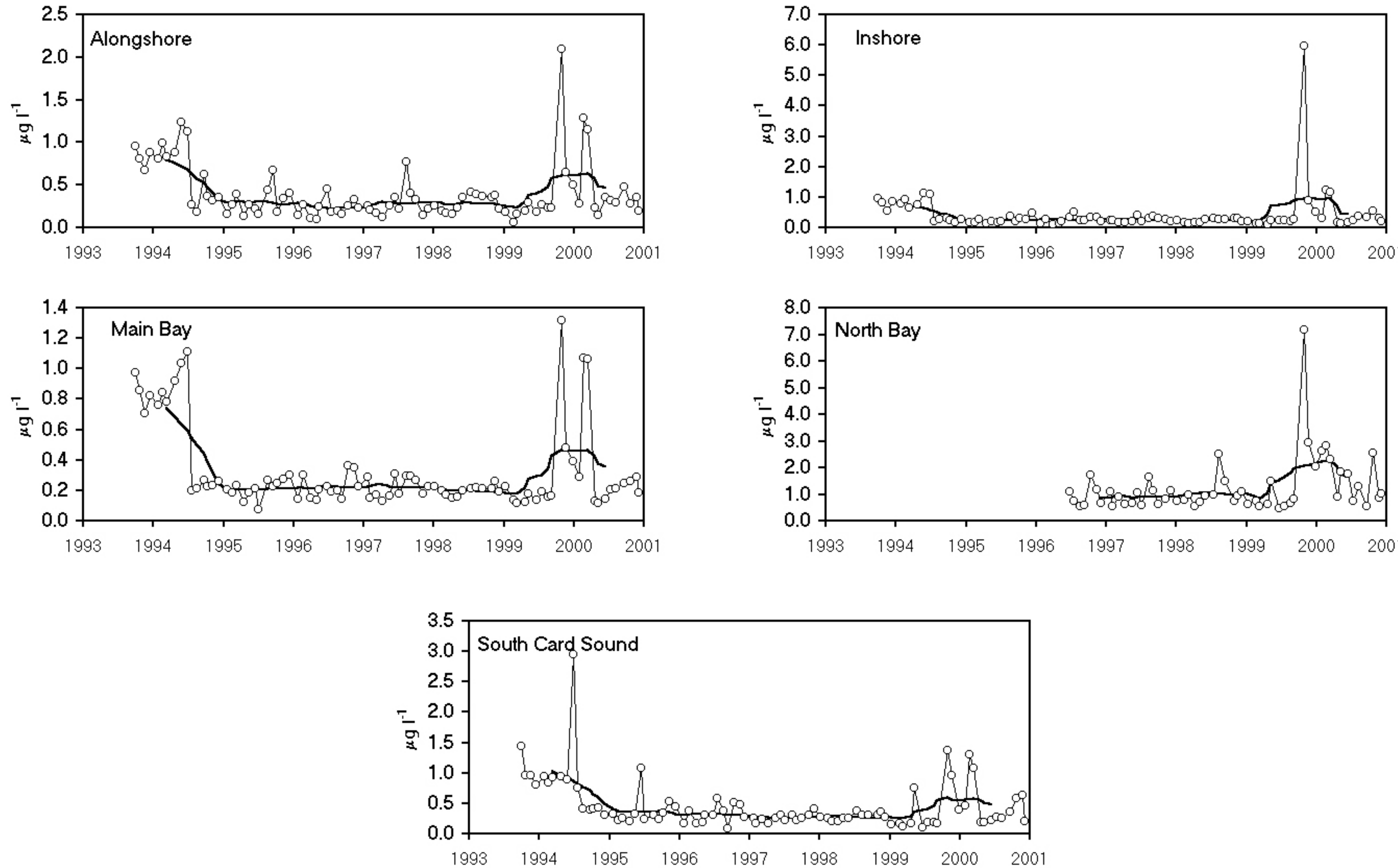


Figure 4.11. Monthly median chlorophyll *a* concentrations in the Biscayne Bay zones.

Median Alkaline Phosphatase Activity

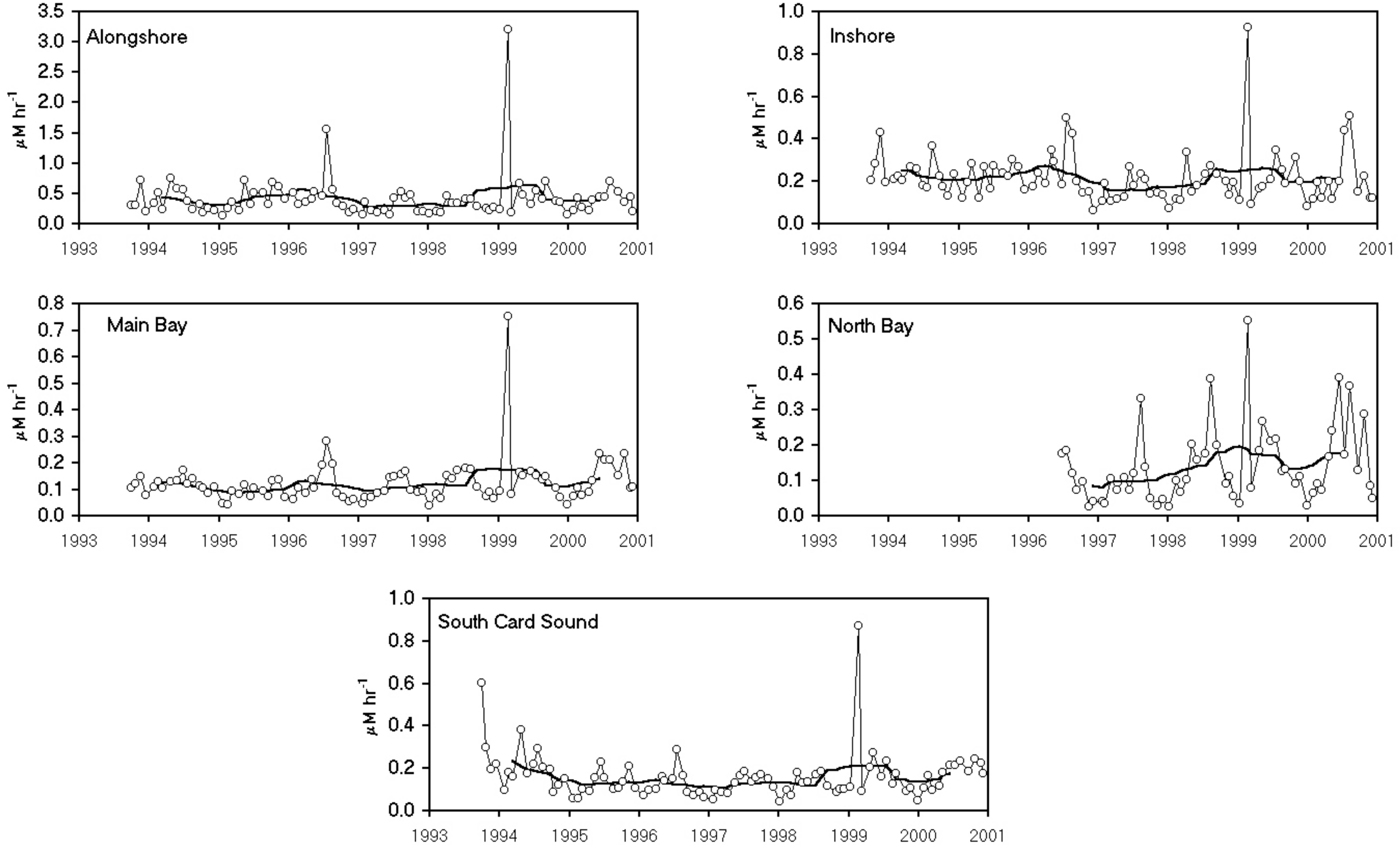


Figure 4.12. Monthly median alkaline phosphatase activity in the Biscayne Bay zones.

Median Total Organic Carbon

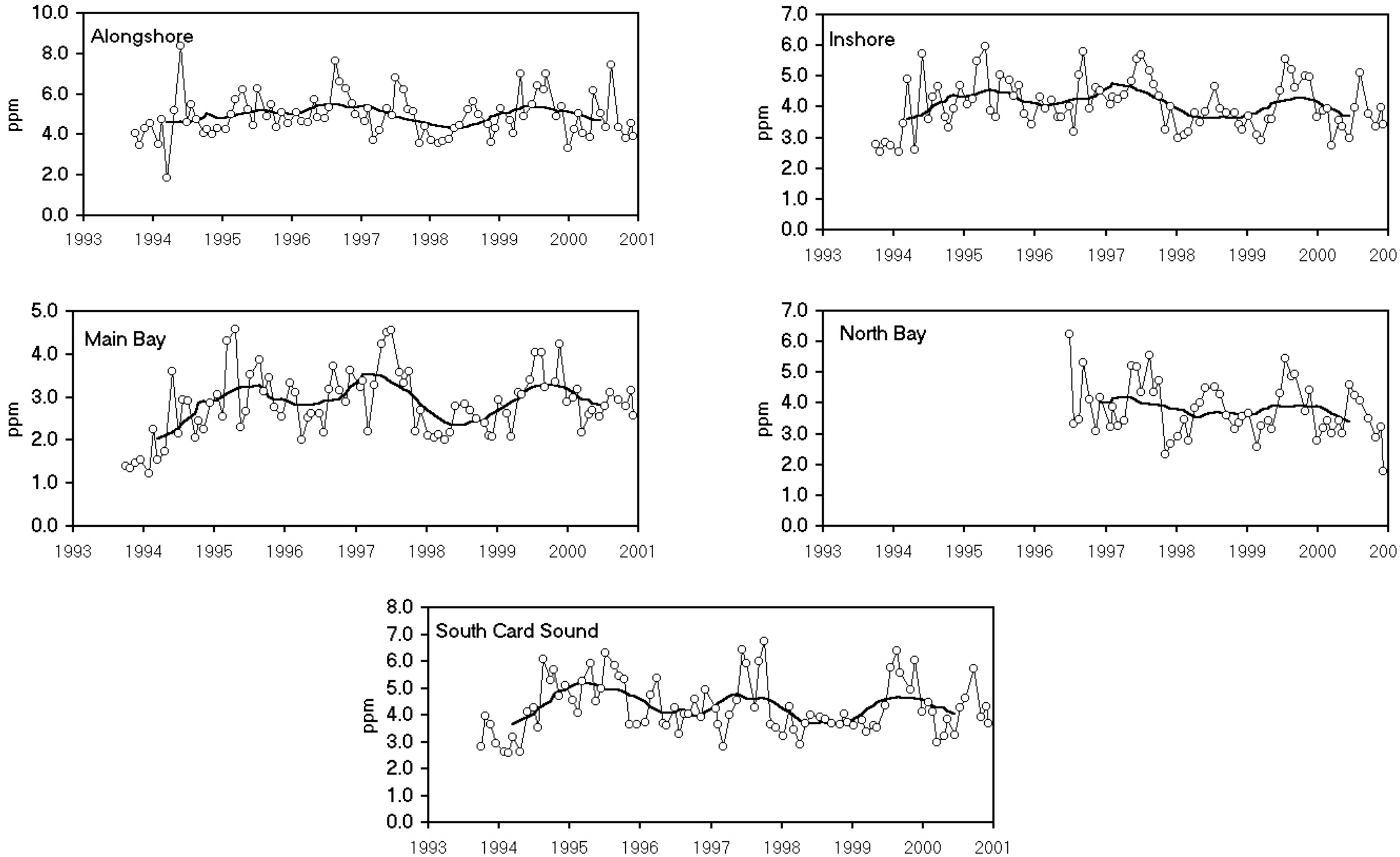


Figure 4.13. Monthly median total organic carbon concentrations in the Biscayne Bay zones.

Median Total Organic Nitrogen

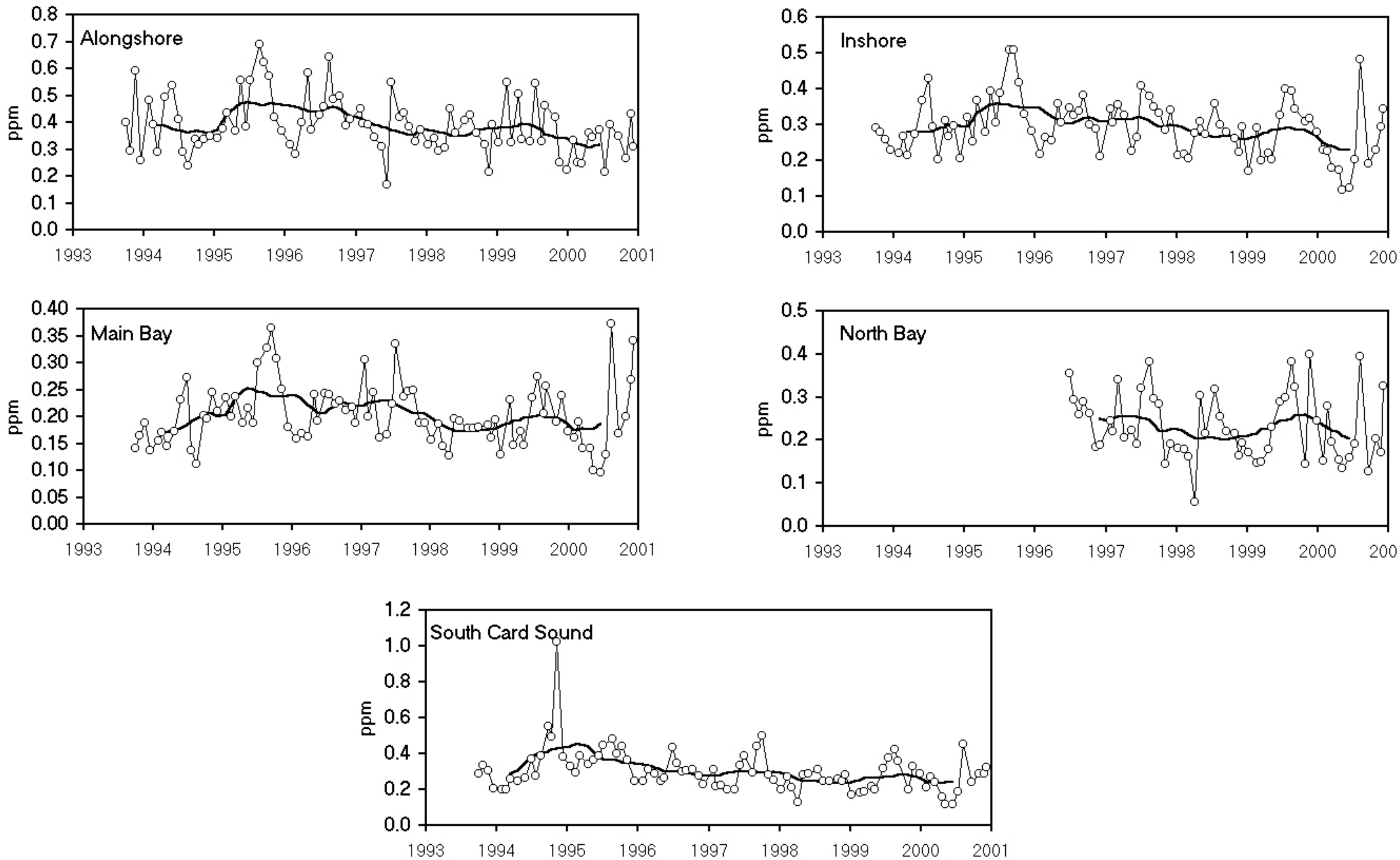


Figure 4.14. Monthly median total organic nitrogen concentrations in the Biscayen Bay zones.

Median Turbidity

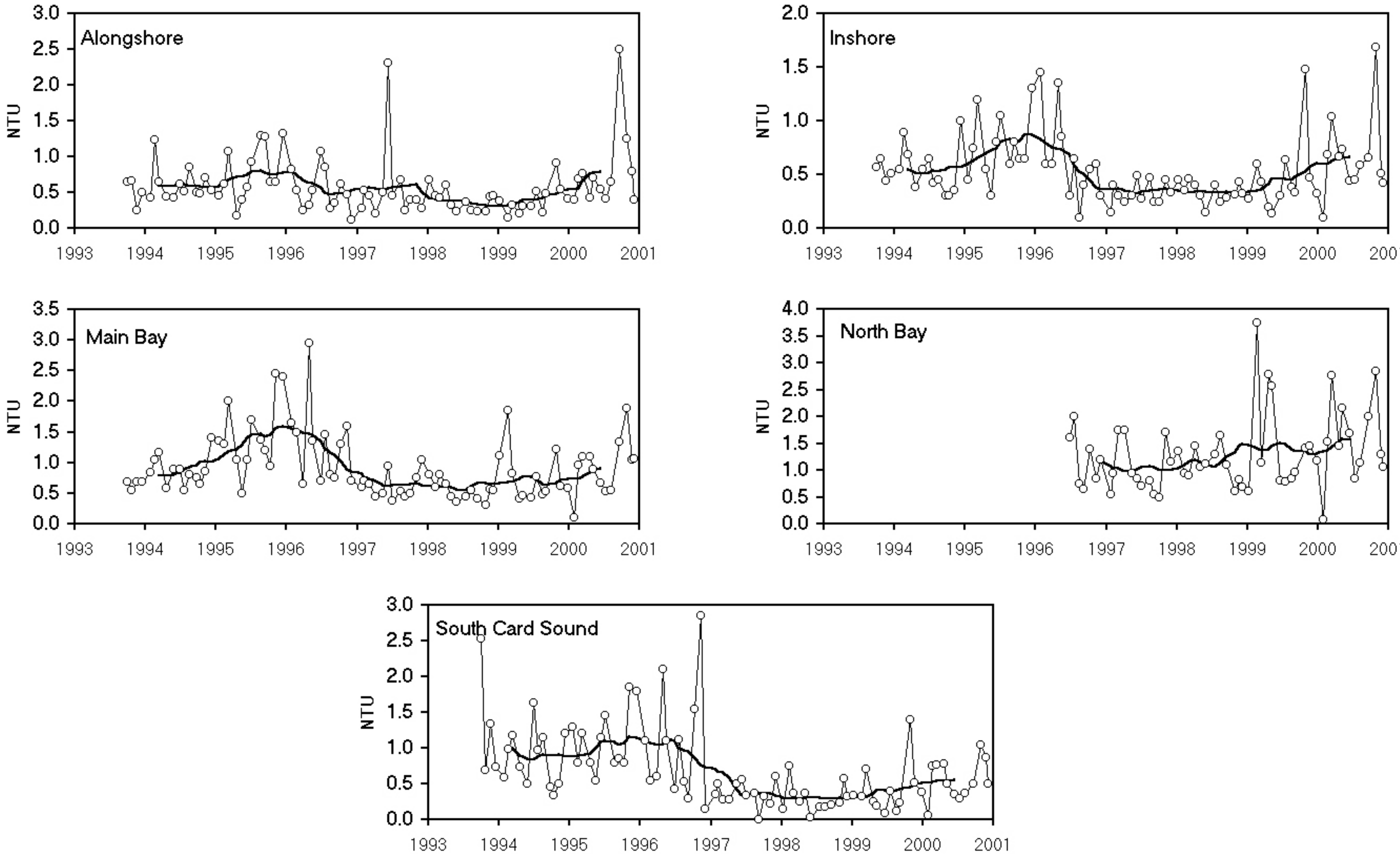


Figure 4.15. Monthly median turbidity in the Biscayne Bay zones.

5. OVERVIEW OF WATER QUALITY OF SOUTHWEST FLORIDA SHELF

The above statistical analysis objectively classified the 49 Shelf sampling sites into 3 zones having similar 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.

It is clear that the SHARK stations have higher concentrations of NO_3^-, NO_2^-, NH_4^+, and SRP while the SHOAL and SHELF stations were similar (Fig. 5.2). In addition, there is a decreasing concentration gradient of SHARK>SHOAL>SHELF for TP, CHLA and turbidity (Fig. 5.3). Finally, the inverse relationship between salinity and $Si(OH)_4$ is evident for all ZSI. The source of $Si(OH)_4$ in this area of carbonate sediments is from silicate sands and siliceous periphyton (diatoms) found in the Shark River watershed (Everglades). $Si(OH)_4$ is can therefore be used as a freshwater tracer in this system.

Although these analyses are very preliminary (only 18 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.

<u>Comparison of 2000 to Overall Period of Record</u>

Since this component of the monitoring program is sampled on a quarterly basis, there is little time series data to analyze. Because of this, only broad generalizations will be discussed. Salinity figures show the rebound from Hurricane Irene (Oct. 1999) influence (Fig. 5.4) with normal temperature variations (Fig. 5.5). The last survey showed anomalously low DO saturation values for all zones (Fig. 5.6). We are not sure as to the cause but further data will be used to determine if the equipment was operating correctly. NH_4^+ showed higher concentrations during 1998-99 with a return to previous levels in 2000 (Fig. 5.7). NO_3^- displayed very high concentrations during 2000 than in previous years (Fig. 5.8). The causes for this are unknown as we did not see high concentrations in the freshwater coming out of the Shark River Slough (Fig 3.8).

As in the Florida Keys National Marine Sanctuary and Biscayne Bay (Fig. 3.9), TP concentrations in the SHOAL and SHELF zones increased over the period of record (Fig. 5.9). Interestingly, TP did not increase in the SHARK sites which were most heavily influenced by freshwater inputs from the Everglades. SRP showed some spikes in 2000 but it is not known if this will continue (Fig.5.10). CHLA showed seasonal variation with highest concentrations occurring in the fall/winter period (Fig. 5.11). APA showed sporadic spikes in activity which were unrelated to CHLA (Fig. 5.12). TOC, TON, and turbidity were unremarkable (Fig. 5.13, 5.14, and 5.15).

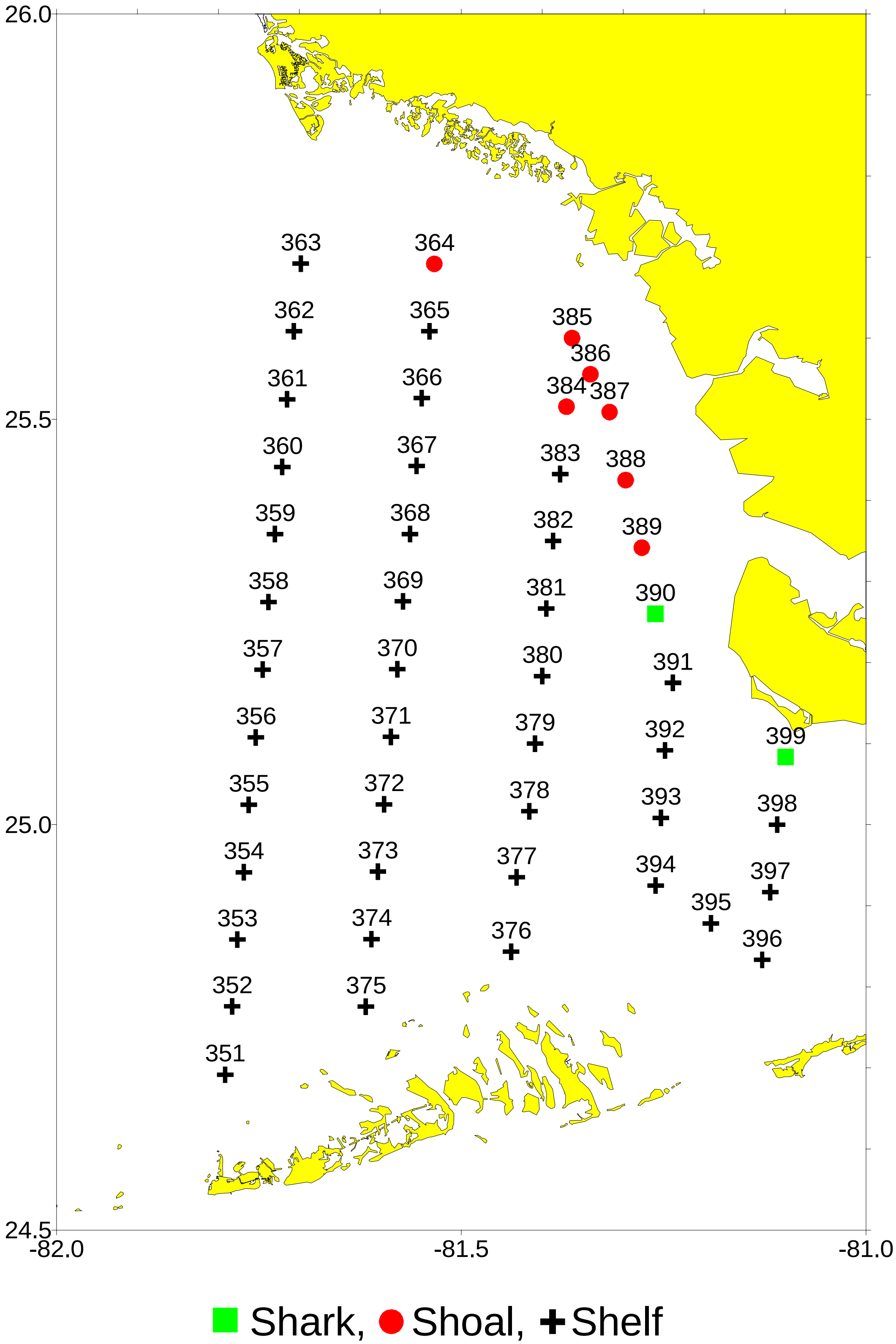


Figure 5.1. Zones of similar water quality on the SW Shelf.

