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Results of the City of Tampa Surface Water Compliance Monitoring Program for the year 1998 and examination of long-term water quality and biological indicator trends in Hillsborough Bay

City of Tampa Department of Sanitary Sewers

RESULTS OF THE CITY OF TAMPA SURFACE WATER COMPLIANCE MONITORING PROGRAM FOR THE YEAR 1998 AND EXAMINATION OF LONG-TERM WATER QUALITY AND BIOLOGICAL INDICATOR TRENDS IN HILLSBOROUGH BAY

SUBMITTED TO

THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
SOUTHWEST DISTRICT

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BY

CITY OF TAMPA
DEPARTMENT OF SANITARY SEWERS
BAY STUDY GROUP

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INTRODUCTION

This report is submitted to the Florida Department of Environmental Protection (FDEP) to satisfy the requirements set forth in specific condition No. 14 of the Howard F. Curren WWTP permit No. D029-184532B. The report is based on data obtained by the City of Tampa (COT) surface water compliance monitoring program approved under construction permit DC29-152799. The report also includes examination of long-term trends for water quality parameters and biological indicators collected by the City of Tampa Bay Study Group and the Environmental Protection Commission of Hillsborough County (EPC). Results from these studies are discussed in four sections: 1) Compliance monitoring of Hillsborough Bay water quality by the COT, 2) long-term monitoring of Hillsborough Bay water quality by the EPC, 3) comparison between COT compliance monitoring stations and selected EPC stations in the upper portion of Hillsborough Bay and 4) long-term monitoring of Tampa Bay water quality and biological indicators by the COT.

Results from the compliance monitoring include data collected monthly by the COT at three stations in the upper portion of Hillsborough Bay (COT15, COT16 and COT17; Figure 1). Sampling of these stations started in January 1990. From these collections, the EPC laboratory analyzes sub-samples for carbonaceous biological oxygen demand (5-day), total phosphorus, ortho-phosphate, total nitrogen, total Kjeldahl nitrogen, nitrite+nitrate-nitrogen and ammonia-nitrogen. In addition, the COT Bay Study Group measures chlorophyll-a and several field measured water quality parameters including dissolved oxygen, salinity, temperature and Secchi depth.

The long-term water quality data base maintained by the EPC is discussed as trends of annual averages for the parameters specified in the study plan entitled "City of Tampa Surface Monitoring Plan of Hillsborough Bay." This discussion includes all 14 EPC stations in Hillsborough Bay (Figure 2) and the group of EPC stations close to the Howard F. Curren WWTP outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1).

The comparison between COT compliance monitoring stations (COT15, COT16 and COT17; Figure 1) and the group of EPC stations close to the Howard F. Curren WWTP discharge (EPC2, EPC6, EPC52 and EPC70; Figure 1) includes examination of averages and standard errors for the year 1998 for the parameters specified in the study plan.

Examination of the COT, multi-disciplinary, long-term water quality and biological indicator monitoring program includes discussion of annual averages for parameters specified in the study plan. The first part of this section reports on results from the water quality and phytoplankton monitoring conducted at two stations located in Hillsborough Bay (COT4 and COT12; Figure 3) and one station located in Middle Tampa Bay (COT13; Figure 3). The second part presents results from the drift macro-algae monitoring conducted at five transects in Hillsborough Bay (Figure 4).

METHODS

Field and laboratory methods are described in the compliance monitoring study plan submitted to the FDER Tampa office on November 16, 1989 entitled "City of Tampa Surface Monitoring Plan of Hillsborough Bay." The study program was modified in January 1993, when a Hydrolab DataSonde 3 probe replaced equipment previously used for measurements of water temperature, salinity and dissolved oxygen.

RESULTS

Compliance Water Quality Monitoring in Hillsborough Bay by the COT

Results from the monthly COT compliance monitoring program of Hillsborough Bay stations COT15, COT16 and COT17 (Figure 1) for the year 1998 are listed in Appendix Table A. Results for all measured parameters for the years 1990 through 1998 are discussed in the text below and illustrated in Figures 5 through 18.

Temperature (Figure 5):
There is little variation in water temperatures among the three stations. The expected seasonal variation is evident.

Salinity (Figure 6):
There is generally little variation in salinity among the three stations. Salinity was substantially reduced at all stations during late summer or early fall in 1991, 1994 and 1995. In addition, a marked reduction in salinity occurred during the winter and spring of 1998.

Secchi Disc Depth (SD; Figure 7):
Secchi disc depths show considerable month-to-month variation. A distinct seasonal pattern is not apparent although annual maxima of water column light penetration generally occurs at all stations during the winter. Further, a long-term trend is not apparent.

Surface Dissolved Oxygen (SDO; Figure 8):
The highest SDO concentrations are generally noted for all stations during the winter and the lowest concentrations are measured during the late summer and early fall. The month-to-month variation between the stations is generally similar and a long-term trend is not apparent.

Middle Dissolved Oxygen (MDO; Figure 9):
Variations in MDO concentrations are similar to those seen for SDO.

Bottom Dissolved Oxygen (BDO; Figure 10):
BDO concentrations are strongly dependent on site specific parameters such as depth and benthic composition. A comparison among the three stations is, therefore, not valid. In general, a strong seasonal pattern is evident with peaks during winter and lows during summer and fall. A long-term trend is not apparent for any of the three stations.

Total Nitrogen (TN; Figure 11):
TN concentrations are often similar at the three stations and a seasonal pattern is not apparent. Concentrations measured in 1994 and 1995 appear elevated in comparison to concentrations found during the earlier portion of this record. In 1998, concentrations remained relatively low and constant throughout the year.

Total Kjeldahl Nitrogen (TKN; Figure 12):
Variations in TKN concentrations are virtually identical to those seen in TN concentrations.

Ammonia Nitrogen (NH3; Figure 13):
There is generally little variation in NH3 concentrations among the three stations and a seasonal pattern is not apparent. NH3 concentrations measured since 1991 are considerably lower in comparison to concentrations found in 1990, the first year of this study.

Nitrite + Nitrate Nitrogen (NO2+NO3; Figure 14):
Considerable month-to-month and station-to-station variation is evident in the NO2+NO3 measurements. A seasonal or long-term trend is not apparent for this parameter. A substantial increase in NO2+NO3 concentration occurred during the winter 1997/1998 season.

Total Phosphorus (TP; Figure 15):
TP concentrations are generally similar at the three stations. A seasonal pattern is lacking for the early portion of the record, generally, however, the record exhibits the highest concentrations in the summer and fall and the lowest in winter and spring. Current concentrations are considerably lower than concentrations measured during the first two years of this study.

Ortho-Phosphorus (PO4; Figure 16):
Variations in PO4 concentrations are similar to those seen for TP. Relatively low concentrations were found at all three stations in February 1996. The PO4 sample collected April 1998 at station COT15 has been removed from the database in accordance with recommendations expressed in a letter from EPC (see Appendix B). The measured PO4 concentration in this sample was substantially greater than the TP concentration.

Carbonaceous Biological Oxygen Demand (CBOD5; Figure 17):
CBOD5 is generally similar for all stations. Seasonal or long-term trends are not evident.

Chlorophyll-a (CHLA; Figure 18:)
CHLA concentrations at the three stations are often very similar. However, considerable differences between stations have been observed on three occasions (1991, 1994 and 1995). A strong seasonal pattern is evident, with maximum concentrations generally recorded in late summer and fall. The lowest concentrations are most often found during the coldest winter months. A long-term trend is not apparent.

Long-Term Trends of Hillsborough Bay Water Quality Parameters Sampled by the EPC

Annual averages for parameters measured by the EPC and specified in the study plan (DO, CBOD5, TP, PO4, TN, TKN and CHLA) are discussed in the text below and illustrated in Figures 19 through 27. The annual averages of all 14 Hillsborough Bay EPC stations (Figure 2), as a group, are compared to the annual averages for the group of EPC stations close to the Howard F. Curren WWTP outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1).

TN (Figure 19):
TN concentrations are very similar between the two station groups. A long-term trend in Hillsborough Bay TN concentrations is not evident. EPC does not report nitrogen data prior to 1980.

TKN (Figure 20):
See the comments for TN.

TP(Figure 21):
TP concentrations have decreased from near 2mg/l in 1974 to current concentrations of approximately 0.4mg/l. The "All Stations" group consistently has higher concentrations than the upper Hillsborough Bay station group, reflecting the influence of the high phosphorus discharges from the Alafia River on the lower and mid portions of Hillsborough Bay. The Alafia River appears to be a major source of TP to the bay (see Figure 31).

PO4 (Figure 22):
See the comments for TP. In addition, PO4 information is based on a much smaller amount of samples than TP.

CBOD5 (Figure 23):
CBOD5 concentrations peaked at nearly 5mg/l during the period 1975 through 1977 and declined to current levels of approximately 2mg/l. The influence of the Howard F. Curren WWTP prior to the conversion to advanced wastewater treatment (AWT) in 1979 may be indicated by the higher values for the upper Hillsborough Bay station group during the period 1973 through 1977. Levels of concentration between the two station groups have been reversed since 1984. Now the lowest values are almost consistently found for the upper Hillsborough Bay station group.

DO (Figures 24-26):
There are no consistent spatial or temporal trends for either SDO, MDO or BDO concentrations, with the exception that SDO was substantially elevated for the "All Stations" group during the years 1976 through 1981.

CHLA (Figure 27):
CHLA concentrations were highest in Hillsborough Bay from the mid-1970's through the early 1980's. During that period values ranged from approximately 25 to 32ug/l. Concentrations then decreased relatively steadily to about 10ug/l in 1993. Concentrations increased in 1994 and 1995 to about 17 ug/l and then dropped in 1996 and 1997 to near 1993 levels. CHLA concentrations increased to approximately 20ug/l in 1998. There is no consistent difference between the groups of

stations, however, the influence of the Howard F. Curren WWTP, prior to conversion to AWT in 1979, may be indicated by the higher values for the upper Hillsborough Bay station group during the mid 1970's.

Comparison Between COT Compliance Monitoring Stations and Selected EPC Stations in Upper Hillsborough Bay

The 1998 annual average values of the parameters specified in the study plan (DO, CBOD5, TP, PO4, TN, TKN and CHLA) are discussed in the text below and illustrated in Figures 28 through 38. The annual average of each individual station from the COT compliance monitoring stations (COT15, COT16 and COT17; Figure 1) and the annual average of each individual EPC station close to the Howard F. Curren WWTP outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1) are used in this comparison. Summary statistics for each station and parameters listed above are shown in Table 1.

TN (Figure 28):
All COT compliance stations had TN concentrations within one standard error of the mean (1 SE) of stations EPC2, EPC52, and EPC70. Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter.

TKN (Figure 29):
All COT compliance stations had TKN concentrations within one standard error of the mean (1 SE) of stations EPC2, EPC6, EPC52, and EPC70. Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter.

TP (Figures 30 and 31):
Station EPC70 had the highest mean TP concentrations. All COT compliance stations had TP concentrations within one standard error of the mean (1 SE) of stations EPC6, EPC52, and EPC70 (Figure 30). Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter. In addition, when comparing TP concentrations for the COT compliance monitoring stations and all EPC stations in Hillsborough Bay (Figure 31) it is evident that station EPC74, at the mouth of the Alafia River, has by far the greatest concentration, suggesting that the Alafia River is a major source of TP to Hillsborough Bay.

PO4 (Figures 32 and 33):
Stations COT16 and EPC52 had the highest mean PO4 concentration, however, all COT compliance stations had PO4 concentrations within one standard error of the mean (1 SE) of stations EPC6, EPC52, and EPC70 (Figure 32). Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter. In addition, when comparing PO4 concentrations for the COT compliance monitoring stations and all EPC stations in Hillsborough Bay (Figure 33) it is evident that EPC74, at the mouth of the Alafia River, has by far the greatest concentration, suggesting that the Alafia River is a major source of PO4 to Hillsborough Bay.

CBOD5 (Figure 34):
Station EPC52 had the highest mean CBOD5 concentration. All COT compliance stations had CBOD5 concentrations within or below one standard error of the mean (1 SE) of the EPC stations.

Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter.

DO (Figures 35, 36 and 37):
Stations EPC52 and COT17generally had the highest mean DO concentrations and the lowest concentrations were found at stations COT15 and EPC2. However, DO concentrations at compliance station COT15 was not statistically different from concentrations found at station EPC2 located at the mouth of the Hillsborough River. Therefore, the relatively low DO concentrations found at compliance station COT15 may have been impacted by discharges of low DO water from the Hillsborough River. In addition, the time of sampling affects the comparison of DO concentrations. The three compliance stations are sampled, in accordance with the study plan, near sunrise when DO concentrations generally are at the lowest daily levels. The EPC stations are most often sampled several hours later (EPC52 up to seven hours later) when DO concentration can be expected to be closer to their diurnal maximum.

CHLA (Figure 38):
Station EPC52 had the highest mean CHLA concentration and the lowest concentration was found at station COT15. All COT compliance stations had CHLA concentrations within one standard error of the mean (1 SE) of all EPC stations. Discharges from the Howard F. Curren WWTP do not appear to have a significant impact on this parameter.

Long-Term Trends of Tampa Bay Water Quality and Biological Indicators Sampled by the COT

Results from the long-term, multi-disciplinary, COT water quality and biological indicator monitoring program are discussed in the text below and illustrated in Figures 39 through 45. The parameters SD, DO, CHLA, phytoplankton production rates, the blue-green alga Schizothrix calcicola *sensu* Drouet filament concentrations and total phytoplankton cell concentrations are presented as annual averages for the study period for two stations located in Hillsborough Bay (COT4 and COT12) and one station located in Middle Tampa Bay (COT13; see Figure 3). It should be noted that the annual average for the blue-green alga is calculated as the average concentration for the period it is present in the samples. Drift macro-algae biomass is shown as the annual average biomass for each of the five transects in Hillsborough Bay (see Figure 4).

The growth of submerged seagrass and the attached benthic alga Caulerpa prolifera in Hillsborough Bay was discussed in the COT report submitted to FDEP on March 1, 1999.

SD (Figure 39):
SD depth increased at station COT13 in the Middle Tampa Bay from approximately 2m in the early 1980's to a depth between 2.5m and 3m for the period 1985 through 1997. In 1998, however, SD was substantially reduced in this bay segment to about 2m. A long-term trend is not apparent for the Hillsborough Bay stations COT4 and COT12. Although major reductions of phytoplankton biomass (CHLA) have occurred both in Middle Tampa Bay and Hillsborough Bay during the study period (see Figure 41), these reductions are not reflected in the Hillsborough Bay SD trend. Apparently, other factors such as sediment resuspension are important in influencing water column light penetration (SD) in Hillsborough Bay.

DO (Figure 40):
SDO and BDO concentrations generally declined over the period 1986 to 1990. Concentrations have remained relatively stable since 1990 at all stations except at COT4B and COT12B where recent decreases have occurred.

