1998 CSO SEDIMENT STUDY SYNTHESIS REPORT

FINAL

submitted to

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EXECUTIVE SUMMARY

Combined sewer systems were designed to collect sewage as well as stormwater runoff and transport both to treatment facilities. During heavy rains, overflows from these combined systems—called combined sewer overflows (CSOs)— discharge a mixture of sewage and storm runoff directly into local waters. CSO discharges can potentially affect public health. In 1987, MWRA agreed to plan and build projects to control CSOs in its combined sewer communities. These improvements have included small-scale projects, such as blocking off rarely used CSOs, increasing the storage capacity of others, and installing tide gates to keep seawater out, thereby increasing the combined sewer systems' capacity for handling the flows for which they were intended. Projects completed as of 1997 resulted in decreased CSO discharges, enabling more sewage to be pumped to the treatment plant during rainy weather. Large-scale projects, planned to begin in the year 2000, include upgrading five of the six existing CSO treatment facilities, building two additional facilities, and ultimately closing three existing facilities by 2008. The overall effect of these ongoing improvements is that CSO discharges have decreased from 3.3 billion gallons per year in 1987 to 1 billion gallons per year in 1997 and 58 percent of this overflow is treated at MWRA's CSO treatment facilities (Rex 1999).

The main goals of this study were to assess the effects of specific CSOs on the concentrations of pollutants in the sediments around the CSOs, and to determine if sediment concentrations of these pollutants at specific stations in Dorchester Bay have declined between the sampling years 1998, 1994, and 1990. Two areas of Dorchester Bay were studied: (1) the Old Harbor area, which may receive direct discharge from seven untreated CSOs (BOS-81 through BOS-87), and (2) the area near the Fox Point (BOS-89) and Commercial Point (BOS-90) CSOs, which may receive direct discharge from these two CSO treatment facilities, from BOS-88, and indirect discharge from CSOs in the Neponset River. Several other Boston Harbor stations, outside the Dorchester Bay area, were included in the 1998 sample collection to compare sediment quality at locations not directly impacted by the CSOs.

Because there are many sources of contaminants to Boston Harbor, it is usually difficult to measure the relative impact from various sources. To help discriminate the pollution due to treatment plants and CSO discharges from other confounding point and nonpoint sources of contamination, the microbial indicator, *Clostridium perfringens* spores, and sewage tracers, such as linear alkyl benzenes (LABs) and coprostanol, were included in the monitoring. Organic and metal contaminants were measured to help associate contaminated sediments with specific CSOs.

The data generated by this study were compared to data generated by similar studies performed in 1994 and 1990, and to other historical data to assess if contaminant concentrations have changed in recent years. In all surveys, sediments were collected near ("Near" stations) and far from ("Far" stations) known CSO outfalls to determine if the CSOs are likely to significantly impact the local sediment quality.
As in past studies, few parameters show statistically significant differences in contaminant concentrations between individual stations. This is most likely a result of large intrasite variability, coupled with the relatively small number of samples collected at each site. Although grouping stations as "Near" and "Far" did suggest somewhat greater impacts at the "Near" stations

Sewage Tracers

The density of *Clostridium perfringens* declined at all stations between 1990 and 1998 at all stations. However, concentrations in the last five years (1994 and 1998) were similar at most stations. The largest declines overall were observed at "Near" Stations DB14 (near BOS-90, the Commercial Point CSO), DB13 (near BOS-89, the Fox Point CSO), and DB04 (near the BOS-83 CSO).

The coprostanol values measured in 1998 were lower than those measured in either 1990 or 1994 at all stations, except for "Near" Stations DB13 and DB14, which are adjacent to major CSOs in South Dorchester Bay. Comparison of LABs and coprostanol in sediments through 1997 suggests that the observed concentration increase in the sediment near these CSOs in August 1998 may be a result of localized input from major storm events in June 1998 rather than from chronic inputs at these locations. Concentrations at stations in the vicinity of the CSOs, but not directly adjacent to them (such as "Far" Station DB10), and at other "Far" stations (distant from the CSOs), did not show a corresponding increase in sewage tracers in 1998. In comparison, concentrations of sewage tracers measured at "Far" Station DB10, located south of these CSOs, decreased in 1998.

Organic Contaminants

PAH concentrations at most stations sampled in 1998 were similar to or lower than those measured previously, except at four stations in South Dorchester Bay. In general, concentrations measured in South Dorchester Bay in 1998 were elevated relative to other study locations. This was consistent with measurements made in 1994. At "Far" Station DB10, which is adjacent to a large storm drain, a significant increase in total sediment PAHs was measured in 1998 relative to previous years (1990 and 1994). Compared to 1990 and 1994, however, the composition of the PAHs did not change, suggesting that the source was probably similar in all years. In contrast, the significant increases in total PAH concentrations at "Near" Stations DB13 and DB14 in 1998 were accompanied by a decrease in the percent contributed by pyrogenic PAHs. These results may reflect a change in the source and suggest increased input from petroleum-related sources associated with CSOs in that area (BOS-89, BOS-88, and BOS-90).

Overall, the elevated PAH concentrations at "Near" Stations DB13 and DB14 may indicate increased loading at the nearby Fox Point and Commercial Point CSOs, respectively. Estimated flow data show that the volume of water discharged in 1998 from BOS-89, the CSO adjacent to Station DB13, was the largest volume of water discharged since 1990. The elevated precipitation recorded in early 1998 may have contributed to the significant increase in PAH concentrations observed in the 1998 study, as well as to the change in PAH composition.

The statistical comparison of the 1994 and 1998 data indicates that total PCB concentrations were not significantly different at any stations, except the "Near" Station DB04, where existing low concentrations increased very slightly in 1998, and the "Far" Station DB10, where concentrations decreased in 1998 by approximately 30 percent. The total DDT concentrations measured in 1998 decreased significantly at a number of stations, including both "Near" and "Far" Stations DB01, DB06, DB10, T01, T02, and C019.

Metal Contaminants

Concentrations of metals have remained fairly constant at most stations, although slight decreases were observed at stations in the Old Harbor area. Between 1990 and 1998, a small, but statistically significant decrease in the concentrations of cadmium, copper, nickel, and zinc (Cd, Cu, Ni, and Zn) was observed at "Near" Station DB04. Also between 1990 and 1998, a relatively large decrease in these metals was observed at "Near" Station DB01, where the 1998 concentrations were similar to those measured in 1994. Concentrations of chromium (Cr), Ni, and Zn have also declined slightly since 1990 at "Far" Station DB10. Silver (Ag) was only measured in 1994 and 1998, but the concentrations decreased significantly at Stations DB01, DB10, DB13, T02, SWEX3, and CO19. Mercury (Hg) concentrations were similar in both 1994 and 1998 at all stations, except DB10, where a slight decrease was detected.

General Trends

As observed by others (Durell 1995), contaminant concentrations in South Dorchester Bay were, on average, slightly higher than those in the Old Harbor area. Comparison of the various sediment parameters measured during the past three CSO studies indicates that the largest differences were detected between the stations near and far from CSOs. Concentrations still remain statistically higher at stations near the CSOs, although an overall decrease in sewage tracers (C. *perfringens*, LABs, and coprostanol) suggests that, harborwide, sewage input is decreasing. The largest decline in C. *perfringens* spores, one of the best indicators of raw sewage, was observed at "Near" Stations DB14 (near BOS-90, the Commercial Point CSO), DB13 (near BOS-89, the Fox Point CSO), and DB04 (near the BOS-83 CSO). The general decline in both LAB and coprostanol concentrations at all "Far" stations and at most "Near" stations also reflects the reduced influx of sewage to Boston Harbor since 1991. Interestingly, significant increases in the concentrations of some sewage tracer compounds measured in August 1998 at major CSOs (BOS-88, BOS-89, and BOS-90) may be due to localized input from a major storm event, which occurred in June 1998, rather than due to chronic inputs at these locations. In 1998, corresponding increases in sewage tracers were not observed at "Far" Station DB10, located just south of these CSOs and adjacent to a large storm drain. This suggests that CSO-related short-term impacts to sediment quality may remain localized.

Conclusions

Past studies have concluded that available data were insufficient to attribute changes in concentrations of organic and metal contaminants in this area strictly to the CSOs. The 1998 data, considered in context with the 1994 and 1990 studies, indicate that reductions of sewage tracers and, to some extent, metals and organic constituents throughout Dorchester Bay and Boston Harbor, are partially due to improved sewage treatment at the Deer Island and Nut Island facilities, as well as reductions in discharges at the individual CSOs. Moreover, a decline in the general use of certain contaminants (*e.g.,* PCBs and DDTs) has probably also contributed to improved sediment quality. The sediment data from stations near the CSOs generally suggest an improvement in sediment quality in these areas over the past decade, but also point to the potential importance of substantial meteorological events on the contaminant signatures.

1.0 INTRODUCTION

Combined sewer systems were designed to collect sewage as well as stormwater runoff and transport both to treatment facilities. Relief points, called combined sewer overflows (CSOs) were designed to discharge into rivers and the ocean if the capacity of the system is exceeded. During heavy rains, CSOs discharge a mixture of sewage and storm runoff directly into local waters. Discharges of contaminated flows from CSOs can affect public health. In 1987, MWRA agreed to plan and build projects to control CSOs in its combined sewer communities. These improvements have included small-scale projects, such as blocking off rarely used CSOs, increasing the storage capacity of others, and installing tide gates to keep seawater out, thereby increasing capacity. Projects completed as by 1997 resulted in decreased CSO discharges, enabling more sewage to be pumped to the treatment plant during rainy weather. Large-scale projects, planned to begin in the year 2000, include upgrading five of the six existing CSO treatment facilities, building two additional facilities, and ultimately closing three existing facilities by 2008. The overall effect of these ongoing improvements is that CSO discharges have decreased from 3.3 billion gallons per year in 1987 to 1 billion gallons per year in 1997, and 58 percent of this overflow is treated at MWRA's CSO treatment facilities (Rex 1999).

As part of their monitoring requirements for National Pollutant Discharge Elimination System (NPDES) permits, municipalities and agencies that own CSOs are required to measure the effects of the CSOs on receiving waters. MWRA is tasked with the responsibility of overseeing NPDES monitoring of the local municipalities that have CSOs, and began an integrated monitoring program in 1989. MWRA's monitoring activities have aided in assessing the effects of the recent improvements as described above. Results of water quality monitoring activities by MWRA and the Boston Water and Sewer Commission (BWSC) (Rex 1991, 1993; BWSC 1990a, b) have shown substantial decreases in CSO-related water quality parameters—such as fecal coliform concentrations—where overall counts over the past five years have been reduced by approximately 35 percent (Rex 1999).

As part of the overall monitoring of Boston Harbor, MWRA has also conducted sediment surveys to assess the potential impact of CSOs on sediment quality at selected Dorchester Bay locations (Durell *et al.* 1991, Durell 1995). The first survey was conducted in November 1990 and the second survey in August 1994. The study described in this report was performed in August 1998 in the same general area as the two previous studies, and included revisiting most sites established previously. Data on toxic metals, organic pollutants, and sewage tracer compounds were generated to assess changes in sediment quality between 1990 and 1998. In all surveys, sediments were collected near ("Near" stations) and far from ("Far" stations) known CSO outfalls to determine if the CSOs are likely to significantly impact the local sediment quality.

The primary objectives of the 1998 study were to

(1) Generate sediment quality data for specific Dorchester Bay locations
(2) Consider the apparent impact of the studied CSOs on the local sediment quality
(3) Discuss changes in contaminant concentrations between 1998 and historical studies (1990 and 1994)

These objectives were met by measuring concentrations of selected contaminants in sediments at sites that were expected to be affected by CSOs and at sites that are in the same general area, but that were expected to be relatively free of CSO-related impacts. Comparisons of the results from the 1998 survey to results from the two previous studies were made to determine if sediment contaminant concentrations have changed in the past eight years. This report is not intended to be an exhaustive contaminant impact assessment study; rather, it provides a summary of the sediment quality in Dorchester Bay at the sites near CSOs relative to the sites farther away.

One of the most difficult problems in environmental monitoring is to measure the relative impact of different sources of pollution. In Boston Harbor, the effects of CSO input are confounded by input from sources such as treatment plants, upstream river sources, boats, stormwater (including street runoff), atmospheric deposition, and others. In addition, all of these inputs can be dispersed and reconcentrated in depositional areas not necessarily near the original source.

Bacterial contamination is generally considered to be the primary pollution problem associated with CSOs, and microbiological parameters are most often monitored to assess pollution from wastewater treatment plants and CSOs. Toxic compounds and low dissolved oxygen are also recognized as additional potential problems. To help discriminate the pollution due to treatment plants and CSO discharges from other confounding point and nonpoint sources of contamination to Boston Harbor, the microbial indicators, *Clostridium perfringens* spores, *Enteroccocus* and fecal coliform, and sewage tracers, such as linear alkyl benzenes (LABs) and coprostanol, were included in the monitoring study. Toxic chemical pollutants (selected organic and metal contaminants) in sediments were measured in relation to specific CSOs. CSOs are never the sole source of any of these pollutants, and it is impossible to accurately determine the exact proportion of a contaminant originating from a specific CSO, although relative magnitudes of a pollutant originating at a source may be determined if sufficient information is available. Other potential sources of these pollutants include

- Stormwater not associated with CSOs
- Illegal connections to what should otherwise be uncontaminated storm drains
- Street runoff and runoff/discharge from nearby industrial and commercial activities
- Flow upstream of CSOs
- Sediment release of contaminants
- Transport and deposition of pollutants originating elsewhere in the Harbor

The approach and methods used in this study are presented in Section 2. Results from this study are presented in Section 3, and are compared to data from surveys conducted at the same locations in 1994 (Durell 1995) and 1990 (Durell *et al.* 1991). Conclusions and further recommendations are provided in Section 4.