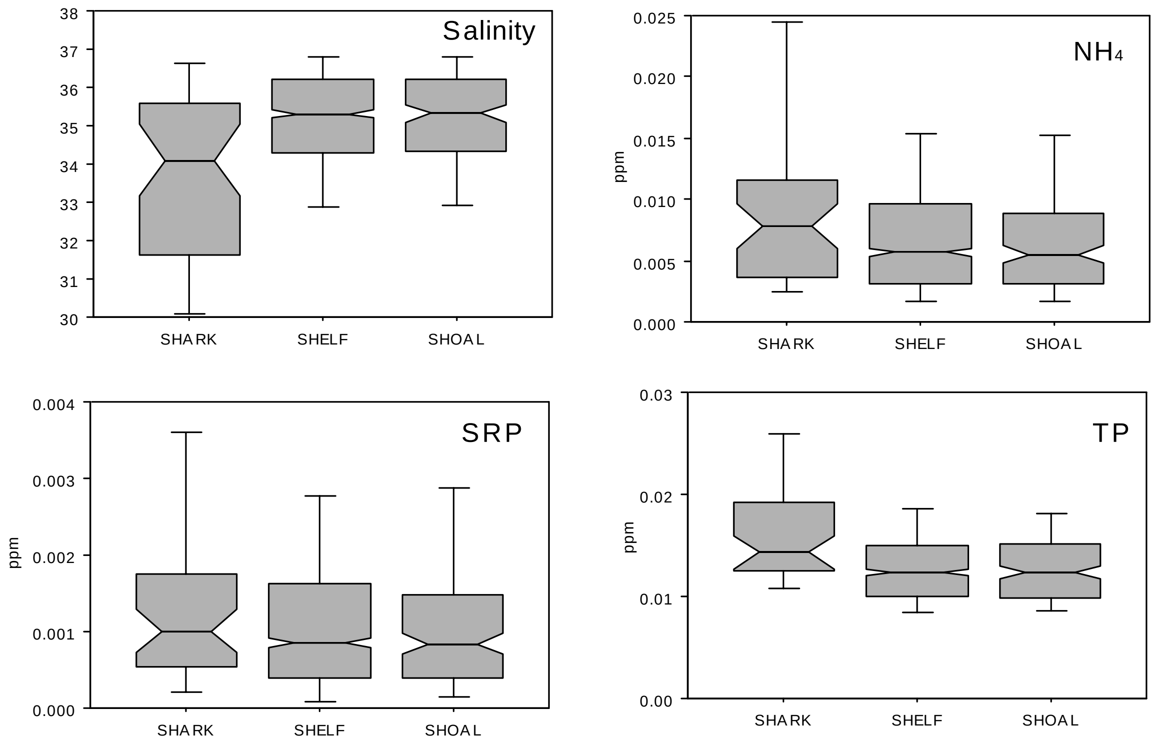


Figure 5.2. Box plots showing influence of freshwater source from Everglades on SHARK stations.

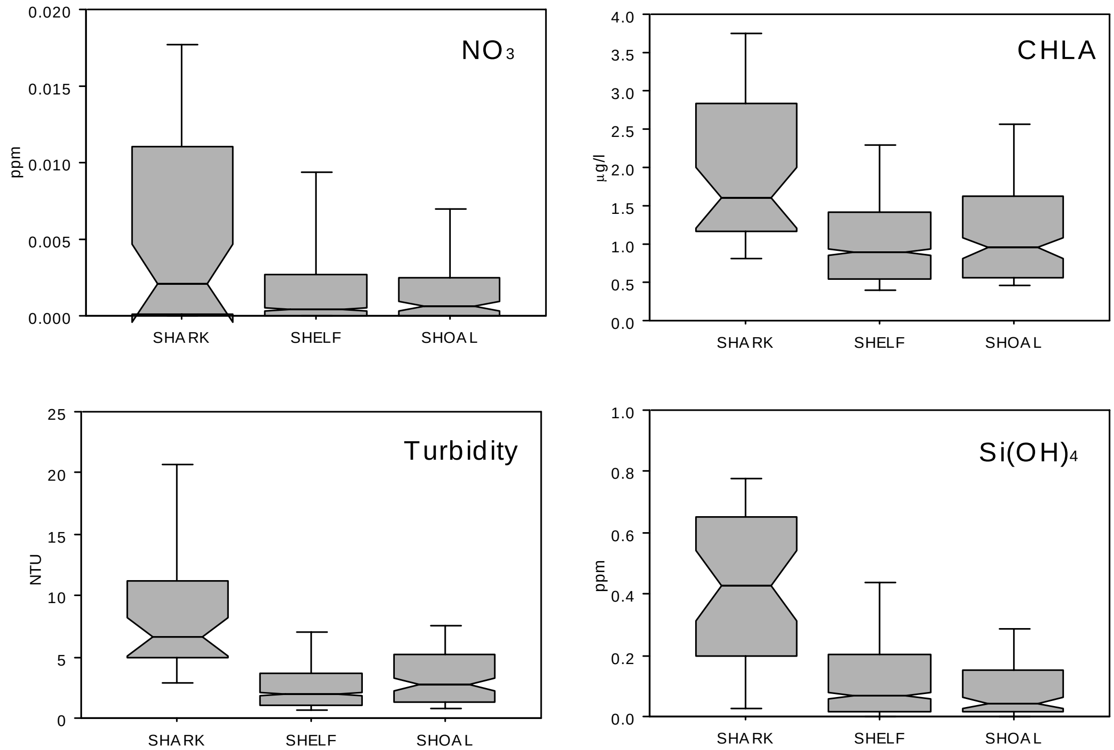


Figure 5.3. Plots showing variables most affected by freshwater inputs from Everglades.

Median Salinity

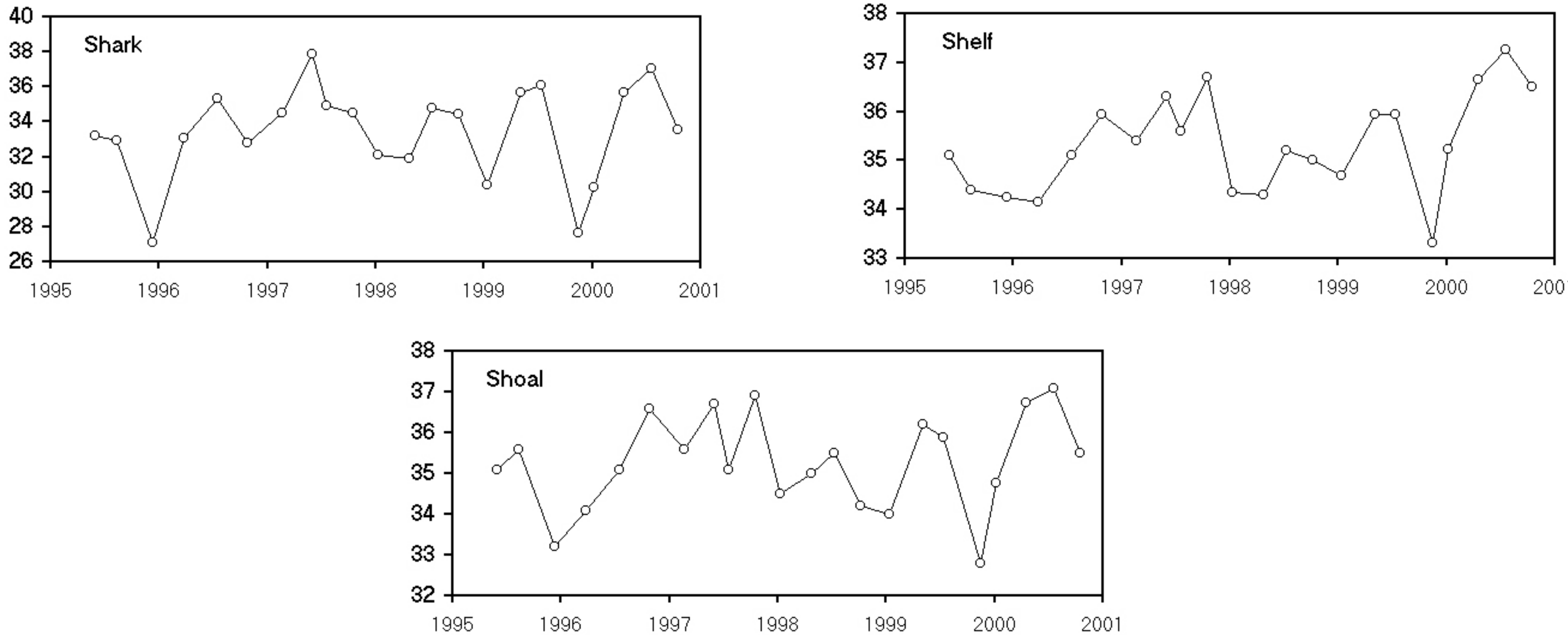


Figure 5.4. Quarterly median salinity in the Shelf zones.

Median Temperature

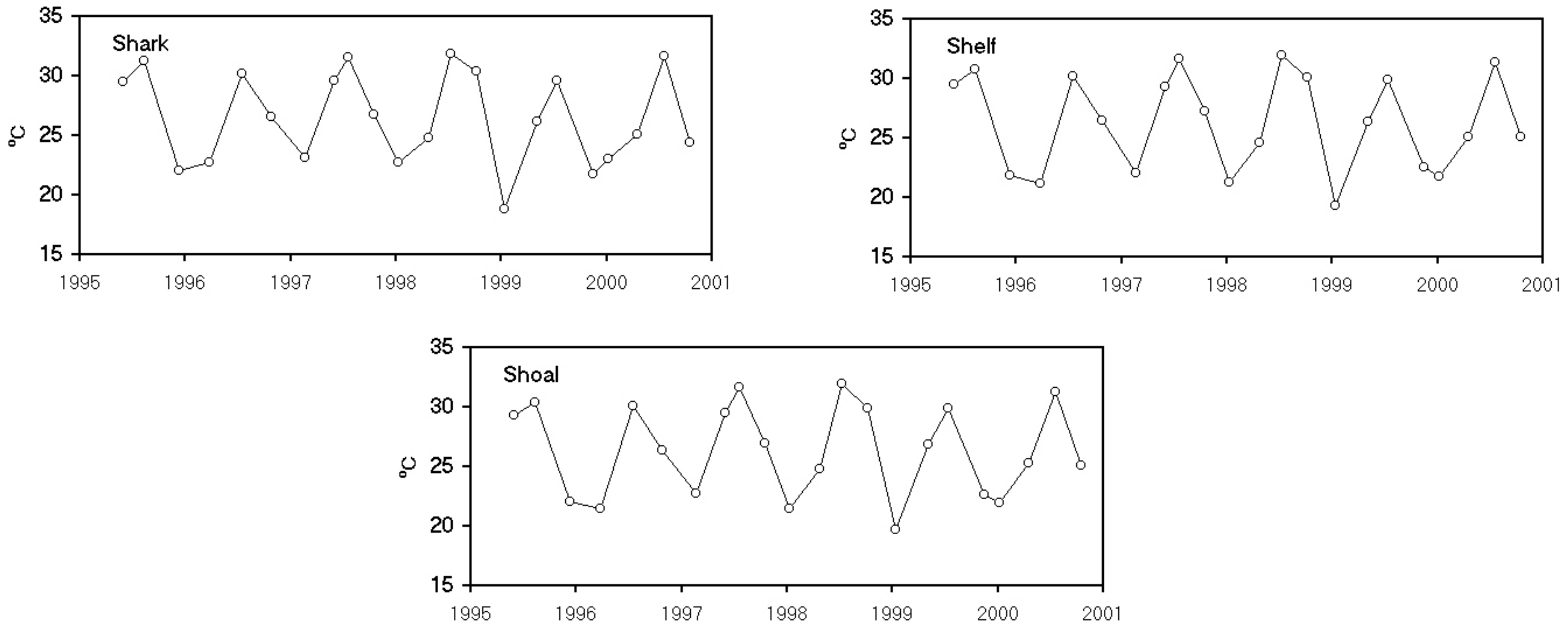


Figure 5.5. Quarterly median temperature in the Shelf zones.

Median DO Saturation

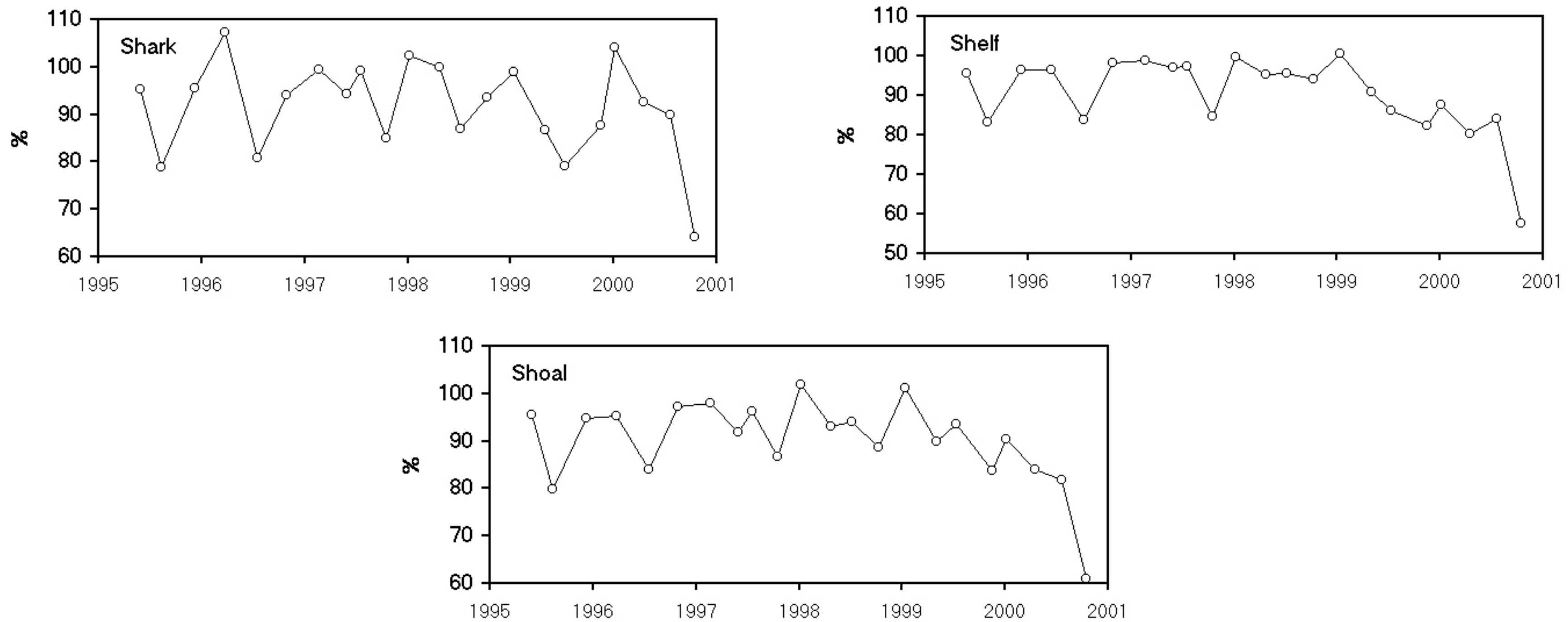


Figure 5.6. Quarterly DO saturation in the Shelf zones.

Median Ammonium

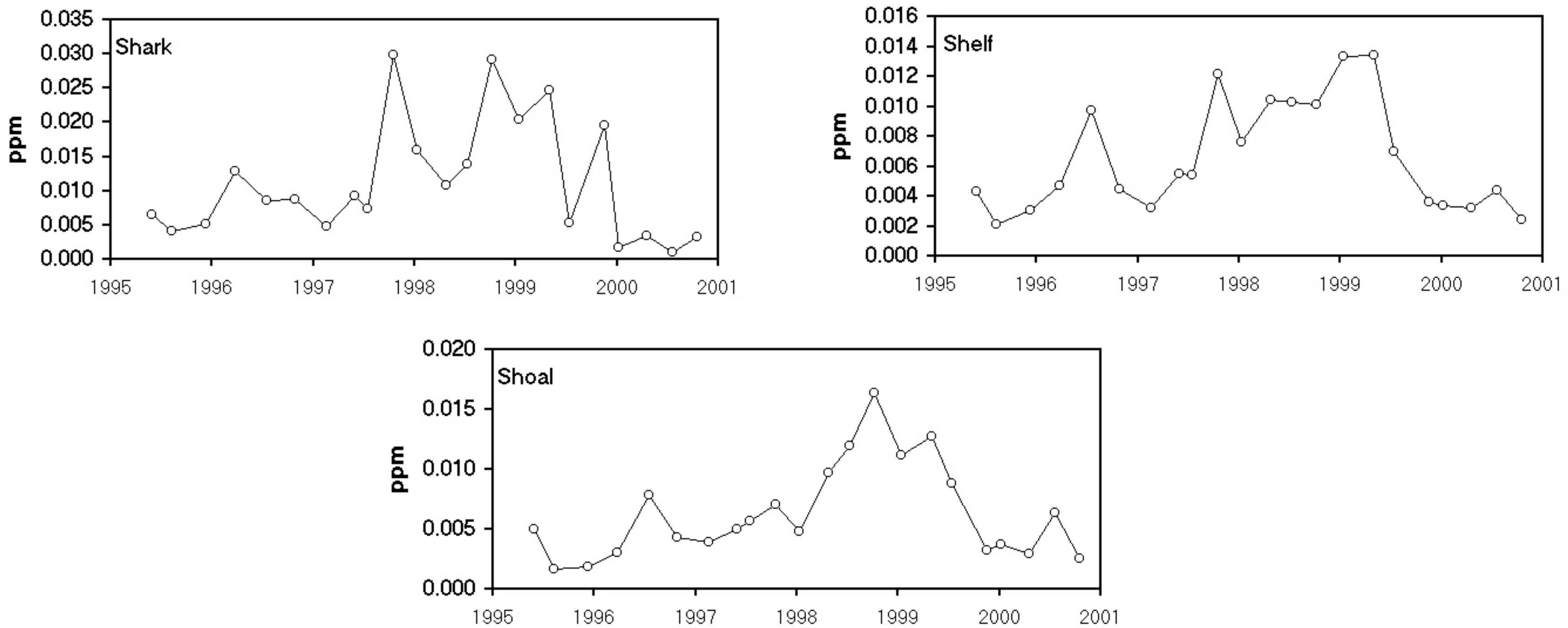


Figure 5.7. Quarterly median ammonium concentrations in the Shelf zones.

Median Nitrate

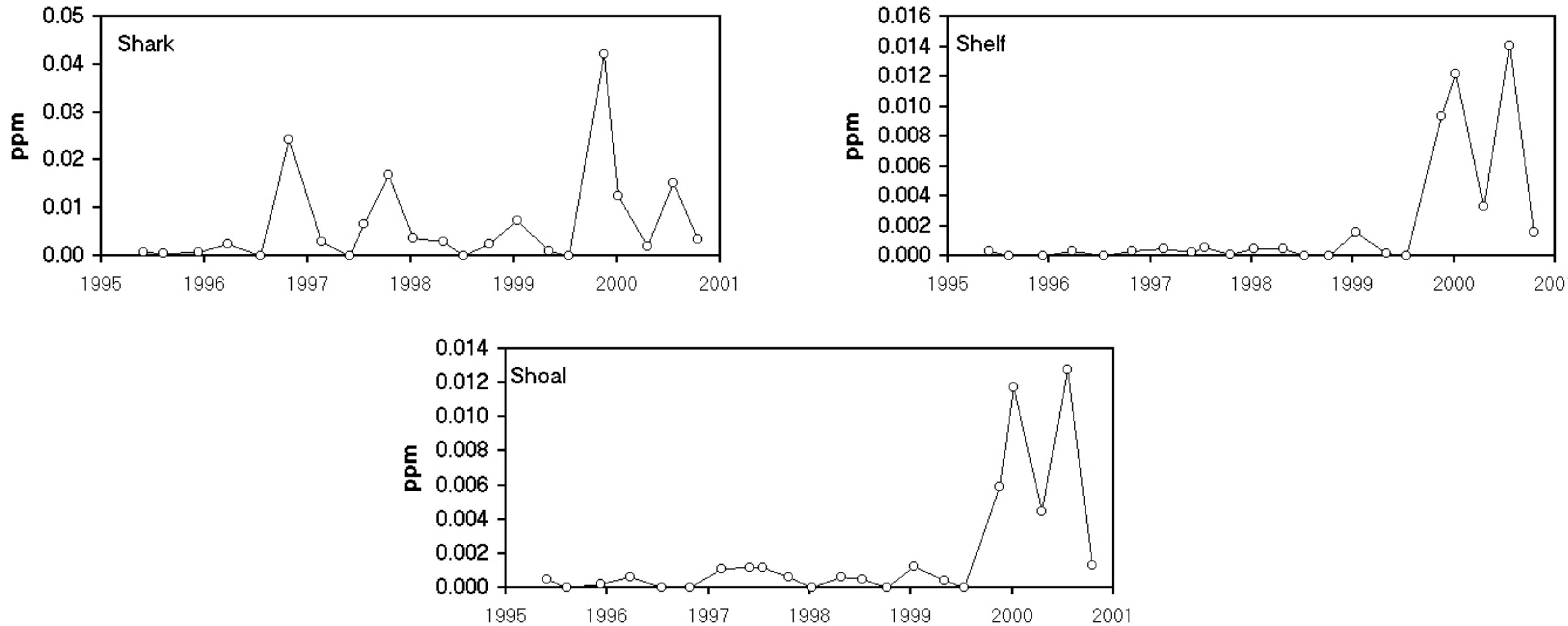


Figure 5.8. Quarterly median nitrate concentrations in the Shelf zones.