CHLA (Figure 41):
Surface CHLA concentrations were relatively high from 1979 through 1982, however, concentrations decreased sharply in 1983 for stations COT4 and COT12 and for station COT13 in 1985. This decline continued to 1989 when average annual concentrations of approximately 15, 10 and 6ug/l were recorded for stations COT4, COT12 and COT13, respectively. Following 1989, CHLA concentrations remained relatively constant until increases in 1995. In 1996 and 1997, CHLA concentrations for stations COT12 and COT13 were near 1989 levels, however, station COT4 concentrations for this period were substantially below the 1989 level. In 1998, CHLA concentrations increased slightly at the three stations. The current CHLA concentrations are very low in comparison to concentrations found during the late 1970's and early 1980's, indicating that eutrophic conditions in Tampa Bay have been greatly reduced.

Phytoplankton Production (Figure 42):
Annual primary production rates decreased almost steadily at all three stations from near 250 $mgC/m^2/hr$ in the early 1980's to less than 100 $mgC/m^2/hr$ in 1992. Rates have increased slightly since 1992, however, they are still very low in comparison to production rates from the early 1980's. Similar to CHLA, the large reduction in phytoplankton production seen over the study period indicates that eutrophic conditions in Tampa Bay have been greatly reduced or eliminated.

Schizothrix calcicola *sensu* Drouet Abundance (Figure 43):
The abundance of this blue-green alga has decreased substantially since 1983. Concentrations during the last 15 years have been approximately one-third or less of the pre-1984 levels. This blue-green was virtually absent from Hillsborough Bay and Middle Tampa Bay in 1996 and 1998.

Total Phytoplankton Abundance (Figure 44):
A long-term trend of decreasing total phytoplankton abundance is evident for all three stations. The Hillsborough Bay stations have almost consistently higher cell concentrations than the Middle Tampa Bay station. Peak concentrations of phytoplankton abundance for the Hillsborough Bay stations COT4 and COT12 occurred in 1987, the same year ambient Hillsborough Bay TN concentrations, were high (see Figure 19). The 1993 cell concentration was the lowest recorded concentration during the entire sampling program. Phytoplankton abundance increased from 1993 to 1996 at all three stations. Abundance in 1997 and 1998, however, was lower than during the recent peak in 1996.

Macro-Algae Standing Crop (Figure 45):
The long-term record of drift macro-algae biomass shows that transect B in northeastern Hillsborough Bay and transect E in northwestern Hillsborough Bay generally have higher average drift macro-algae accumulations than the other three transects. It is also apparent that the current Hillsborough Bay macro-algae biomass is at a study record low and that several transects consistently lack macro-algae biomass.

DISCUSSION

There are no indications, either from the compliance monitoring program or from the comparison between the COT compliance monitoring stations and the group of EPC stations close to the discharge site, that the discharge from the Howard F. Curren WWTP, during the year 1998, had a negative impact on water quality and biological indicators in Hillsborough Bay.

Long-term trends of water quality and biological indicators monitored in Hillsborough Bay by both the EPC and the COT programs have shown substantial improvements during the last decade. It is apparent that several important indicators of estuarine health, such as CHLA, blue-green alga abundance and seagrass growth (discussed in the report submitted to FDEP on March 1, 1999), have improved since the Howard F. Curren WWTP converted from primary treatment to AWT in 1979. These findings agree with the recently acquired understanding of the nutrient, specifically nitrogen, loading history of Hillsborough Bay (Johansson 1991).

Statistical relationships have been developed between external nitrogen loading to Hillsborough Bay and the response of phytoplankton biomass (Johansson 1991; Wade and Janicki 1995). These relationships suggest that the reduction in external nitrogen loading to the bay that occurred when the Howard F. Curren WWTP converted from primary treatment to AWT caused a substantial reduction of phytoplankton biomass in Hillsborough Bay. Therefore, the conversion of the Howard F. Curren WWTP from primary treatment to AWT has, without doubt, had a substantial beneficial long-term effect on water quality and biological indicators in Hillsborough Bay. Further, it is reasonable to assume that the recent water quality improvements seen in other major sections of Tampa Bay (Boler 1992), such as Middle Tampa Bay and Lower Tampa Bay, are at least partly related to the conversion of the Howard F. Curren WWTP.

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Boler, R. 1992. Surface water quality, 1990-1991. Hillsborough County, Florida. Hillsborough County Environmental Protection Commission.

Johansson, J.O.R. 1991. Long-term trends of nitrogen loading, water quality and biological indicators in Hillsborough Bay, Florida. pp. 157-176. In: Treat, S.F. and P.A. Clark (eds.), Proceedings, Tampa Bay Area Scientific Information Symposium 2. 1991 Feb. 27 - March 1; Tampa, FL. Text, Tampa, Fl.

Wade, D. and A.J. Janicki. 1995. Estimating critical nitrogen loads for the Tampa Bay estuary: An empirically based approach to setting management targets. Tampa Bay National Estuary Program, Tech. Publ. #03-95.

Table 1. Summary statistics for COT compliance monitoring stations and selected EPC monitoring stations in the upper portion of Hillsborough Bay for the year 1998.

STATION	STATISTICS	TN	TKN	TP	PO4	SDO	MDO	BDO	CBOD5	CHLA
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l
COT15	N of cases	12	12	12	11	12	12	12	12	12
	Minimum	0.57	0.55	0.27	0.20	3.23	1.67	1.01	0.50	4.08
	Maximum	1.03	0.94	0.55	0.41	9.17	8.69	6.88	2.25	28.83
	Mean	0.85	0.79	0.40	0.30	5.86	5.31	4.42	1.45	15.58
	Standard Dev	0.13	0.12	0.10	0.06	1.73	2.31	2.11	0.57	7.52
COT16	N of cases	12	12	12	12	12	12	12	12	12
	Minimum	0.48	0.46	0.28	0.18	3.74	3.02	0.42	0.70	3.68
	Maximum	1.20	1.04	0.57	0.48	9.74	9.71	7.54	3.55	36.59
	Mean	0.85	0.80	0.42	0.32	6.28	5.92	4.54	1.57	18.52
	Standard Dev	0.20	0.18	0.09	0.09	1.80	2.05	2.54	0.82	10.50
COT17	N of cases	12	12	12	12	12	12	12	12	12
	Minimum	0.60	0.58	0.29	0.17	4.66	4.62	3.21	0.50	6.34
	Maximum	1.29	1.13	0.58	0.42	9.81	9.76	8.42	5.10	45.65
	Mean	0.84	0.80	0.41	0.30	6.67	6.58	5.93	1.81	21.01
	Standard Dev	0.20	0.16	0.08	0.07	1.75	1.72	1.79	1.26	11.37
EPC2	N of cases	12	12	12	12	12	12	12	12	11
	Minimum	0.51	0.50	0.18	0.15	2.70	0.10	0.30	1.00	3.47
	Maximum	1.29	1.14	0.40	0.32	8.30	7.40	7.90	4.80	35.58
	Mean	0.90	0.83	0.33	0.26	5.53	4.42	3.80	1.82	18.52
	Standard Dev	0.23	0.19	0.07	0.06	1.75	2.41	2.40	1.02	10.51
EPC52	N of cases	12	12	12	12	12	12	12	12	12
	Minimum	0.45	0.44	0.21	0.18	6.20	2.40	2.70	0.90	6.69
	Maximum	1.59	1.59	0.62	0.51	11.00	10.80	7.60	11.30	119.53
	Mean	0.84	0.80	0.42	0.32	8.24	6.98	5.36	2.80	24.96
	Standard Dev	0.30	0.29	0.12	0.08	1.29	2.25	1.74	2.83	30.81
EPC6	N of cases	0	12	12	12	12	12	12	12	12
	Minimum		0.56	0.22	0.17	5.40	4.40	2.10	0.90	5.14
	Maximum		1.02	0.57	0.38	8.60	8.40	7.90	5.10	49.99
	Mean		0.79	0.41	0.30	6.86	6.55	5.50	1.95	18.29
	Standard Dev		0.15	0.10	0.06	1.17	1.27	1.76	1.07	13.47
EPC70	N of cases	12	12	12	12	12	12	12	4	12
	Minimum	0.61	0.60	0.25	0.19	3.50	2.00	1.00	1.10	6.59
	Maximum	1.27	1.25	0.69	0.42	8.30	8.30	8.00	2.50	52.69
	Mean	0.94	0.90	0.45	0.31	6.69	6.10	4.78	1.90	21.95
	Standard Dev	0.22	0.22	0.12	0.08	1.33	1.78	1.98	0.59	13.88

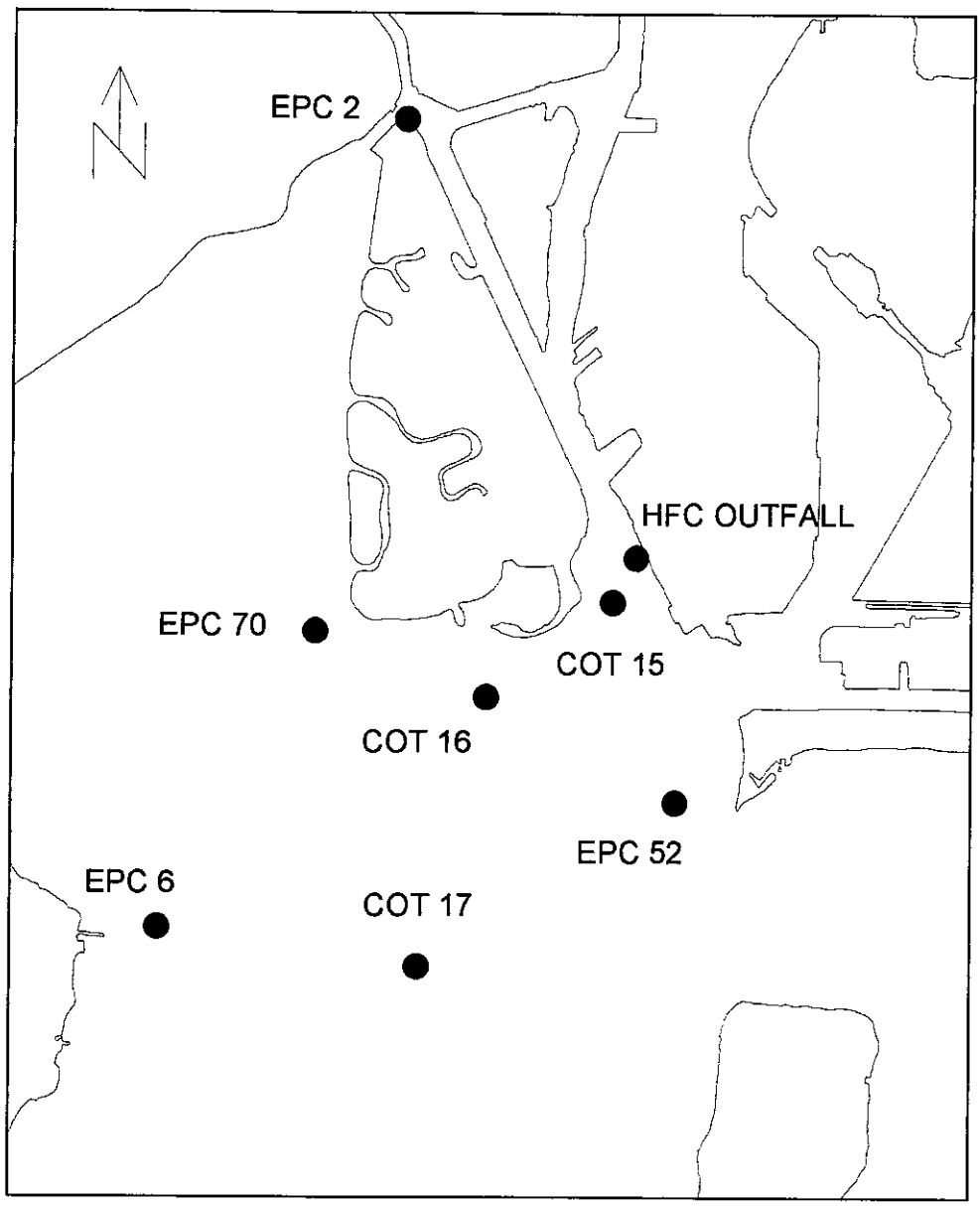

Figure 1. The Howard F. Curren WWTP discharge site, COT compliance monitoring stations and selected EPC stations in upper Hillsborough Bay.

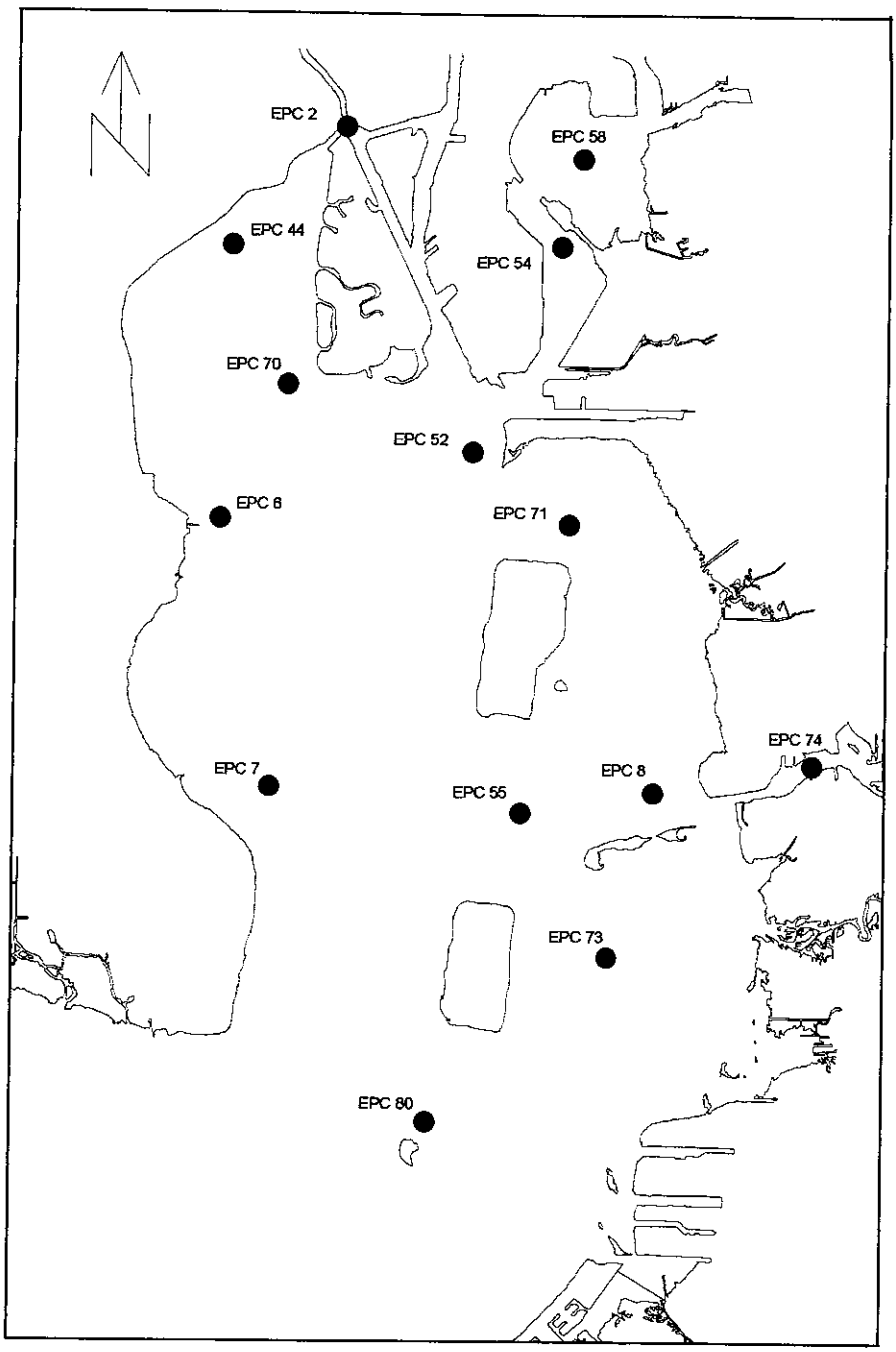

Figure 2. Water quality monitoring stations in Hillsborough Bay sampled by the EPC (modified from Boler 1992).