2.0 TECHNICAL APPROACH

In August 1998, sediment samples were collected from 14 sites, most of which were in the Dorchester Bay region of Boston Harbor. Sample collection, transport, storage, and analysis procedures are described in the applicable survey and combined work/quality assurance project plan (CW/QAPP) (Kropp and Boyle 1998). The field and laboratory procedures used in 1998 are the same as those used to conduct the 1994 and 1990 CSO surveys (Durell 1995, Durell *et al.* 1991). The technical procedures are only briefly summarized in this report; detailed technical descriptions can be found in the survey plan and the CW/QAPP.

Sediment samples were analyzed for a number of environmentally important chemical and microbiological parameters. The data were reviewed to determine the differences in sediment quality among sites expected to be significantly influenced by CSOs and sites remote from CSO sources. Additionally, the data were compared with data from the earlier surveys (Durell 1995, Durell *et al.* 1991) to determine if contaminant concentrations had changed.

2.1 Station Selection – Rationale and Objectives

The locations of the 14 sampling stations selected for this study are presented in Figure 2-1 and Table 2-1. Sampling stations are grouped as “Near” CSO discharges or “Far” from CSO discharges, based on physical distance. These designations are consistent with station groupings in the 1994 CSO report (Durell 1995). These stations represent areas likely to be influenced by CSO discharges, as well as areas unaffected by the CSOs chosen for the investigation. The study focused on the Old Harbor area of Dorchester Bay (Stations DB01, DB04, and DB06) and on South Dorchester Bay (Stations DB10, DB13, and DB14). BOS-89 and BOS-90 are discharge points for CSO treatment (*e.g.,* screening and chlorination) facilities. The other CSOs are untreated.

Station description and rationale for the 14 sampling stations (except Station T07, which was added in 1998) are provided in detail in the 1994 CSO report (Durell 1995). Station DB11, surveyed in 1994, was excluded from the 1998 study. Station T02 was used as the reference station to evaluate all other stations through the statistical analyses conducted for the 1990 and 1994 surveys. However, no statistical comparison to Station T02 was performed on the 1998 survey results. Based on the 1994 study, the concentrations of many constituents detected at Station T02, especially the sewage tracer compounds, appeared to be elevated. It was concluded that Station T02 was probably not an ideal reference site because the station was not representative of the background contaminant concentrations typical of the Harbor. The focus of this report is on qualitative and quantitative analysis of data collected near and far from the CSOs.

Figure 2-2 shows additional sediment sampling locations associated with the National Oceanic and Atmospheric Administration’s (NOAA) Status and Trends Program in Boston Harbor. Data collected at these locations since 1986 are presented in Section 3 and are discussed in terms of their comparability to this study and to previous CSO studies.

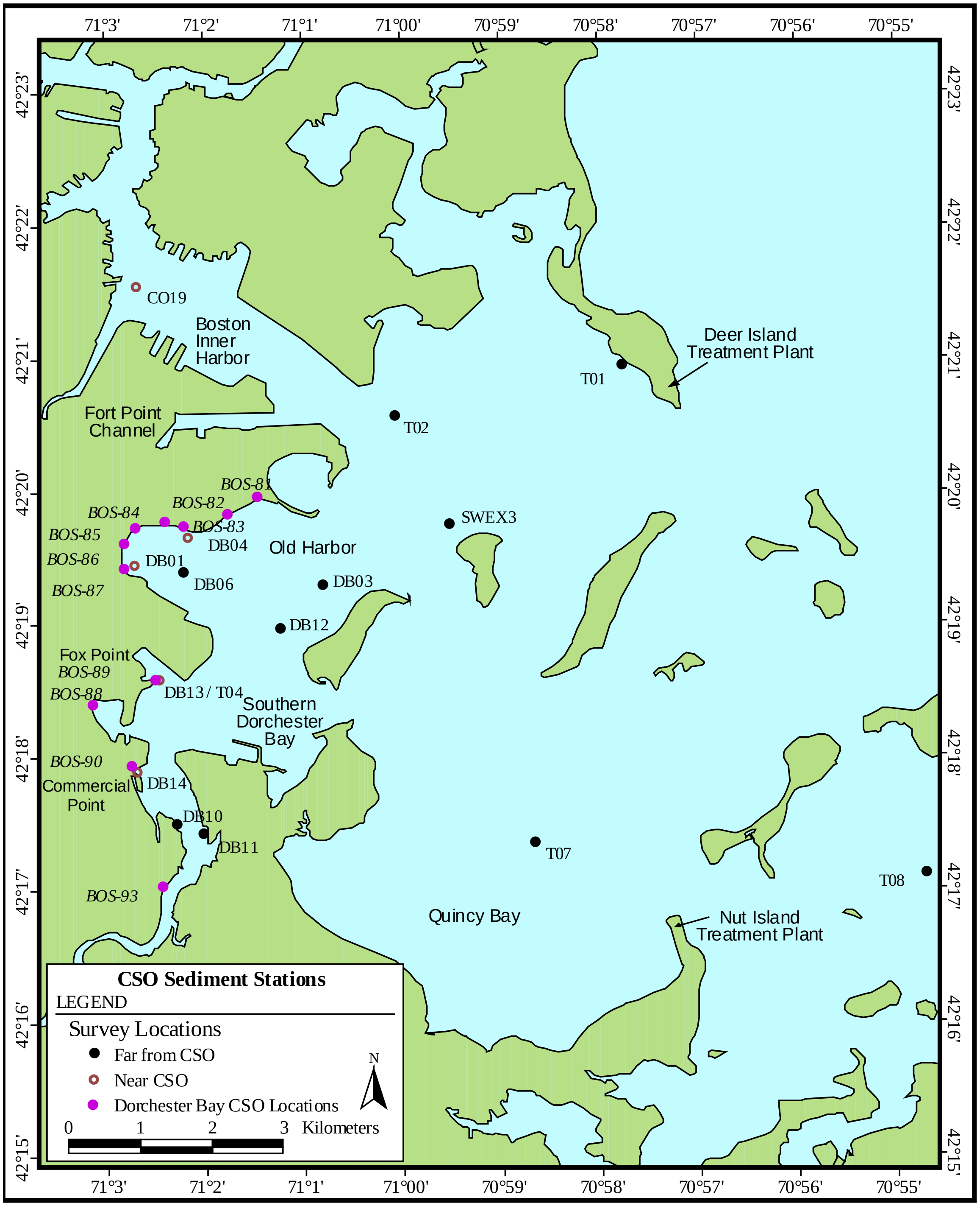


Figure 2-1. Dorchester Bay Study Area with CSO and Sampling Site Locations.

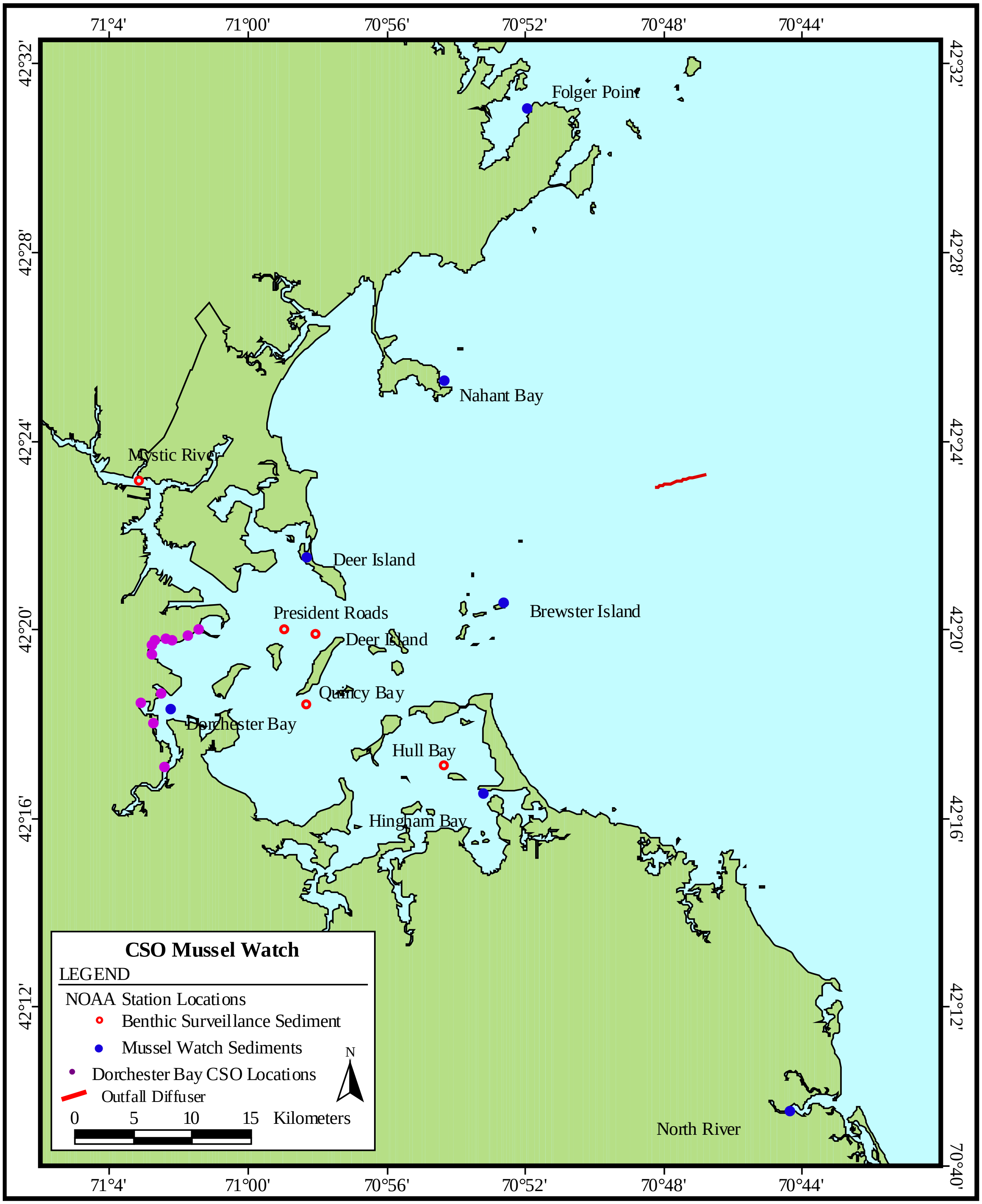


Figure 2-2. NOAA Status and Trends Mussel Watch and Benthic Surveillance Sediment Sampling Locations in the Boston Harbor Area.

Table 2-1. Sampling Locations for 1998 CSO Survey.

Stations	Near (N) or Far (F) from CSO	CSO	Station Arrival	Latitude	Longitude	Depth (m)
Old Harbor						
DB01	N	BOS-86, BOS-87, BOS-82, BOS-84, BOS-81, BOS-85, BOS-83	8/4/98 7:48	42°19.46’	-71°02.75’	11
DB03	F	No direct CSO input	8/4/98 12:19	42°19.30’	-71°00.85’	16.4
DB04	N	BOS-86, BOS-87, BOS-82, BOS-84, BOS-81, BOS-85, BOS-83	8/4/98 7:11	42°19.67’	-71°02.21’	14.2
DB06	F	No direct CSO input	8/4/98 8:36	42°19.40’	-71°02.26’	10.3
South Dorchester Bay						
DB10	F	No Direct CSO; storm drain input	8/4/98 9:32	42°17.51’	-71°02.33’	4
DB12	F	No direct CSO input	8/4/98 11:45	42°18.98’	-71°01.29’	20.3
DB13	N	BOS-89	8/4/98 11:08	42°18.60’	-71°02.50’	8.4
DB14	N	BOS-90	8/4/98 10:21	42°17.91’	-71°02.74’	4.8
Outside Dorchester Bay						
T01	F	No direct CSO input	8/4/98 15:13	42°20.97’	-70°57.83’	14.9
T02	F	No direct CSO input	8/4/98 13:37	42°20.55’	-71°00.13’	21.8
T07	F	No direct CSO input	8/4/98 16:55	42°17.34’	-70°58.73’	19.7
T08	F	No direct CSO input	8/4/98 16:05	42°17.11’	-70°54.75’	38
CO19	N	CSO in Fort Point Channel	8/4/98 14:20	42°21.56’	-71°02.72’	26
SWEX3	F	No direct CSO input	8/4/98 13:02	42°19.76’	-70°59.57’	30

2.2 Sample Collection and Field Procedures

2.2.1 Vessel/Navigation

The CSO sediment survey was conducted onboard the Battelle-owned *R/V Aquamonitor*. Navigation procedures followed those described in the Water Column CW/QAPP (Albro *et al.* 1998). Station positioning was within ± 5 m of the target location for each sample collected.