Median Total Phosphorus

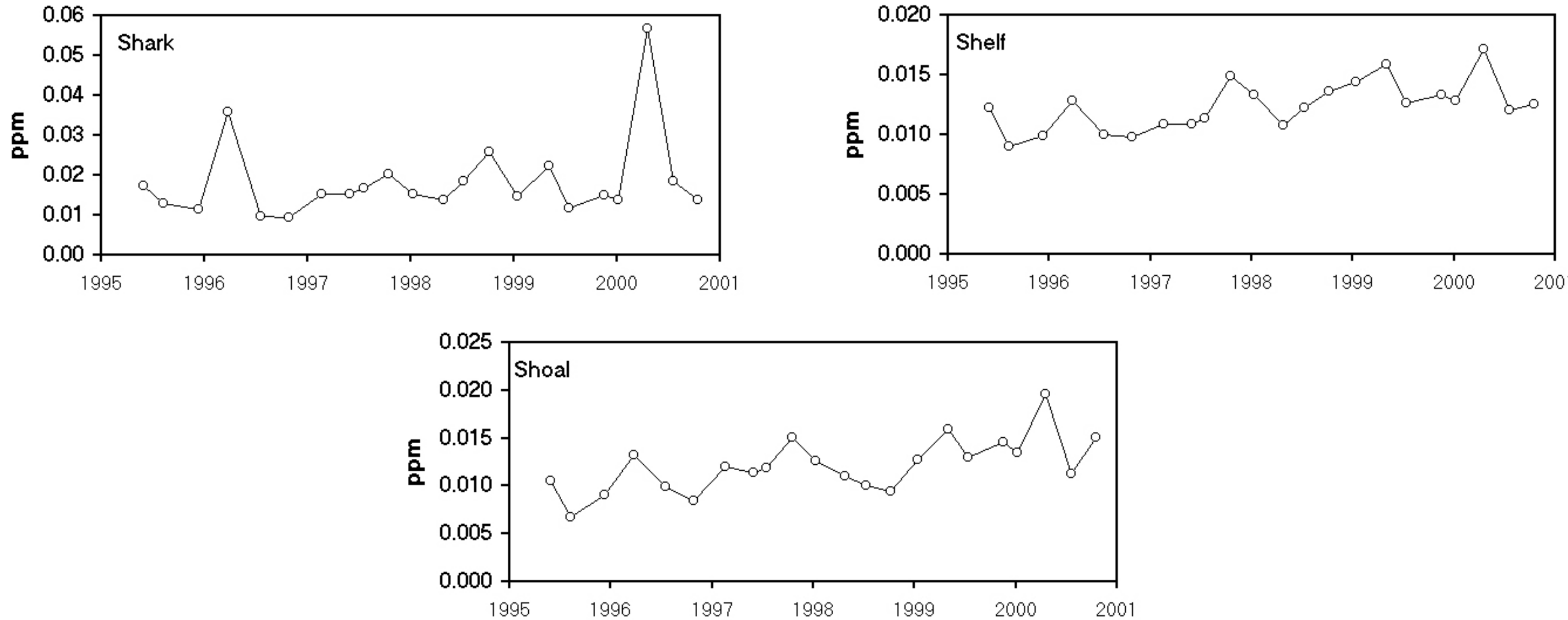


Figure 5.9. Quarterly median total phosphorus concentrations in the Shelf zones.

Median Soluble Reactive Phosphorus

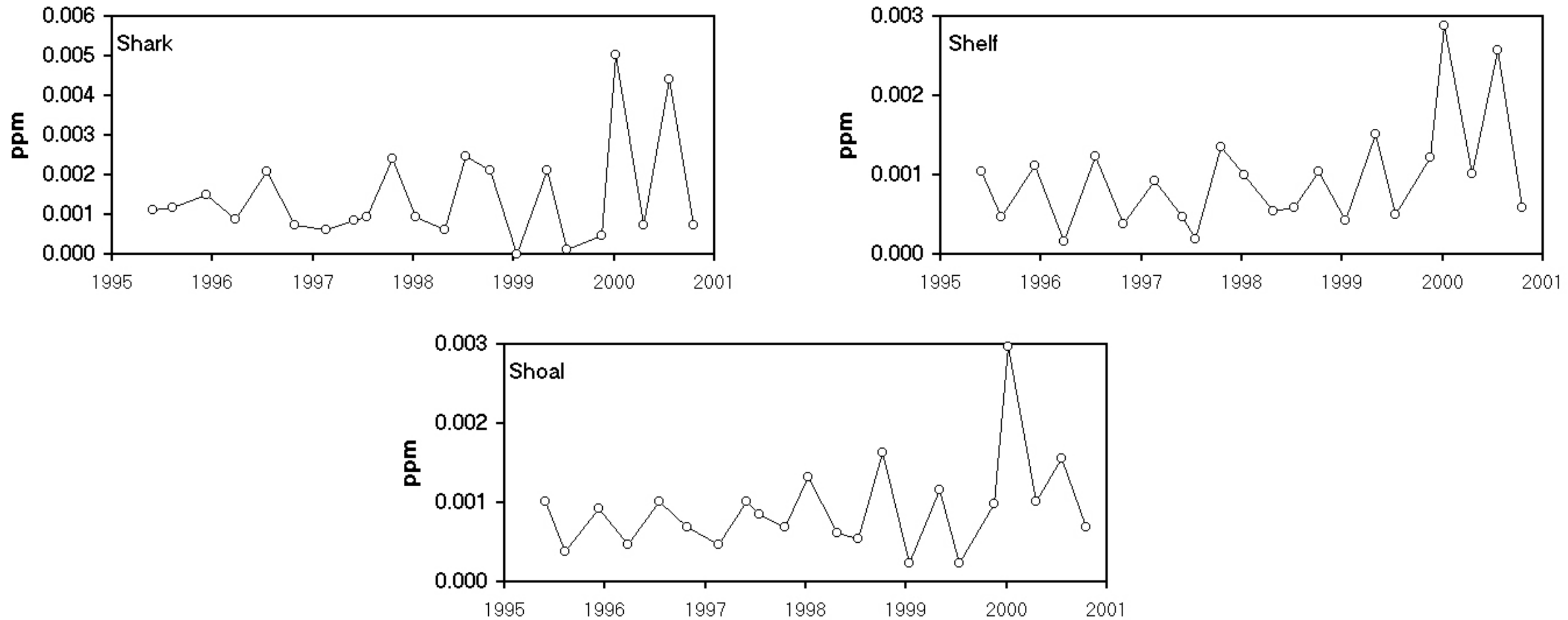


Figure 5.10. Quarterly median soluble reactive phosphorus concentrations in the Shelf zones.

Median Chlorophyll *a*

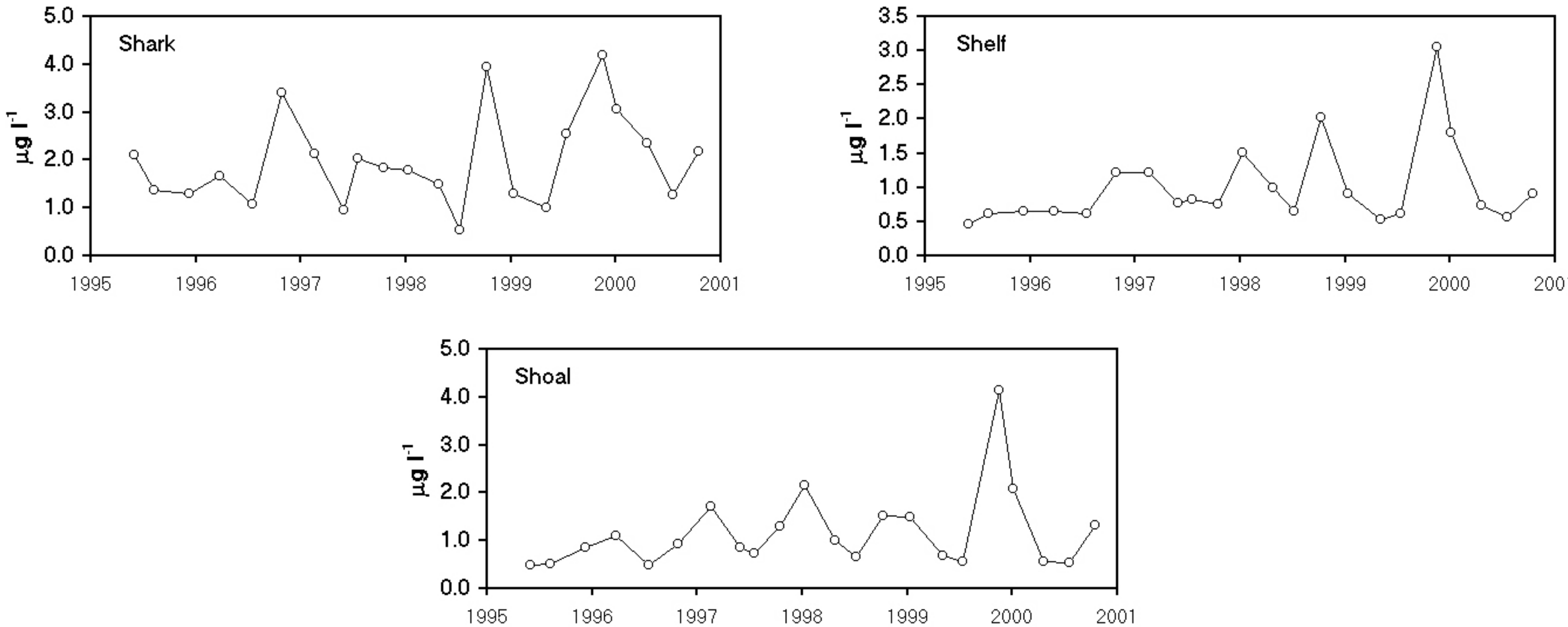


Figure 5.11. Quarterly median chlorophyll *a* concentrations in the Shelf zones.

Median Alkaline Phosphatase Activity

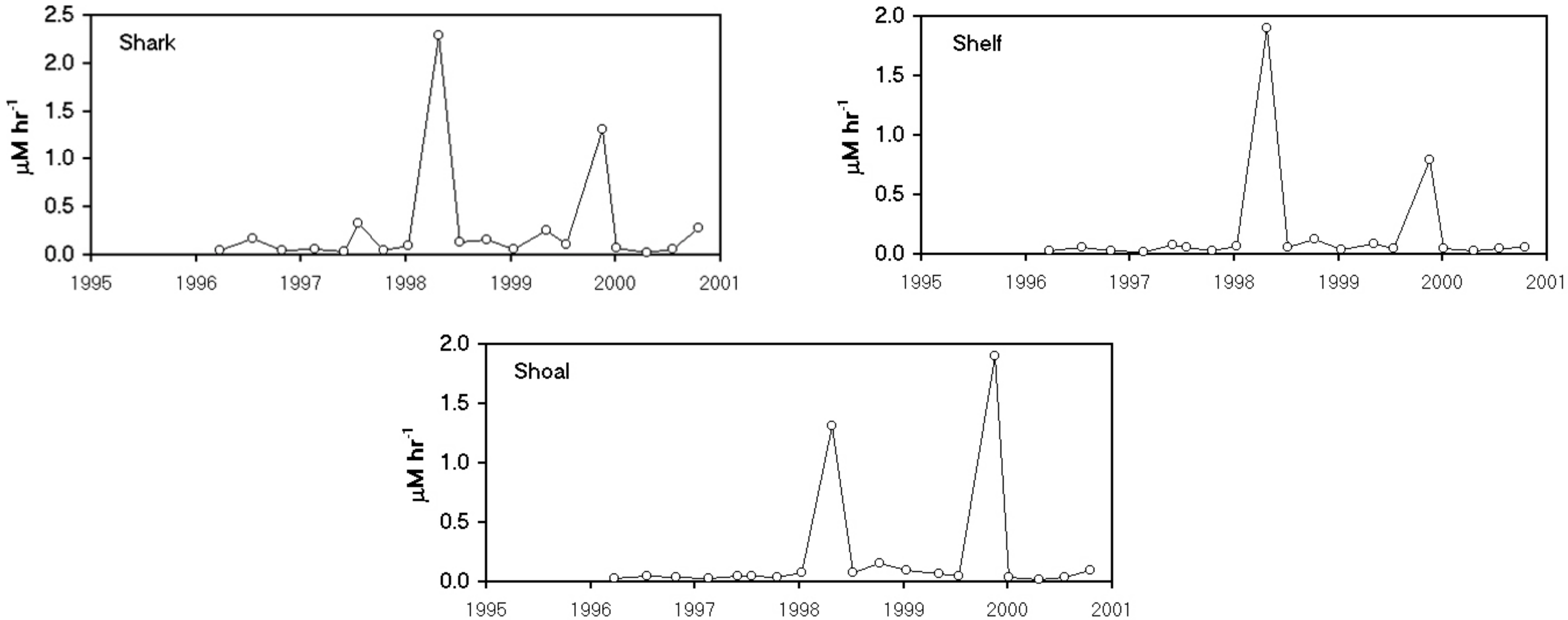


Figure 5.12. Quarterly median alkaline phosphatase activity in the Shelf zones.

Median Total Organic Carbon

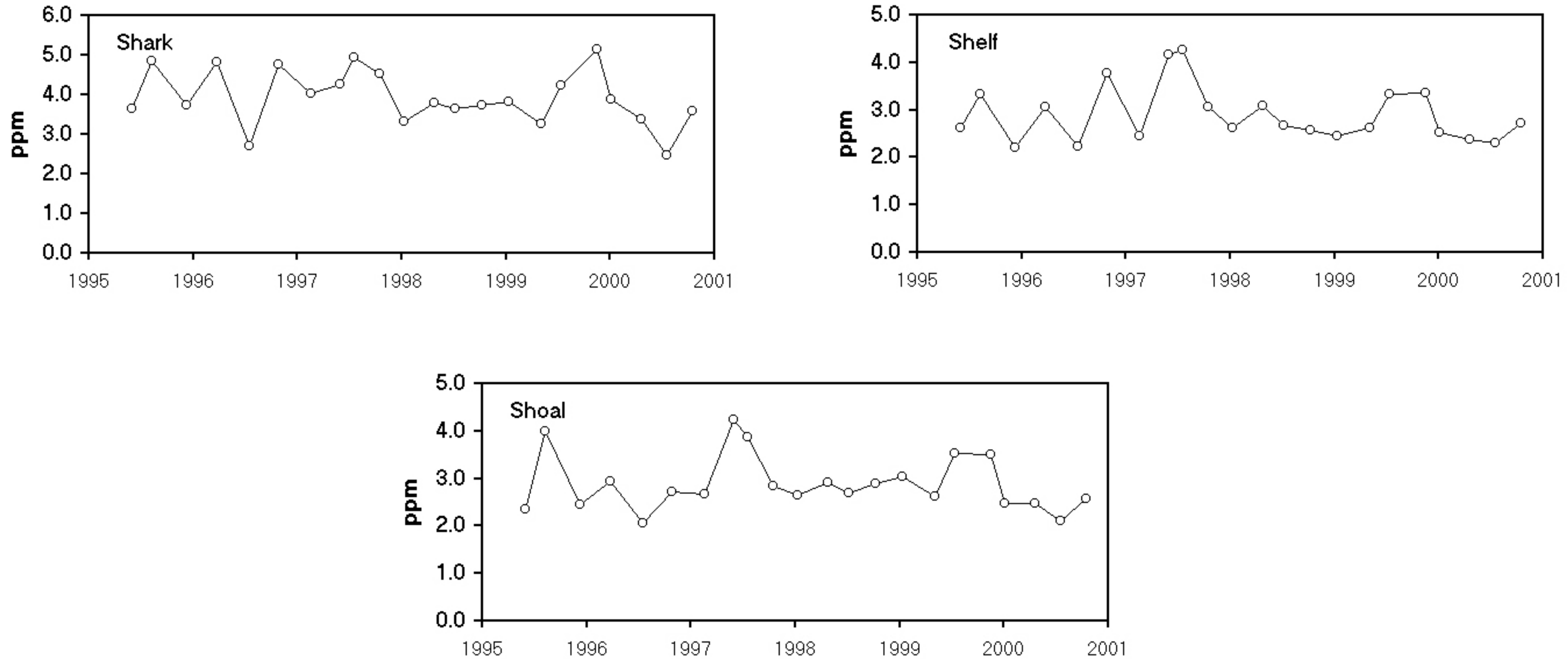


Figure 5.13. Quarterly median total organic carbon concentrations in the Shelf zones.

Median Total Organic Nitrogen

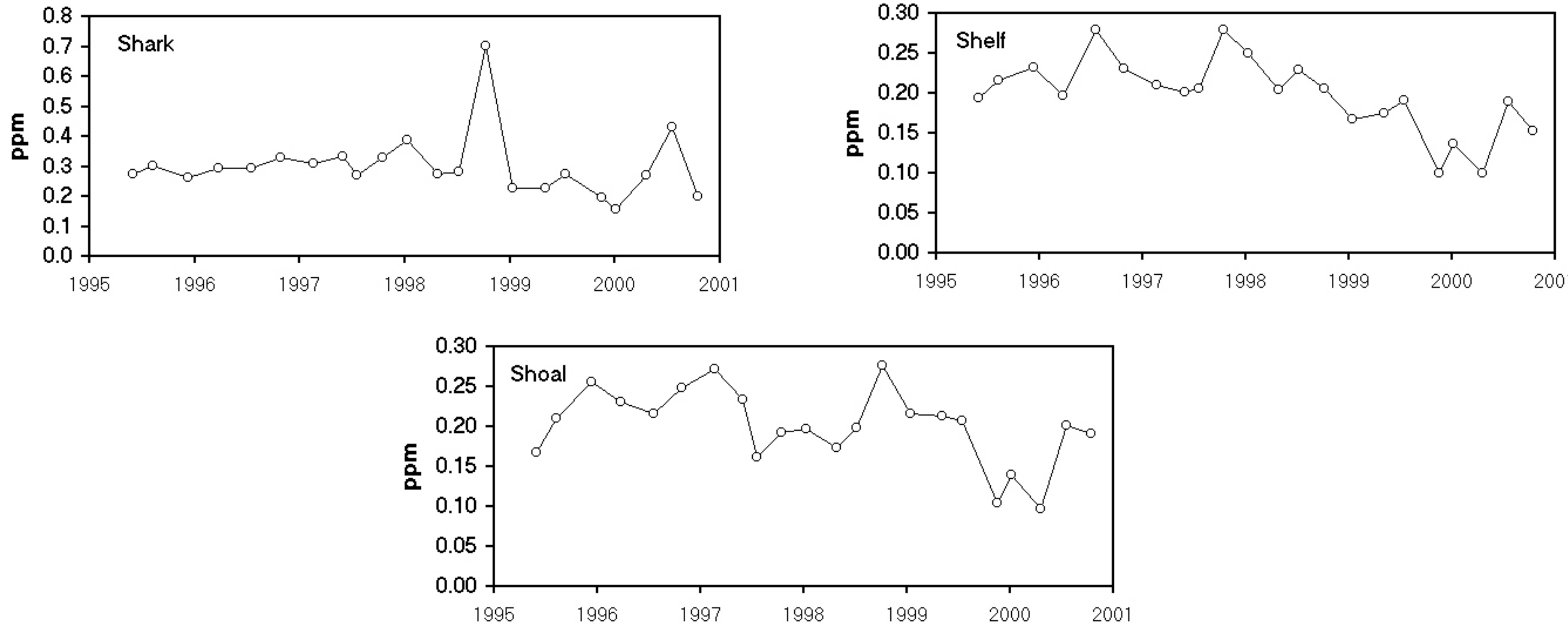


Figure 5.14. Quarterly median total organic nitrogen concentrations in the Shelf zones.

Median Turbidity

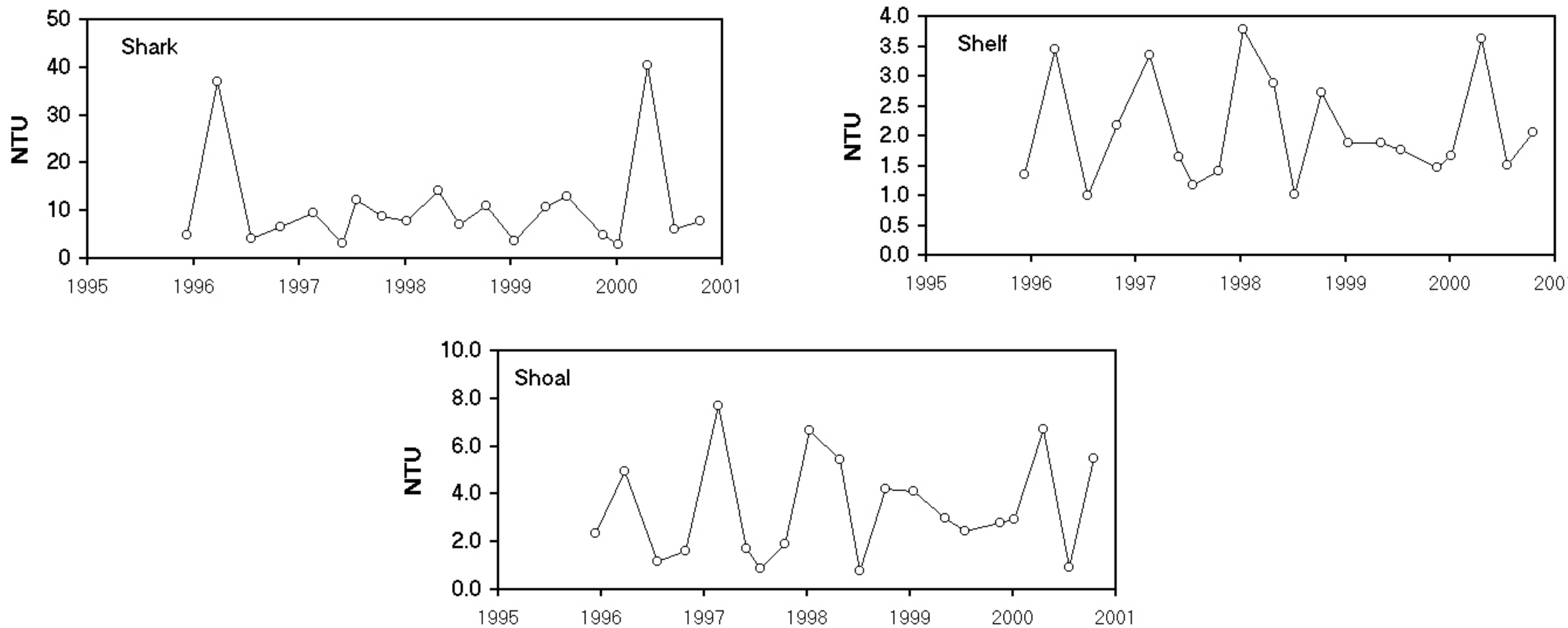


Figure 5.15. Quarterly median turbidity in the Shelf zones.

6. OVERVIEW OF WATER QUALITY OF CAPE ROMANO-PINE ISLAND SOUND AREA

Sampling in this area began Jan. 1999 so there is only one year of data available. This makes it unfeasible to perform a spatial statistic analysis. Therefore we will use generally accepted geomorphological characteristics to group the stations (Fig. 6.1). These groupings are the Cochatchee 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).

San Carlos Bay is located at the mouth of the Caloosahatchee River, a major managed outlet for freshwater from Lake Okeechobee. The SCB sites experienced the lowest median salinity and had the largest range in salinity as well. SCB also had highest concentrations of NO_3^-, TP, SRP, and TOC (Fig. 6.2 & 6.3). Estero Bay also exhibited lower salinities than the other areas, most probably 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, NO_3^-, and TP.

Overall, this area has significantly higher concentrations of TP, SRP, NO_3^-, and CHLA than the bulk of the TenThousand Islands stations. Much of this is due to geological changes from carbonates to silicates which facilitates transport of phosphorus and to major landuse changes from the Big Cypress National Preserve to suburban and agricultural uses.

Comparison of 2000 to Overall Period of Record

As there are only two years of data in the record; we will reserve discussion of trends until we have a significant time series. For comparison, we present the data in a similar format as above (Fig. 6.4-6.15).