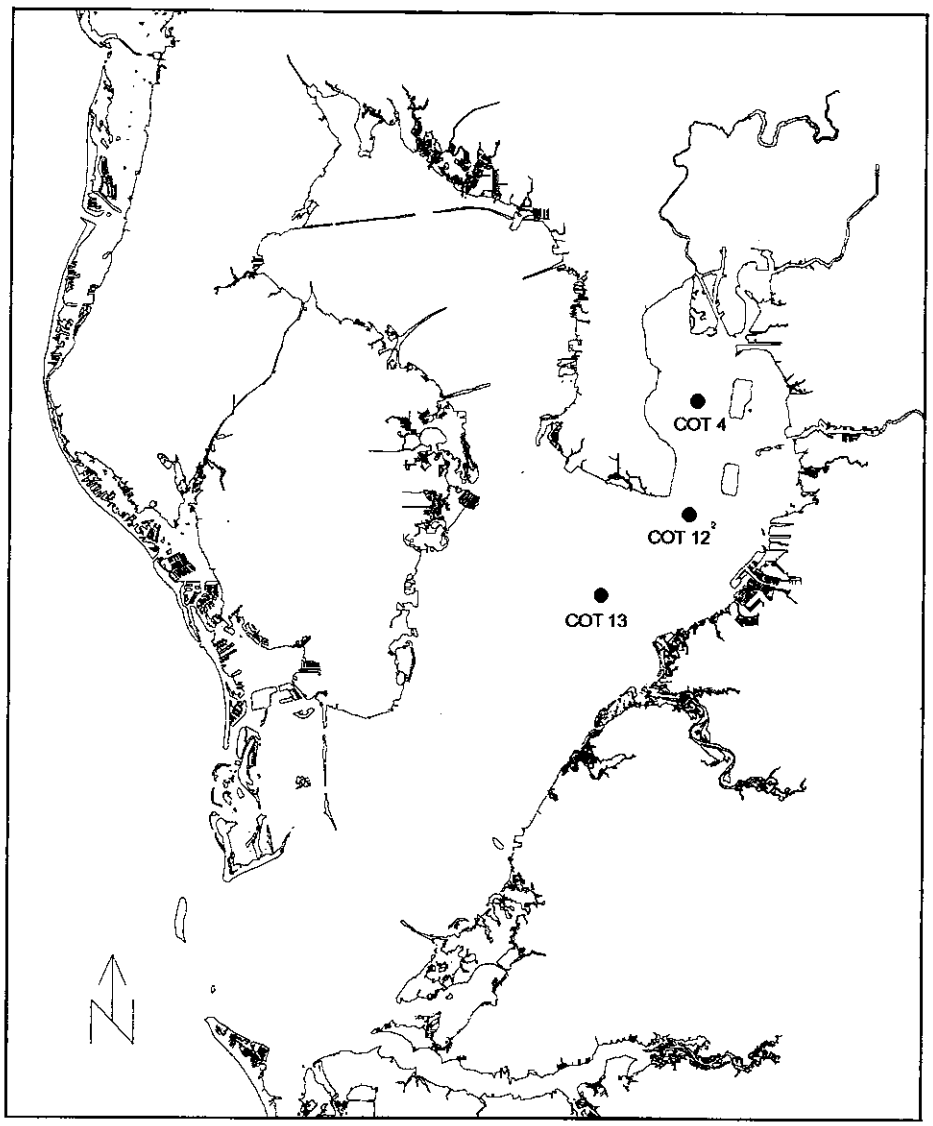

Figure 3. Water quality and phytoplankton monitoring stations in Tampa Bay sampled by the COT.

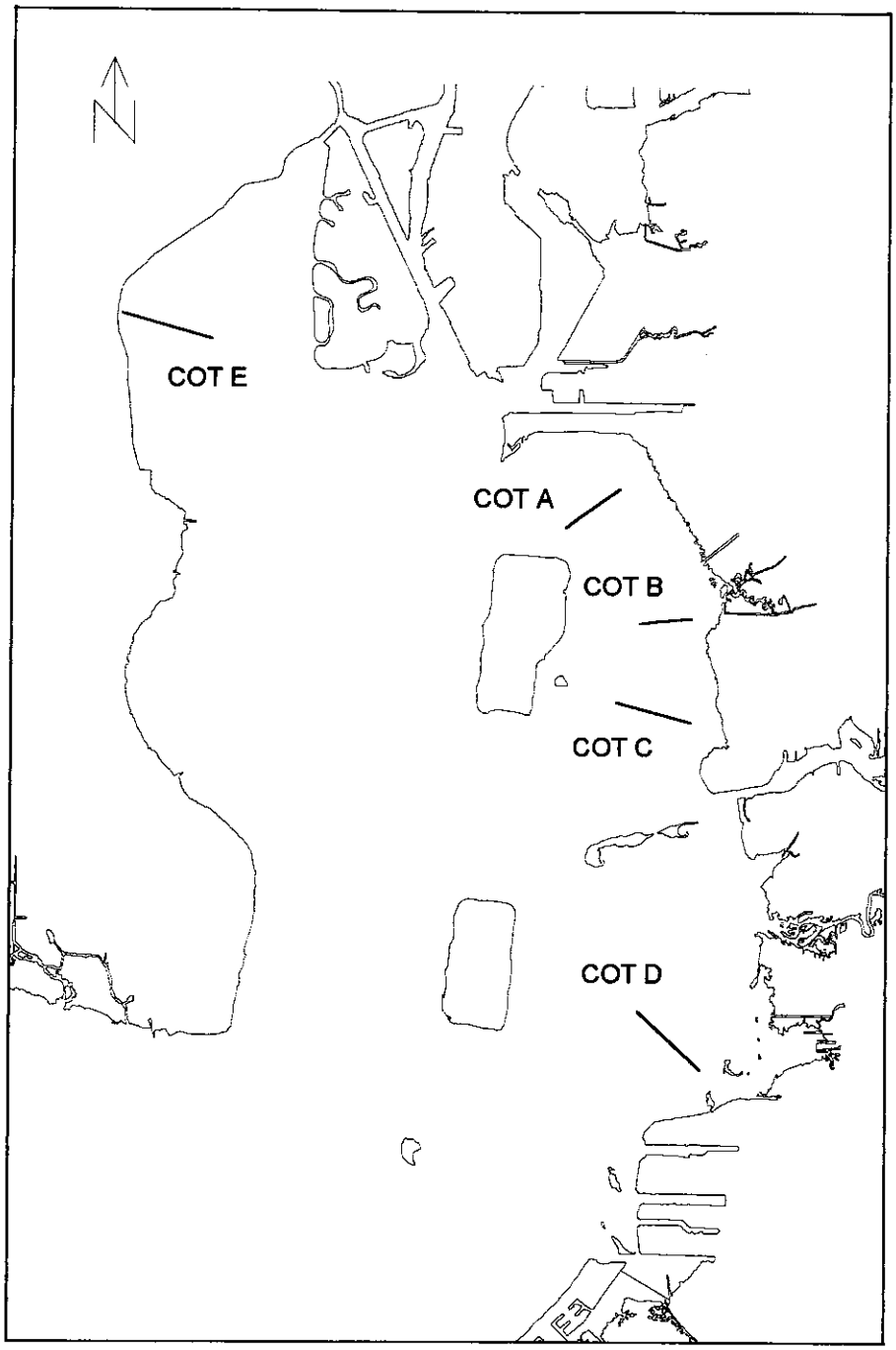

Figure 4. Macro-algae monitoring transects in Hillsborough Bay sampled by the COT.

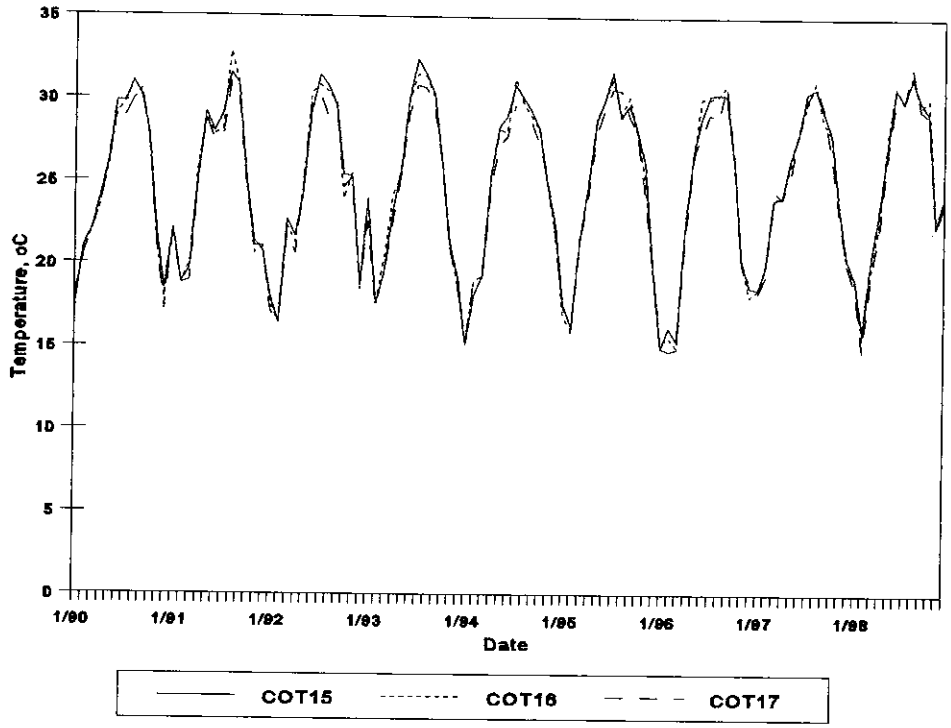

Figure 5. Monthly mid-depth temperatures at the COT compliance monitoring stations.

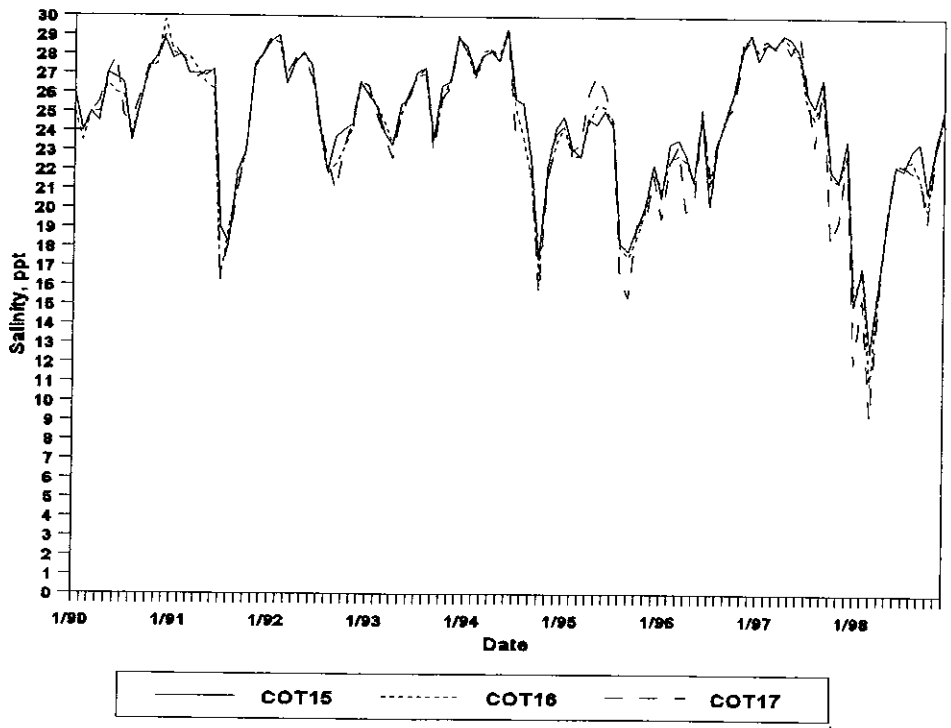

Figure 6. Monthly mid-depth salinities at the COT compliance monitoring stations.

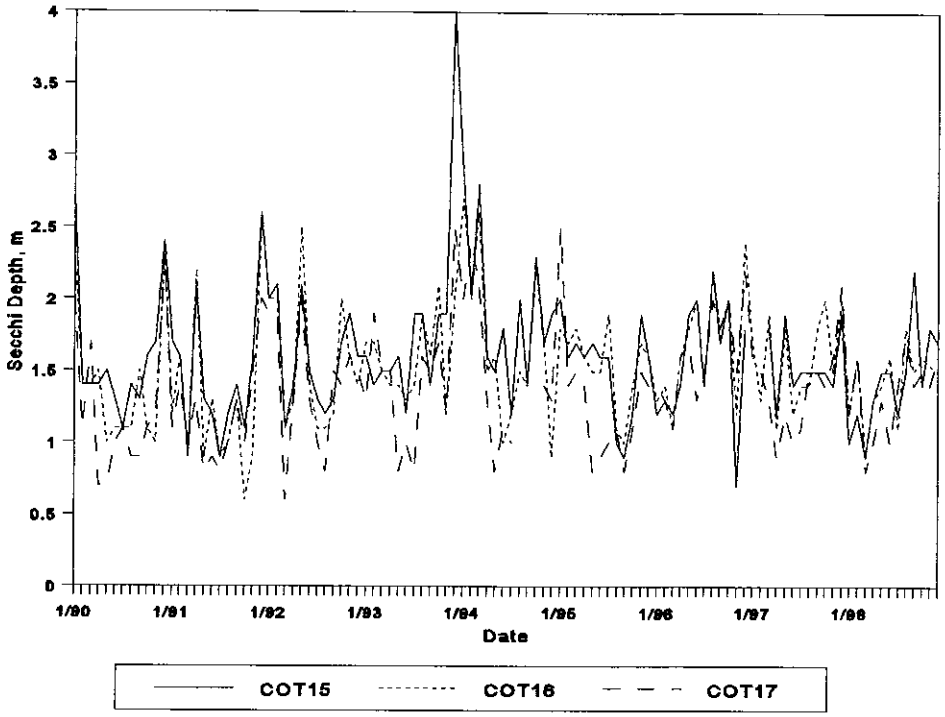

Figure 7. Monthly SD depths at the COT compliance monitoring stations.