2.2.2 Grab Sampling

At each station, three replicate grab samples were collected with a 0.1-m^2 Kynar-coated van Veen grab sampler. The top two centimeters of the grab were removed and processed for sedimentological and microbiological parameters. Samples were analyzed for sediment grain size, total organic carbon (TOC), fecal coliform, *Enterococcus* and *Clostridium perfringens*, as well as the organic and metal contaminants summarized in Table 2-2. Samples for grain size and fecal coliform, *Enterococcus* and *C. perfringens* analysis were placed on ice in coolers, whereas the samples for TOC, organics, and metal analyses samples were frozen. A total of 42 samples was collected for analysis.

Grain size, TOC, fecal coliform, *Enterococcus* and *Clostridium perfringens* samples were shipped, on ice, to Battelle subcontractors for subsequent analysis. Geo/Plan Associates in Hingham, Massachusetts, performed the grain size analyses. TOC analyses were performed by Applied Marine Sciences in League City, Texas. Fecal coliform, *Enterococcus* and *C. perfringens* analyses were performed by MTH Environmental Associates in Marston Mills, Massachusetts. The samples for analysis of organic and metal contaminants were placed in a freezer at Battelle and stored at or below 20°C until laboratory processing was initiated.

2.3 Laboratory Sample Analysis Procedures

Sediment samples were analyzed for selected physicochemical and environmentally important organic, trace metal, and microbiological parameters (Table 2-2). Table 2-2 also presents the approximate method detection limits for the analyses. Laboratory procedures followed those outlined in the Benthic Monitoring CW/QAPP (Kropp and Boyle 1998). Concise summaries of the procedures are provided below.

2.3.1 Sample Analysis for Grain Size, TOC, fecal coliform, *Enterococcus* and *Clostridium perfringens*

Grain Size. Samples were analyzed for grain size by a sequence of wet sieving and dry sieving. Methodologies followed those of Folk (1974). The sand/gravel fraction was separated from the mud fraction and then transferred to a 200-mL beaker, decanted, and dried overnight at 95ºC. The dried sand/gravel fraction was mixed by hand to disaggregate the material, and then dry-sieved on stacked sieves ranging in size from -1 phi to 4 phi. Each size class was weighed to the nearest 0.1 mg on a top-loading balance. Particles smaller than 4 phi were analyzed using the pipette method. The data were presented in weight percent by size class. In addition, the gravel:sand:silt:clay ratio, and a numerical approximation of mean size and sorting (standard deviation) were calculated.

TOC. A portion of the sample analyzed for TOC content was dried at 70ºC for 24-36 hours and then ground to a fine powder. The sample was treated with 10 percent HCl to remove inorganic carbon, followed by drying at 70ºC for 24 hours. A 10-500 mg portion of finely ground, homogenized sample was weighed to the nearest 0.1 mg and placed in a crucible that had been precombusted for 4 hours at 500ºC. A Coulometric Carbon Analyzer was used to determine the TOC content of the samples according to Battelle SOP-9703.

Fecal coliform, *Enterococcus and Clostridium perfringens.* Sediment extraction methods for microbiological parameters followed those developed by Emerson and Cabelli (1982), as modified by Saad (1992). Analysis of the supernatant was performed by membrane filtration. Enumeration of fecal coliform and *Enterococcus* are described in the EPA method 600/4-85/076 (EPA 1985) with a modification to the Enterococcus EPA procedure following the method of Messer and Dufour (1998).

The filters for enumeration of *C. perfringens* spores were incubated anaerobically at 44.5ºC for 24 hours. Following incubation, the filters were exposed to ammonium hydroxide for 15-30 seconds. Yellowish colonies that turned red to dark pink upon exposure were counted as *C. perfringens*. Data were reported as spores per gram dry weight of sediment.

Table 2-2. Sediment Target Analytes and Approximate Detection Limits.

Parameter	MDL[1]	Parameter	MDL[1]
Physical Sediment Parameters/Sewage Tracers		***PAHs (Continued)***	
Total organic carbon	0.01%	Dibenzofuran	0.07
Grain size	—	**Acenaphthene***	0.16
Clostridium perfringens	—	**Fluorene***	0.12
Coprostanol[2]	503	C$_1$-fluorenes	0.12
Fecal coliforms, *Enterococcus*	—	C$_2$-fluorenes	0.12
Linear alkyl benzenes		C$_3$-fluorenes	0.12
Phenyldecanes (C$_{10}$)	31.3	**Anthracene***	0.10
Phenylundecanes (C$_{11}$)	48.0	**Phenanthrene***	0.12
Phenyldodecanes (C$_{12}$)	53.2	C$_1$-phenanthrenes/anthracenes*	0.12
Phenyltridecanes (C$_{13}$)	53.1	C$_2$-phenanthrenes/anthracenes	0.12
Phenyltetradecanes (C$_{14}$)	60.5	C$_3$-phenanthrenes/anthracenes	0.12
		C$_4$-phenanthrenes/anthracenes	0.12
Metals		Dibenzothiophene	0.14
Al Aluminum	2300	C$_1$-dibenzothiophenes	0.14
Fe Iron	6	C$_2$-dibenzothiophenes	0.14
Ag Silver	0.063	C$_3$-dibenzothiophenes	0.14
Cd Cadmium	0.058	**Fluoranthene***	0.07
Cr Chromium	9	**Pyrene***	0.18
Cu Copper	2	C$_1$-fluoranthenes/pyrenes	0.18
Hg Mercury	0.028	**Benzo(a)anthracene***	0.18
Ni Nickel	2	**Chrysene***	0.12
Pb Lead	2	C$_1$-chrysenes	0.12
Zn Zinc	2	C$_2$-chrysenes	0.12
		C$_3$-chrysenes	0.12
Polychlorinated Biphenyls		C$_4$-chrysenes	0.12
2,4-Cl$_2$(8)	0.33	**Benzo(b)fluoranthene***	0.15
2,2’,5-Cl$_3$(18)	0.22	**Benzo(k)fluoranthene***	0.09
2,4,4’-Cl$_3$(28)	0.11	Benzo(e)pyrene*	0.14
2,2’,3,5’-Cl$_4$(44)	0.07	**Benzo(a)pyrene***	0.14
2,2’,5,5’-Cl$_4$(52)	0.13	Perylene*	1.96
2,3’,4,4’-Cl$_4$(66)	0.17	**Indeno(1,2,3-c,d)pyrene***	0.14
3,3’,4,4’-Cl$_4$(77)	0.33	**Dibenz(a,h)anthracene***	0.07
2,2’,4,5,5’-Cl$_5$(101)	0.14	**Benzo(g,h,i)perylene***	0.07
2,3,3’,4,4’-Cl$_5$(105)	0.17	Benzothiozole[3]	32.9
2,3’,4,4’,5-Cl$_5$(118)	0.25		
3,3’,4,4’,5-Cl$_5$(126)	0.17	***Pesticides***	
2,2’,3,3,4,4’-Cl$_6$(128)	0.09	Hexachlorobenzene	0.07
2,2’,3,4,4’,5-Cl$_6$(138)	0.15	Lindane (g-BHC)	0.09
2,2’,4,4’,5,5’-Cl$_6$(153)	0.22	Heptachlor	0.05
2,2’,3,3’,4,4’,5-Cl$_7$(170)	0.12	Aldrin	0.08
2,2’,3,4,4’,5,5’-Cl$_7$(180)	0.18	Heptachlorepoxide	0.09
2,2’,3,4,5,5’,6-Cl$_7$(187)	0.08	Alpha-chlordane (cis-Chlordane)	0.07
2,2’,3,3’,4,4’,5,6-Cl$_8$(195)	0.08	Trans-nonachlor	0.11
2,2’,3,3’,4,4’,5,5’,6-Cl$_9$(206)	0.08	Dieldrin	0.10
Decachlorobiphenyl-Cl$_{10}$(209)	0.09	Endrin	0.11
		Mirex	0.06
Polynuclear Aromatic Hydrocarbons (PAHs)		2,4’-DDD	0.18
Naphthalene*	0.20	4,4’-DDD	0.46
C$_1$-naphthalenes*	0.20	2,4’-DDE	0.80
C$_2$-naphthalenes*	0.20	4,4’-DDE	0.15
C$_3$-naphthalenes*	0.20	2,4’-DDT	0.21
Biphenyl*	0.08	4,4’-DDT	0.19
Acenaphthylene*	0.19	4,4 DDMU	0.98

[1] μg/g dry weight for metals; ng/g dry weight for organic analytes.

[2] Coprostanol was determined as coprostanol (5β-cholestan-3β-ol) plus epicoprostanol (5β-cholestan-3α-ol).

*The asterisked PAH compounds were used to compare to the 1990 CSO results against the 1994 and 1998 total PAH data, and the summed concentration is referred to as “Total 24 PAHs.” The two methylnaphthalene isomers in the 1990 work are considered part of the C1-naphthalene homologous series in this work, which is the reason that only 23 PAH compounds are asterisked. The bolded PAH compounds represent the 16 priority pollutant PAHs. Note: MDL concentration for PAHs, PCBs, and pesticides are based on surrogate-corrected data.

[3] Not included in total PAHs.

2.3.2 Sample Analysis for Organic Contaminants

Analyses of sediments for organic contaminants were performed according to methods listed in the following table. Detailed information is provided in Kropp and Boyle (1998). Analytical methods for organic contaminants used in the 1998 study are completely comparable to CSO sediment analytical methods used by the historical studies (Durell *et al.* 1991, Durell 1995, ENSR 1997, NS&T 1998).

Parameter	Analysis Lab	Unit of Measurement	Method	Reference
Linear Alkyl Benzenes (LABs)	Battelle	ng/g	GC/MS	Battelle SOP 5-157
Polycyclic Aromatic Hydrocarbons (PAHs)	Battelle	ng/g	GC/MS	Battelle SOP 5-157
Polychlorinated Biphenyls (PCB)/ Pesticides	Battelle	ng/g	GC/ECD	Battelle SOP 5-128
Coprostanol	Battelle	ng/g	GC/MS	Battelle SOP 5-157

2.3.3 Sample Analysis for Metals

Analyses of sediments for metal contaminants were performed in accordance with the methods listed below. Detailed information is provided in Kropp and Boyle (1998). The methods for the analysis of metals are completely comparable to CSO sediment analytical methods used by the investigators of the historical studies (Durell *et al.* 1991, Durell 1995, Blake, *et al.*1998, NOAA 1998).

Parameter	Analysis Lab	Unit of Measurement	Method	Reference
Major Metals (Al, Fe)	KLM	Percent Dry Weight	EDXRF	KLM Tech. Proc. 7-40.48
Trace Metals (Cr, Ni, Pb, Zn, Cu)	KLM	µg/g	EDXRF	KLM Tech. Proc. 7-40.48
Trace Metals (Ag, Cd, and Hg)	Battelle	µg/g	GFAA (Ag, Cd) CVAA (Hg)	EPA 1640 EPA 1631

2.4 Data Analysis Procedures

Data analyses were performed on station mean data (*i.e.*, the mean of three replicates from each station). Sediment grain size, as percent fines (sum of silt/clay), TOC, *Clostridium perfringens*, and organic and metal contaminant concentrations (station mean) were compared from all stations using histogram plots.

Linear regression analyses were performed on sediment grain size and TOC data to examine the correlation between parameters. Advanced statistical analyses were also employed to understand differences observed in the data. These analyses were performed by Technology Planning & Management Corporation (TPMC) to determine if there were significant differences in contaminant loadings among CSO-impacted sites and sites expected to be relatively unimpacted by CSOs, and to determine if contaminant concentrations changed since the previous CSO surveys (1994, 1990). Specific tests are described in the next section.

2.4.1 General Statistical Treatment of Data

All data used for t-tests and ANOVAs were tested for normality and homogeneity of variance prior to statistical analysis. The statistical analysis system SAS was used for all analyses. An alpha-level of 0.05 was used for all analyses. Levene's test was used to determine the homogeneity of variance. Samples that were not normally distributed were analyzed by the method of Box and Cox. This analysis determined that, in all cases where a normal distribution of the data could be induced, a log transformation was sufficient. Therefore, the data were either analyzed in the raw form or transformed to the base-10 logarithm.

Normalization of the data to TOC content, percent Al, and percent fines in the sediment was investigated as a technique for decreasing the variance in the data and improving statistical evaluations. Normalization did not change the results of the ANOVAs (one-way and nested). Therefore, the raw data (or transformed values) were used for all statistical analyses.

Multivariate analyses (principal components analyses and discriminant analyses) were also performed on some data. However, these analyses did not provide additional insight or information that could not be concluded from the univariate analyses alone. Therefore, results of the multivariate tests were not included in this report.

The following statistical tests were performed:

Student T-test

- Evaluated whether station T07, sampled only in 1998, was different from the other "Far" stations
- Evaluated "Near" vs. "Far" stations for all parameters over all years (for like parameters and stations only)
- Compared results for common parameters and stations between 1994 and 1998

One-Way Nested ANOVA

- Determined if grouping of "Near" and "Far" stations would result in the ability to discriminate these stations as different (between stations and between years)
- Used to determine if there were differences between and among the groups and subgroups (year, "Near" or "Far" stations)

Correlations

- Used Pearson product-moment correlations for analyses between the common parameters 1990-1998, and TOC, and fines
- Used to assess the intensity of association between the various variables
- Used on common stations and parameters between1994 and 1998.