Combined Data

The combined efforts of Collier County Pollution Control and FIU are shown in Fig. 6.16-6.23. Water quality sampling by Collier County was modified in 1999 to provide a more integrated picture of the connections between watershed and estuary. Significant watershed influences in the Faka Union Basin were observed including elevated TP, NO_3^-, NH_4^+, and lower DO. These trends were also evident for the Gordon River – Naples Bay and Cocohatchee River – Wiggins Pass. This is a preliminary analysis and will be repeated after more data collection.

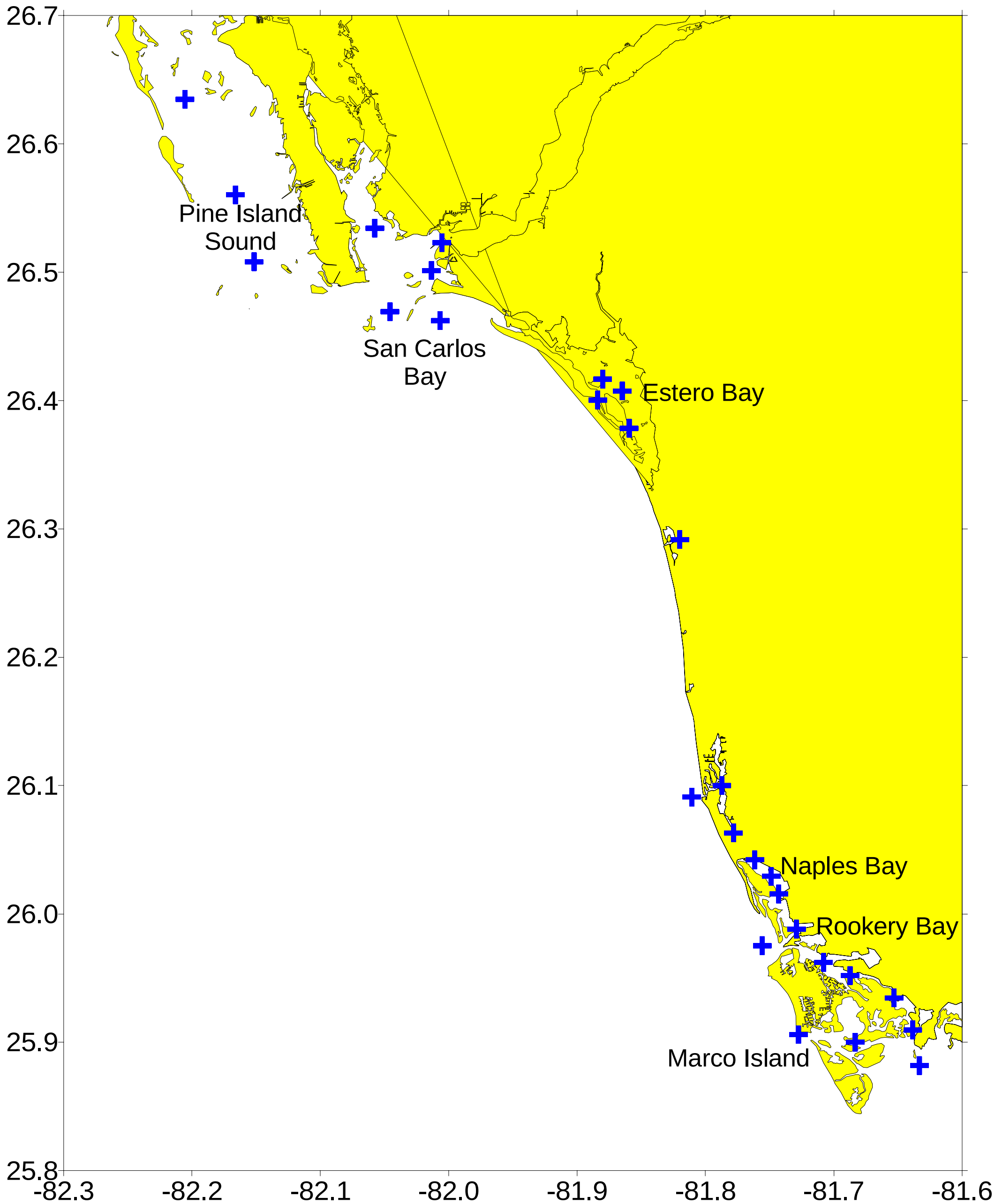


Figure 6.1. Map of station locations in Cape Romano-Pine Island Sound area.

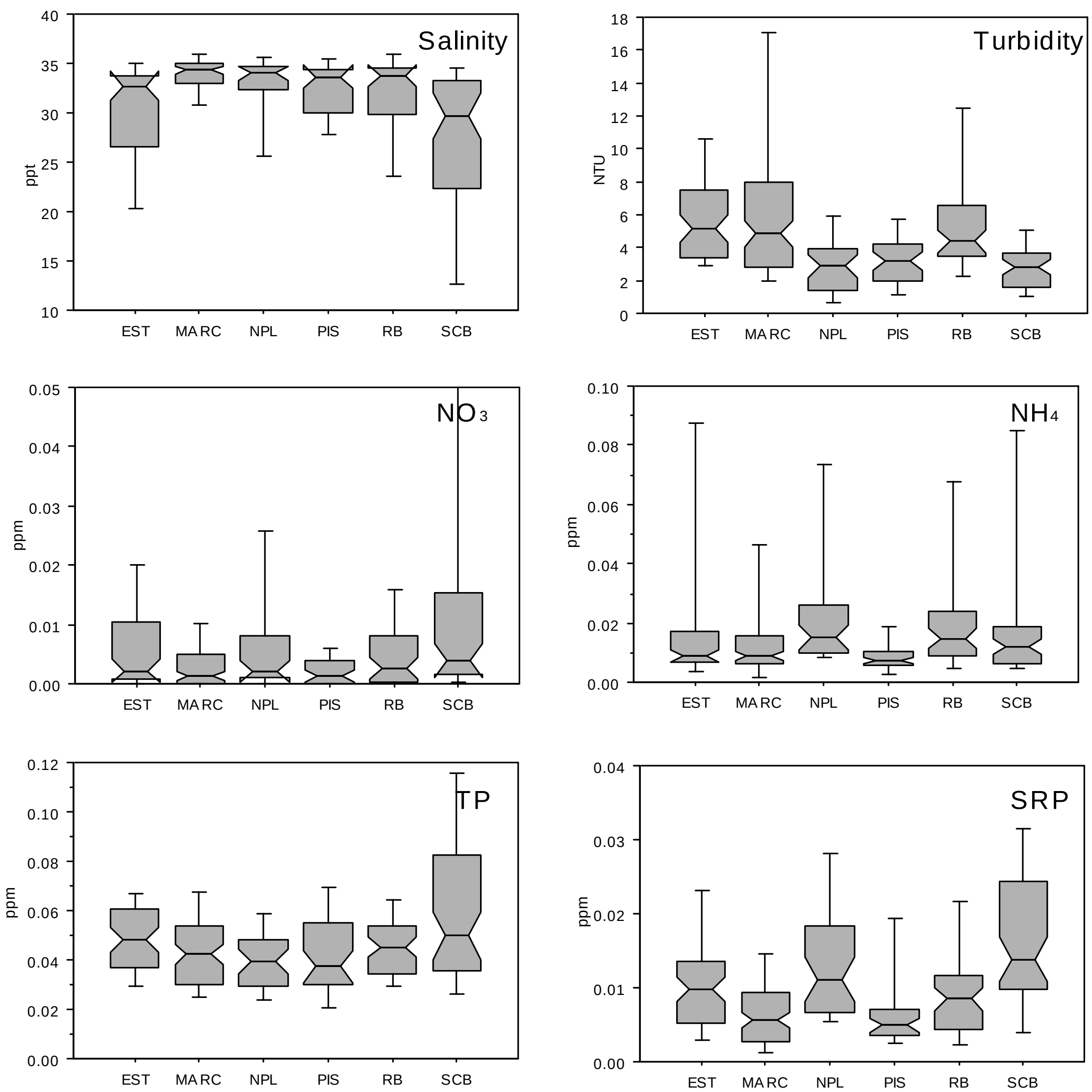


Figure 6.2. Box-and-whisker plots of salinity, turbidity, nitrate (NO_3), ammonia (NH_4), total phosphorus (TP), and soluble reactive phosphorus (SRP) for the various water bodies.

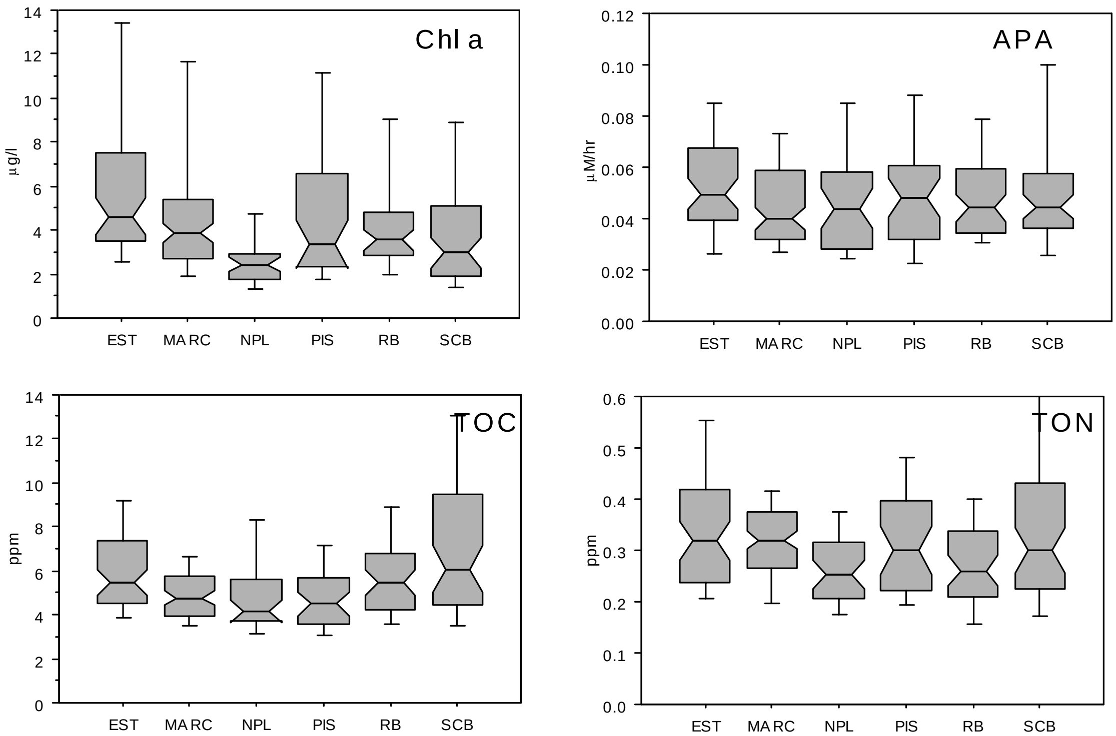


Figure 6.3. Box-and-whisker plots of chlorophyll *a* (CHLA), alkaline phosphatase activity (APA), total organic carbon (TOC), and total organic nitrogen (TON) for the various water bodies.

Median Salinity

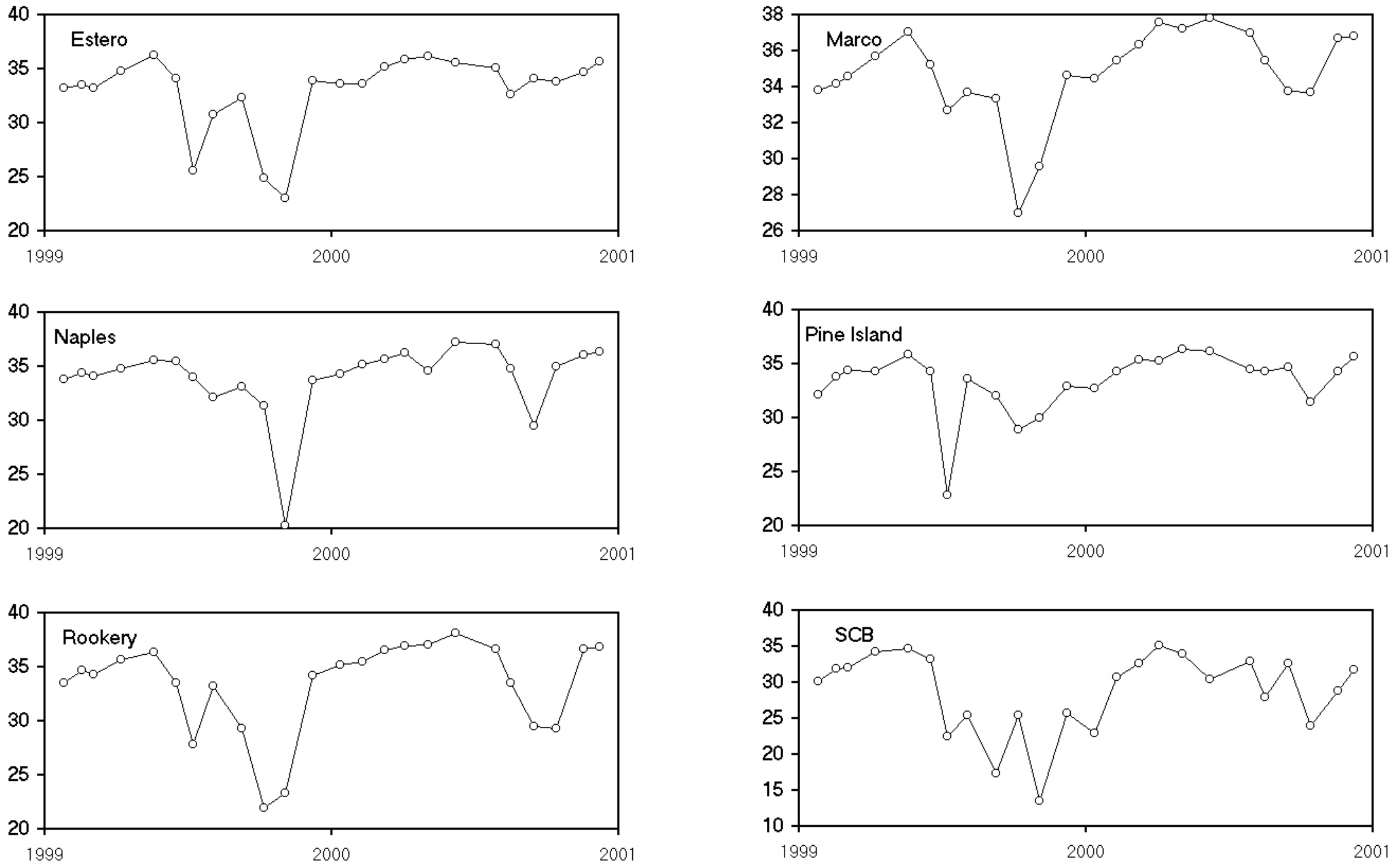


Figure 6.4. Monthly median salinity in the Cape Romano-Pine Island Sound zones.

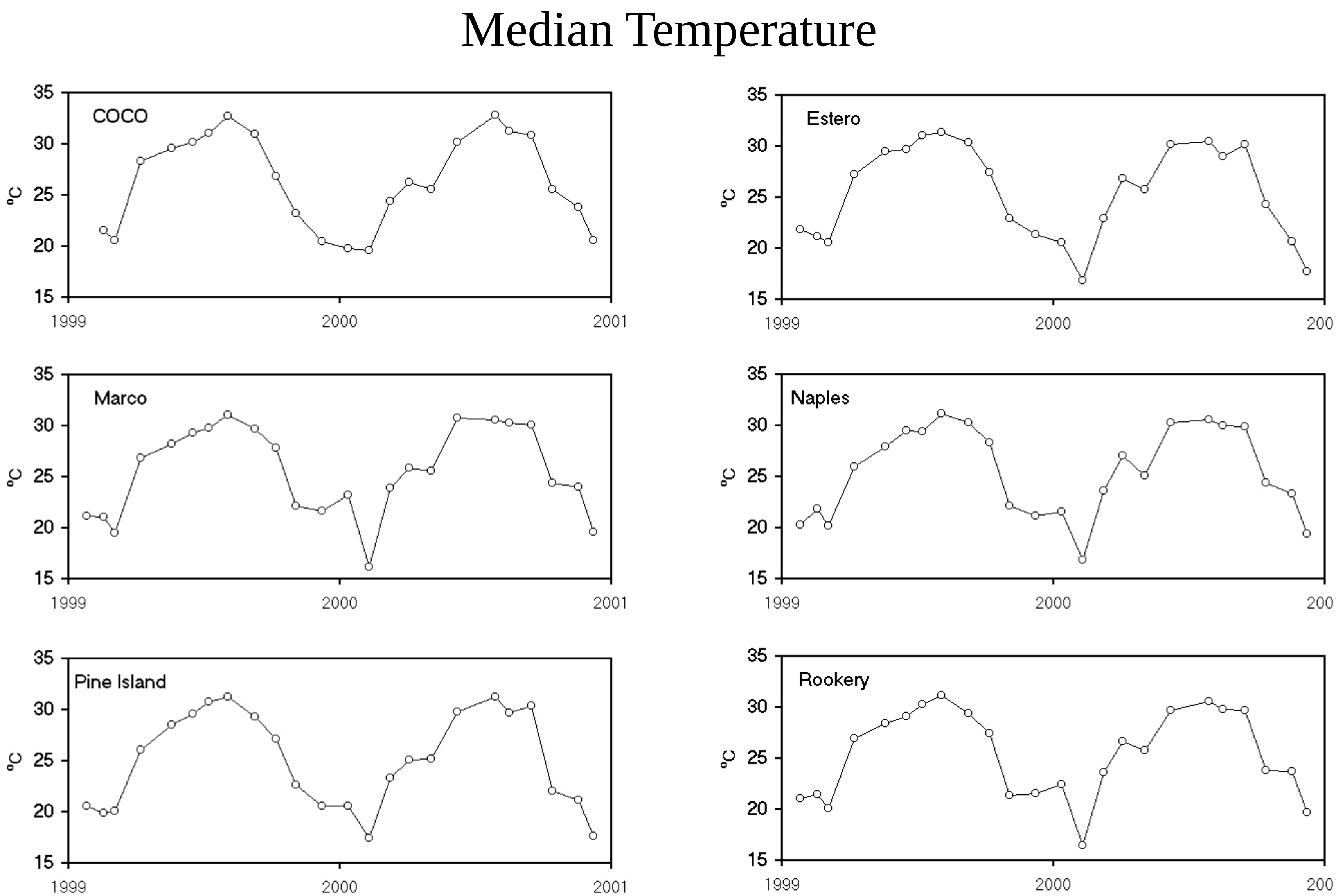


Figure 6.5. Monthly temperature in the Cape Romano-Pine Island Sound zones.

Median DO Saturation

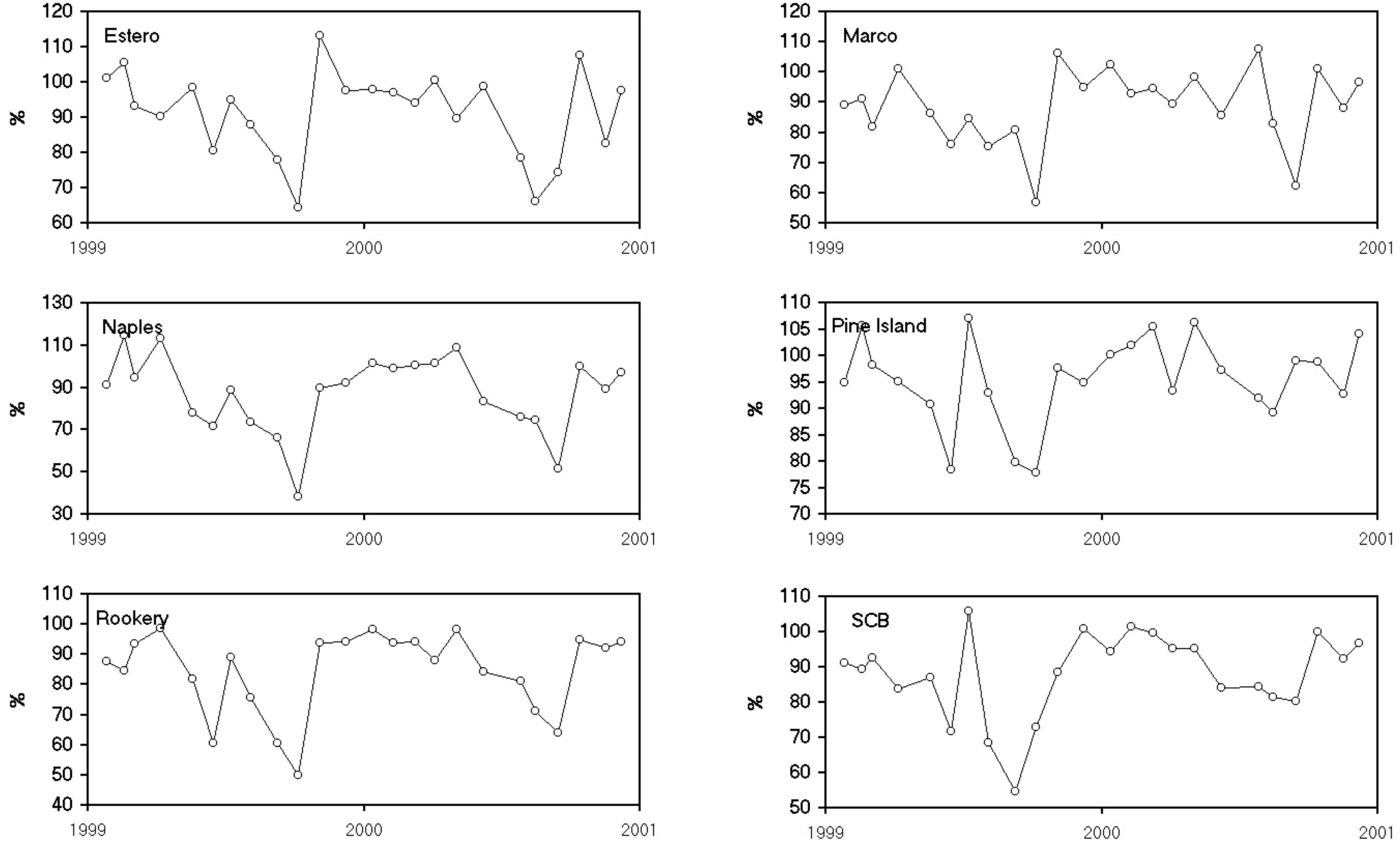


Figure 6.6. Monthly median DO saturation in the Cape Romano-Pine Island Sound zones.