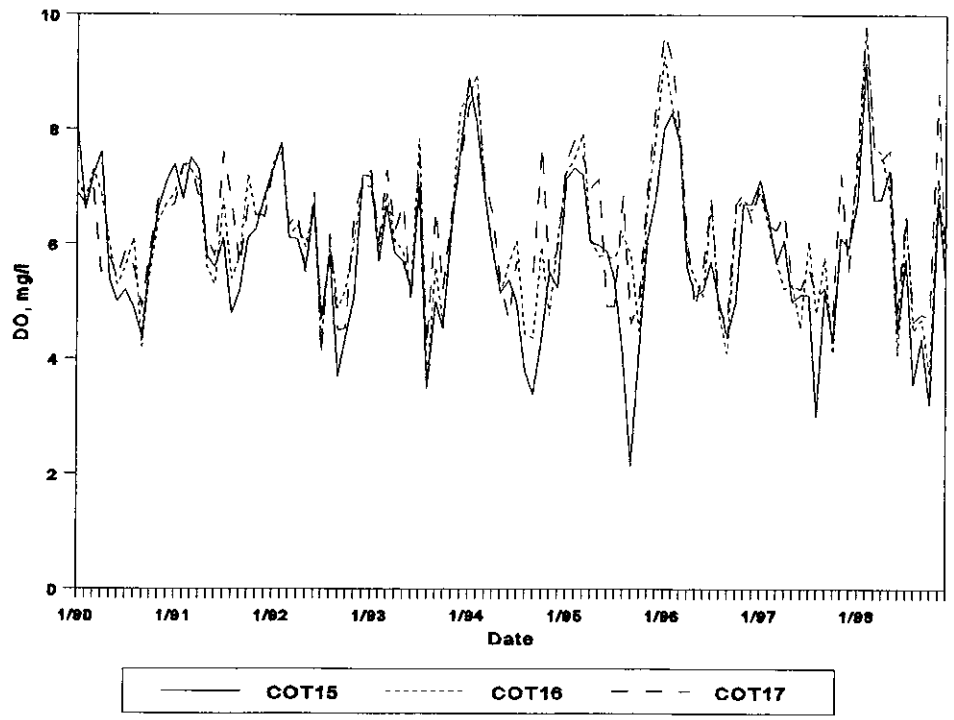

Figure 8. Monthly SDO concentrations at the COT compliance monitoring stations.

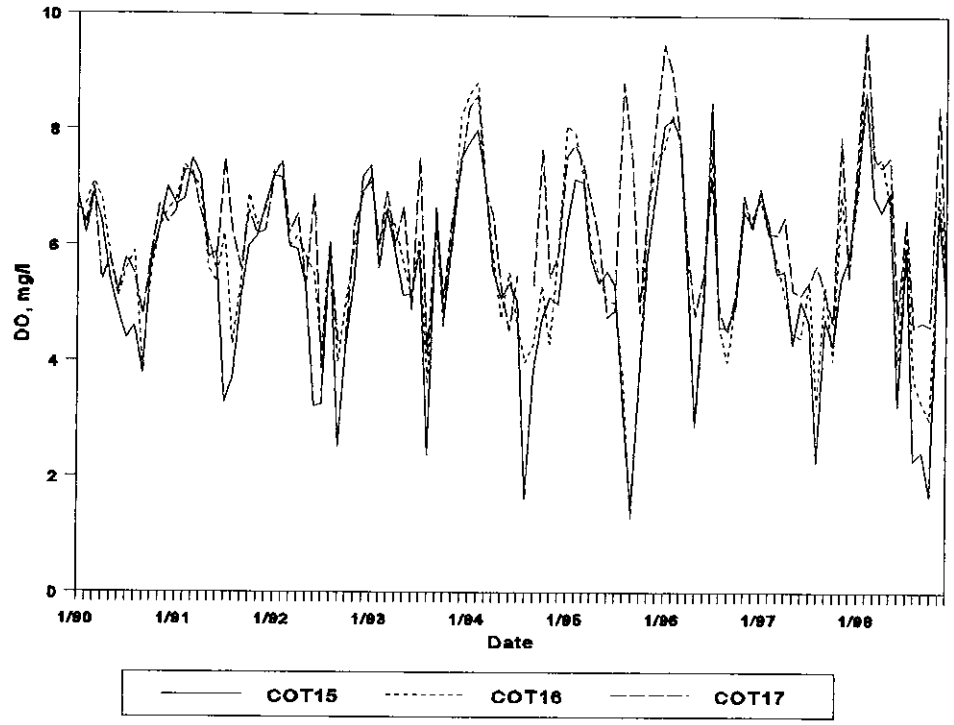

Figure 9. Monthly MDO concentrations at the COT compliance monitoring stations.

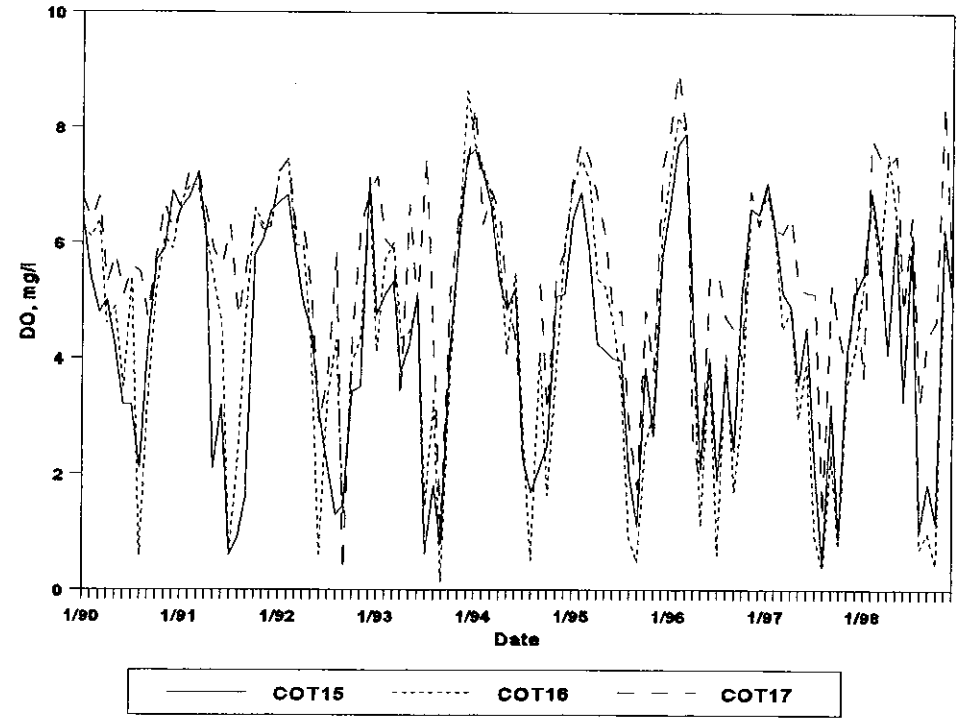

Figure 10. Monthly BDO concentrations at the COT compliance monitoring stations.

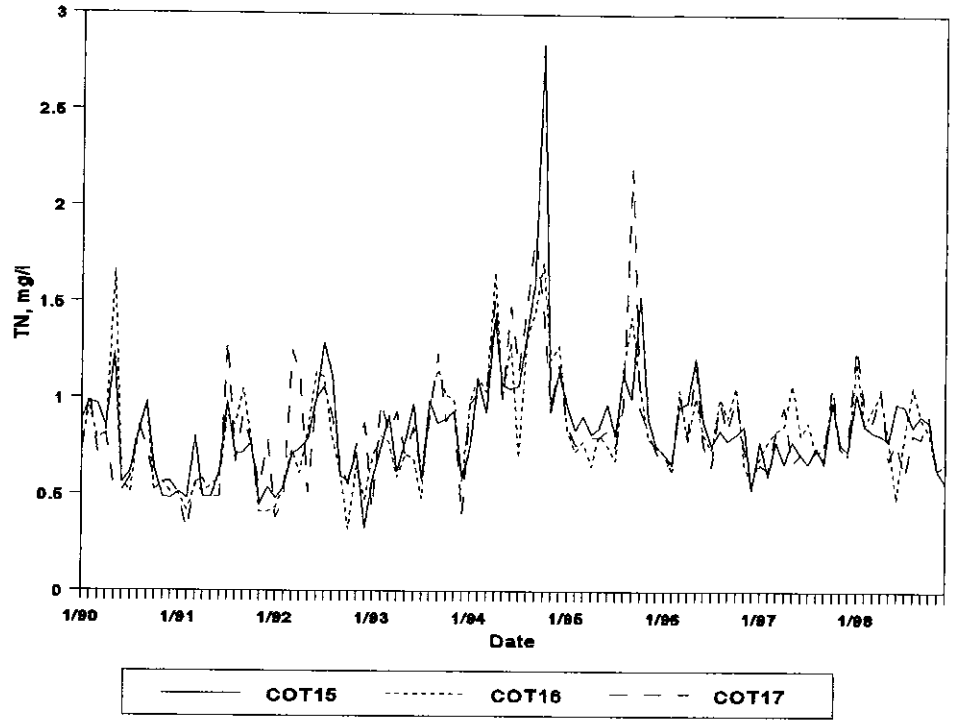

Figure 11. Monthly mid-depth TN concentrations at the COT compliance monitoring stations.

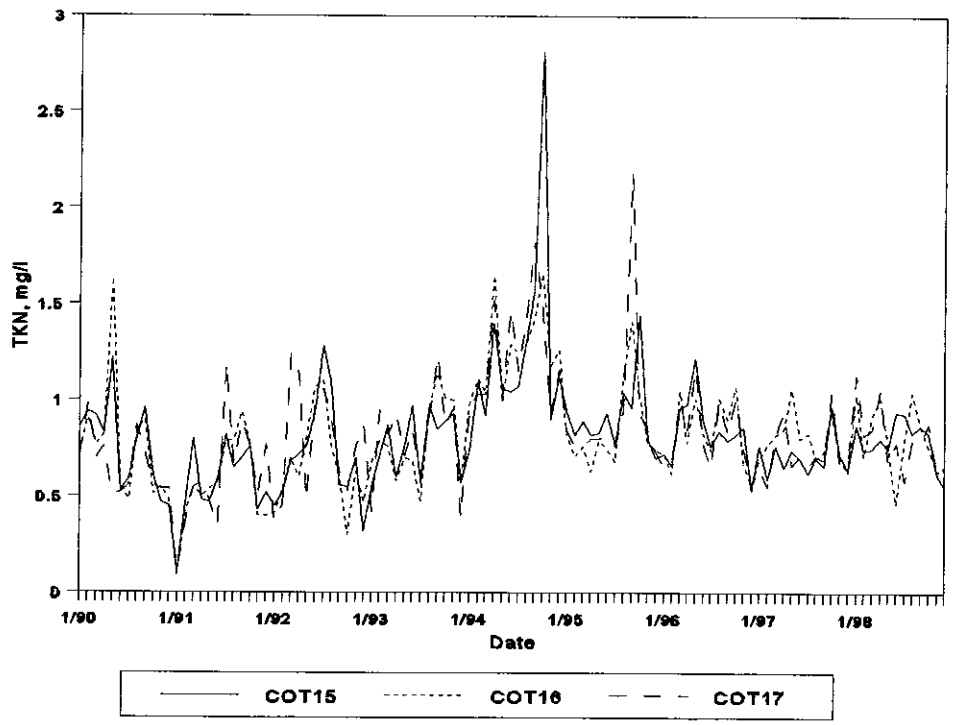

Figure 12. Monthly mid-depth TKN concentrations at the COT compliance monitoring stations.

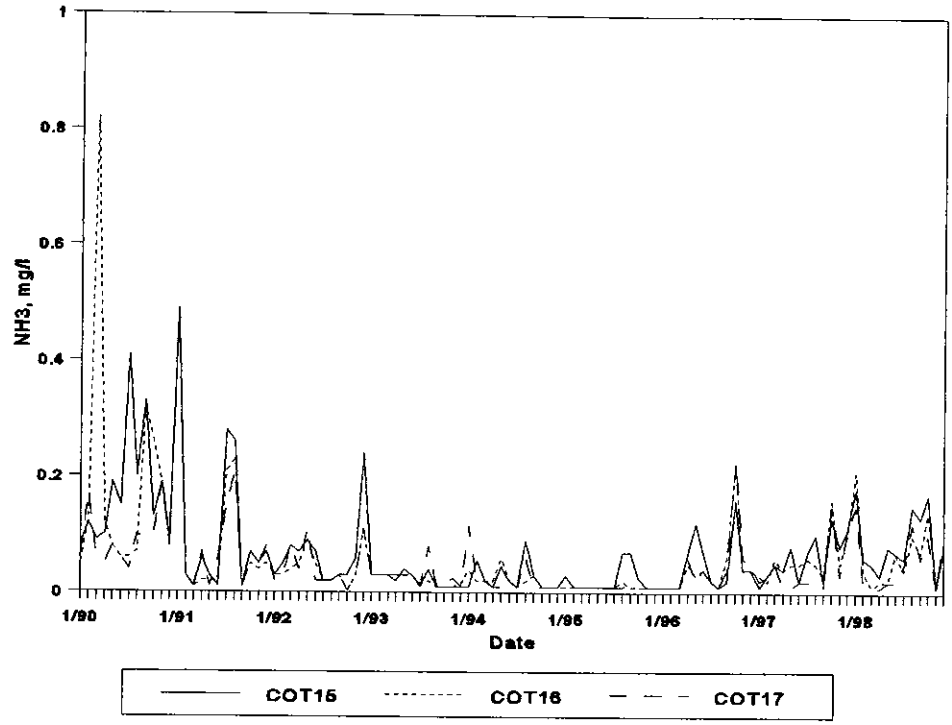

Figure 13. Monthly mid-depth NH3 concentrations at the COT compliance monitoring stations.