One-Way ANOVA

- Used to examine temporal trends between 1990 and 1998. Results were evaluated to determine if there was a significant difference between results of individual parameters at each station over the three studies.

2.4.2 Statistical Analyses Performed on 1998 Results

Statistical analyses of 1998 results were conducted as described in Section 2.4.1 on the following parameters:

- TOC
- Sediment grain size (measured as percent fines)
- *Clostridium perfringens*
- PAHs (measured as total PAHs, total 24-PAHs, petro-PAHs, and pyro-PAHs)
- Total LABs
- Coprostanol (measured as sum of the ∀- and ∃-isomers)
- PCBs (measured as total PCBs)
- DDTs (measured as sum of six DDTs)
- Metals

2.4.3 Statistical Analyses Performed on 1998 and 1994 Results

A separate comparison of 1998 and 1994 data was conducted due to an increase in the number of parameters and stations that could be compared and statistically analyzed (*e.g.*, PCBs, DDTs, Ag, and Hg) in addition to the list noted in Section 2.4.4. Statistical analyses were conducted on the 1998 and 1994 results as described in Section 2.4.1.

2.4.4 Statistical Analyses Performed on 1990, 1994, and 1998 Results

Statistical analyses were performed on the 1990, 1994, and 1998 data. The only parameters that were included in this comparison were those measured at all stations in all years. This included eight stations and *C. perfringens*, percent fines, percent TOC, PAH-24 compounds, and selected metals. Statistical analyses were conducted as described in Section 2.4.1.

3.0 RESULTS AND DISCUSSION

The primary goals of this study are to assess the current impact of specific CSOs on contamination of sediments in the Dorchester Bay area, and to determine if there have been changes in the sediment contaminant concentrations between 1998, 1994, and 1990. The discussion presented in Section 3 is based on the data generated in this study (1998 samples), relevant historical data where appropriate, and comparison with the 1994 and 1990 study data. A brief compilation of selected historical data and a discussion of the state of the CSOs are presented in Section 3.1, followed by a discussion of sediment contaminant results (Section 3.2), and statistical analysis of all data (Section 3.3). Analytical results include grain size, TOC, organic, sewage tracer, and metal contaminant concentrations that were determined for Dorchester Bay in this (1998) and in previous (1994 and 1990) CSO studies. Data are presented as histograms, including error bars, for all parameters for all years. Complete data sets for samples collected in 1998, with results for each individual station, including means and standard deviation between replicates, are presented in Appendix A.

Although all data were normalized to various parameters (TOC, percent fines, Al) in an attempt to reduce the variability in the results, no normalized data were used in statistical analysis of the data, as discussed in Section 3.5. All normalized results for all three studies are presented in Appendix B. For normalized data, individual replicates were normalized prior to determining the station average.

3.1 Historical Data

For comparison with this study, data from other studies are limited. Most historical data for the area of the CSO discharges in Boston Harbor are not useful for comparison with this study because they are either not from the same station locations or the sample matrix generally is not the same or the analytical methods were not comparable or sufficiently well documented to allow comparisons. A review of pertinent information was provided as part of the 1994 CSO report (Durell 1995) and is summarized below. A limited amount of additional information and contaminant data is also presented.

3.1.1 Studies of Contaminant Transport and Fate in Boston Harbor

Historical data discussed in the 1994 CSO report (Durell 1995) suggested that most chemicals measured in the sediments of Dorchester Bay originated from Deer Island and Nut Island discharges. Sludge, untreated effluent, and treated effluent were all discharged from the treatment facilities in the past. However, the elimination of sludge discharges from the Deer Island and Nut Island facilities in December 1991 has significantly reduced the amount of contaminants transported into Dorchester Bay. Until December 1991, the sludge discharges occurred predominantly with outgoing tides, while the effluent discharges have been continuous. Even after sludge discharge stopped, the majority of the contaminant inputs to Boston Harbor is still attributed to sewage effluent (Alber and Chan 1994). Stormwater and tributaries also contribute significantly to the contaminants in the Harbor. For example, up to 30 percent of the lead and 18 percent of the zinc entering the Harbor are thought to come from stormwater drainage and tributary discharges (Alber and Chan 1994). However, significant improvement in sediment quality, as reflected in decreased sediment metals concentrations, has been documented since the late 1970s, some of which is directly attributable to source reduction within Boston Harbor (Bothner *et al*., 1998).

Transport and deposition of pollutants has been shown to be important in regulating contaminant concentrations in Boston Harbor (Gallagher *et al*. 1992, MDC 1979, Wallace *et al*. 1988a,b,c). Studies have shown that concentrations of most metals are relatively uniform in the water column within much of Boston Harbor. However, Wallace *et al*. (1988c) found that some of the highest concentrations of particulate-phase metals in the water column were found in Dorchester Bay, but that dissolved-phase concentrations of metals were comparable to most other Harbor sites. Wallace *et al*. (1991) determined the metal concentrations in the Fox Point CSO discharge, and in water and sediment samples collected near the CSO. They concluded that, although the CSO effluent increases the concentrations of several metals in the water column near the point of discharge, both during and shortly after the time of discharge, the elevated concentrations found in the sediment were due primarily to transport from other locations within the Harbor and not directly from the Fox Point discharge. Similar conclusions were drawn by Eganhouse and Sherblom (1990) for organic pollutants in the Fox Point area.

The sewage outfall from the Deer Island and Nut Island plants accounts for approximately 50 percent of the total freshwater input into Boston Harbor (Wallace *et al*. 1988). The treatment plant discharges do not completely disperse into Massachusetts Bay, but re-enter the Harbor through President Roads and other routes such as Nantasket Roads. Transport back into the Harbor by either of these routes is supported by known tidal-current patterns, and measured water and sediment contaminant distribution patterns (Gallagher *et al.* 1992, MDC 1979, MDEQE 1986; Wallace *et al.* 1988, Wallace *et al*. 1991). The data from these studies suggest that there is a plume of elevated concentrations of contaminants that extends from the Deer Island/President Roads area into South Dorchester Bay. Additionally, Kelly (1993) estimated that approximately 10 percent of the nitrogen input to the Harbor remains in the Harbor, while roughly 90 percent is exported to western Massachusetts Bay. Tracking of the Nut Island plume in 1990 (McDowell *et al*. 1991) also suggested that this discharge may be a likely source of contaminants into Dorchester Bay. These historical chemistry data suggest that this may be the main route of transport into Dorchester Bay for most toxic chemicals, and that most of the chemicals have historically originated in Deer Island and Nut Island discharges.

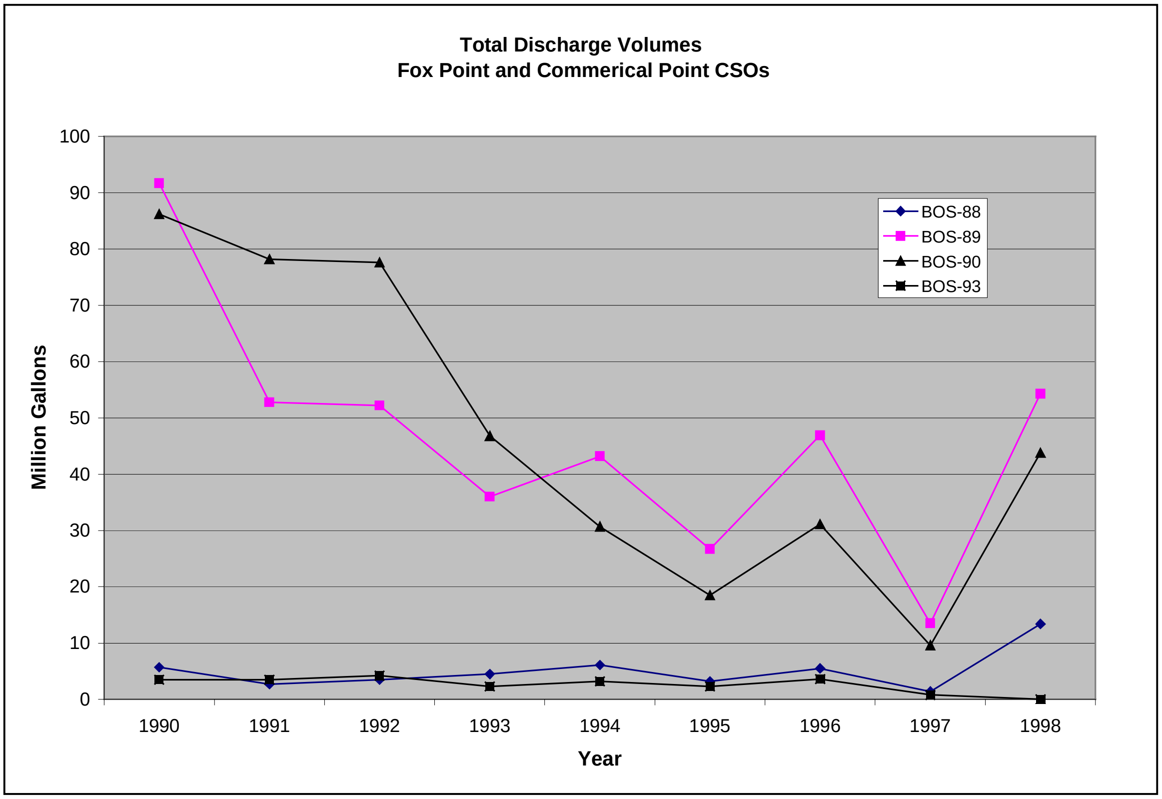
Transport and deposition of pollutants is also tightly linked to sediment transport, and the subsequent regulation of these contaminants is dependent on the ability to predict the sources and fate of these sediments. Based on various estimates of sediment transport and on calculations of deposition rates in Boston Harbor, it appears that most sediments deposited in the Harbor are imported from sources outside the Harbor (Stolzenbach and Adams 1998). More recent estimates of particle and contaminant retention in Boston Harbor have shown that, except for PAHs, the differences between average concentrations within the Inner Harbor and in the Southeast Harbor are generally not more than a factor of three, in spite of the high concentration of sources in the Inner and Northwest Harbor. This finding is consistent with the concept that a significant fraction of the particles discharged into the Harbor is transported throughout the Harbor, perhaps undergoing multiple cycles of deposition and resuspension. Although, for particles discharged into regions of the Inner Harbor, the percent retained may be somewhat higher (Buchholtz ten Brink *et al.* 1994, Stolzenbach and Adams 1998).

Although the percent of contaminant loading to Boston Harbor from CSOs is thought to be small, relative to loadings from other sources (Alber and Chan 1994), the localized impacts of CSO inputs can be significant. Throughout the 1970s and early 1980s, discharges of contaminated flows from CSOs were a public health threat to swimmers and recreational boaters, and contaminated local shellfish beds. The substantial CSO system improvements that have been made since early 1990 are having a positive effect on a number of water quality parameters such as fecal coliform counts. Specific system improvements have been made at a number of Dorchester Bay CSOs, including construction of treatment facilities at the Fox Point CSO (BOS-89) in 1989 and the Commercial Point CSO (BOS-90) in 1990. Upgrades to these facilities are planned for 2001, with ultimate elimination of these CSOs by 2008 (Rex 1999).

Table 3-1 presents the total discharge, based on modeling studies conducted by BSWC (1990a) at each of the Dorchester Bay CSOs from 1990 through 1998, along with the number of discharge events per year (BSWC 1990-1998). The data, presented in million gallons per year, are shown graphically in Figure 3-1.

Table 3-1. Estimated Volume of Discharge and Number of Events Per Year at Each Dorchester Bay CSO. Estimates of Volume were Obtained from Modeling Studies (BWSC 1990a).