Median Ammonium

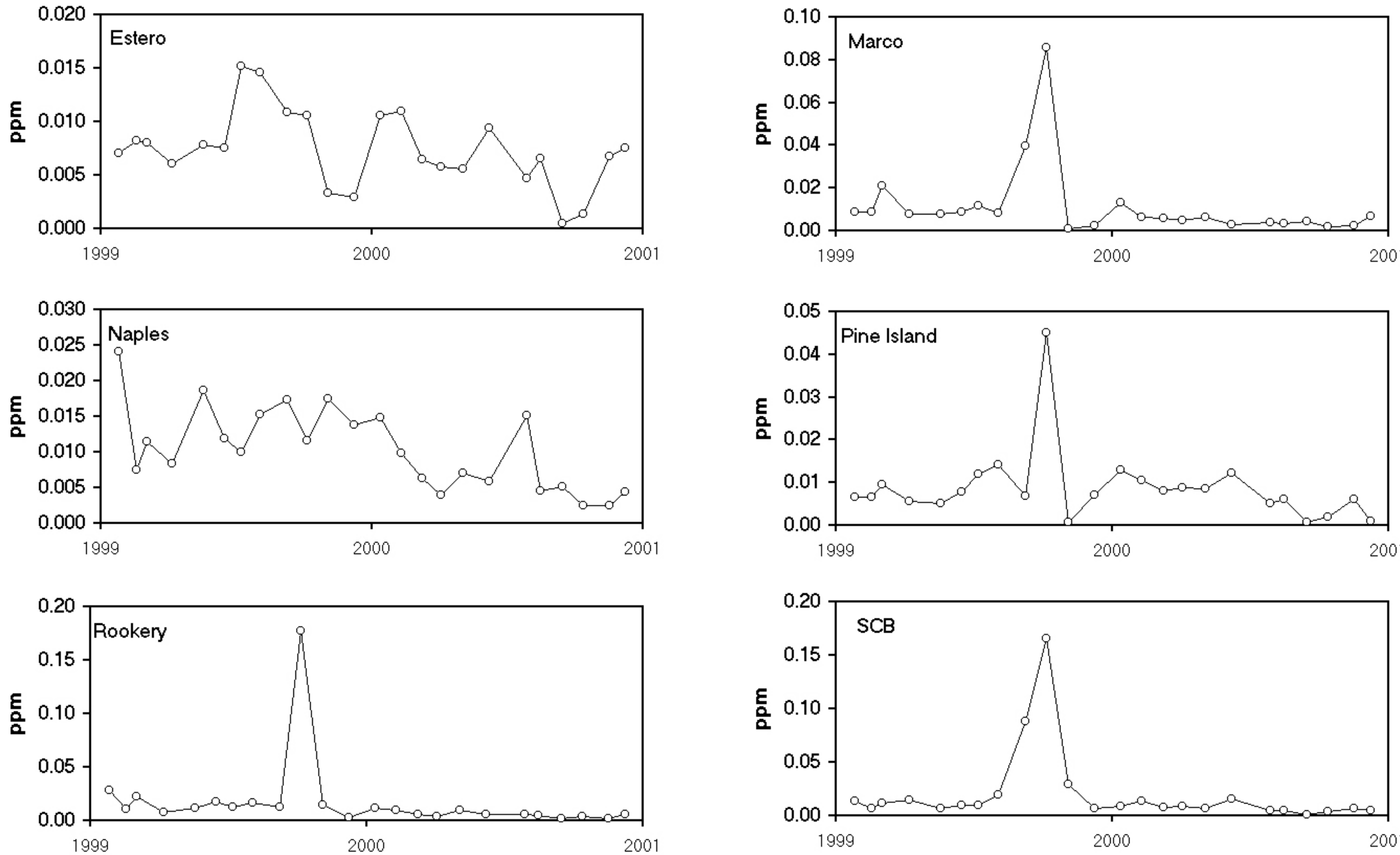


Figure 6.7. Monthly median ammonium concentrations in the Cape Romano-Pine Island Sound zones.

Median Nitrate

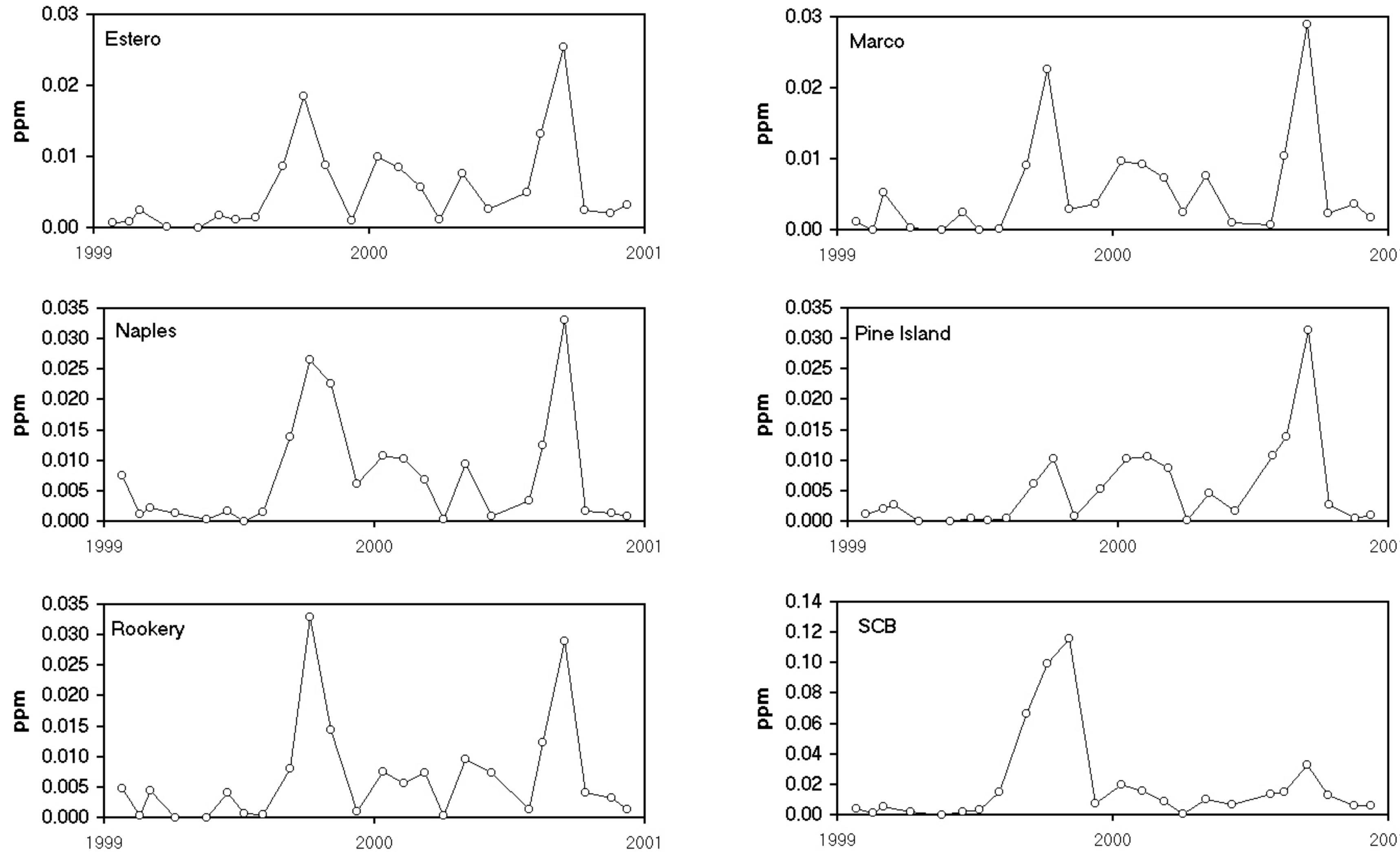


Figure 6.8. Monthly median nitrate concentrations in the Cape Romano-Pine Island Sound zones.

Median Total Phosphorus

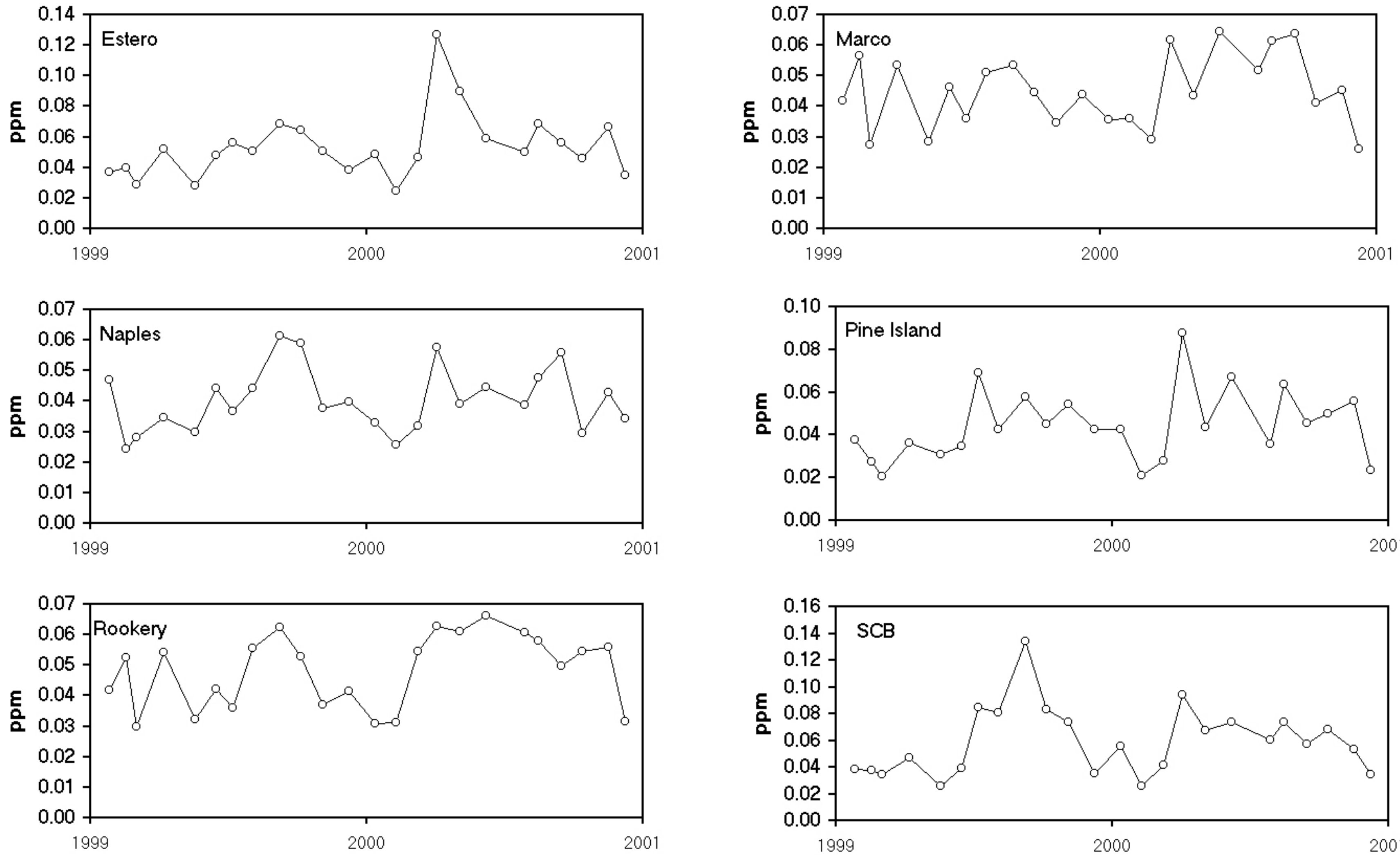


Figure 6.9. Monthly median total phosphorus concentrations in the Cape Romao-Pine Island Sound zones.

Median Soluble Reactive Phosphorus

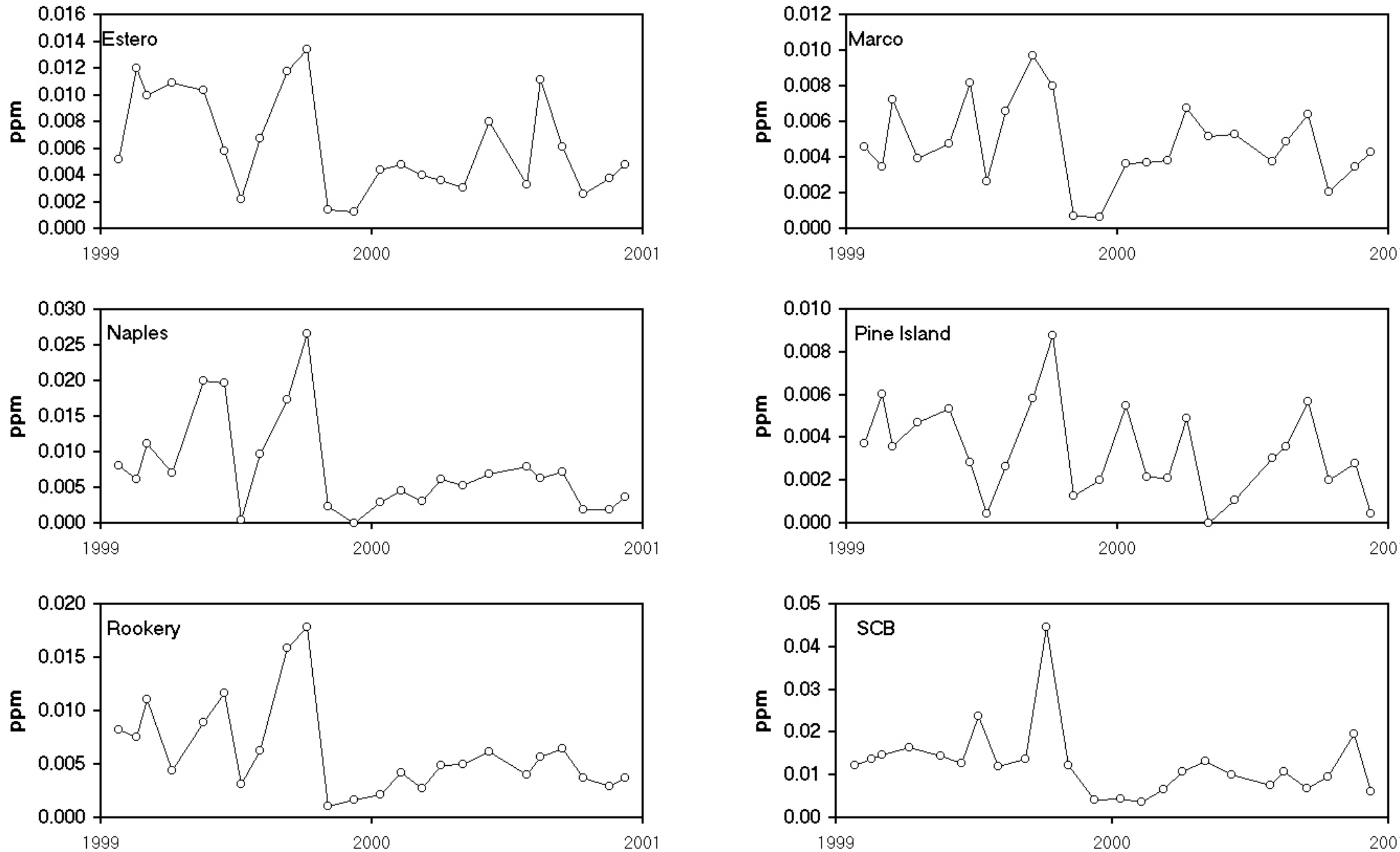


Figure 6.10. Monthly median soluble reactive phosphorus concentrations in the Cape Romano-Pine Island Sound zones.

Median Chlorophyll *a*

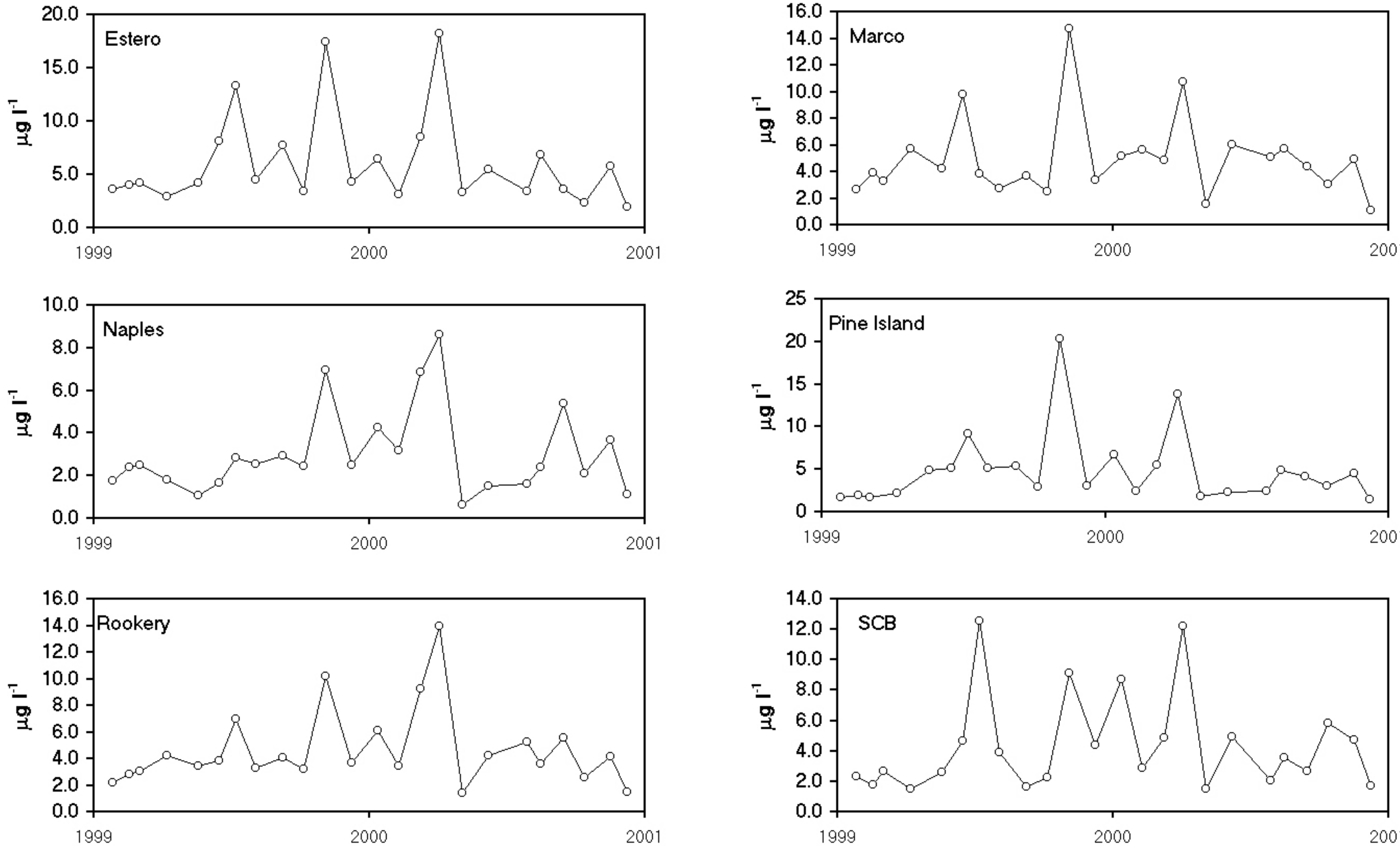


Figure 6.11. Monthly median chlorophyll *a* concentrations in the Cape Romano-Pine Island Sound zones.

Median Alkaline Phosphatase Activity

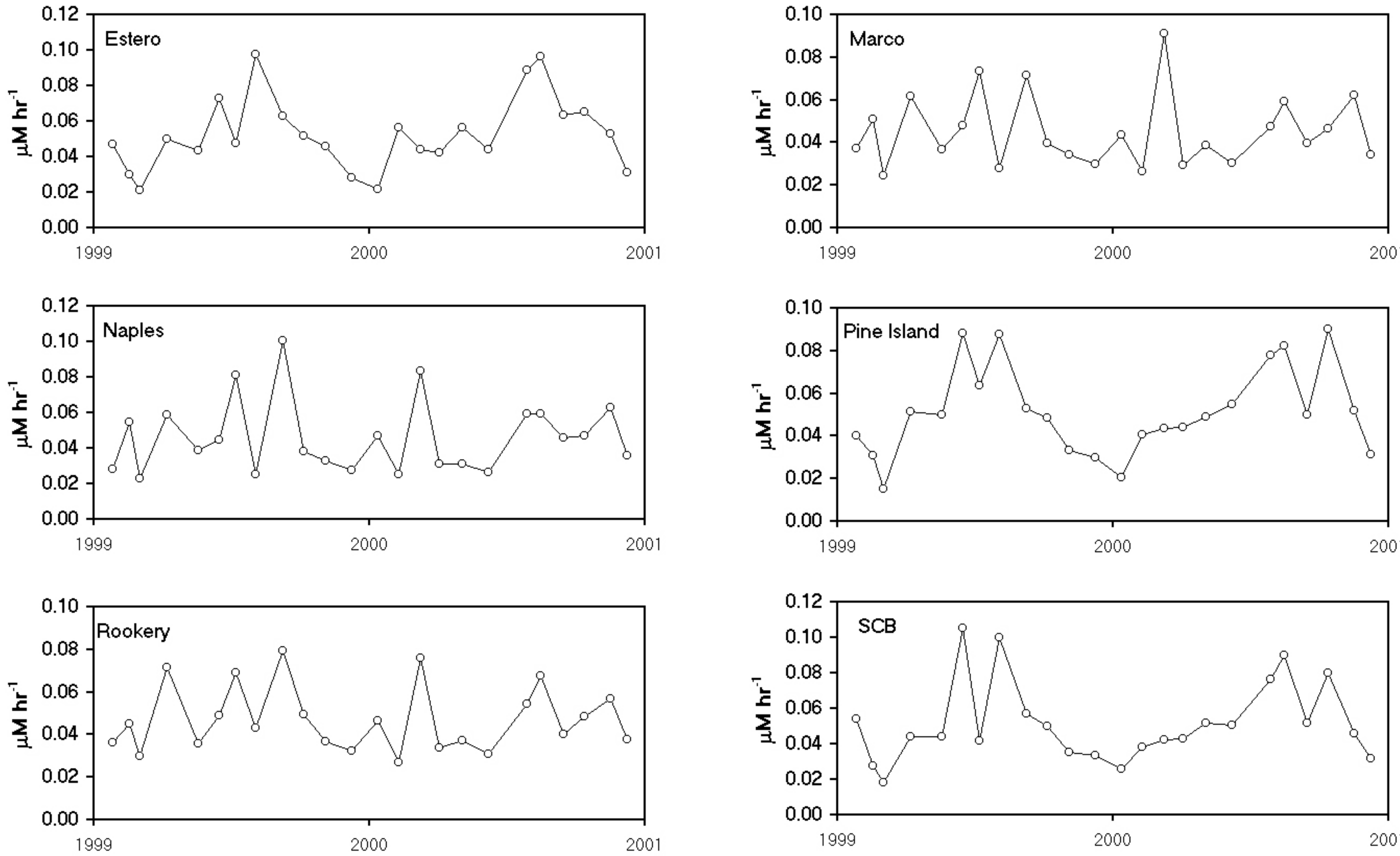


Figure 6.12. Monthly median alkaline phosphatase activity in the Cape Romao-Pine Island Sound zones.