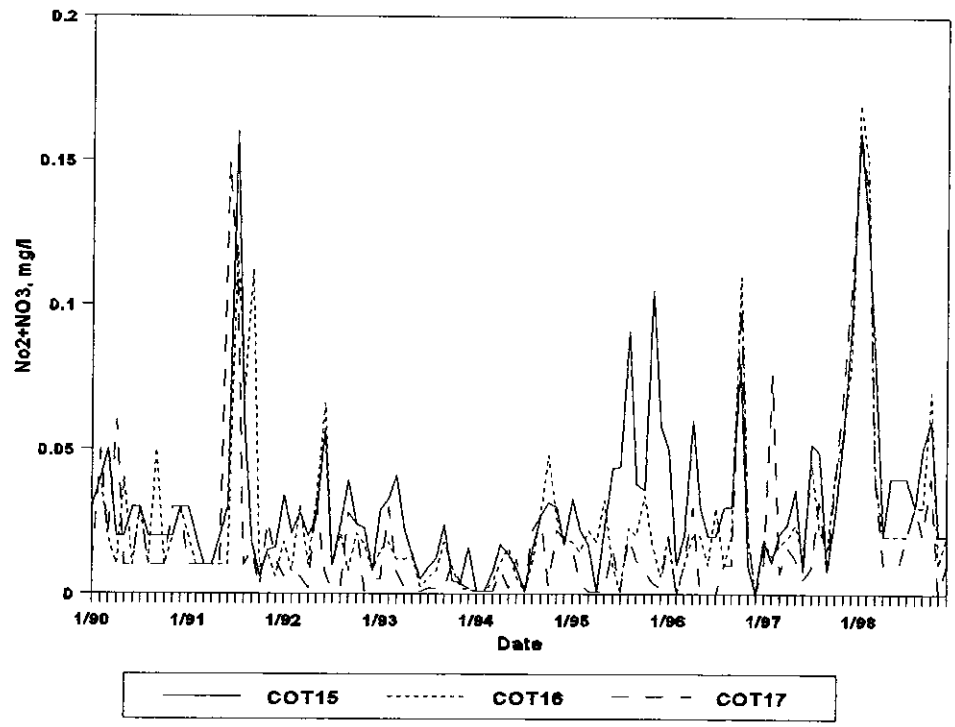

Figure 14. Monthly mid-depth NO2+NO3 concentrations at the COT compliance monitoring stations.

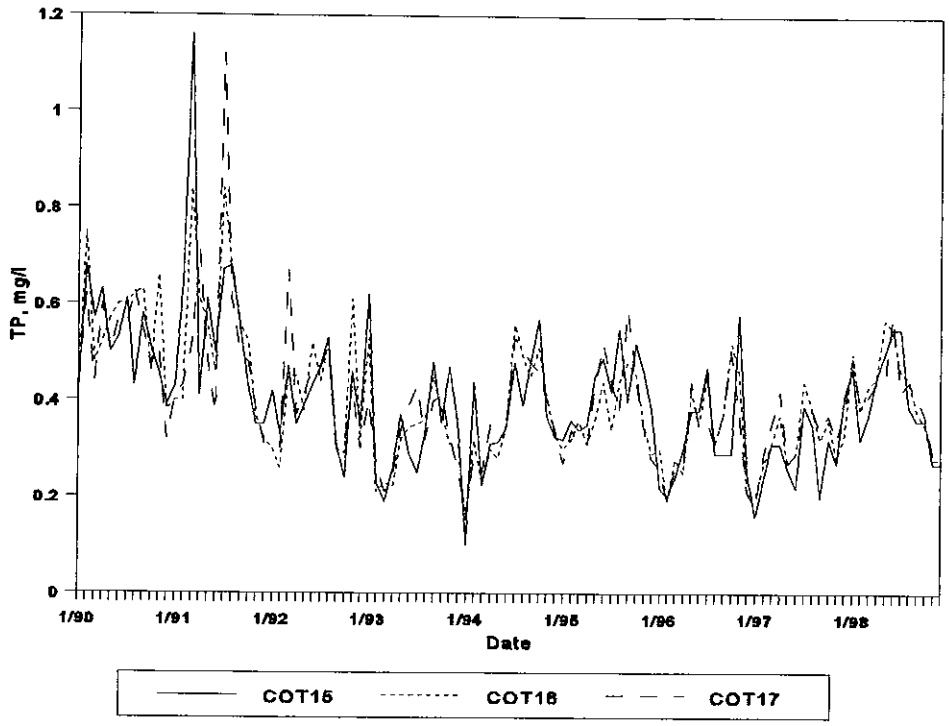

Figure 15. Monthly mid-depth TP concentrations at the COT compliance monitoring stations.

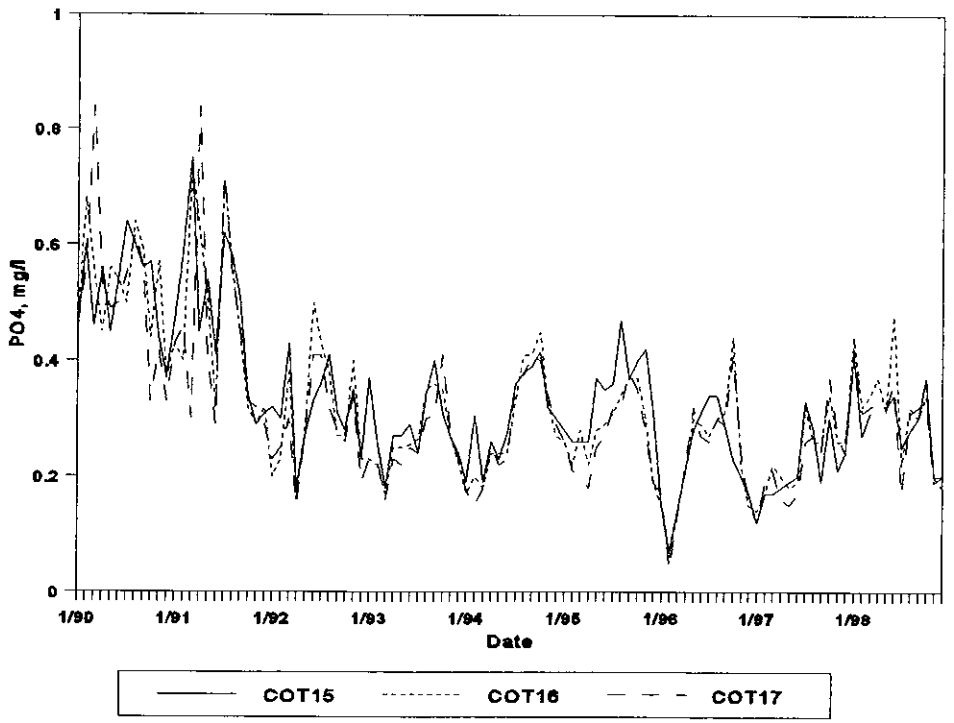

Figure 16. Monthly mid-depth PO4 concentrations at the COT compliance monitoring stations.

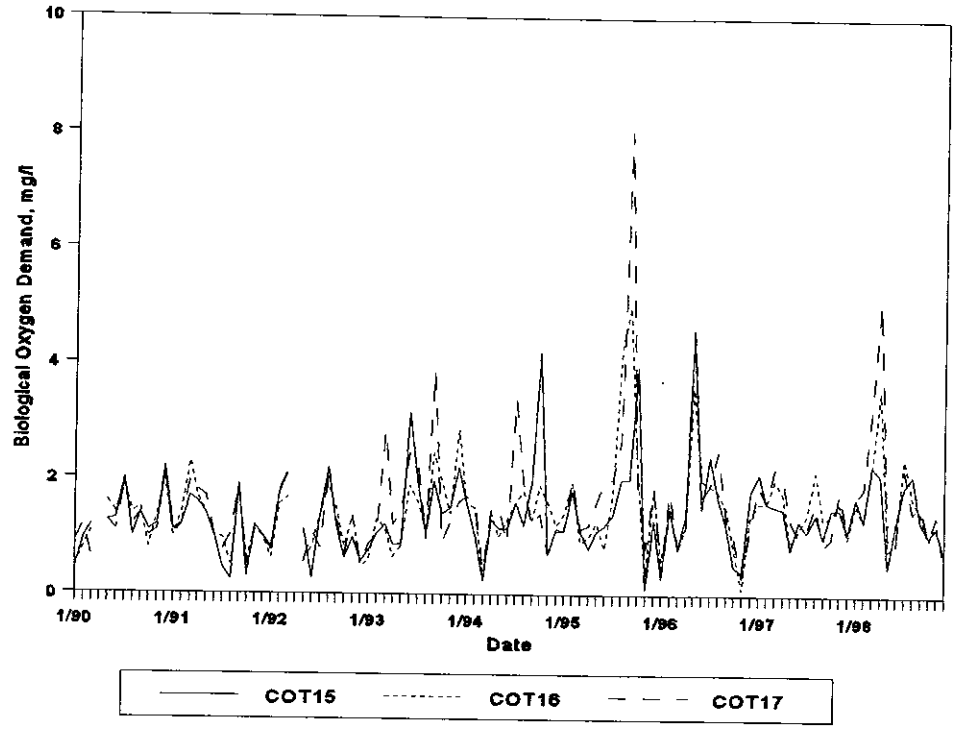

Figure 17. Monthly mid-depth CBOD5 concentrations at the COT compliance monitoring stations.

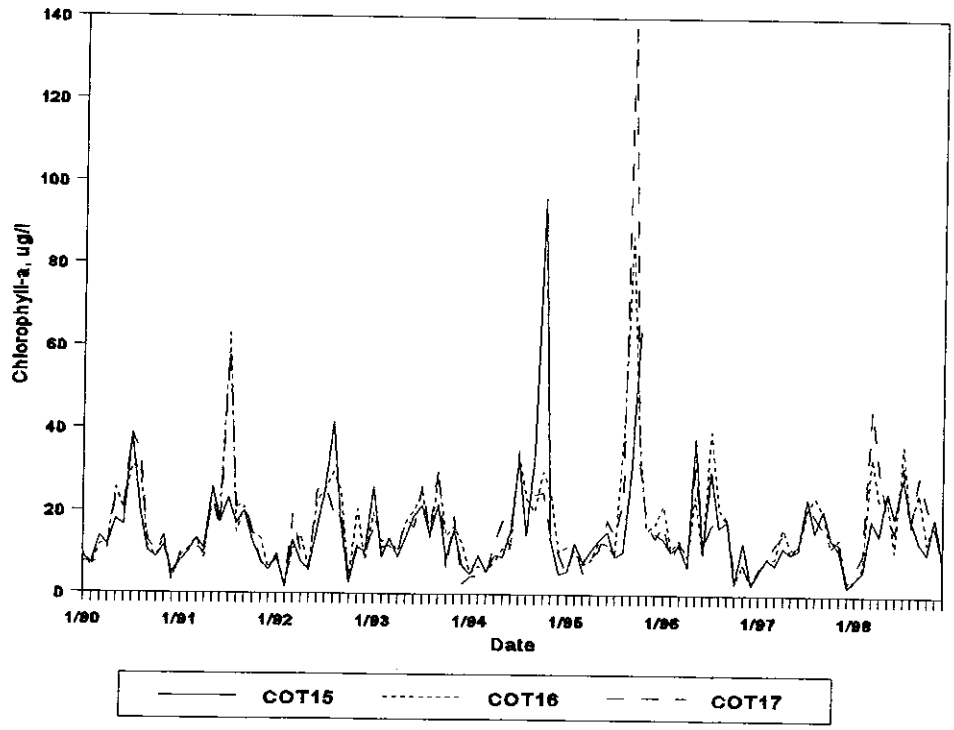

Figure 18. Monthly mid-depth CHLA concentrations at the COT compliance monitoring stations.

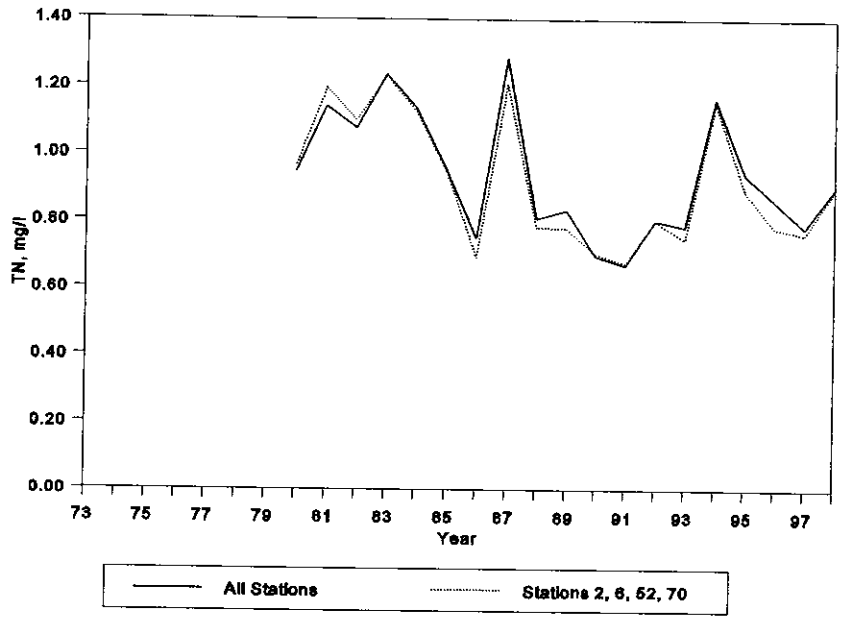

Figure 19. Long-term trend of TN concentrations for stations sampled in Hillsborough Bay by the EPC.

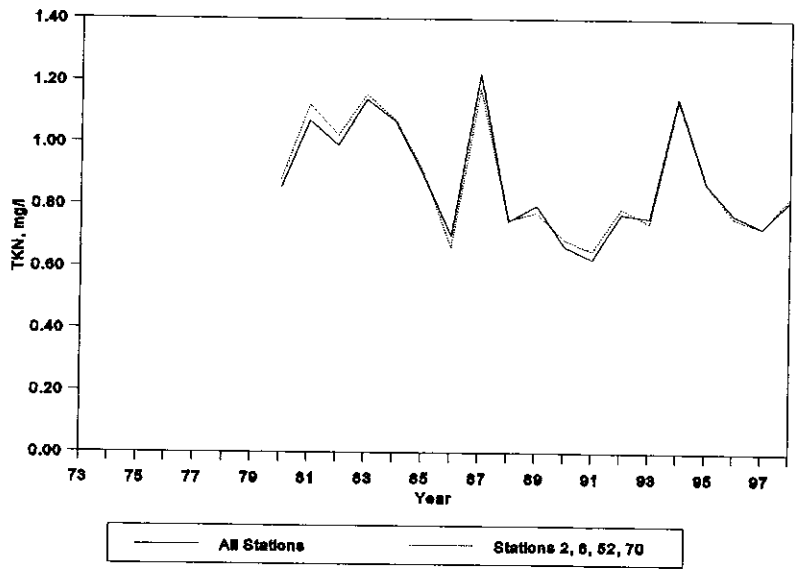

Figure 20. Long-term trend of TKN concentrations for stations sampled in Hillsborough Bay by the EPC.