	1990		1991		1992		1993		1994		1995		1996		1997		1998	
CSO	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events	Total Vol. (MG)	Number of Events
BOS-81	2.6	34	2.4	26	2.4	27	0.6	14	0.2	7	0.1	5	0.1	5	<0.1	2	0.4	8
BOS-82	5.7	34	5.5	26	5.4	27	3.5	27	5.7	26	3.5	18	6.4	20	1.5	18	8	34
BOS-83	1.1	18	0.7	18	0.9	12	0.4	19	0.8	19	0.6	9	0.8	12	0.2	7	1.3	22
BOS-84	5	40	4.8	36	4.7	41	2.6	37	3	31	1.8	20	3.4	26	0.8	21	4.3	40
BOS-85	1.2	18	0.1	3	0.3	4	<0.1	1	0.3	3	0.1	3	<0.1	3	<0.1	1	0.6	5
BOS-86	12.6	16	5.6	16	66.9	22	91.5	25	249.7	58	93.6	59	128.7	48	88.2	82	112.7	57
BOS-87	7.2	37	0.3	3	0.7	6	1.5	15	3.6	25	2.3	13	3.8	16	0.9	14	5.7	30
BOS-88	5.7	28	2.7	18	3.5	16	4.5	25	6.1	25	3.2	17	5.5	24	1.4	13	13.4	33
BOS-89	91.7	56	52.8	40	52.2	42	36	49	43.2	45	26.7	34	46.9	38	13.5	31	54.3	52
BOS-90	86.2	58	78.2	41	77.6	48	46.8	48	30.7	43	18.5	27	31.1	36	9.6	29	43.8	50
BOS-93	3.5	55	3.5	38	4.2	42	2.3	44	3.2	42	2.3	26	3.6	33	0.8	25	<0.1	3
TOTALS	222.5		156.6		218.8		189.7		346.5		152.7		230.3		116.9		244.5	



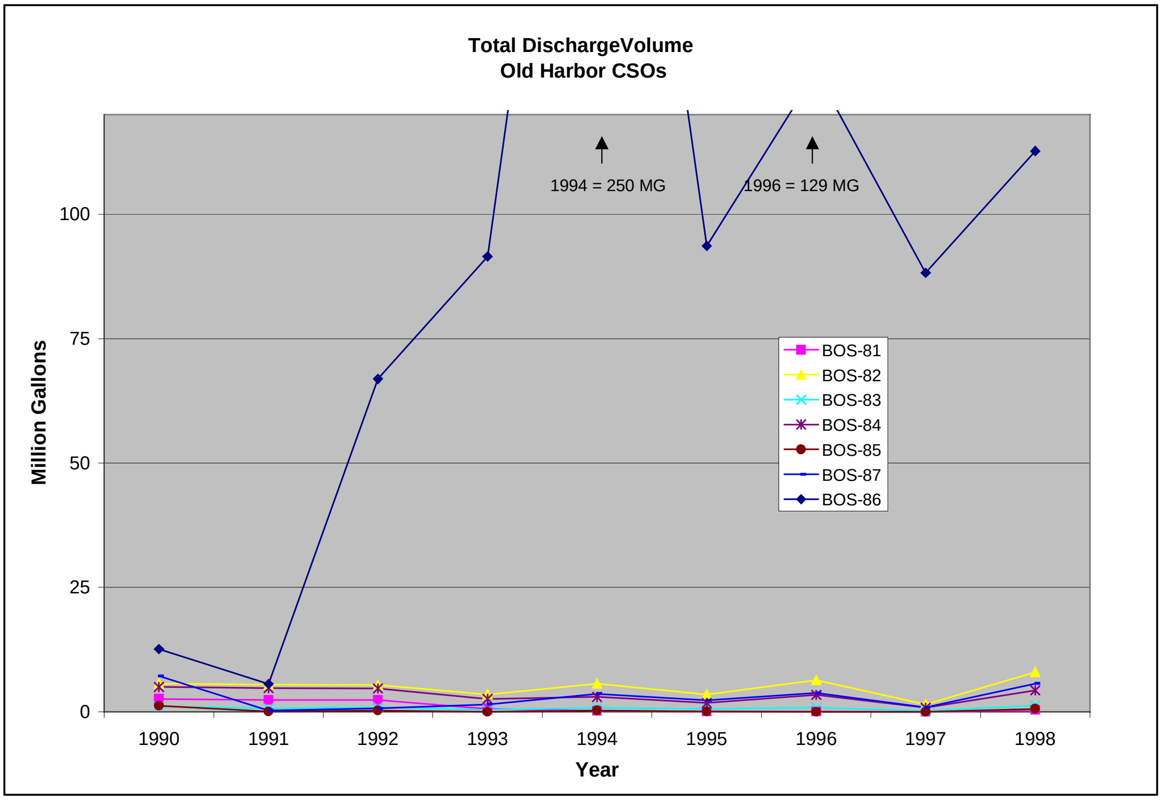


Figure 3-1. Total Annual Discharge Volumes at Selected Dorchester Bay CSOs (1990-1998).

The discharge volumes from individual CSOs in the Old Harbor were generally similar—under 10 million gallons annually—and fairly constant from 1990 to 1997, with the exception of BOS-86 which exhibited a marked increase in discharge volumes in 1992 and in the number of discharge events starting in 1994. The discharge volumes at two of the Fox Point and Commercial Point Facility CSOs (BOS-89 and BOS-90, respectively) were generally higher than in the Old Harbor area. However, discharges at these CSOs have decreased steadily since 1990. At all CSO locations, a marked increase in discharge volumes was observed in 1998 and, to a lesser extent, an increase in the number of discharge events. This increase during 1998 most likely corresponds to increased precipitation, especially during the spring, as a result of the El Niño weather pattern. In February 1998, discharge was eliminated from BOS-93 because that CSO was closed.

3.1.2 Contaminant Concentrations in Boston Harbor and Massachusetts Bay

The NOAA Mussel Watch Program is one source of Massachusetts Bay data that were generated using analytical methods comparable to the ones used in this study. Table 3-2 lists concentrations of metals, PAHs, PCBs, and DDTs in sediment samples collected between 1985 and 1990 at eight Mussel Watch sites. Figure 2-2 illustrates the sampling locations for these sites. More recently, NOAA collected sediment samples in Boston Harbor as part of its Benthic Surveillance Program. Data for up to three years of sampling at five locations in Boston Harbor are provided in Table 3-3. Only two of the Mussel Watch sites are located in the area addressed by the current (1998) study, while all five of the Benthic Surveillance sites fall within the current study area.

Although sediment data have been collected sporadically over the years in Boston Harbor, and were discussed in some detail by Durell (1995), most were not directly comparable to results generated by this and previous MWRA CSO studies. Additional data for a number of the “T” stations, sampled as part of the 1994 and 1998 CSO studies, were also analyzed for a similar list of contaminants in 1997 as part of the MWRA Harbor Benthic Study (Blake *et al.* 1998). Results from this study are presented in Section 3.2, as appropriate.

Table 3-2. Sediment Concentrations for Organic and Metal Contaminants in Boston Harbor and Massachusetts Bay – NOAA Status and Trends Mussel Watch Program (1986-1989).

Analyte Concentration[a]													
	Location	**Year**	**Ag**	**Hg**	**Cu**	**Pb**	**Cd**	**Cr**	**Ni**	**Zn**	**ΣPAH_{24}[b]**	**ΣPCB**	**ΣDDTs**
CAGH	Cape Ann, Gap Head	(a)	0.08	0.07	9.0	28.3	0.13	33.7	10.9	40.3	–1,840[d]	20.1	4.5
SHFP	Salem Harbor, Folger Point	(a)	1.04	0.68	58.0	133	1.95	6.0	31.7	150	–5,120[d]	80.6	57.9
MBNB	Massachusetts Bay, Nahant Bay	(a)	0.12	0.04	7.5	24.1	0.11	52.0	NA[c]	NA	883	9	1
BHDI	Boston Harbor, Deer Island	(a, e)	3.10	0.69	103	110	1.13	191	29.2	145	–3,320[d]	233[e] 24.4	
BHDB	Boston Harbor, Dorchester Bay	(a, e)	3.12	0.83	118	132	1.43	192	30.8	183	–7,670[d]	644[e] 45.2	
BHHB	Boston Harbor, Hingham Bay	(a)	1.13	0.21	25.00	35.5	0.27	56.8	14.5	58.5	814[d]	66.2	6.9
MBNR	Massachusetts Bay, North River	(a)	0.33	0.17	13.33	32.5	0.24	26.9	NA	NA	1,230	17	9
DBCI	Duxbury Bay, Clark's Island	(a)	0.28	0.01	4.8	11.1	0.04	18.5	6.5	19.7	156	13	2.2

[a] Concentration in sediment samples collected between 1986 and 1989. Mean concentration if site was analyzed more than one time.
Concentrations of metals are µg/g dry weight; concentrations of PAHs, PCBs, and DDTs are ng/g dry weight.
Data for Massachusetts Bay, Nahant Bay and Massachusetts Bay, North River are from Hillman *et al.* (1991). All other data are from Hillman *et al.* (1990).

[b] ΣPAH_{24}: Sum of the 24 individual PAH analytes asterixed in Table 2-2.

[c] NA: Not readily available.

[d] Approximate ΣPAH_{24} determined by multiplying the sum of the low- and high- molecular weight PAHs reported in Battelle (1990) by 1.1; expected to be within 10 percent of true value.

[e] PCB data for Deer Island and Dorchester Bay sites are average of data for samples collected in 1986 and 1987. Concentrations were 247 and 219 ng/g for Deer Island for 1986 and 1987, respectively. Concentrations were 602 and 685 ng/g for Dorchester Bay for 1986 and 1987, respectively. The TOC content of the 1986 samples was 1.01 and 1.73% for Deer Island and Dorchester Bay, respectively, and the grain size was 48.9 and 68.8% mud for these same samples.

Table 3-3. Sediment Concentrations of Organic and Metal Contaminants in Boston Harbor – NOAA Status and Trends Benthic Surveillance Program.

Analyte Concentration[a]														
Site	**Location**	**Year**	**Ag**	**Hg**	**Cu**	**Pb**	**Cd**	**Cr**	**Ni**	**Zn**	**ΣPAH$_{24}$[b]**	**ΣPCB**	**ΣDDTs**	**COPROS-TANOL**
BOSDI	Deer Island	1987	1.14	0.67	67.9	88.8	1.06	59.9	28.0	139	11881	2578	17	NA[c]
BOSDI	Deer Island	1988	2.79	0.31	78.0	79.1	1.17	126.5	24.6	139	7336	87	2	39967
BOSDI	Deer Island	1993	4.29	0.65	97.4	89.0	1.33	158.7	27.8	144	5586	86	2	15500
BOSHB	Hull Bay	1993	4.02	0.65	78.6	101.9	0.66	136.1	30.4	144	2941	44	6	7967
BOSMR	Mystic River	1993	2.41	0.74	126.1	158.9	1.81	120.5	35.6	224	51263	413	44	5767
BOSPR	President Roads	1986	6.20	1.05	148.0	124.0	1.61	223.7	29.8	292	10256	185	34	NA
BOSPR	President Roads	1988	7.91	1.04	167.0	129.3	2.32	293.0	36.1	247	26437	NA	210	NA
BOSPR	President Roads	1989	4.24	0.92	119.4	77.5	1.66	179.4	25.0	178	11515	NA	18	NA
BOSQB	Quincy Bay	1986	5.60	1.38	133.7	95.6	0.90	224.3	29.9	192	5484	154	31	NA
BOSQB	Quincy Bay	1993	5.43	1.39	127.2	145.5	1.51	202.7	30.9	197	25599	204	34	6067

[a] All data taken from NOAA 1999 [http://www_orca.nos.noaa.gov/projects/nsandt/rawdata.html]; Concentrations of metals are µg/g dry weight; concentrations of organic contaminants are ng/g dry weight.

[b] ΣPAH$_{24}$: Sum of the 24 individual PAH analytes asterixed in Table 2-2.

[c] NA: Not readily available.

3.2 Evaluation of Sediment Parameters Measured from 1990 to 1998

A limited number of stations and parameters was measured during each MWRA CSO study. Evaluation of long-term trends focused on the results common to all years. The data were compared to evaluate the following:

- Have there been detectable changes in the Harbor over time?
- Was there a detectable difference between stations "Near" vs. "Far" stations?
- Were any trends evident over time at individual stations?

Mean concentrations of all parameters measured since 1990 are summarized in Tables 3-4 through 3-6. All results are presented as means of three replicate measurements at each station. Concentrations of TOC and grain size are percent dry weight. Concentrations of all organic parameters are presented in ng/g dry weight and metals in µg/g dry weight.

3.2.1 Grain Size and TOC Measurements

Table 3-4 presents the percent fines and TOC data collected in 1990, 1994, and 1998. Figure 3-2(a) and Figure 3-2(b) present percent fines and TOC, respectively, measured at all stations in 1990, 1994, and 1998. Overall, the percent fines have been highest at the stations nearest the CSOs. Grain size measurements indicate some variability at a number of stations over time, with the largest change in percent fines occurring at Stations DB01, DB04 and DB10. Stations DB01 and DB04 are both "Near" to CSOs. Station DB10 is not directly adjacent to a CSO; however, it is near a large storm drain and receives input from Pine Neck Creek.

TOC concentrations appear to be higher at the "Near" stations, relative to those furthest from the CSOs (or the "Far" stations). TOC concentrations measured in 1998 were generally highest at Stations DB13 and DB14, which represented an increase of approximately 30 percent since 1994. At most other locations, TOC concentrations have been relatively constant or slightly lower than in previous studies.

As is typically observed in marine sediments, TOC generally increased with percent fines in sediments at the Far stations as illustrated in Figure 3-3(a) showing a plot of common "Far" stations measured in 1990, 1994 and 1998. However, as shown in Figure 3-3(b), sediments collected from common "Near" stations in all three study years, did not follow this commonly observed association. For example, at Stations DB13 and DB14, the TOC content was higher than expected, based on the grain size, possibly due to excess organic matter being discharged from the Commercial Point CSO.

Organic and inorganic measurements were normalized to both percent fines and percent TOC. While normalization reduced the range of contaminant concentrations, it did not reduce the variability in the data and did not affect the results of statistical analyses performed on the data, as discussed below (Section 3.5). Therefore, all data presented in this report are raw data, not normalized to either TOC or grain size. Normalized data are provided in Appendix A (1998 individual replicates) and Appendix B (means for 1990, 1994, and 1998).

Table 3-4. Sediment Grain Size and TOC Results – 1998, 1994, and 1990.