Median Total Organic Carbon

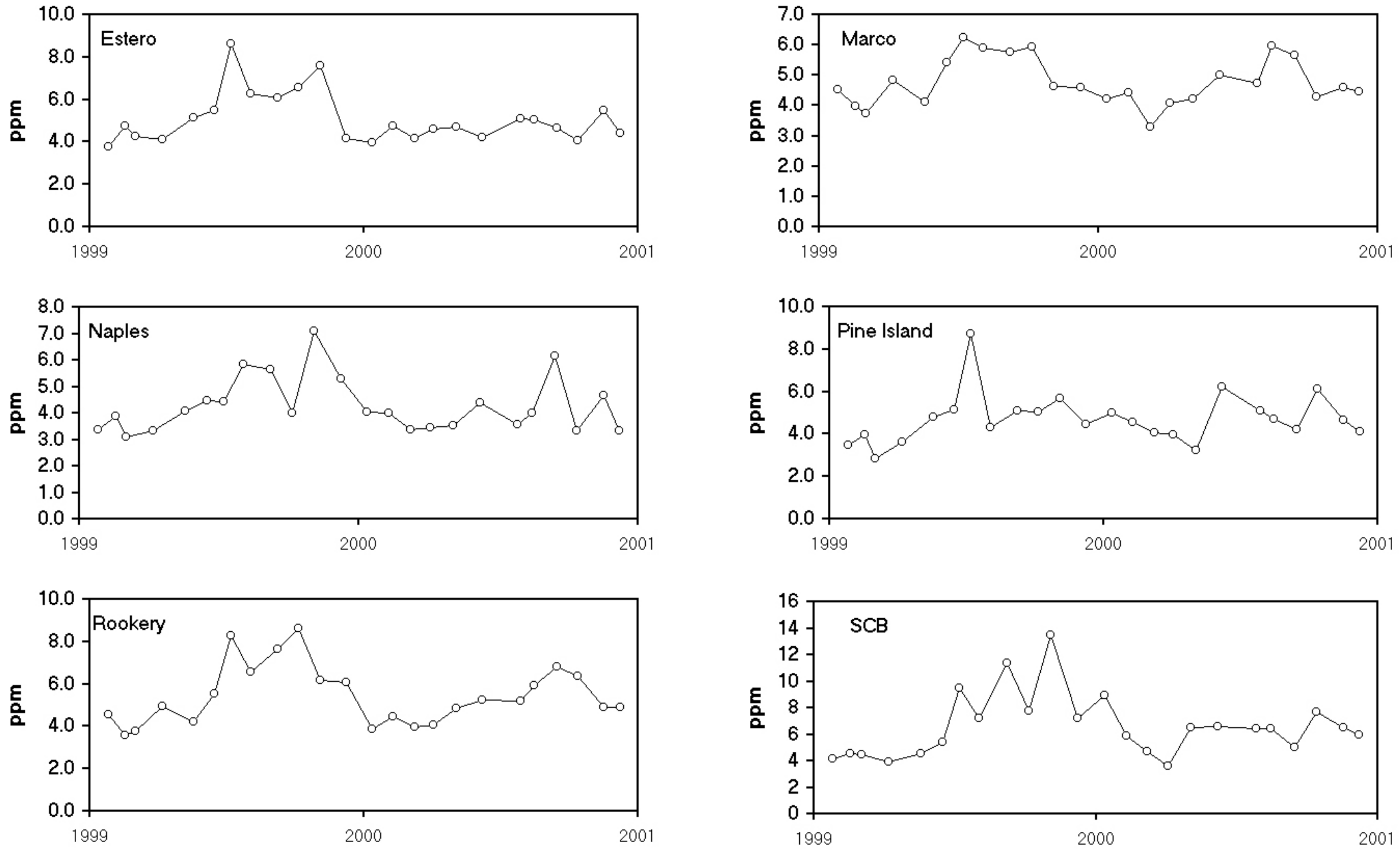


Figure 6.13. Monthly median total organic carbon concentrations in the Cape Romano-Pine Island Sound zones.

Median Total Organic Nitrogen

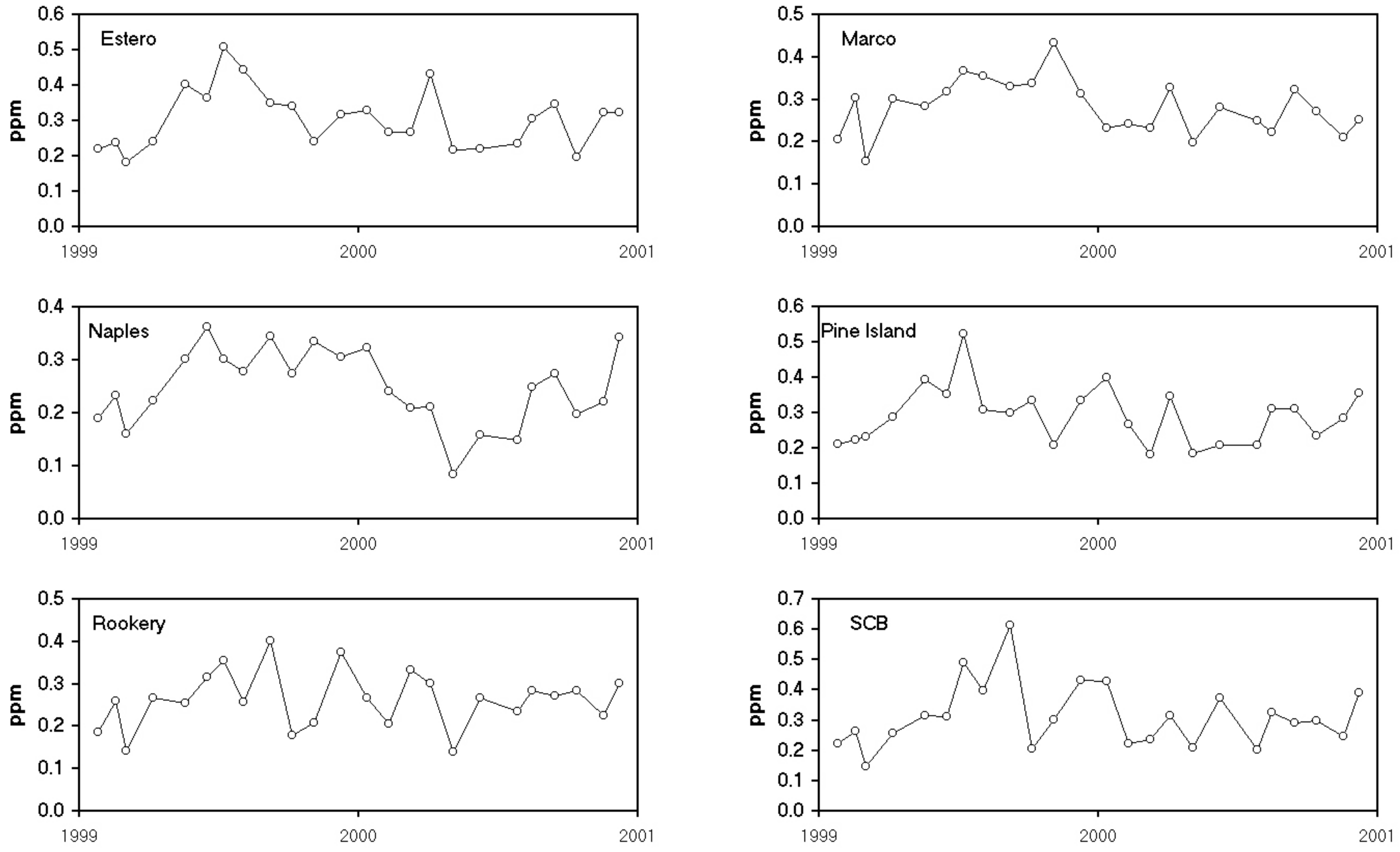


Figure 6.14. Monthly median total organic nitrogen concentrations in the Cape Romano-Pine Island Sound zones.

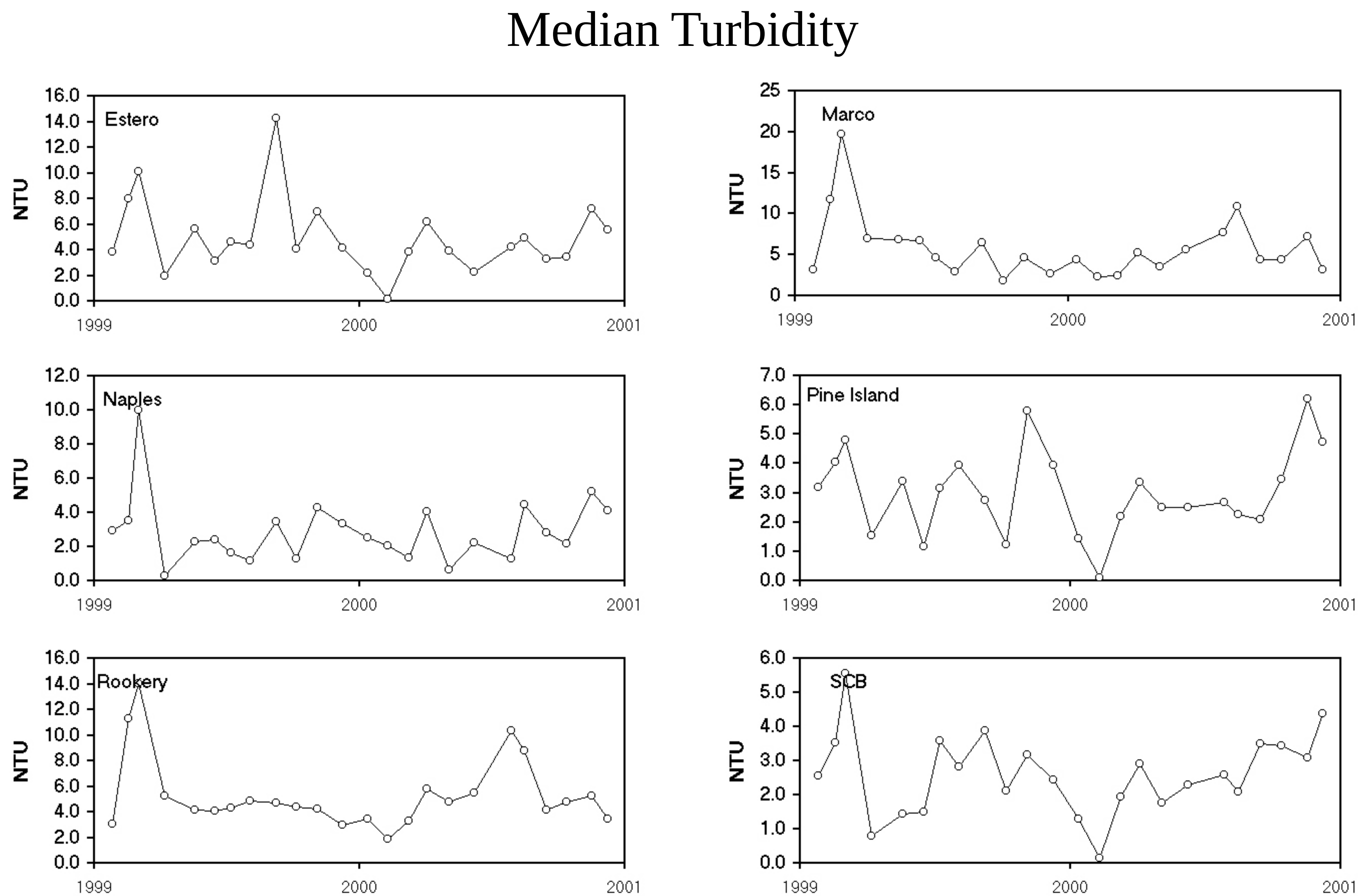


Figure 6.15. Monthly median turbidity in the Cape Romano-Pine Island Sound zones.

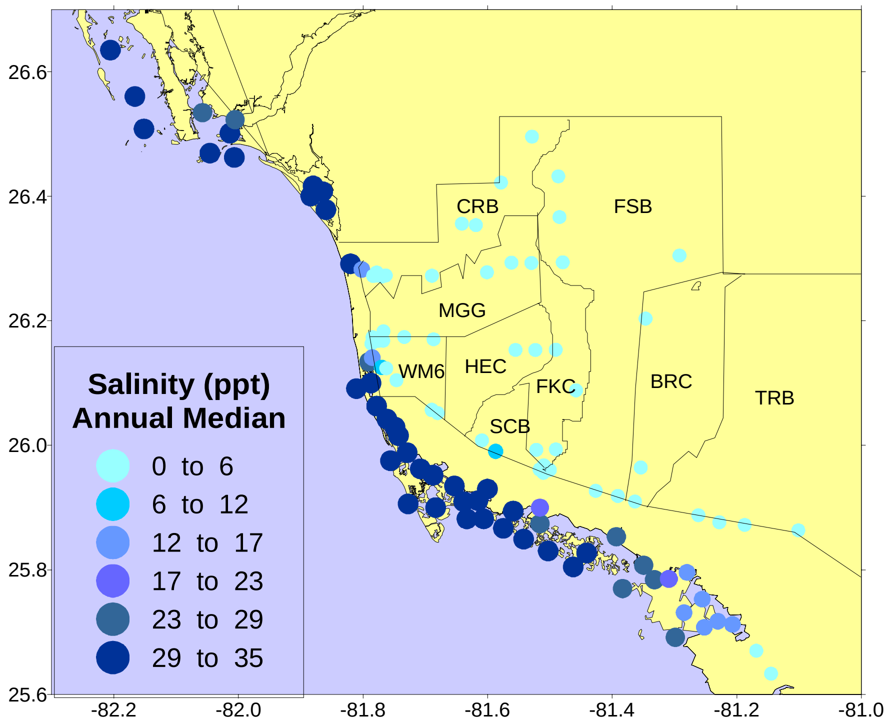


Figure 6.16. Combined median salinity data from Collier County and FIU.

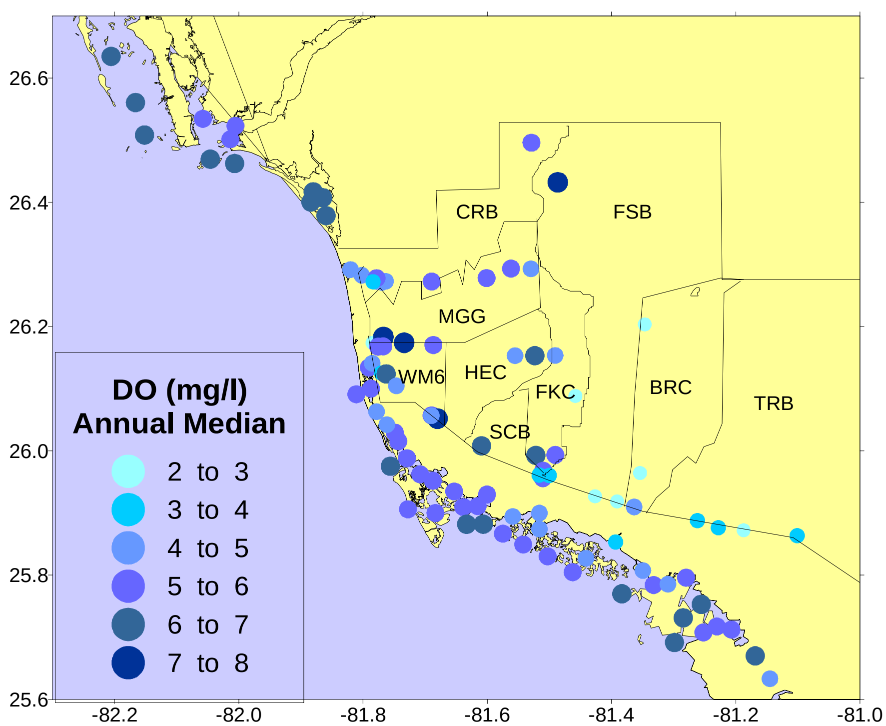


Figure 6.17. Combined median dissolved oxygen data from Collier County and FIU.

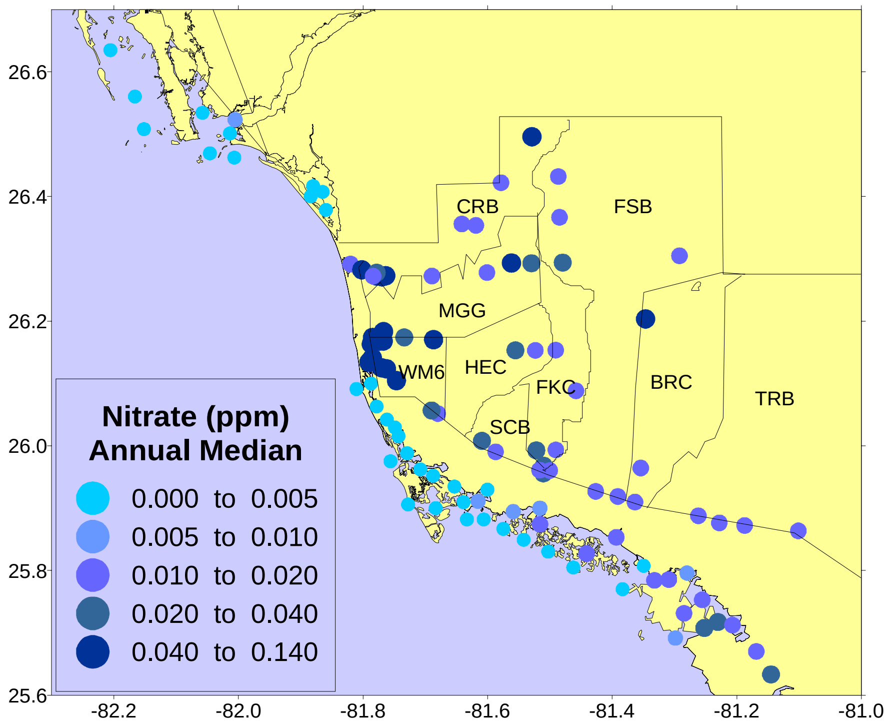


Figure 6.18. Combined median nitrate data from Collier County and FIU.

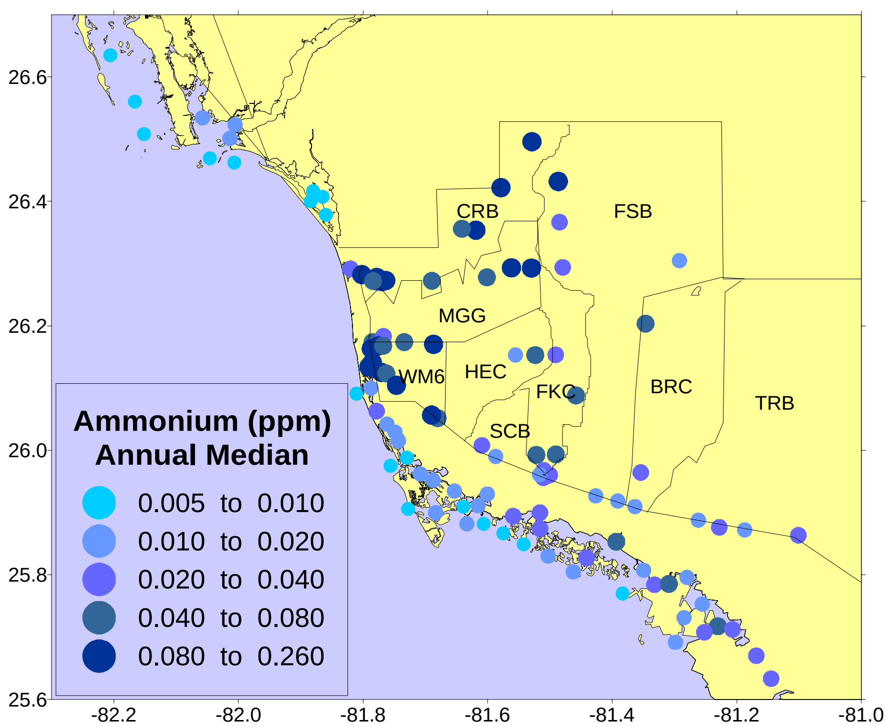


Figure 6.19. Combined median ammonium data from Collier County and FIU.

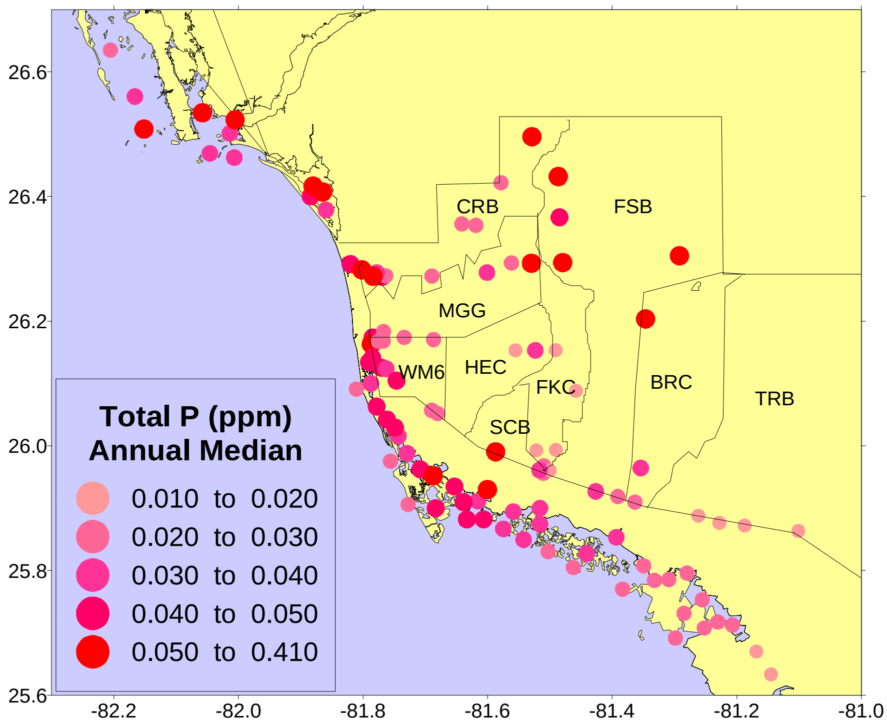


Figure 6.20. Combined median total phosphate data from Collier County and FIU.

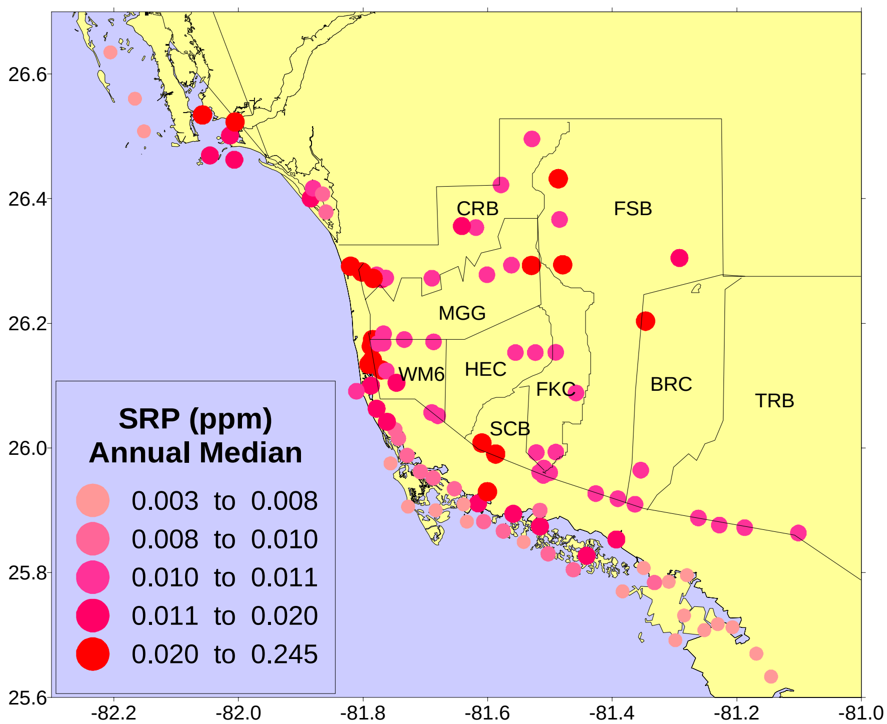


Figure 6.21. Combined median soluble reactive phosphate data from Collier County and FIU.

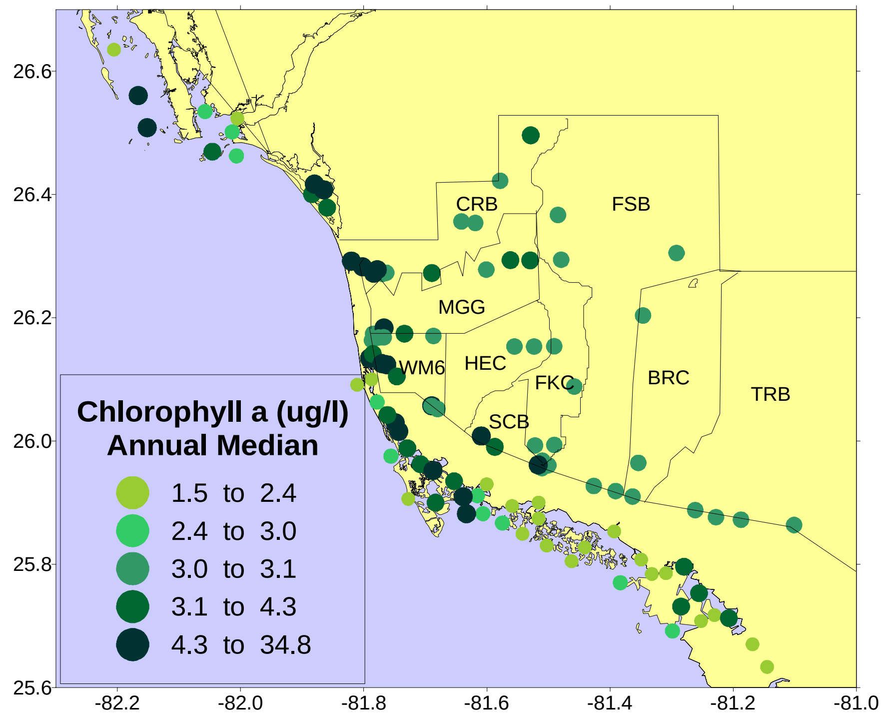


Figure 6.22. Combined median chlorophyll *a* data from Collier County and FIU.