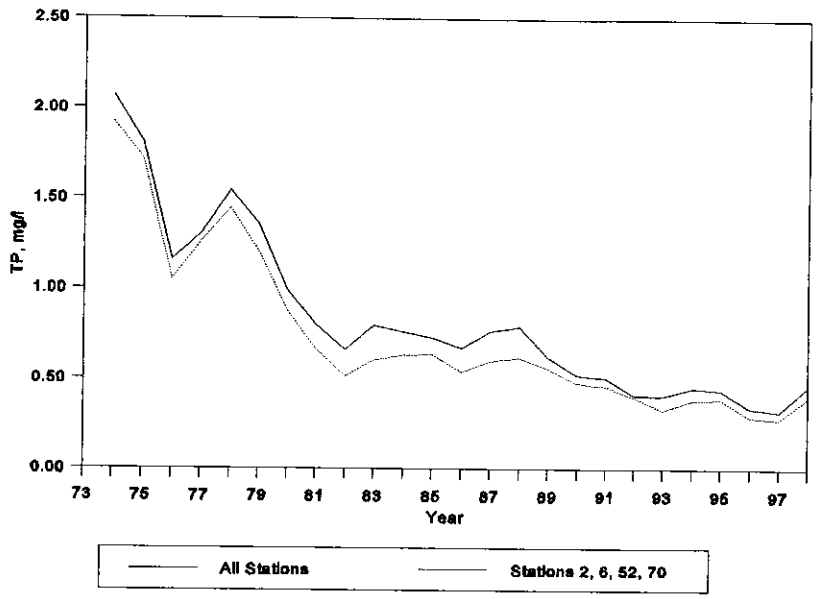

Figure 21. Long-term trend of TP concentrations for stations sampled in Hillsborough Bay by the EPC.

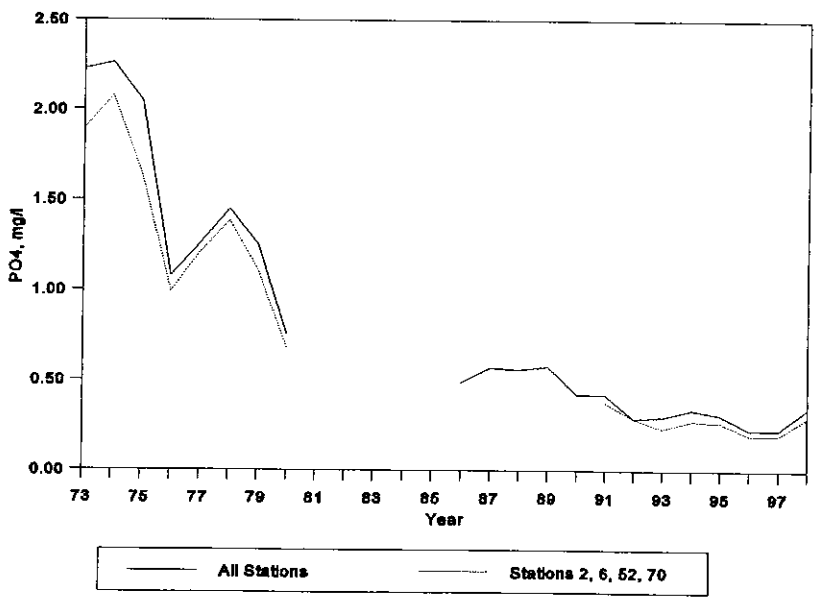

Figure 22. Long-term trend of PO4 concentrations for stations sampled in Hillsborough Bay by the EPC.

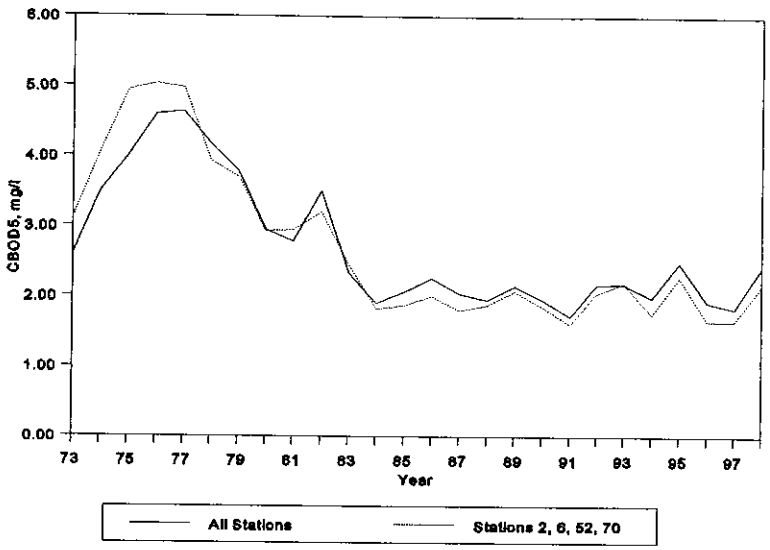

Figure 23. Long-term trend of CBOD5 concentrations for stations sampled in Hillsborough Bay by the EPC.

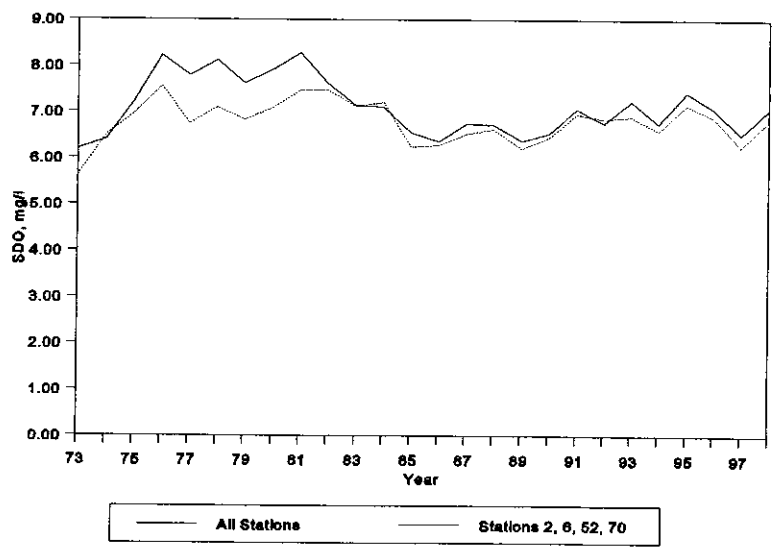

Figure 24. Long-term trend of SDO concentrations for stations sampled in Hillsborough Bay by the EPC.

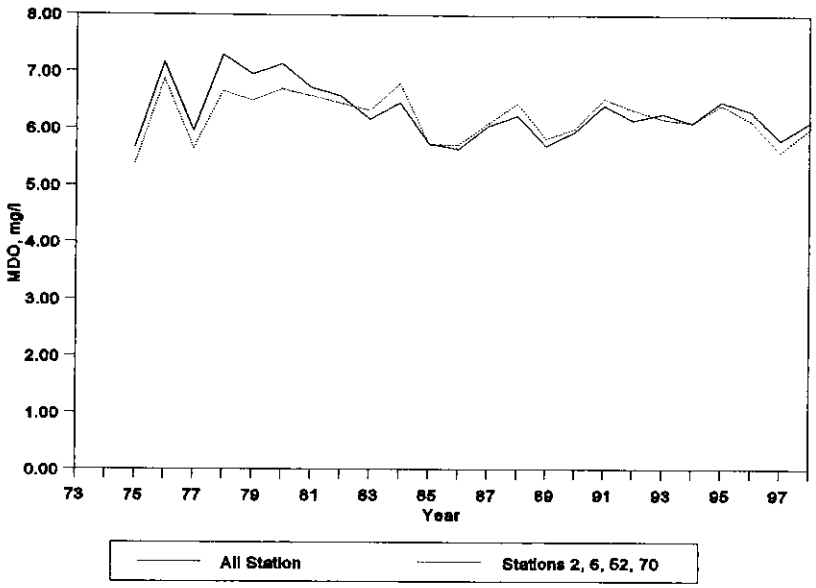

Figure 25. Long-term trend of MDO concentrations for stations sampled in Hillsborough Bay by the EPC.

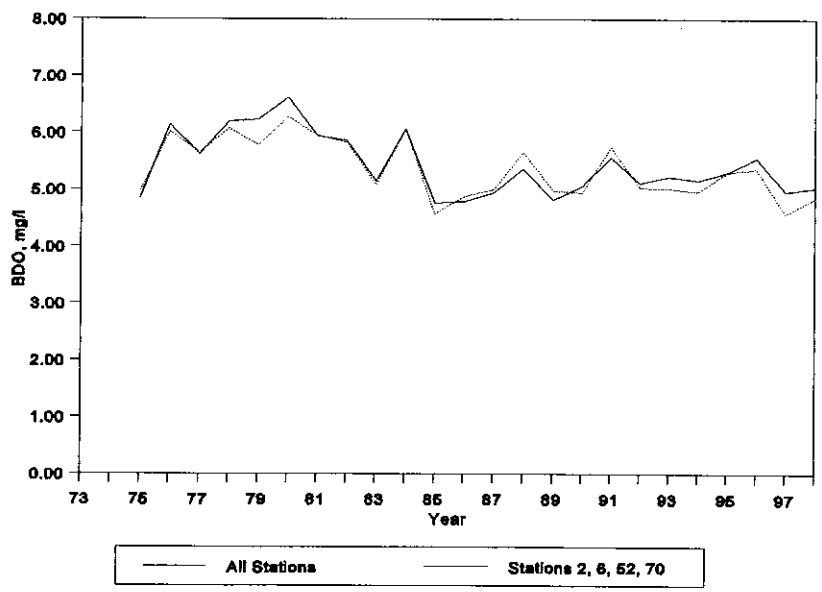

Figure 26. Long-term trend of BDO concentrations for stations sampled in Hillsborough Bay by the EPC.

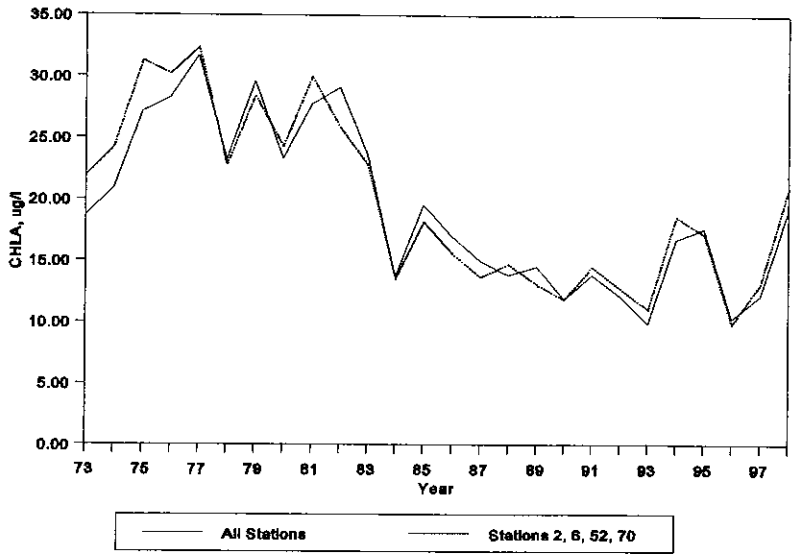

Figure 27. Long-term trend of CHLA concentrations for stations sampled in Hillsborough Bay by the EPC.

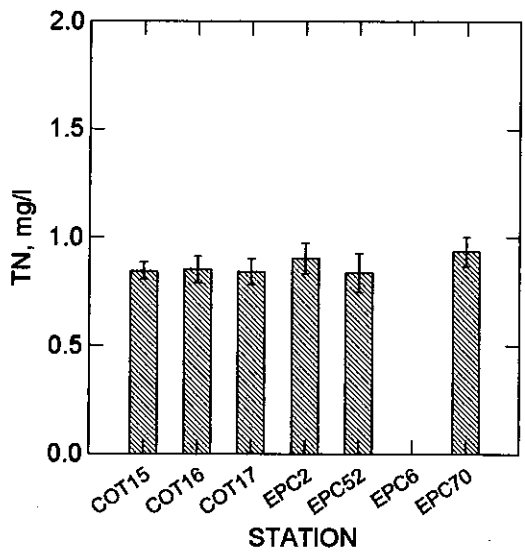

Figure 28. Comparison of mean values and standard errors for TN concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998. Data were not collected for EPC6.

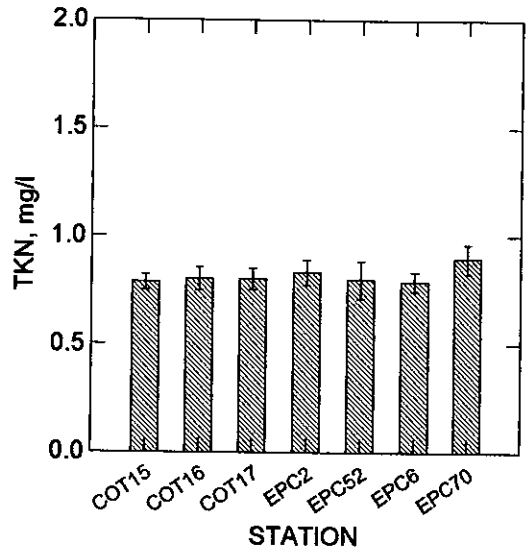

Figure 29. Comparison of mean values and standard errors for TKN concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

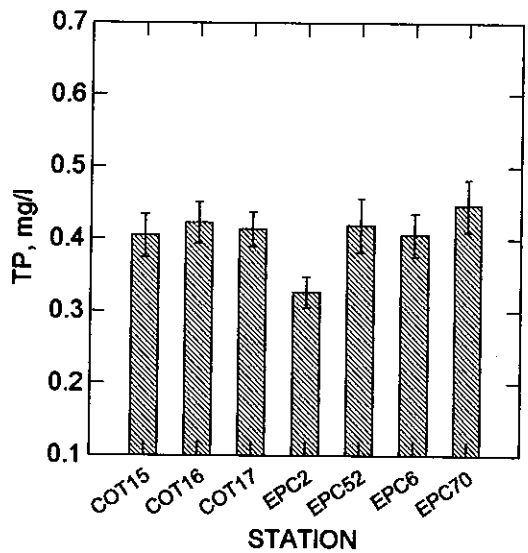

Figure 30. Comparison of mean values and standard errors for TP concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

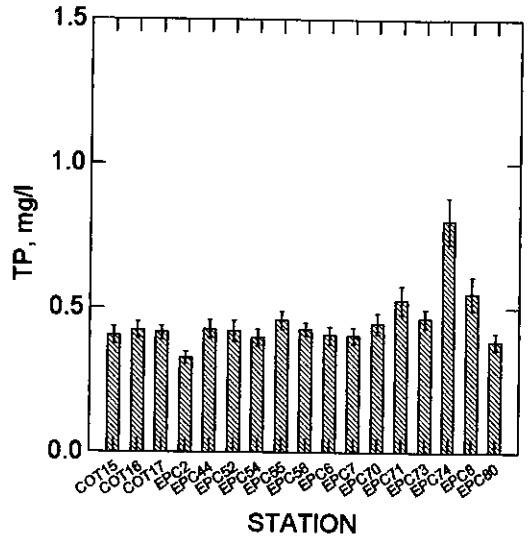

Figure 31. Comparison of mean values and standard errors for TP concentrations measured at the COT compliance monitoring stations and all EPC stations in Hillsborough Bay for the year 1998.