Station	%Fines[1]	TOC (%)	%Fines	TOC (%)	%Fines	TOC (%)
	1998		1994		1990	
DB01	85.4	2.32	74.4	2.78	30.1	6.26
DB03	19.1	0.54	18.6	1.05	18.5	0.973
DB04	89.7	2.62	60.8	2.35	63.8	3.15
DB06	5.87	0.24	7.43	0.213	6.1	0.263
DB10	54.1	2.96	87.9	4.12	62.7	4.54
DB11	-[2]	-	39.6	1.12	-	-
DB12	43.5	2.5	45.6	2.64	44.1	1.88
DB13	78.3	7.14	85.7	3.2	77.7	3.82
DB14	53.6	6.76	51.9	5.06	64.1	4.31
T01	25	1.8	36.4	1.82	-	-
T02	53	1.44	37.9	1.61	-	-
T07	57.4	2.16	-	-	-	-
T08	5.43	0.427	6.13	1.14	-	-
CO19	96.7	2.87	95.9	2.82	-	-
SWEX3	66.4	2.14	54	2.6	-	-

[1] Percent Fines is the sum of %silt and %clay.
[2] No data available.

3.2.2 Organic Contaminants and Sewage Tracers

Table 3-5 presents all organic contaminant data, including sewage tracers, for samples collected in 1990, 1994, and 1998. All results are presented in ng/g dry weight, except for the microbiological parameters (fecal coliform, *Enterococcus* and *Clostridium perfringens*) data, which are presented in spores per gram.

3.2.2.1 PAH Concentrations

Consistent with the 1994 study, PAH data are presented as total PAHs, total 24-PAHs (consistent with NOAA Status and Trends PAH list), petro-PAHs, pyro-PAHs, and %pyro-PAHs of the total PAHs. Total PAHs are defined as the sum of target PAH compounds (listed in Table 2-2), excluding benzothiozole. The total 24-PAH parameter is a subset of total PAHs, and is used to compare the 1994 and 1990 PAH concentrations. The petro-PAH parameter is the sum of petroleum-related PAHs, whereas pyro-PAHs represent the sum of pyrogenic (combustion and creosote/coal-tar related) PAHs. The petrogenic (petro-PAHs) are mostly found in refined and unrefined petroleum products, and are primarily the lighter-molecular-weight PAHs. The pyrogenic compounds (pyro-PAHs) are primarily principal components of creosote and coal-tar mixtures or are derived from the combustion of fossil fuels, and are primarily the heavier-molecular-weight PAHs. The petro-PAHs are, for the purposes of this study, defined as the PAHs in Table 2-2 from naphthalene through C_3-dibenzothiophene, while the pyro-PAHs are defined as fluoranthene through benzo[*g*,*h*,*i*]perylene. Although PAH compounds cannot exclusively be attributed to one of these two discrete source types (*e.g.,* varying concentrations of chrysenes are present in various petroleum products), this classification represents a good general approximation of the relative proportion of petrogenic and pyrogenic PAH compounds.

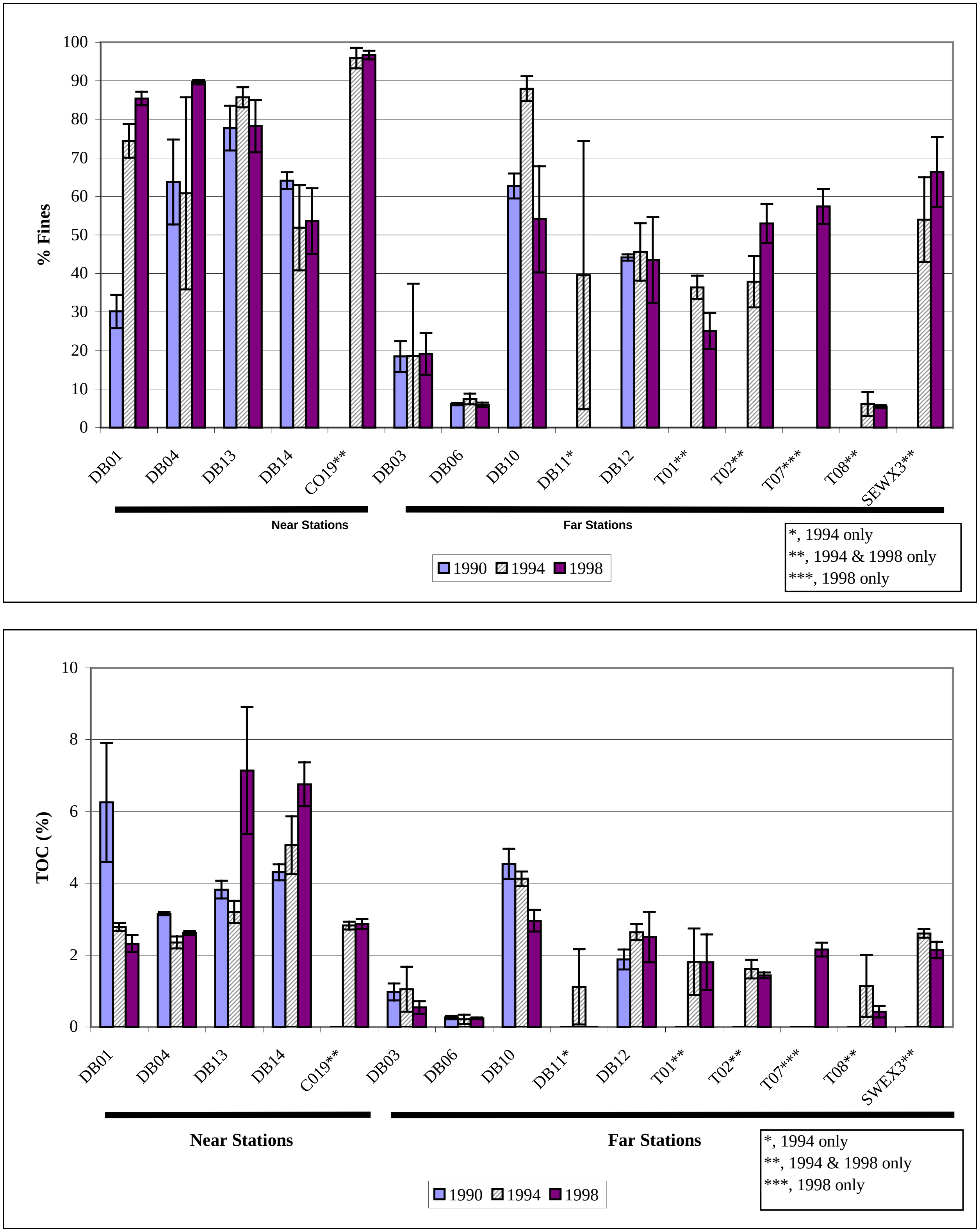


Figure 3-2. (a) Sediment Percent Fines ; (b) Sediment Percent TOC. Data are from 1990, 1994, and 1998 Studies. Error Bars Are One Standard Deviation.

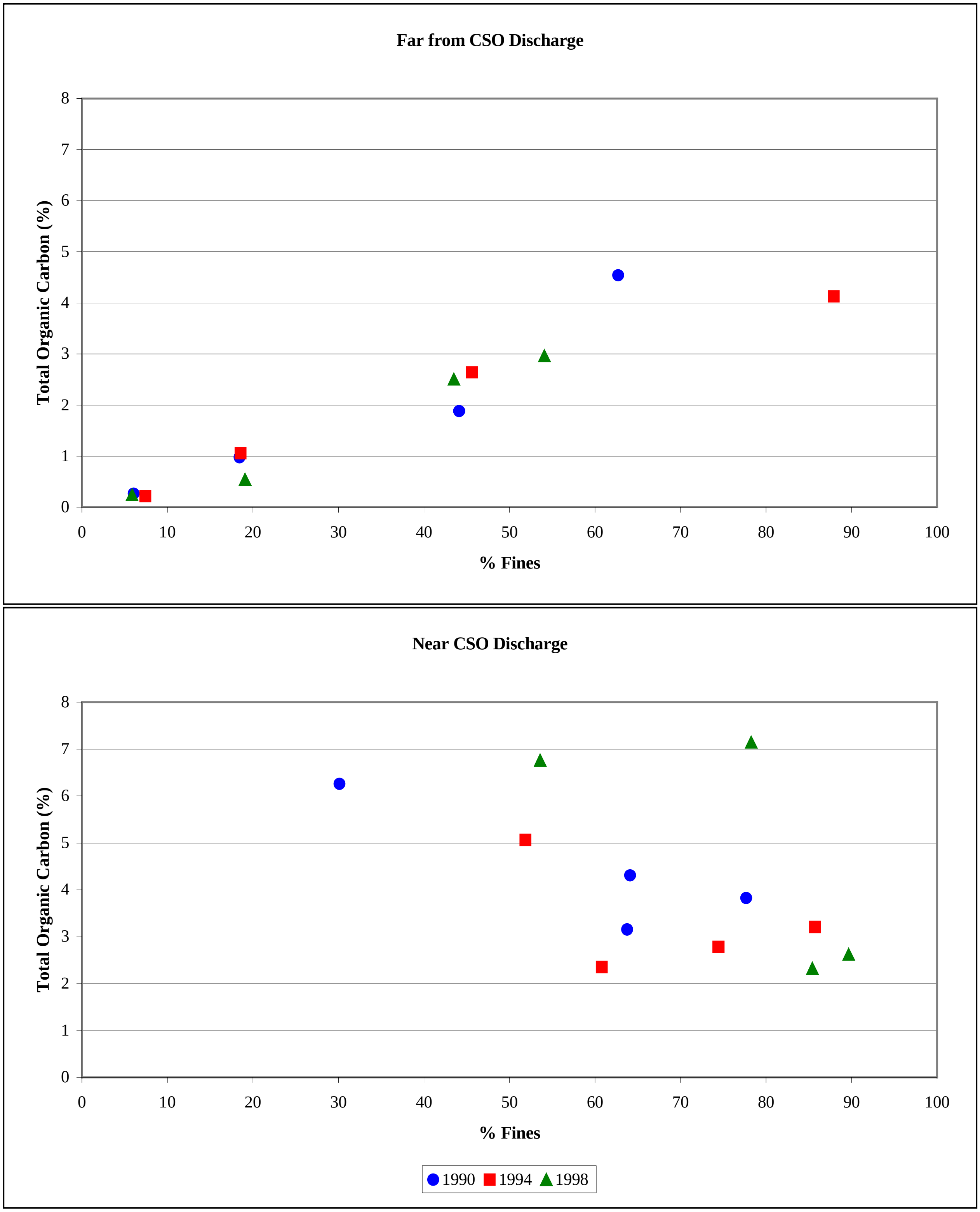


Figure 3-3. (a) Mean TOC vs. Percent Fines for "Far" Stations; (b) Mean TOC vs. Percent Fines for "Near" Stations. Data are from common stations in 1990, 1994, and 1998 Studies.

Table 3-5. Comparison of Sediment Organic Contaminants (ng/g dry wt.) and Microbiological Data for 1998, 1994, and 1990 Samples. Raw Data Are Not Normalized.