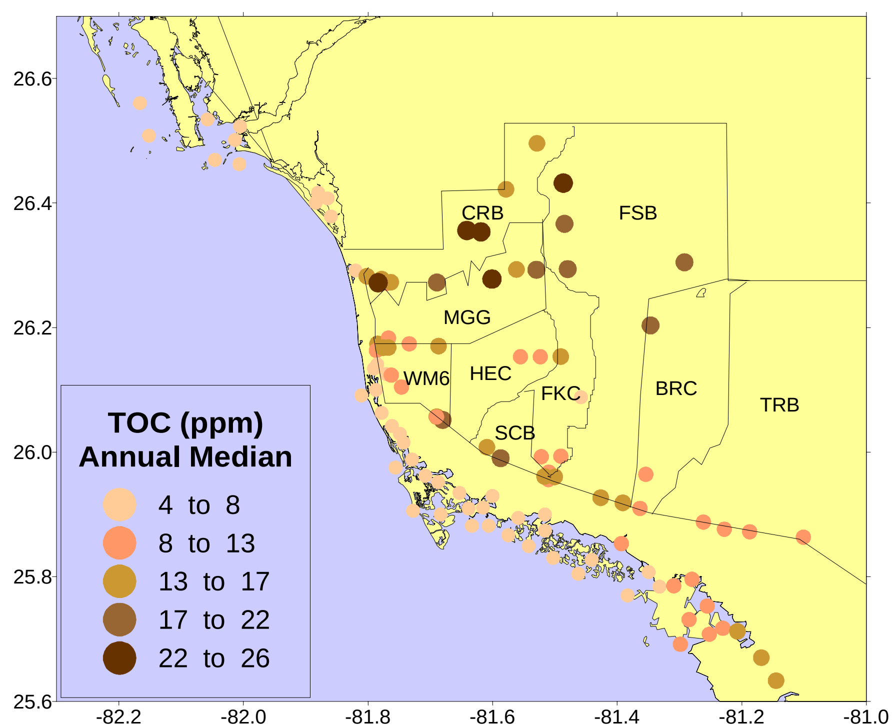


Figure 6.23. Combined median total organic carbon data from Collier County and FIU.

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1. 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.
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3. BOYER, J. N., AND R. D. JONES. 1999. Effects of freshwater inputs and loading of phosphorus and nitrogen on the water quality of Eastern Florida Bay, p. 545-561. *In* K. R. Reddy, G. A. O'Connor, and C. L. Schelske (eds.) Phosphorus biogeochemistry in sub-tropical ecosystems: Florida as a case example. CRC/Lewis Publishers, Boca Raton.
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10. LU, X., J. N. BOYER, AND R. JAFFE. (in review) Source characterization of dissolved organic matter in Southwest Florida Estuaries by UV-visible and synchronous fluorescence analysis. *Marine Chemistry*.
11. BOYER, J. N., AND R. D. JONES. (in prep.) Influence of coastal geomorphology and watershed characteristics on the water quality of mangrove estuaries in the Ten Thousand Islands-Whitewater Bay complex, Florida. *Estuaries*.
12. FOURQUREAN, J. W., J. N. BOYER, AND M. J. DURAKO. (in prep.) The influence of water quality on seagrass distribution and abundance in Florida Bay: predictive models from long-term monitoring programs. *Applied Ecology*.

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1. BOYER, J. N., J. W. FOURQUREAN, AND R. D. JONES. 1995. Spatial analysis of long term water quality data from Florida Bay. Estuarine Research Federation - Corpus Christi, TX.
2. BOYER, J. N. AND R. D. JONES. 1996. The Florida Bay water quality monitoring program: assessing status and trends. 1996 Florida Bay Science Conference - Key Largo, FL.
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14. Lu, X., J. N. Boyer, and R. Jaffe. 2000. Source characterization of DOM in southwest Florida estuaries by UV-Visible and fluorescence analysis. ASLO, Albuquerque, NM.
15. BOYER, J. N., AND R. D. JONES. 2001. Trends in water quality of Florida Bay. 2001 Florida Bay Science Conference, Key Largo, FL.
16. Fourqurean, J. W., J. N. Boyer, M. J. Durako. The statistical relationship between benthic habitats and water quality in Florida Bay. 2001 Florida Bay Science Conference, Key Largo, FL.

9. TABLES

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 00	1-118
Middle Key	2	FB	25 17.102	-80 23.702	Mar 91 - Dec 00	1-118
Manatee Bay	3	FB	25 15.062	-80 24.910	Mar 91 - Dec 00	1-118
Barnes Sound	4	FB	25 13.304	-80 23.299	Mar 91 - Dec 00	1-118
Blackwater Sound	5	FB	25 10.443	-80 25.385	Mar 91 - Dec 00	1-118
Little Blackwater Sound	6	FB	25 12.401	-80 26.424	Mar 91 - Dec 00	1-118
Highway Creek	7	FB	25 15.216	-80 26.649	Mar 91 - Dec 00	1-118
Long Sound	8	FB	25 13.642	-80 27.700	Mar 91 - Dec 00	1-118
Duck Key	9	FB	25 10.624	-80 29.494	Mar 91 - Dec 00	1-118
Joe Bay	10	FB	25 13.468	-80 32.195	Mar 91 - Dec 00	1-118
Little Madeira Bay	11	FB	25 10.510	-80 37.615	Mar 91 - Dec 00	1-118
Terrapin Bay	12	FB	25 08.422	-80 42.967	Mar 91 - Dec 00	1-118
Whipray Basin	13	FB	25 05.485	-80 45.287	Mar 91 - Dec 00	1-118
Garfield Bight	14	FB	25 09.029	-80 48.553	Apr 91 - Dec 00	2-118
Rankin Lake	15	FB	25 07.283	-80 48.173	Mar 91 - Dec 00	1-118
Murray Key	16	FB	25 07.096	-80 56.379	Mar 91 - Dec 00	1-118
Johnson Key Basin	17	FB	25 02.548	-80 54.889	Mar 91 - Dec 00	1-118
Rabbit Key Basin	18	FB	25 00.145	-80 54.006	Mar 91 - Dec 00	1-118
Twin Key Basin	19	FB	24 58.660	-80 45.211	Apr 91 - Dec 00	2-118
Peterson Keys	20	FB	24 55.770	-80 45.028	Mar 91 - Dec 00	1-118
Porpoise Lake	21	FB	25 00.396	-80 40.876	Mar 91 - Dec 00	1-118
Captain Key	22	FB	25 02.405	-80 36.843	Apr 91 - Dec 00	2-118
Park Key	23	FB	25 07.078	-80 35.983	Apr 91 - Dec 00	2-118
Butternut Key	24	FB	25 06.105	-80 31.884	Mar 91 - Dec 00	1-118
East Cape	25	FB	25 05.022	-81 04.835	July 92 - Dec 00	17-118
Oxfoot Bank	26	FB	24 58.844	-81 00.098	July 92 - Dec 00	17-118
Sprigger Bank	27	FB	24 55.116	-80 56.092	July 92 - Dec 00	17-118
Old Dan Bank	28	FB	24 52.032	-80 48.429	July 92 - Dec 00	17-118
First Bay	29	WWB	25 33.272	-81 11.020	Sept 92 - Dec 00	19-118
Third Bay	30	WWB	25 34.810	-81 07.256	Sept 92 - Dec 00	19-118
Big Lostmans Bay	31	WWB	25 34.055	-81 04.288	Sept 92 - Dec 00	19-118
Cabbage Island	32	WWB	25 31.764	-81 02.603	Sept 92 - Dec 00	19-118
Broad River Bay	33	WWB	25 29.984	-81 02.939	Sept 92 - Dec 00	19-118
Middle Broad River	34	WWB	25 29.163	-81 06.669	Sept 92 - Dec 00	19-118
Broad River Mouth	35	WWB	25 28.501	-81 09.176	Sept 92 - Dec 00	19-118
Harney River Mouth	36	WWB	25 24.701	-81 08.487	Sept 92 - Dec 00	19-118
Harney Rivers Junction	37	WWB	25 25.901	-81 04.943	Sept 92 - Dec 00	19-118
Tarpon Bay	38	WWB	25 25.037	-80 59.906	Sept 92 - Dec 00	19-118
Gunboat Island	39	WWB	25 22.735	-81 01.844	Sept 92 - Dec 00	19-118
Ponce de Leon Bay	40	WWB	25 20.983	-81 07.474	Sept 92 - Dec 00	19-118
Oyster Bay	41	WWB	25 19.869	-81 04.360	Sept 92 - Dec 00	19-118
North Marker 36	42	WWB	25 19.560	-81 00.873	Sept 92 - Dec 00	19-118
West Marker 34	43	WWB	25 17.168	-81 01.419	Sept 92 - Dec 00	19-118
Watson River Chickee	44	WWB	25 19.912	-80 59.022	Sept 92 - Dec 00	19-118
North River Mouth	45	WWB	25 18.054	-80 57.620	Sept 92 - Dec 00	19-118
Midway Keys	46	WWB	25 17.102	-80 58.548	Sept 92 - Dec 00	19-118
Roberts River Mouth	47	WWB	25 16.779	-80 55.846	Sept 92 - Dec 00	19-118
West Marker 18	48	WWB	25 14.448	-80 57.476	Sept 92 - Dec 00	19-118

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
Southeast Marker 12	49	WWB	25 13.704	-80 55.980	Sept 92 - Dec 00	19-118
Coot Bay	50	WWB	25 11.452	-80 54.848	Sept 92 - Dec 00	19-118
Chokoloskee	51	TTI	25 48.450	-81 20.970	Sept 94 - Dec 00	43-118
Rabbit Key Pass	52	TTI	25 46.200	-81 23.000	Sept 94 - Dec 00	43-118
Lopez Bay	53	TTI	25 47.050	-81 19.930	Sept 94 - Dec 00	43-118
Lopez River	54	TTI	25 47.130	-81 18.550	Sept 94 - Dec 00	43-118
Sunday Bay	55	TTI	25 47.760	-81 16.800	Sept 94 - Dec 00	43-118
Huston Bay	56	TTI	25 45.180	-81 15.330	Sept 94 - Dec 00	43-118
Upper Chatham River	57	TTI	25 43.050	-81 13.830	Sept 94 - Dec 00	43-118
Watson Place	58	TTI	25 42.470	-81 15.130	Sept 94 - Dec 00	43-118
Gun Rock Point	59	TTI	25 41.500	-81 17.920	Sept 94 - Dec 00	43-118
Huston River	60	TTI	25 43.880	-81 17.080	Sept 94 - Dec 00	43-118
Chevalier Bay	61	TTI	25 42.750	-81 12.420	Sept 94 - Dec 00	43-118
Alligator Bay	62	TTI	25 40.210	-81 10.120	Sept 94 - Dec 00	43-118
Lostmans Five Bay	63	TTI	25 38.000	-81 08.700	Sept 94 - Dec 00	43-118
Barron River	64	TTI	25 51.196	-81 23.602	Sept 94 - Dec 00	43-118
Indian Key Pass	65	TTI	25 49.631	-81 26.465	Sept 94 - Dec 00	43-118
Indian Key	66	TTI	25 48.290	-81 27.750	Sept 94 - Dec 00	43-118
West Pass	67	TTI	25 49.820	-81 30.170	Sept 94 - Dec 00	43-118
Panther Key	68	TTI	25 50.960	-81 32.530	Sept 94 - Dec 00	43-118
Faka Union Pass	69	TTI	25 52.450	-81 30.960	Sept 94 - Dec 00	43-118
Faka Union Bay	70	TTI	25 54.000	-81 30.960	Sept 94 - Dec 00	43-118
White Horse Key	71	TTI	25 52.007	-81 34.489	Sept 94 - Dec 00	43-118
Dismal Key	72	TTI	25 53.668	-81 33.532	Sept 94 - Dec 00	43-118
Long Rock	73	TTI	25 52.920	-81 36.380	Sept 94 - Dec 00	43-118
Shell Key	74	TTI	25 54.670	-81 36.920	Sept 94 - Dec 00	43-118
Blackwater River	75	TTI	25 55.788	-81 36.019	Sept 94 - Dec 00	43-118
Convoy Point	101	BB	25 28.700	-80 19.250	Sept 93 - Dec 00	31-118
Black Point	102	BB	25 32.750	-80 17.680	Sept 93 - Dec 00	31-118
Near Black Ledge	103	BB	25 34.400	-80 17.200	Sept 93 - Dec 00	31-118
BNP Marker C	104	BB	25 36.100	-80 13.250	Sept 93 - Dec 00	31-118
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 00	31-118
North Midbay	109	BB	25 33.850	-80 14.100	Sept 93 - Dec 00	31-118
Fender Point	110	BB	25 30.300	-80 17.250	Sept 93 - Dec 00	31-118
Featherbed Bank	111	BB	25 30.950	-80 14.400	Sept 93 - Dec 00	31-118
Sands Cut	112	BB	25 29.300	-80 11.300	Sept 93 - Dec 00	31-118
Elliott Key	113	BB	25 26.500	-80 13.400	Sept 93 - Dec 00	31-118
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 00	31-118
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 00	31-118
West Arsenicker	122	BB	25 25.210	-80 18.650	Sept 93 - Dec 00	31-118

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
Pelican Bank	123	BB	25 26.700	-80 17.000	Sept 93 - Dec 00	31-118
South Midbay	124	BB	25 28.350	-80 14.000	Sept 93 - Dec 00	31-118
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 00	64-118
Shoal Point	127	BB	25 37.800	-80 15.000	June 96 - Dec 00	64-118
Matheson Beach	128	BB	25 41.300	-80 14.000	June 96 - Dec 00	64-118
Marker G-71	129	BB	25 44.200	-80 11.100	June 96 - Dec 00	64-118
South Dodge Island	130	BB	25 45.800	-80 10.300	June 96 - Dec 00	64-118
North Venetian Basin	131	BB	25 48.000	-80 10.000	June 96 - Dec 00	64-118
North I-195 Basin	132	BB	25 49.000	-80 10.000	June 96 - Dec 00	64-118
North Normandy Isle	133	BB	25 52.000	-80 09.000	June 96 - Dec 00	64-118
Oleta River Park	134	BB	25 54.300	-80 08.000	June 96 - Dec 00	64-118
South Card Sound	135	BB	25 19.000	-80 19.000	June 96 - Dec 00	64-118
Lower Harbor Keys	351	SHELF	24 41.500	-81 47.500	May 95 - Dec 00	1-22
	352	SHELF	24 46.550	-81 46.980	May 95 - Dec 00	1-22
	353	SHELF	24 51.500	-81 46.600	May 95 - Dec 00	1-22
	354	SHELF	24 56.480	-81 46.120	May 95 - Dec 00	1-22
	355	SHELF	25 01.480	-81 45.750	May 95 - Dec 00	1-22
	356	SHELF	25 06.460	-81 45.230	May 95 - Dec 00	1-22
	357	SHELF	25 11.470	-81 44.720	May 95 - Dec 00	1-22
	358	SHELF	25 16.480	-81 44.290	May 95 - Dec 00	1-22
	359	SHELF	25 21.500	-81 43.800	May 95 - Dec 00	1-22
	360	SHELF	25 26.470	-81 43.260	May 95 - Dec 00	1-22
	361	SHELF	25 31.480	-81 42.900	May 95 - Dec 00	1-22
	362	SHELF	25 36.520	-81 42.400	May 95 - Dec 00	1-22
Off Cape Romano	363	SHELF	25 41.520	-81 41.900	May 95 - Dec 00	1-22
	364	SHELF	25 41.500	-81 32.000	May 95 - Dec 00	1-22
	365	SHELF	25 36.510	-81 32.360	May 95 - Dec 00	1-22
	366	SHELF	25 31.560	-81 32.930	May 95 - Dec 00	1-22
	367	SHELF	25 26.550	-81 33.300	May 95 - Dec 00	1-22
	368	SHELF	25 21.510	-81 33.800	May 95 - Dec 00	1-22
	369	SHELF	25 16.530	-81 34.320	May 95 - Dec 00	1-22
	370	SHELF	25 11.510	-81 34.750	May 95 - Dec 00	1-22
	371	SHELF	25 06.500	-81 35.210	May 95 - Dec 00	1-22
	372	SHELF	25 01.500	-81 35.720	May 95 - Dec 00	1-22
	373	SHELF	24 56.530	-81 36.180	May 95 - Dec 00	1-22
	374	SHELF	24 51.530	-81 36.650	May 95 - Dec 00	1-22
Off Johnson Key	375	SHELF	24 46.540	-81 37.070	May 95 - Dec 00	1-22
Harbor Key Bank	376	SHELF	24 50.600	-81 26.300	May 95 - Dec 00	1-22
	377	SHELF	24 56.100	-81 25.900	May 95 - Dec 00	1-22
	378	SHELF	25 01.000	-81 24.950	May 95 - Dec 00	1-22
	379	SHELF	25 06.000	-81 24.530	May 95 - Dec 00	1-22
	380	SHELF	25 11.000	-81 24.000	May 95 - Dec 00	1-22
	381	SHELF	25 16.000	-81 23.700	May 95 - Dec 00	1-22
	382	SHELF	25 21.000	-81 23.200	May 95 - Dec 00	1-22
	383	SHELF	25 25.950	-81 22.670	May 95 - Dec 00	1-22
	384	SHELF	25 30.930	-81 22.200	May 95 - Dec 00	1-22
	385	SHELF	25 36.010	-81 21.790	May 95 - Dec 00	1-22
	386	SHELF	25 33.330	-81 20.430	May 95 - Dec 00	1-22

Station Name	Station Number	Area	Latitude	Longitude	Period of Record	Surveys
	387	SHELF	25 30.530	-81 19.010	May 95 - Dec 00	1-22
	388	SHELF	25 25.500	-81 17.820	May 95 - Dec 00	1-22
	389	SHELF	25 20.500	-81 16.620	May 95 - Dec 00	1-22
	390	SHELF	25 15.600	-81 15.610	May 95 - Dec 00	1-22
	391	SHELF	25 10.500	-81 14.320	May 95 - Dec 00	1-22
	392	SHELF	25 05.500	-81 14.900	May 95 - Dec 00	1-22
	393	SHELF	25 00.500	-81 15.200	May 95 - Dec 00	1-22
	394	SHELF	24 55.500	-81 15.600	May 95 - Dec 00	1-22
Off Bluefish Bank	395	SHELF	24 52.700	-81 11.500	May 95 - Dec 00	1-22
Off Bullard Bank	396	SHELF	24 50.000	-81 07.700	May 95 - Dec 00	1-22
	397	SHELF	24 55.000	-81 07.100	May 95 - Dec 00	1-22
	398	SHELF	25 00.000	-81 06.600	May 95 - Dec 00	1-22
Off East Cape	300	SHELF	25 05.000	-81 05.960	May 95 - Dec 00	1-22
Coon Key Pass, G3	451	ROOK	25 54.626	-81 38.309	Jan 99 - Dec 00	97-118
Coon Key Light	452	ROOK	25 52.918	-81 37.954	Jan 99 - Dec 00	97-118
Fred Key, G5	453	ROOK	25 53.978	-81 41.027	Jan 99 - Dec 00	97-118
Caxambas Pass, R4	454	ROOK	25 54.360	-81 43.733	Jan 99 - Dec 00	97-118
Capri Pass, R2A	455	ROOK	25 59.285	-81 43.740	Jan 99 - Dec 00	97-118
Rt. 951 Bridge, R26	456	ROOK	25 57.737	-81 42.524	Jan 99 - Dec 00	97-118
Big Marco River, R24	457	ROOK	25 57.122	-81 41.243	Jan 99 - Dec 00	97-118
Goodland Bridge, G15	458	ROOK	25 56.080	-81 39.204	Jan 99 - Dec 00	97-118
Johnson Bay	459	ROOK	25 59.291	-81 43.748	Jan 99 - Dec 00	97-118
Hall Bay	460	ROOK	26 00.941	-81 44.566	Jan 99 - Dec 00	97-118
Rookery Bay	461	ROOK	26 01.755	-81 44.888	Jan 99 - Dec 00	97-118
First National	462	ROOK	26 02.441	-81 45.955	Jan 99 - Dec 00	97-118
Kewaydin Channel, G55	463	ROOK	26 03.611	-81 46.713	Jan 99 - Dec 00	97-118
Dollar Bay, G73	464	ROOK	26 06.000	-81 47.213	Jan 99 - Dec 00	97-118
Outer Gordon Pass, G1	465	ROOK	26 05.480	-81 48.686	Jan 99 - Dec 00	97-118
New Pass	466	ROOK	26 22.692	-81 51.508	Jan 99 - Dec 00	97-118
Wiggins Pass Bridge	467	ROOK	26 17.441	-81 49.105	Jan 99 - Dec 00	97-118
Big Carlos Pass Bridge	468	ROOK	26 24.146	-81 52.850	Jan 99 - Dec 00	97-118
Coon Key, R2A	469	ROOK	26 25.422	-81 52.400	Jan 99 - Dec 00	97-118
Central Estero Bay, R2	470	ROOK	26 24.459	-81 51.885	Jan 99 - Dec 00	97-118
Point Ybel, R8	471	ROOK	26 27.492	-82 00.444	Jan 99 - Dec 00	97-118
San Carlos Bay, R4	472	ROOK	26 28.013	-82 02.723	Jan 99 - Dec 00	97-118
Kitchel Key, G13	473	ROOK	26 30.070	-82 00.789	Jan 99 - Dec 00	97-118
Shell Point	474	ROOK	26 31.368	-82 00.417	Jan 99 - Dec 00	97-118
Reckems Point	475	ROOK	26 32.108	-82 03.548	Jan 99 - Dec 00	97-118
Sanibel	476	ROOK	26 30.472	-82 09.113	Jan 99 - Dec 00	97-118
Pine Island Sound	477	ROOK	26 33.702	-82 09.934	Jan 99 - Dec 00	97-118
Cayo Costa	478	ROOK	26 38.150	-82 12.517	Jan 99 - Dec 00	97-118

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	0.38	0.01	6.44	3198
	FBC	1.63	0.01	6.44	484
	FBE	0.36	0.01	6.11	2027
	FBW	0.20	0.01	4.93	687
Chlorophyll *a* (µg l^{-1})	All	0.88	0.04	35.61	3288
	FBC	1.99	0.19	35.61	494
	FBE	0.61	0.04	11.35	2080
	FBW	1.62	0.18	22.08	714
Surface Dissolved Oxygen (mg l^{-1})	All	6.6	0.4	12.3	3336
	FBC	6.4	2.8	12.3	501
	FBE	6.7	0.4	11.7	2102
	FBW	6.3	3.0	11.5	733
Bottom Dissolved Oxygen (mg l^{-1})	All	6.5	1.4	13.4	3117
	FBC	6.3	1.5	12.2	470
	FBE	6.7	1.4	13.4	1987
	FBW	6.2	3.0	11.1	660
Ammonium (ppm)	All	0.033	0.000	1.681	3268
	FBC	0.055	0.000	1.681	487
	FBE	0.041	0.000	1.149	2073
	FBW	0.012	0.000	0.342	708
Nitrite (ppm)	All	0.002	0.000	0.111	3273
	FBC	0.002	0.000	0.111	491
	FBE	0.003	0.000	0.037	2074
	FBW	0.001	0.000	0.025	708
Nitrate (ppm)	All	0.006	0.000	0.154	3256
	FBC	0.003	0.000	0.080	489
	FBE	0.009	0.000	0.154	2064
	FBW	0.002	0.000	0.101	703
Surface Salinity	All	31.80	0.20	63.00	3367
	FBC	33.70	8.70	63.00	506
	FBE	28.70	0.20	54.30	2120
	FBW	35.00	16.50	52.00	741
Bottom Salinity	All	31.30	0.20	63.00	3079
	FBC	32.80	11.90	63.00	466
	FBE	28.30	0.20	54.30	1953
	FBW	34.60	16.60	51.00	660
Silicate (ppm)	All	0.409	0.000	4.060	540
	FBC	1.196	0.002	4.060	80
	FBE	0.323	0.001	3.426	340
	FBW	0.396	0.000	2.932	120
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.026	3246
	FBC	0.001	0.000	0.026	489
	FBE	0.001	0.000	0.016	2056
	FBW	0.001	0.000	0.010	701
Surface Temperature	All	26.6	16.0	36.0	3366