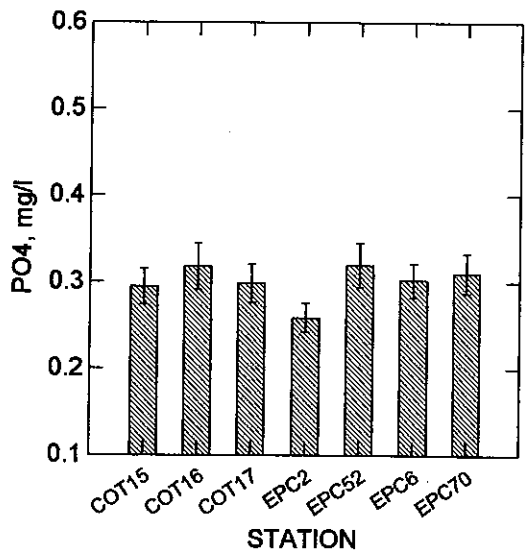

Figure 32. Comparison of mean values and standard errors for PO4 concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

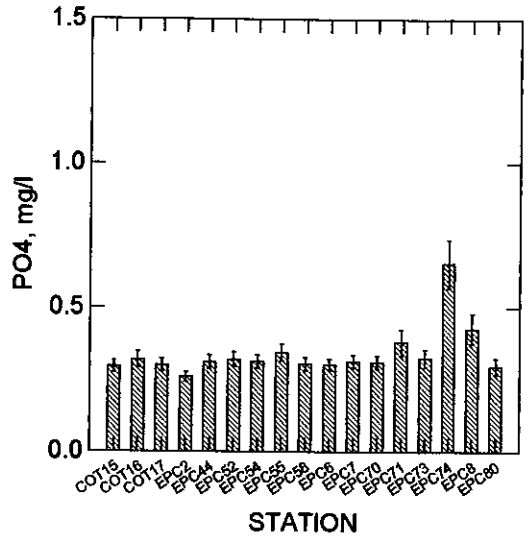

Figure 33. Comparison of mean values and standard errors for PO4 concentrations measured at the COT compliance monitoring stations and all EPC stations in Hillsborough Bay for the year 1998.

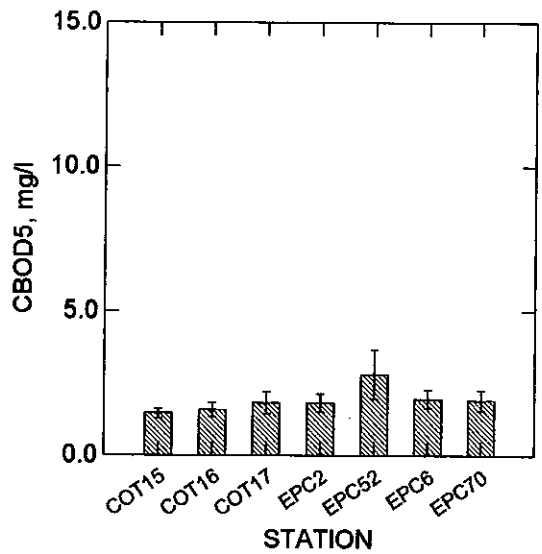

Figure 34. Comparison of mean values and standard errors for CBOD5 concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

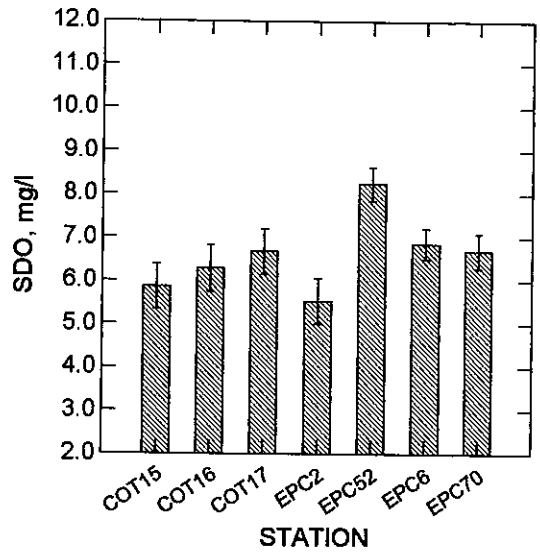

Figure 35. Comparison of mean values and standard errors for SDO concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

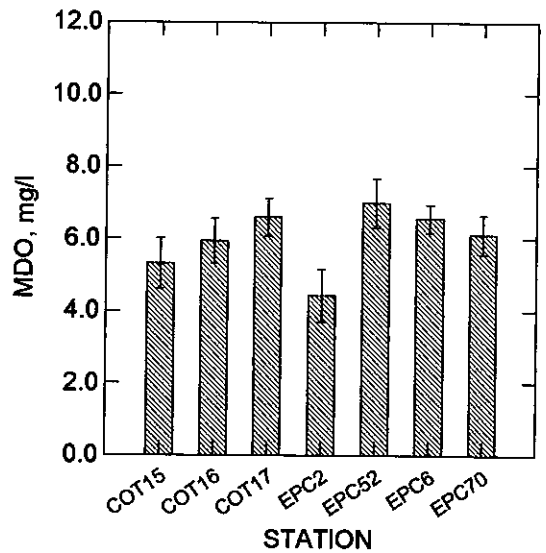

Figure 36. Comparison of mean values and standard errors for MDO concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

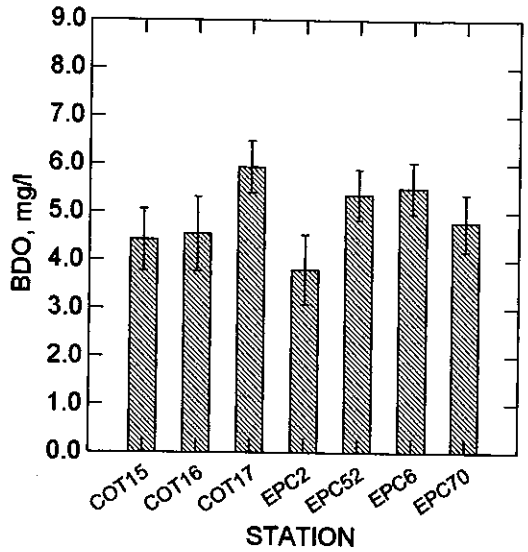

Figure 37. Comparison of mean values and standard errors for BDO concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

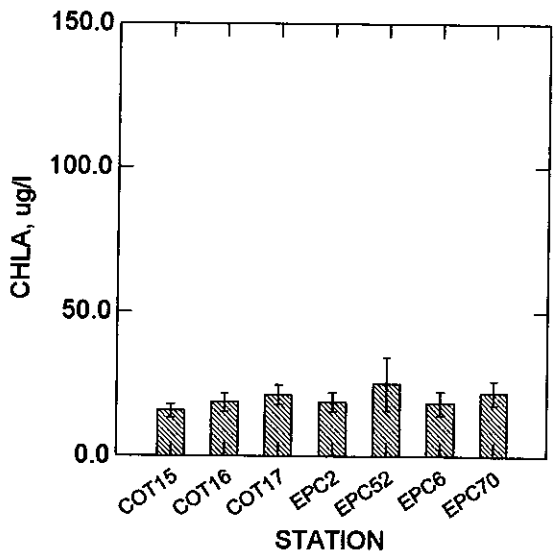

Figure 38. Comparison of mean values and standard errors for CHLA concentrations measured at the COT compliance monitoring stations and the group of EPC stations close to the Howard F. Curren WWTP discharge site for the year 1998.

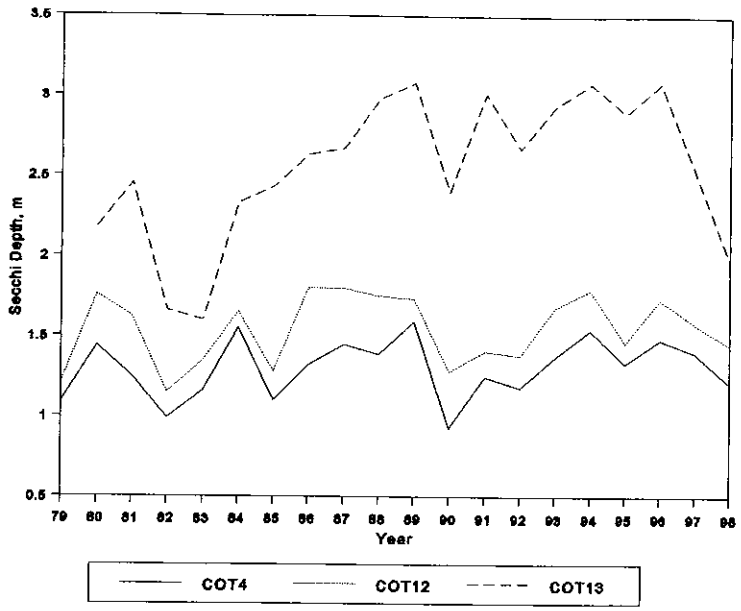

Figure 39. Long-term trend of SD depth by COT Tampa Bay.

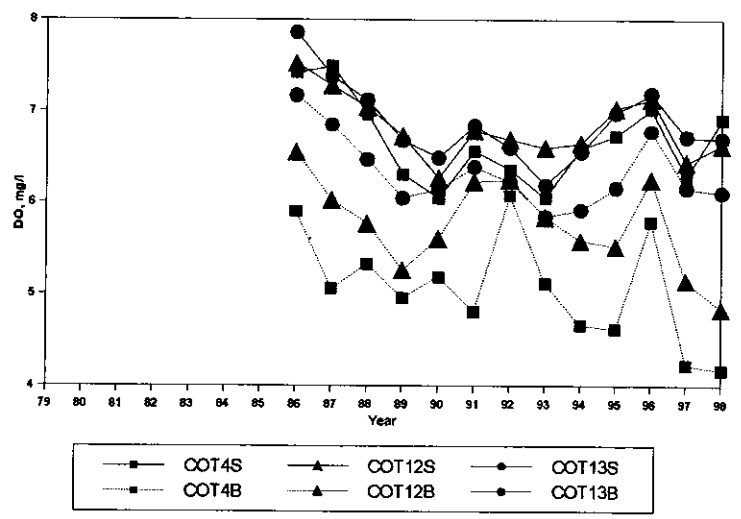

Figure 40. Long-term trend of DO concentrations measured by the COT in Tampa Bay.

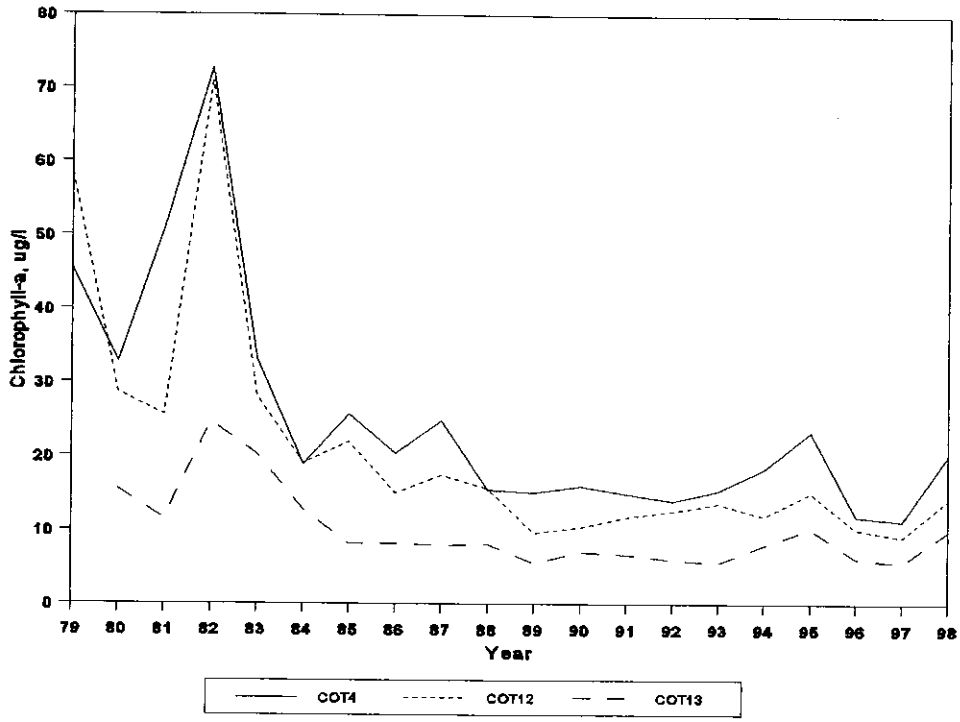

Figure 41. Long-term trend of surface CHLA concentrations measured by the COT in Tampa Bay.

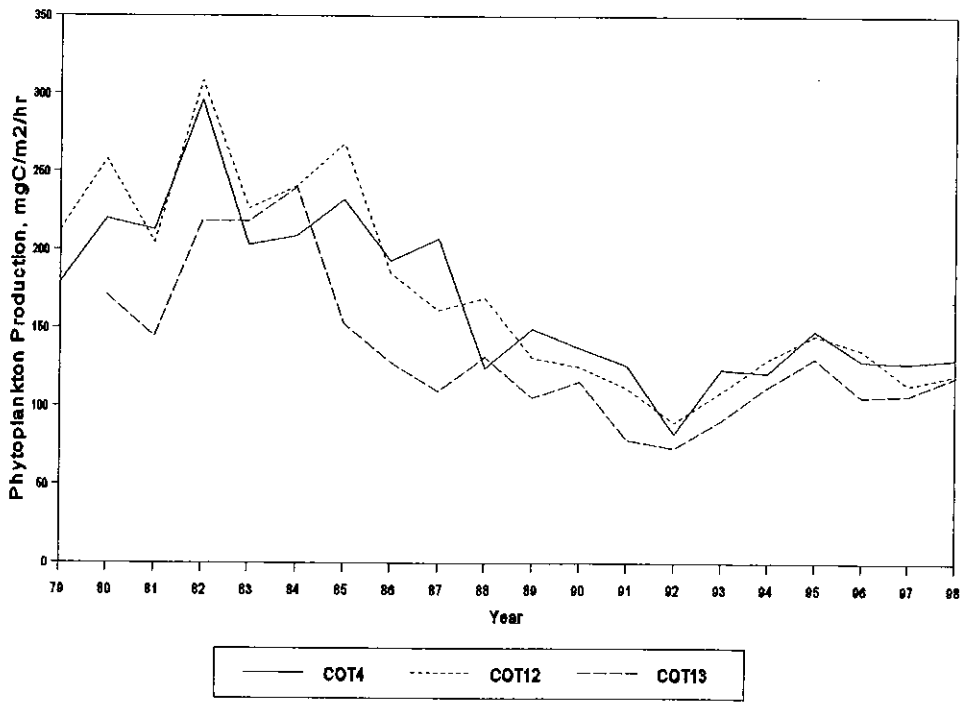

Figure 42. Long-term trend of depth integrated phytoplankton production measured by the COT in Tampa Bay.