Station	Total PAH[1]	Total 24 PAH[2]	Petro-PAH[3]	Pyro-PAH[4]	%Pyro of Total PAH	Total PCB[5]	Total DDT[5]	Total LAB[5]	Copros-tanol	Total LAB/ Copros-tanol	Fecal Coliform (cfu/g DW)	*Enterococcus* (cfu/g DW)	*C. perfringens* (spores/g DW)	*C. perfringens* Log 10
1998														
DB01	18700	15400	4650	14100	75.2%	95.5	13.5	384	2650	0.145	ND[6]	ND	3980	3.59
DB03	3180	2420	820	2360	73.9%	60.5	10.2	158	832	0.19	ND	ND	5720	3.76
DB04	11600	9330	3080	8550	73.5%	90.9	12.5	502	2970	0.171	ND	ND	1360	3.09
DB06	371	303	78.6	292	78.8%	6.77	0.599	53.5	148	0.394	ND	ND	397	2.59
DB10	44200	36000	11300	32900	74.5%	255	39.9	580	1960	0.611	ND	91.7	5340	3.64
DB12	19400	15200	5720	13700	70.9%	316	55.4	420	2100	0.198	ND	ND	9270	3.95
DB13	76700	59600	28200	48500	63.7%	472	70.2	3690	378000	0.0106	373	9000	9030	3.84
DB14	156000	122000	58200	97500	62.8%	540	143	2300	100000	0.0234	866	4133	6790	3.83
T01	4790	3410	1930	2860	60.7%	24.5	2.93	188	2030	0.0929	ND	ND	4370	3.64
T02	6730	5300	1840	4890	72.7%	45.3	6.98	520	3920	0.135	ND	113	6250	3.78
T07	5200	4120	1360	3840	73.8%	83.2	12	1270	3530	0.366	ND	ND	7760	3.89
T08	650	482	229	421	64.8%	5.92	0.59	80.1	733	0.129	ND	ND	1890	3.25
CO19	17300	14000	4130	13200	76.1%	205	24	925	6040	0.153	ND	ND	15100	4.16
SWEX3	6540	5000	1800	4740	72.9%	91.3	54.5	358	3850	0.11	ND	ND	6590	3.81
1994														
DB01	26300	21200	6980	19300	73.4%	88.1	25.8	792	5600	0.141	-[7]	-	3040	3.48
DB03	10400	8250	3860	6540	64.5%	45.7	9.68	264	1610	0.164	-	-	5280	3.72
DB04	39800	31800	12800	27000	69.8%	62.2	29.3	974	6060	0.161	-	-	5120	3.71
DB06	495	424	96.5	399	80.8%	7.21	1.28	32.2	2820	0.0115	-	-	1280	3.11
DB10	20800	16000	5380	15400	74.1%	373	151	1530	5680	0.27	-	-	12000	4.08
DB11	8400	6320	2190	6210	73.5%	127	23.1	425	2140	0.199	-	-	3340	3.52
DB12	19400	14600	6440	12900	67.1%	266	50.6	681	2830	0.241	-	-	16500	4.22
DB13	22600	17300	6140	16400	73.0%	417	71.8	1940	9260	0.209	-	-	10500	4.02
DB14	128000	100000	40800	87500	68.5%	348	164	3200	32200	0.0992	-	-	7290	3.86
T01	7620	5010	3130	4490	58.8%	28.8	10.9	343	4200	0.0817	-	-	4830	3.68
T02	7580	5750	2180	5400	71.1%	55.8	14.1	1270	9800	0.13	-	-	12100	4.08
T08	3000	2340	1230	1770	61.9%	7.9	2.94	360	1770	0.204	-	-	2570	3.41
CO19	19600	14800	5010	14500	74.4%	186	39.8	2570	10700	0.24	-	-	12600	4.1
SWEX3	9960	7300	3170	6790	68.2%	90.6	23.6	1190	6730	0.176	-	-	12400	4.09
1990														
DB01	-	65800	-	-	-	-	-	1350	4220	0.32	3.2	15.4	27000	4.43
DB03	-	2440	-	-	-	-	-	-	-	-	8.0	4.9	13000	4.11
DB04	-	8030	-	-	-	-	-	1170	5160	0.227	9.3	4.7	45500	4.66
DB06	-	550	-	-	-	-	-	-	-	-	16.4	6.3	1990	3.3
DB10	-	18100	-	-	-	-	-	-	-	-	33.3	27.1	34600	4.54
DB11	-	-	-	-	-	-	-	-	-	-	56.9	31.8	25400	4.4
DB12	-	4490	-	-	-	-	-	1230	4860	0.253	8.5	5.4	27800	4.44
DB13	-	9010	-	-	-	-	-	2430	16800	0.145	22.4	46.2	53400	4.73
DB14	-	35700	-	-	-	-	-	3210	31000	0.103	35.1	190	115000	5.06

[1] Total PAH is the sum of all target PAH compounds (Table 2-2).

[2] Total 24 PAH is the sum of all asterisked (*) PAH compounds which were used to compare to the 1990, 1994, and 1998 CSO survey total PAH data (Table 2-2).

[3] Petro-PAH is the sum of petrogenic PAH compounds (Table 2-2; Naphthalene through C_3-Dibenzothiophenes).

[4] Pyro-PAH is the sum of pyrogenic PAH compounds (Table 2-2; Fluoranthene through Benzo(g,h,i)perylene).

[5] Total PCBs, DDTs, and LABs are the sum of all target PCB congeners, individual DDTs , and LABs, respectively (Table 2-2).

[6] ND indicates “not detected”. [7] “-” indicates “not analyzed”.

Figure 3-4 presents the Total PAHs, quantified as a subset of 24 individual PAH compounds (24-PAHs) common to all three study years. As shown, PAH concentrations in the sediment samples varied greatly. Total PAH concentrations measured in 1998 ranged from 371 (at Station DB06) to 156,000 ng/g (at Station DB14) and total 24-PAH concentrations ranged from 303 (at Station DB06) to 122,000 ng/g (at Station DB14). The range of PAH concentrations was reduced when the data were normalized to sediment TOC content (Appendix B-1). For example, the TOC-normalized total PAH concentrations in 1998 varied by a factor of 15, ranging from approximately 1,570 (at DB06) to 23,100 ng/g/percent TOC (at DB14), and the difference in concentration for the raw PAH data from these two sites was a factor of approximately 400. The reduction in data variability due to normalization did not change the interpretation of the ANOVA results concerning the locations where changes in PAH concentrations were detected over the sampling years.

PAH concentrations varied greatly between stations and within stations. Replicate values at a given station exhibited a wide range, especially at stations near CSOs. Highest concentrations in 1998 were observed at Station DB14. Concentrations at this location were two to three times higher than at other stations in the same general area. This result was consistent with measurements made in 1994. Concentrations at Stations DB10, DB12, DB13, and DB14 appeared to increase since 1990. However, concentrations at the remaining stations sampled in 1998 were similar or lower than those measured previously. This same trend was evident for the extended list of Total PAHs measured in 1994 and 1998 (Figure 3-5).

Examination of the types of PAH compounds present allows for potential source allocation and helps to interpret trends in total PAHs observed. A more complete set of PAHs necessary to perform this type of examination was only quantified in the 1994 and 1998 studies. Figure 3-6 presents the total PAH fraction arising primarily from petroleum products (Petro-PAH) for sediments collected in 1994 and 1998. Figure 3-7 presents the total PAH fraction representing primarily combustion products and/or creosote/coal tar for the 1994 and 1998 samples. The PAH makeup was fairly consistent across the sites in both years, with pyrogenic PAHs making up 60-80 percent of the total PAHs at all stations (Figure 3-8.). In most cases, the percent pyrogenic PAHs increased slightly in 1998, except at Stations DB13, DB14, and DB06, where the proportion of petrogenic PAHs increased in 1998.

The highest percent of pyrogenic PAHs was measured at Station DB06, even though the lowest total PAH concentrations in the study area were measured at this station. A significant increase in total PAHs (both the subset of 24 compounds and the extended list) was measured in sediment from Station DB10 in 1998. However, the composition of the PAHs did not change, indicating that the source was probably similar in all years. In contrast, the significant increases in Total PAHs at Stations DB13 and DB14 in 1998 reflected a decrease in the percent pyrogenic PAHs. These changes may reflect different sources and reflect increased input from petroleum-related sources associated with CSOs in that area (BOS-89, BOS-88, and BOS-90).

Sediment PAHs were also measured in 1997 as part of the MWRA Harbor Benthic Survey (Blake *et al.* 1998). Total 24-PAH results were determined for Stations T01 (3,883 ng/g), T02 (4,664 ng/g), and T08 (1,213 ng/g), as well as for Station T04 (9,237 ng/g), which corresponds to Station DB13. Interestingly, the concentrations are very similar to those measured in 1994, except at Station T04. The marked increase in total 24-PAH at Station DB13 in 1998 appears to be a recent occurrence, possibly due to the large precipitation event in June 1998, prior to sampling.

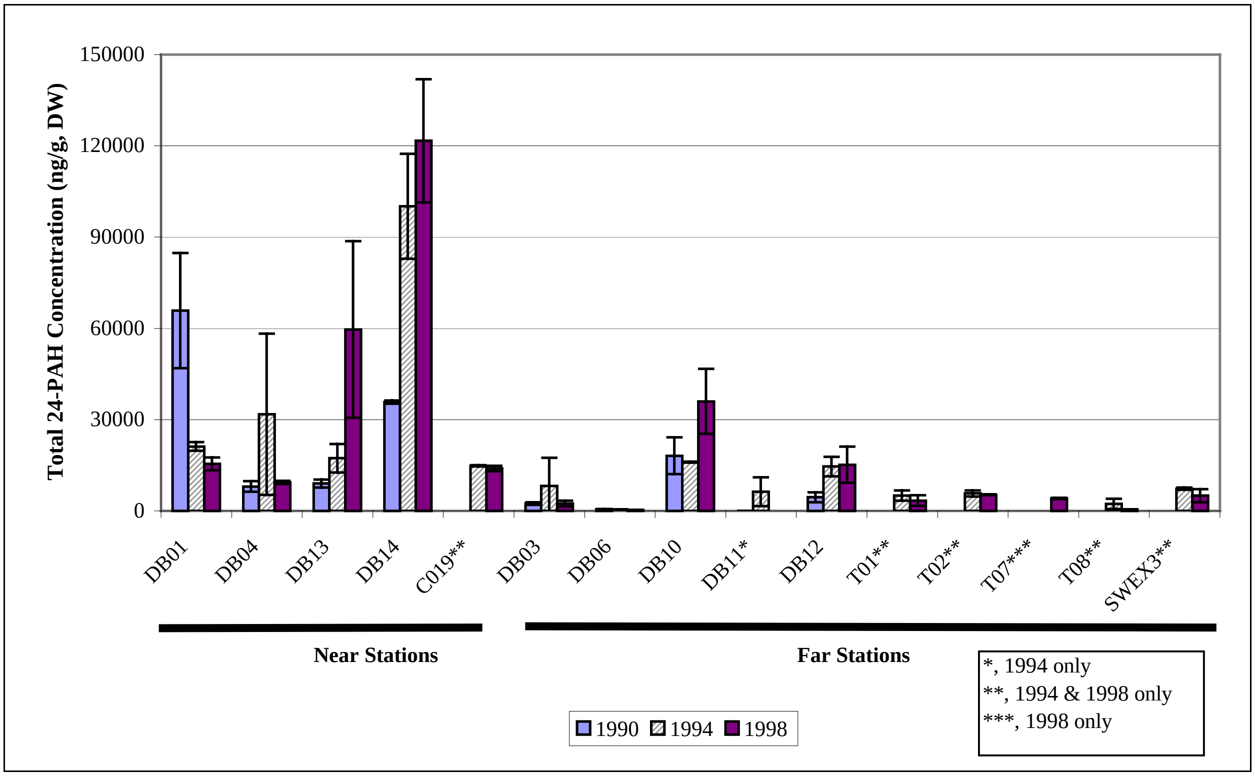


Figure 3-4. Total 24-PAHs in 1990, 1994, and 1998 Samples. Error Bars Are One Standard Deviation.

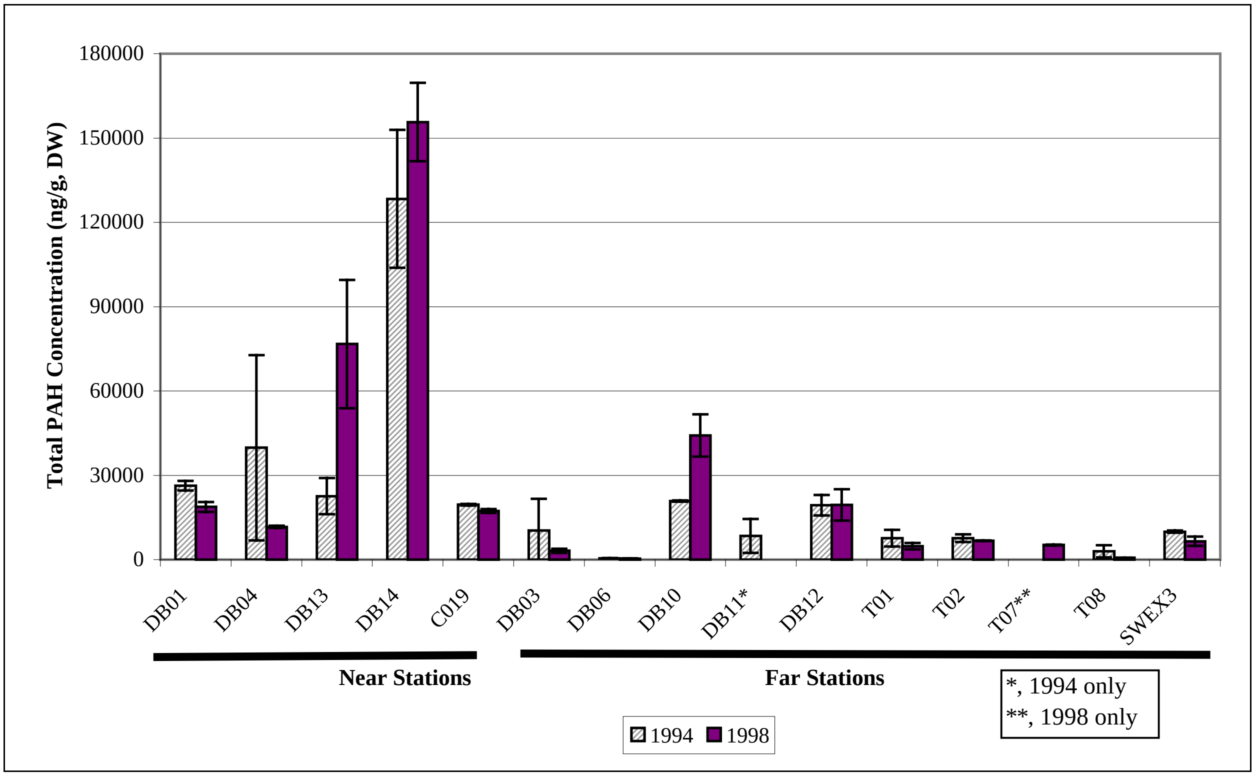


Figure 3-5. Total PAHs in 1994 and 1998 Samples. Error Bars Are One Standard Deviation.