(^{o}C)	FBC	26.6	16.2	35.3	506
	FBE	26.6	16.0	33.5	2119
	FBW	26.4	17.6	36.0	741
Bottom Temperature	All	26.5	1.8	35.3	3137
(^{o}C)	FBC	26.5	16.2	35.3	474
	FBE	26.6	1.8	33.9	1997
	FBW	26.3	2.1	34.7	666
Total Organic	All	8.148	0.000	58.043	3245
Carbon (ppm)	FBC	13.335	4.518	42.872	484
	FBE	8.351	0.000	58.043	2064
	FBW	4.913	1.199	20.216	697
Total Organic	All	0.570	0.000	4.355	3250
Nitrogen (ppm)	FBC	0.992	0.151	4.355	485
	FBE	0.585	0.000	3.098	2063
	FBW	0.358	0.046	1.680	702
Total Phosphorus	All	0.010	0.001	0.131	3275
(ppm)	FBC	0.019	0.004	0.131	490
	FBE	0.008	0.001	0.041	2075
	FBW	0.015	0.002	0.127	710
Turbidity	All	3.39	0.01	178.55	3143
(NTU)	FBC	6.69	0.15	134.85	475
	FBE	2.29	0.01	172.95	2003
	FBW	6.15	0.07	178.55	665

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	0.15	0.00	6.00	4046
	BLK	0.04	0.02	0.28	149
	COOT	1.74	0.00	6.00	98
	GI	0.04	0.00	3.23	947
	IW	0.11	0.00	3.53	822
	MR	0.22	0.00	3.70	1238
	WWB	1.22	0.00	5.96	792
Chlorophyll *a* (µg l^{-1})	All	2.89	0.12	45.11	4047
	BLK	3.26	0.25	17.02	150
	COOT	6.64	1.21	38.37	98
	GI	2.69	0.12	23.78	948
	IW	3.34	0.20	45.11	822
	MR	2.61	0.19	28.76	1238
	WWB	2.84	0.33	29.78	791
Surface Dissolved Oxygen (mg l^{-1})	All	5.8	0.3	13.9	4049
	BLK	5.5	1.8	10.3	150
	COOT	7.1	0.3	10.4	99
	GI	5.8	2.9	12.1	948
	IW	5.9	1.8	11.8	822
	MR	5.1	0.8	13.9	1238
	WWB	6.9	2.2	11.1	792
Bottom Dissolved Oxygen (mg l^{-1})	All	5.8	0.0	12.3	4049
	BLK	5.4	1.9	9.8	150
	COOT	7.0	0.0	10.4	99
	GI	5.8	2.2	11.8	948
	IW	5.8	1.2	11.9	822
	MR	5.0	0.7	12.3	1238
	WWB	6.9	0.4	11.1	792
Ammonium (ppm)	All	0.014	0.000	1.046	4049
	BLK	0.021	0.001	0.189	150
	COOT	0.016	0.002	1.046	99
	GI	0.011	0.000	0.165	948
	IW	0.017	0.000	0.285	822
	MR	0.016	0.000	0.402	1238
	WWB	0.011	0.000	0.301	792
Nitrite (ppm)	All	0.002	0.000	0.139	4049
	BLK	0.003	0.000	0.017	150
	COOT	0.003	0.000	0.139	99
	GI	0.002	0.000	0.033	948
	IW	0.003	0.000	0.036	822
	MR	0.003	0.000	0.012	1238
	WWB	0.002	0.000	0.086	792
Nitrate (ppm)	All	0.010	0.000	0.268	4049
	BLK	0.009	0.000	0.080	150
	COOT	0.005	0.000	0.238	99

	GI	0.008	0.000	0.135	948
	IW	0.011	0.000	0.133	822
	MR	0.015	0.000	0.142	1238
	WWB	0.005	0.000	0.268	792
Surface Salinity	All	14.7	0.0	40.3	4046
	BLK	31.6	1.4	39.9	150
	COOT	10.7	4.4	25.9	99
	GI	28.1	1.3	40.1	948
	IW	12.9	0.1	39.5	822
	MR	4.6	0.0	40.3	1235
	WWB	10.6	0.3	33.1	792
Bottom Salinity	All	15.9	0.0	53.6	4046
	BLK	31.6	1.4	39.9	150
	COOT	10.8	4.2	26.5	99
	GI	28.6	1.0	40.2	948
	IW	14.1	0.2	53.6	822
	MR	5.4	0.0	40.3	1235
	WWB	10.9	0.3	33.6	792
Silicate (ppm)	All	1.724	0.000	4.880	887
	BLK	1.690	0.000	3.657	36
	COOT	2.823	0.017	4.166	20
	GI	1.589	0.000	4.705	217
	IW	1.765	0.000	4.688	198
	MR	2.070	0.000	4.367	256
	WWB	1.495	0.002	4.880	160
Soluble Reactive Phosphorus (ppm)	All	0.003	0.000	0.066	4038
	BLK	0.019	0.002	0.066	150
	COOT	0.002	0.000	0.023	99
	GI	0.008	0.000	0.044	943
	IW	0.003	0.000	0.028	822
	MR	0.002	0.000	0.034	1235
	WWB	0.002	0.000	0.026	789
Surface Temperature (^oC)	All	26.9	12.5	37.5	4049
	BLK	27.5	15.9	33.3	150
	COOT	27.0	14.5	35.0	99
	GI	27.0	15.0	33.3	948
	IW	27.1	15.2	37.5	822
	MR	26.5	13.6	34.4	1238
	WWB	26.6	12.5	34.2	792
Bottom Temperature (^oC)	All	26.8	11.8	33.9	4049
	BLK	27.3	16.0	33.8	150
	COOT	27.1	14.5	33.9	99
	GI	27.0	15.0	33.3	948
	IW	27.1	15.2	33.3	822
	MR	26.5	13.6	33.3	1238
	WWB	26.5	11.8	33.5	792
Total Organic Carbon (ppm)	All	11.889	3.805	64.008	4046
	BLK	7.150	3.805	21.385	149

	COOT	23.235	16.260	39.632	98
	GI	7.082	3.808	27.170	947
	IW	11.376	5.187	22.462	822
	MR	13.629	5.064	64.008	1238
	WWB	16.161	6.143	31.680	792
Total Organic Nitrogen (ppm)	All	0.612	0.000	2.989	4046
	BLK	0.380	0.156	0.937	149
	COOT	1.277	0.300	2.120	98
	GI	0.404	0.108	1.748	947
	IW	0.601	0.150	1.566	822
	MR	0.694	0.131	2.989	1238
	WWB	0.840	0.000	2.535	792
Total Phosphorus (ppm)	All	0.028	0.002	0.112	4036
	BLK	0.058	0.016	0.098	146
	COOT	0.038	0.017	0.101	98
	GI	0.035	0.004	0.112	941
	IW	0.032	0.002	0.092	822
	MR	0.022	0.006	0.092	1237
	WWB	0.018	0.003	0.094	792
Turbidity (NTU)	All	4.05	0.06	107.81	4046
	BLK	7.35	0.49	40.50	149
	COOT	6.16	1.00	94.15	98
	GI	5.16	0.47	68.00	947
	IW	4.30	0.06	43.60	822
	MR	2.70	0.17	47.65	1238
	WWB	3.75	0.21	107.81	792

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	0.134	0.008	3.209	2039
	AS	0.332	0.093	3.209	174
	IS	0.196	0.036	2.119	368
	MAIN	0.107	0.008	0.894	1022
	NBAY	0.108	0.017	0.902	268
	SCARD	0.141	0.041	0.942	207
Chlorophyll *a* (µg l^{-1})	All	0.28	0.04	9.18	2017
	AS	0.28	0.06	2.46	172
	IS	0.27	0.06	6.37	364
	MAIN	0.23	0.04	5.89	1011
	NBAY	0.95	0.16	9.18	265
	SCARD	0.31	0.06	3.61	205
Surface Dissolved Oxygen (mg l^{-1})	All	6.4	2.8	11.6	2039
	AS	7.3	3.1	11.6	172
	IS	6.7	4.0	11.5	368
	MAIN	6.3	2.8	10.2	1022
	NBAY	6.2	4.1	10.2	270
	SCARD	6.5	4.0	9.0	207
Bottom Dissolved Oxygen (mg l^{-1})	All	6.5	2.8	12.9	2039
	AS	7.6	3.7	12.9	172
	IS	6.9	3.9	11.8	368
	MAIN	6.4	2.8	10.6	1022
	NBAY	6.2	4.2	10.4	270
	SCARD	6.5	3.3	9.5	207
Ammonium (ppm)	All	0.012	0.000	0.228	2043
	AS	0.014	0.001	0.228	174
	IS	0.013	0.000	0.095	369
	MAIN	0.010	0.000	0.083	1023
	NBAY	0.015	0.000	0.114	270
	SCARD	0.015	0.000	0.121	207
Nitrite (ppm)	All	0.002	0.000	0.060	2043
	AS	0.003	0.000	0.032	174
	IS	0.002	0.000	0.021	369
	MAIN	0.001	0.000	0.010	1023
	NBAY	0.002	0.000	0.060	270
	SCARD	0.002	0.000	0.019	207
Nitrate (ppm)	All	0.007	0.000	1.082	2043
	AS	0.032	0.000	1.082	174
	IS	0.012	0.000	0.672	369
	MAIN	0.005	0.000	0.295	1023
	NBAY	0.016	0.000	0.174	270
	SCARD	0.010	0.000	0.129	207
Surface Salinity	All	33.2	12.3	42.3	2043
	AS	27.0	12.3	42.3	174
	IS	30.6	15.1	42.2	369
	MAIN	34.9	22.5	40.4	1023

	NBAY	31.8	19.3	37.9	270
	SCARD	31.8	21.0	39.0	207
Bottom Salinity	All	33.8	3.4	42.2	2042
	AS	27.7	12.8	42.2	174
	IS	31.4	3.4	42.2	369
	MAIN	35.0	24.2	40.3	1022
	NBAY	33.3	25.2	37.9	270
	SCARD	32.6	20.9	39.0	207
Silicate (ppm)	All	0.068	0.000	1.287	450
	AS	0.204	0.000	0.851	36
	IS	0.090	0.000	0.828	90
	MAIN	0.035	0.000	0.720	198
	NBAY	0.245	0.001	1.287	90
	SCARD	0.040	0.000	0.260	36
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.021	2025
	AS	0.001	0.000	0.010	173
	IS	0.001	0.000	0.009	365
	MAIN	0.000	0.000	0.009	1016
	NBAY	0.001	0.000	0.021	266
	SCARD	0.001	0.000	0.008	205
Surface Temperature (^{o}C)	All	26.3	10.2	33.3	2043
	AS	26.9	10.2	32.9	174
	IS	26.3	15.7	33.3	369
	MAIN	26.2	15.5	32.8	1023
	NBAY	25.8	16.5	32.5	270
	SCARD	26.3	16.4	32.5	207
Bottom Temperature (^{o}C)	All	26.3	10.3	33.8	2043
	AS	26.8	10.3	33.2	174
	IS	26.3	15.7	33.4	369
	MAIN	26.1	15.6	32.5	1023
	NBAY	25.7	16.5	32.9	270
	SCARD	26.6	16.6	33.8	207
Total Organic Carbon (ppm)	All	3.401	0.326	9.330	2042
	AS	4.787	1.379	9.330	174
	IS	3.988	1.463	9.168	368
	MAIN	2.825	0.326	6.522	1023
	NBAY	3.777	1.518	8.208	270
	SCARD	4.086	1.968	7.572	207
Total Organic Nitrogen (ppm)	All	0.232	0.048	1.229	2042
	AS	0.366	0.091	0.825	174
	IS	0.293	0.078	0.877	368
	MAIN	0.195	0.054	1.010	1023
	NBAY	0.215	0.048	0.652	270
	SCARD	0.281	0.068	1.229	207
Total Phosphorus (ppm)	All	0.006	0.001	0.038	2042
	AS	0.006	0.002	0.025	174
	IS	0.006	0.002	0.026	368
	MAIN	0.005	0.001	0.030	1023

	NBAY	0.009	0.003	0.038	270
	SCARD	0.006	0.002	0.030	207
Turbidity (NTU)	All	0.69	0.00	22.35	2041
	AS	0.49	0.05	3.73	174
	IS	0.45	0.00	3.75	368
	MAIN	0.81	0.00	19.00	1022
	NBAY	1.08	0.01	22.35	270
	SCARD	0.57	0.00	3.80	207

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	0.055	0.004	12.017	900
	SHARK	0.071	0.016	2.485	37
	SHOAL	0.054	0.004	12.017	732
	SHELF	0.055	0.012	7.627	131
Chlorophyll *a* (μg l^{-1})	All	0.925	0.000	10.463	1078
	SHARK	1.597	0.254	4.651	44
	SHOAL	0.893	0.000	10.463	880
	SHELF	0.950	0.240	6.560	154
Surface Dissolved Oxygen (mg l^{-1})	All	6.3	2.8	12.8	1061
	SHARK	6.2	3.6	8.3	43
	SHOAL	6.3	2.8	12.6	866
	SHELF	6.3	3.1	12.8	152
Bottom Dissolved Oxygen (mg l^{-1})	All	5.7	1.7	13.0	365
	SHARK	5.3	2.8	7.2	14
	SHOAL	5.7	1.7	13.0	298
	SHELF	5.9	2.6	9.7	53
Ammonium (ppm)	All	0.006	0.000	0.129	1078
	SHARK	0.008	0.001	0.049	44
	SHOAL	0.006	0.000	0.129	880
	SHELF	0.006	0.000	0.064	154
Nitrite (ppm)	All	0.000	0.000	0.008	1078
	SHARK	0.001	0.000	0.006	44
	SHOAL	0.000	0.000	0.008	880
	SHELF	0.000	0.000	0.005	154
Nitrate (ppm)	All	0.000	0.000	0.078	1078
	SHARK	0.002	0.000	0.072	44
	SHOAL	0.000	0.000	0.078	880
	SHELF	0.001	0.000	0.022	154
Surface Salinity	All	35.3	24.4	38.9	1065
	SHARK	34.1	24.4	38.9	43
	SHOAL	35.3	27.0	38.0	870
	SHELF	35.3	27.9	37.8	152
Bottom Salinity	All	35.6	26.0	38.0	369
	SHARK	34.3	26.0	37.3	14
	SHOAL	35.7	27.8	38.0	302
	SHELF	35.5	31.0	37.8	53
Silicate (ppm)	All	0.069	0.000	2.238	975
	SHARK	0.427	0.000	1.199	40
	SHOAL	0.070	0.000	2.238	796
	SHELF	0.042	0.000	1.038	139
Soluble Reactive Phosphorus (ppm)	All	0.001	0.000	0.014	1078
	SHARK	0.001	0.000	0.006	44
	SHOAL	0.001	0.000	0.014	880
	SHELF	0.001	0.000	0.008	154
Surface Temperature	All	26.5	17.6	32.7	1065

(°C)	SHARK	26.5	18.7	32.1	43
	SHOAL	26.5	18.2	32.7	870
	SHELF	26.6	17.6	32.3	152
Bottom Temperature	All	25.2	20.9	32.0	369
(°C)	SHARK	25.1	21.6	31.4	14
	SHOAL	25.2	21.1	31.9	302
	SHELF	25.4	20.9	32.0	53
Total Organic	All	2.914	1.544	10.790	1078
Carbon (ppm)	SHARK	3.929	2.221	5.812	44
	SHOAL	2.899	1.544	10.790	880
	SHELF	2.841	1.606	5.864	154
Total Organic	All	0.204	0.043	1.021	1069
Nitrogen (ppm)	SHARK	0.280	0.083	0.957	43
	SHOAL	0.201	0.043	1.021	872
	SHELF	0.210	0.059	0.511	154
Total Phosphorus	All	0.012	0.000	0.190	1078
(ppm)	SHARK	0.014	0.008	0.079	44
	SHOAL	0.012	0.000	0.190	880
	SHELF	0.012	0.006	0.027	154
Turbidity	All	2.10	0.00	66.25	980
(NTU)	SHARK	6.62	2.14	66.25	40
	SHOAL	1.91	0.00	45.05	800
	SHELF	2.79	0.21	20.70	140

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	0.046	0.015	0.292	670
	COCO	0.052	0.022	0.126	14
	EST	0.052	0.018	0.115	105
	MARC	0.042	0.023	0.292	191
	NPL	0.044	0.022	0.179	72
	PIS	0.049	0.015	0.161	72
	RB	0.044	0.023	0.108	96
	SCB	0.047	0.017	0.130	120
Chlorophyll *a* (µg l^{-1})	All	3.701	0.377	28.471	669
	COCO	4.717	2.160	15.784	14
	EST	4.293	0.410	24.682	104
	MARC	4.077	0.377	20.852	191
	NPL	2.505	0.438	18.219	72
	PIS	3.546	0.553	21.764	72
	RB	3.692	0.753	15.718	96
	SCB	3.109	0.698	28.471	120
Surface Dissolved Oxygen (mg l^{-1})	All	6.3	2.3	11.5	670
	COCO	4.9	2.9	6.6	14
	EST	6.4	3.3	9.4	105
	MARC	6.2	2.8	9.3	191
	NPL	6.1	2.3	11.5	72
	PIS	6.8	4.2	8.8	72
	RB	6.0	2.7	8.2	96
	SCB	6.6	3.8	11.1	120
Bottom Dissolved Oxygen (mg l^{-1})	All	6.3	1.3	11.7	651
	COCO	5.9	5.0	6.4	3
	EST	6.4	1.8	9.1	97
	MARC	6.2	2.8	9.3	191
	NPL	6.2	2.1	11.7	72
	PIS	6.6	4.2	9.1	72
	RB	6.0	1.3	8.5	96
	SCB	6.5	3.6	10.1	120
Ammonium (ppm)	All	0.008	0.000	0.239	669
	COCO	0.040	0.017	0.215	13
	EST	0.008	0.000	0.126	105
	MARC	0.007	0.000	0.194	191
	NPL	0.010	0.001	0.170	72
	PIS	0.007	0.000	0.077	72
	RB	0.008	0.001	0.239	96
	SCB	0.009	0.000	0.184	120
Nitrite (ppm)	All	0.001	0.000	0.013	669
	COCO	0.002	0.000	0.011	13
	EST	0.001	0.000	0.006	105
	MARC	0.001	0.000	0.010	191
	NPL	0.001	0.000	0.009	72

	PIS	0.001	0.000	0.004	72
	RB	0.001	0.000	0.009	96
	SCB	0.001	0.000	0.013	120
Nitrate (ppm)	All	0.004	0.000	0.405	669
	COCO	0.015	0.002	0.112	13
	EST	0.003	0.000	0.039	105
	MARC	0.003	0.000	0.052	191
	NPL	0.003	0.000	0.054	72
	PIS	0.002	0.000	0.035	72
	RB	0.004	0.000	0.034	96
	SCB	0.007	0.000	0.405	120
Surface Salinity	All	34.3	1.6	39.9	670
	COCO	29.5	1.6	35.7	14
	EST	33.8	14.8	36.5	105
	MARC	35.1	21.2	38.4	191
	NPL	34.7	20.1	37.6	72
	PIS	34.2	20.3	37.6	72
	RB	34.9	18.9	39.9	96
	SCB	30.5	3.6	35.9	120
Bottom Salinity	All	34.4	3.6	38.5	651
	COCO	21.2	10.1	33.9	3
	EST	34.0	18.6	36.5	97
	MARC	35.2	21.9	38.5	191
	NPL	34.9	19.6	37.7	72
	PIS	34.3	25.8	37.5	72
	RB	35.0	20.0	38.2	96
	SCB	32.0	3.6	36.4	120
Silicate (ppm)	All	0.739	0.000	4.175	222
	COCO	1.598	0.611	2.637	4
	EST	0.819	0.103	2.476	35
	MARC	0.687	0.018	2.872	63
	NPL	0.606	0.216	1.591	24
	PIS	0.386	0.000	1.404	24
	RB	0.703	0.079	1.859	32
	SCB	0.920	0.076	4.175	40
Soluble Reactive Phosphorus (ppm)	All	0.005	0.000	0.098	669
	COCO	0.018	0.001	0.041	13
	EST	0.006	0.000	0.026	105
	MARC	0.004	0.000	0.028	191
	NPL	0.006	0.000	0.034	72
	PIS	0.003	0.000	0.027	72
	RB	0.005	0.000	0.026	96
	SCB	0.010	0.000	0.098	120
Surface Temperature (^{o}C)	All	25.6	15.6	32.8	670
	COCO	25.7	19.6	32.7	14
	EST	26.3	16.9	32.8	105
	MARC	25.8	15.6	31.3	191
	NPL	25.5	16.8	31.4	72
	PIS	25.2	17.4	31.5	72

	RB	26.0	15.6	31.7	96
	SCB	25.3	17.0	31.6	120
Bottom Temperature (^oC)	All	25.6	15.6	34.5	651
	COCO	31.1	21.5	32.7	3
	EST	26.6	16.8	31.7	97
	MARC	25.6	15.6	31.3	191
	NPL	25.6	16.8	31.5	72
	PIS	25.1	16.5	31.5	72
	RB	26.0	15.6	31.7	96
	SCB	25.4	16.7	34.5	120
Total Organic Carbon (ppm)	All	4.784	2.226	19.688	670
	COCO	6.674	4.457	16.598	14
	EST	4.893	3.293	11.655	105
	MARC	4.543	2.778	9.658	191
	NPL	4.019	2.226	9.283	72
	PIS	4.681	2.425	9.607	72
	RB	5.057	2.728	10.775	96
	SCB	6.004	2.612	19.688	120
Total Organic Nitrogen (ppm)	All	0.278	0.057	0.832	668
	COCO	0.362	0.222	0.630	13
	EST	0.300	0.161	0.653	105
	MARC	0.278	0.099	0.818	191
	NPL	0.239	0.078	0.449	72
	PIS	0.298	0.113	0.646	72
	RB	0.260	0.104	0.591	96
	SCB	0.294	0.057	0.832	119
Total Phosphorus (ppm)	All	0.046	0.000	0.186	670
	COCO	0.049	0.032	0.072	14
	EST	0.051	0.019	0.186	105
	MARC	0.042	0.000	0.095	191
	NPL	0.039	0.017	0.099	72
	PIS	0.041	0.014	0.148	72
	RB	0.047	0.018	0.099	96
	SCB	0.052	0.019	0.160	120
Turbidity (NTU)	All	3.61	0.06	38.65	670
	COCO	5.67	0.35	8.24	14
	EST	4.41	0.13	15.32	105
	MARC	4.70	0.62	38.65	191
	NPL	2.72	0.25	27.25	72
	PIS	2.72	0.07	12.70	72
	RB	4.54	0.61	35.25	96
	SCB	2.51	0.06	10.09	120