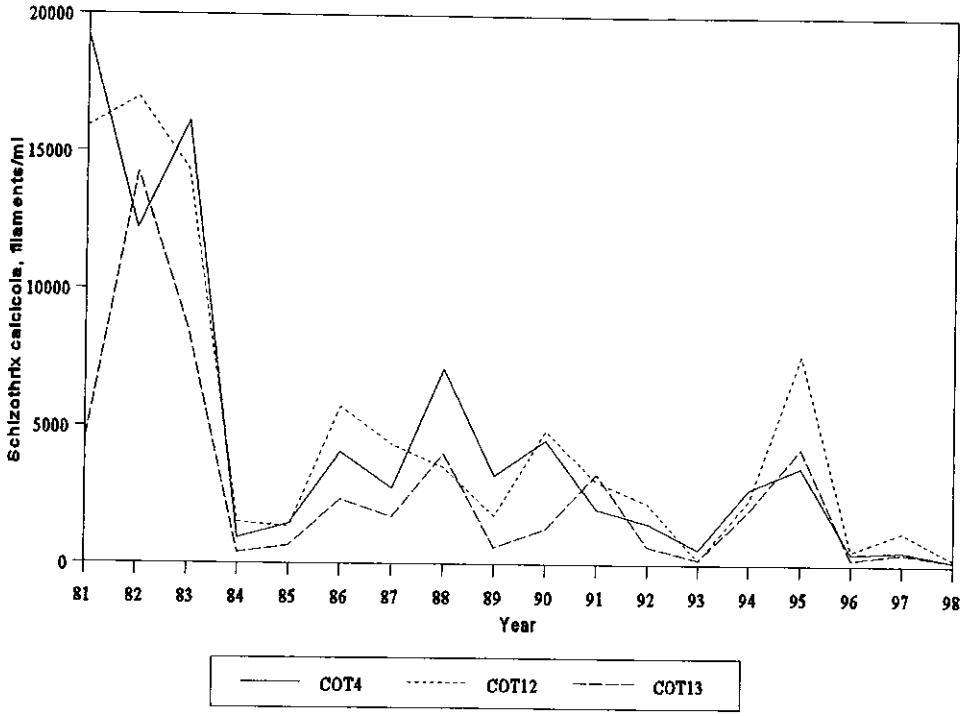

Figure 43. Long-term trend of Schizothrix calcicola *sensu* Drouet concentrations measured by the COT in Tampa Bay.

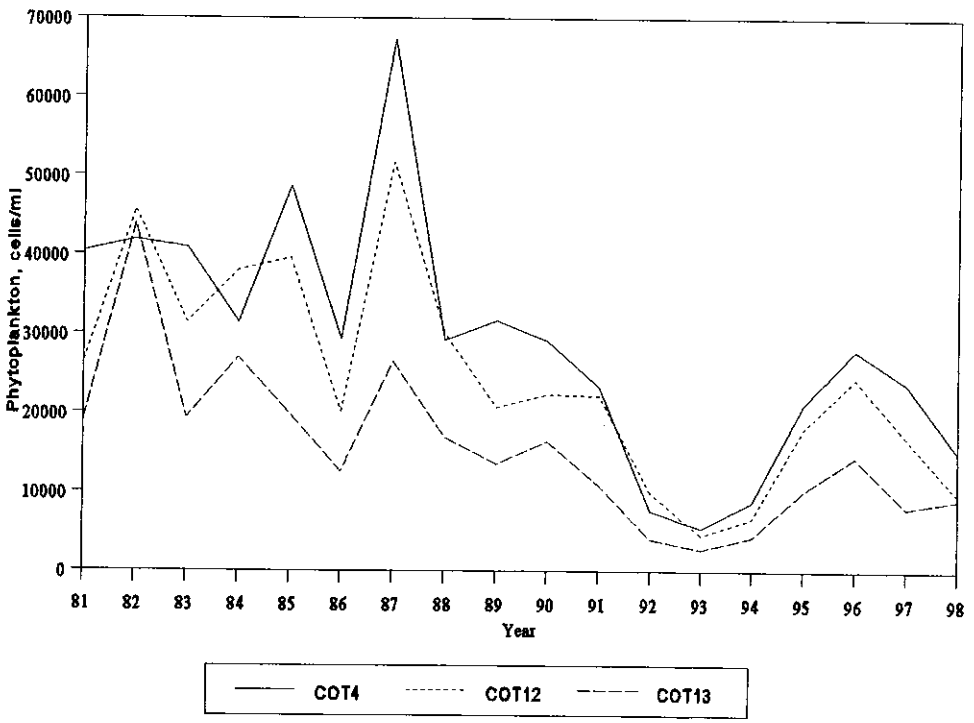

Figure 44. Long-term trend of total phytoplankton concentrations measured by the COT in Tampa Bay.

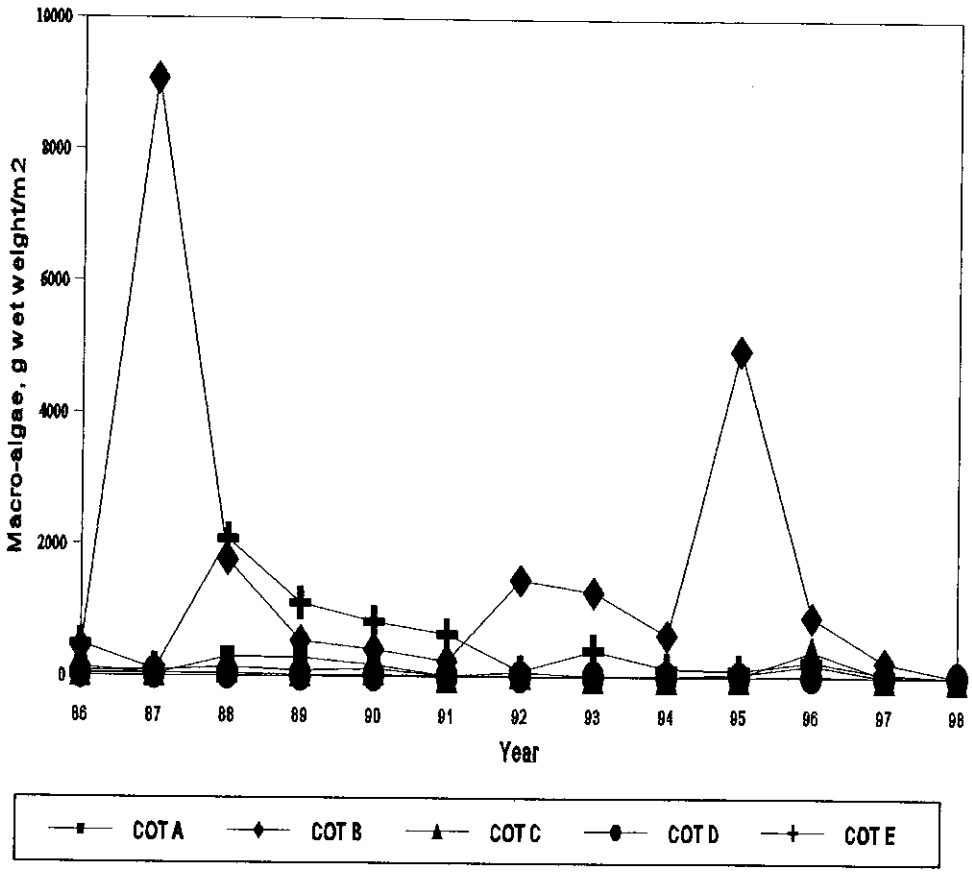

Figure 45. Long-term trend of Hillsborough Bay drift macro-algae biomass collected at five transects by the COT.

APPENDIX A

Appendix Table A. Results from the City of Tampa compliance monitoring in Hillsborough Bay for station COT15, COT16, and COT17 for the year 1998.

Date	Sta	TN mg/l	TKN mg/l	TP mg/l	PO4 mg/l	CBOD5 mg/l	NO2+NO3 mg/l	NH3 mg/l	SDO mg/l	MDO mg/l	BDO mg/l	CHLA ug/l
13-Jan-98	COT15	1.03	0.87	0.47	0.41	1.70	0.161	0.18	6.7	7.1	5.4	4.08
10-Feb-98	COT15	0.87	0.74	0.32	0.27	1.30	0.132	0.06	9.2	8.7	6.9	6.14
10-Mar-98	COT15	0.83	0.75	0.37	0.31	2.25	0.084	0.05	6.8	6.9	5.9	18.63
14-Apr-98	COT15	0.82	0.80	0.45		2.10	0.023	0.03	6.8	6.6	4.1	14.71
12-May-98	COT15	0.79	0.75	0.50	0.32	0.50	0.040	0.08	7.3	7.0	6.2	25.25
9-Jun-98	COT15	0.98	0.94	0.55	0.34	1.25	0.035	0.07	4.5	3.3	3.3	19.06
15-Jul-98	COT15	0.97	0.93	0.55	0.25	1.90	0.036	0.06	5.8	6.0	5.9	28.83
11-Aug-98	COT15	0.86	0.83	0.39	0.28	2.10	0.027	0.15	3.6	2.3	1.0	19.09
8-Sep-98	COT15	0.92	0.87	0.36	0.30	1.30	0.045	0.13	4.4	2.5	1.8	13.08
13-Oct-98	COT15	0.89	0.83	0.36	0.37	1.05	0.057	0.17	3.2	1.7	1.1	10.47
9-Nov-98	COT15	0.64	0.62	0.27	0.20	1.20	0.017	0.01	6.8	6.6	6.3	19.19
2-Dec-98	COT15	0.57	0.55	0.27	0.20	0.70	0.020	0.08	5.4	5.1	5.1	8.45
13-Jan-98	COT16	1.20	1.03	0.50	0.44	1.60	0.173	0.21	7.4	6.9	5.3	3.68
10-Feb-98	COT16	0.86	0.71	0.38	0.32	1.30	0.145	0.04	9.7	9.7	6.8	7.25
10-Mar-98	COT16	0.96	0.92	0.43	0.34	2.20	0.039	0.01	7.7	7.4	5.4	33.83
14-Apr-98	COT16	1.03	1.01	0.45	0.37	3.55	0.015	0.02	7.6	7.5	7.5	23.27
12-May-98	COT16	0.79	0.77	0.57	0.31	0.80	0.021	0.02	6.9	6.7	6.5	23.80
9-Jun-98	COT16	0.48	0.46	0.55	0.48	0.90	0.020	0.07	4.1	4.0	3.3	10.99
15-Jul-98	COT16	0.81	0.80	0.46	0.22	2.40	0.017	0.04	6.5	6.4	6.2	36.59
11-Aug-98	COT16	1.07	1.04	0.45	0.32	1.70	0.029	0.10	4.5	3.7	0.7	18.22
8-Sep-98	COT16	0.90	0.87	0.38	0.30	1.45	0.033	0.07	4.7	3.3	1.0	25.26
13-Oct-98	COT16	0.83	0.76	0.35	0.34	1.00	0.065	0.14	3.7	3.0	0.4	12.91
9-Nov-98	COT16	0.64	0.63	0.28	0.20	1.25	0.014	0.02	7.1	7.0	6.0	18.87
2-Dec-98	COT16	0.67	0.65	0.28	0.18	0.70	0.015	0.07	5.5	5.4	5.4	7.54
13-Jan-98	COT17	1.29	1.13	0.49	0.42	1.70	0.164	0.15	7.7	7.6	3.7	6.34
10-Feb-98	COT17	0.95	0.82	0.39	0.31	1.85	0.139	0.02	9.8	9.8	7.8	10.04
10-Mar-98	COT17	0.89	0.85	0.41	0.32	3.20	0.035	0.01	7.7	7.6	7.5	45.65
14-Apr-98	COT17	1.06	1.05	0.44	0.33	5.10	0.005	0.01	7.5	7.4	7.4	30.22
12-May-98	COT17	0.69	0.68	0.44	0.32	0.85	0.011	0.02	7.6	7.6	7.5	20.02
9-Jun-98	COT17	0.79	0.78	0.58	0.36	0.90	0.007	0.02	4.8	4.8	4.8	15.43
15-Jul-98	COT17	0.60	0.58	0.42	0.17	2.20	0.020	0.05	6.5	6.5	6.5	31.43
11-Aug-98	COT17	0.82	0.79	0.44	0.31	1.45	0.029	0.12	4.7	4.6	3.2	16.50
8-Sep-98	COT17	0.80	0.78	0.41	0.32	1.60	0.016	0.06	4.8	4.7	4.4	29.10
13-Oct-98	COT17	0.92	0.88	0.37	0.33	1.00	0.038	0.10	4.7	4.6	4.6	21.79
9-Nov-98	COT17	0.62	0.62	0.29	0.19	1.40	0.003	0.01	8.6	8.5	8.4	16.81
2-Dec-98	COT17	0.67	0.66	0.29	0.20	0.50	0.011	0.10	5.5	5.5	5.4	8.75

APPENDIX B

ENVIRONMENTAL PROTECTION COMMISSION
HILLSBOROUGH COUNTY

ADMINISTRATIVE OFFICES, LEGAL & WATER MANAGEMENT DIVISION
1900 - 9TH AVENUE
TAMPA, FLORIDA 33605
TELEPHONE (813) 272-5960
FAX (813) 272-5157

AIR MANAGEMENT DIVISION
TELEPHONE (813) 272-5530

WASTE MANAGEMENT DIVISION
TELEPHONE (813) 272-5788

WETLANDS MANAGEMENT DIVISION
TELEPHONE (813) 272-7104

MEMORANDUM

DATE: **January 26, 1999**

TO: **Roger Johansson**

FROM: **Tom Cardinale** T.C.

SUBJECT: **TOTAL AND ORTHO PHOSPHATE RESULTS**

We reviewed our data with respect to the above analysis for EPC Lab ID # 804048 (your sample of Station # 150 collected on 04/14/98).

The total phosphates were repeated and both values are basically the same. The quality control measures for the two total phosphate runs and the one ortho phosphate run indicate an analytical system "in control" and we believe all three numbers are valid.

Because we were able to duplicate the total phosphate run, we have confidence in the value generated. Therefore, we would recommend that the ortho phosphate value for EPC Lab ID # 804048 be removed from the data base.