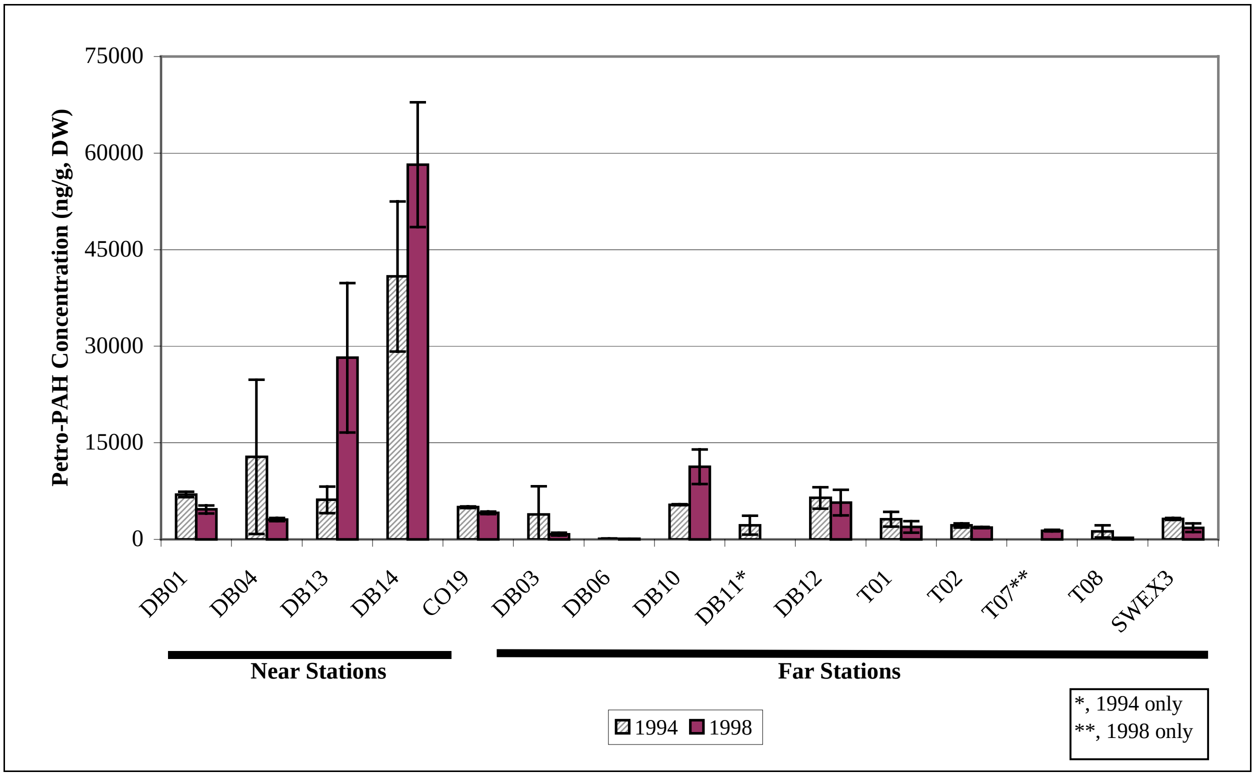


Figure 3-6. Petrogenic PAHs in 1994 and 1998 Samples. Error Bars Are One Standard Deviation.

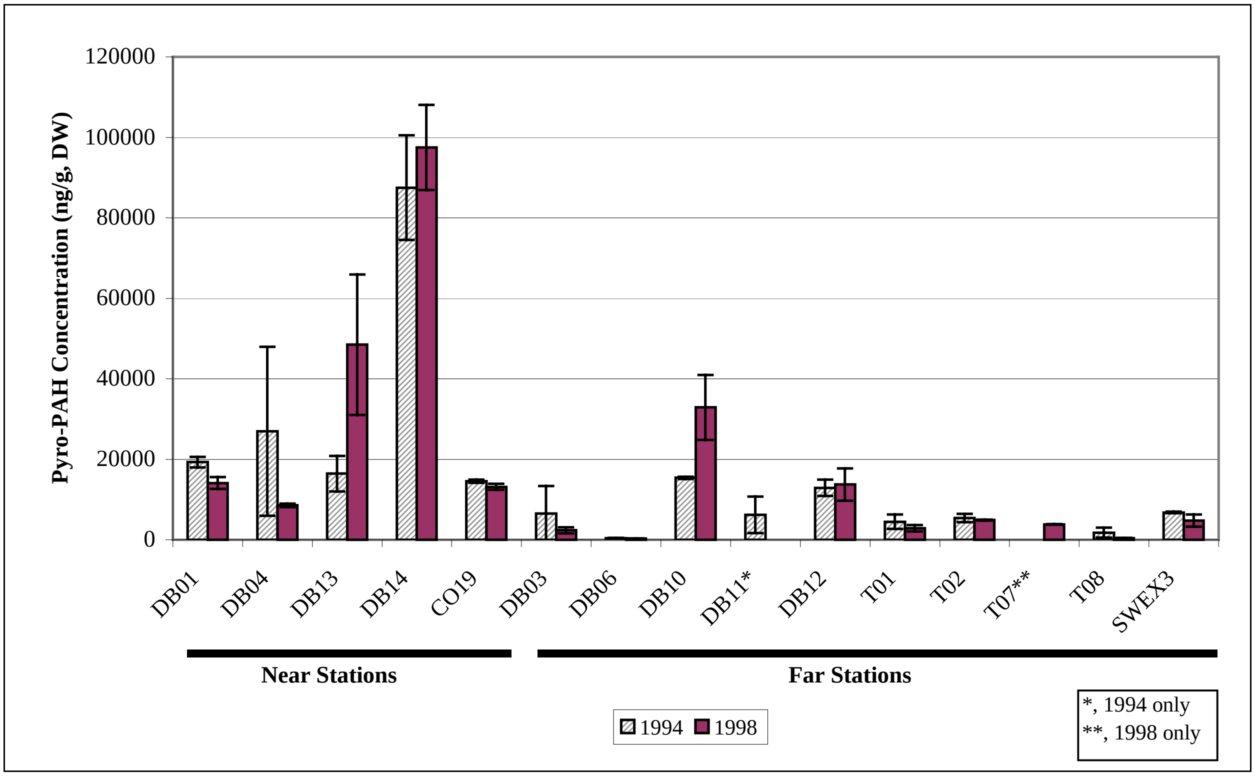


Figure 3-7. Pyrogenic PAHs in 1994 and 1998 Samples. Error Bars Are One Standard Deviation.

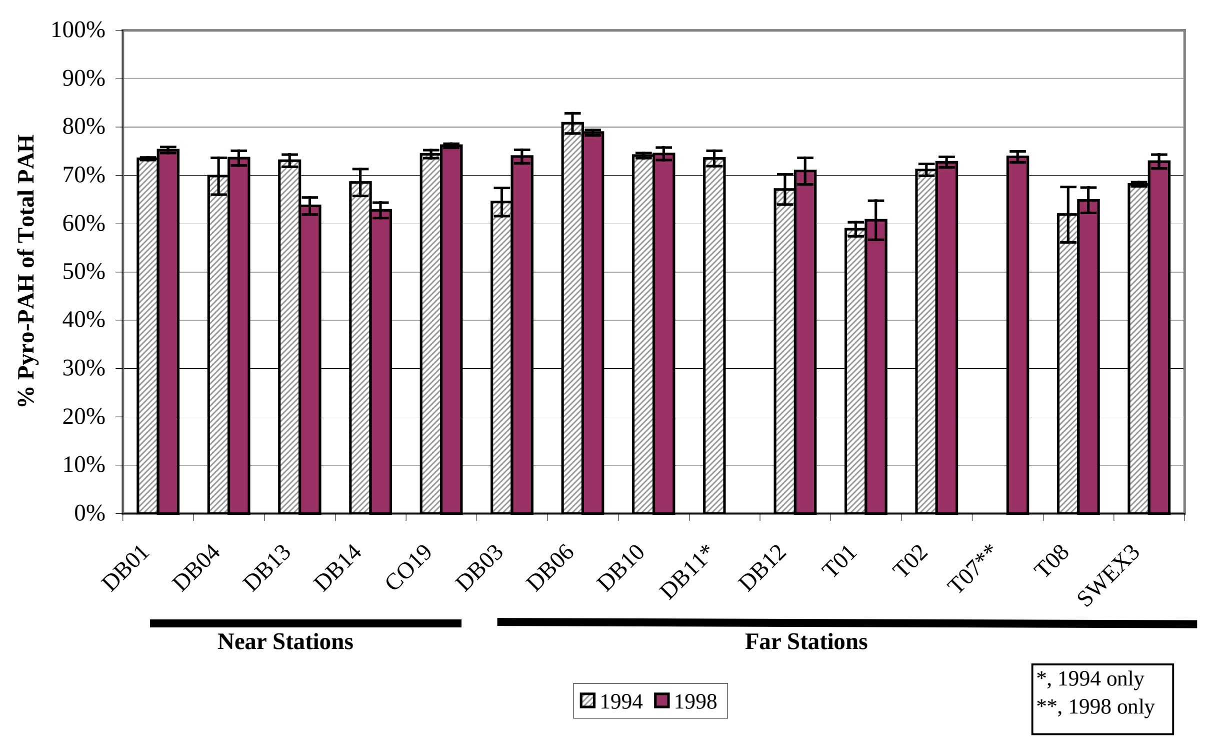


Figure 3-8. Pyrogenic PAHs as a Percent of Total PAHs in 1994 and 1998 Samples. Error Bars Are One Standard Deviation.

Overall, the elevated PAH concentrations at Stations DB13 and DB14 may indicate increased activity at the nearby Fox Point and Commercial Point Facility CSOs, respectively. Estimated flow data show that the volume of water discharged in 1998 from BOS-89, the CSO adjacent to Station DB13, was the largest volume of water discharged since 1990. This may have resulted in an increased impact to the surrounding sediment quality. Station DB10, although not directly adjacent to a CSO, is near a large storm drain. The elevated precipitation recorded in early 1998 may have contributed to the significant increase in sediment PAHs observed in 1998.

3.2.2.2 PCB and Pesticide Concentrations

Figure 3-9 and Figure 3-10 present Total PCB and Total DDT sediment concentrations, respectively, from 1994 and 1998 (PCBs and DDTs were not measured in 1990). Consistent with the 1994 study, PCB and pesticide data are presented as total PCBs and total DDTs. Total PCBs is defined as the sum of the target PCB congeners (listed in Table 2-2) and total DDTs is the sum of the six DDT compounds (2,4- and 4,4-isomers of DDT, DDD, and DDE).

Total PCB concentrations in the sediment samples collected in 1998 ranged from a low value of 5.92 (at Station T08) to a high value of 540 ng/g (at Station DB14). Total DDT concentrations ranged from low values less than 1 (at DB06 and T08) to a high of 143 ng/g (at DB14). As was observed with the PAH data, the range of PCB and pesticide concentrations was reduced once the data were normalized to sediment TOC content (Appendix B-1). The TOC-normalized total PCB concentrations in 1998 ranged from low values of approximately 15 (at T01 and T08) to a high of 126 ng/g/percent TOC (DB12). The sum of the DDT concentrations, normalized to TOC, ranged from a low value of 1.53 (at T08) to a high of 27.6 ng/g/percent TOC (at SWEX3). The concentration range (*i.e.*, ratio between the highest and lowest site concentrations) for the TOC-normalized PCB and pesticide data was approximately one order of magnitude less than the non-normalized data. However, as was also observed for PAHs, normalization of the PCB and pesticide data to TOC did not affect the results of the statistical analyses.

In 1994 and 1998, the highest PCB and DDT concentrations were measured in the South Dorchester Bay areas (Stations DB10 through DB14), as well as at Station DB12. However, the replicate results at each location were highly variable in both years, especially at Stations DB13 and DB14. The largest decrease in Total PCB concentrations was observed at Station DB10 where, in 1998, levels decreased by approximately 30 percent. Total DDT concentrations generally decreased at a number of stations in 1998, including Stations DB01, DB06, DB10, T01, T02, and C019. The largest decrease in Total DDT occurred at Station DB10, where concentrations dropped from approximately 150 ng/g in 1994 to about 40 ng/g in 1998. Total DDT concentrations measured at Stations DB12, DB13, and DB14 were highly variable in both 1994 and 1998.

Sediment PCBs were also measured at a number of Harbor benthic stations in 1997 as part of the MWRA Harbor Benthic Survey (Blake *et al.* 1998). Total PCB concentrations were determined for Stations T01 (51 ng/g), T02 (82 ng/g), and T08 (13 ng/g), as well as for Station T04 (214 ng/g), which corresponds to Station DB13 in the CSO studies. In 1997, concentrations of PCBs at Stations T01, T02, and T08 were approximately a factor of 2 higher than concentrations measured in 1994 and 1998. The 1997 PCB concentration at Station T04 was approximately a factor of 2 lower than the concentration measured in both 1994 and 1998 at the corresponding Station DB13 in 1998. These observations suggest two things: (1) the decrease in PCB concentrations measured from 1994 to 1997 could be a result of the overall decrease in discharges to Boston Harbor; and (2) the increased PCB concentrations measured in 1998, relative to the 1997 measurements, could be a result of the increased CSO discharge due to the large storm even in June of 1998. This trend is similar to the one observed for sediment PAH concentrations.

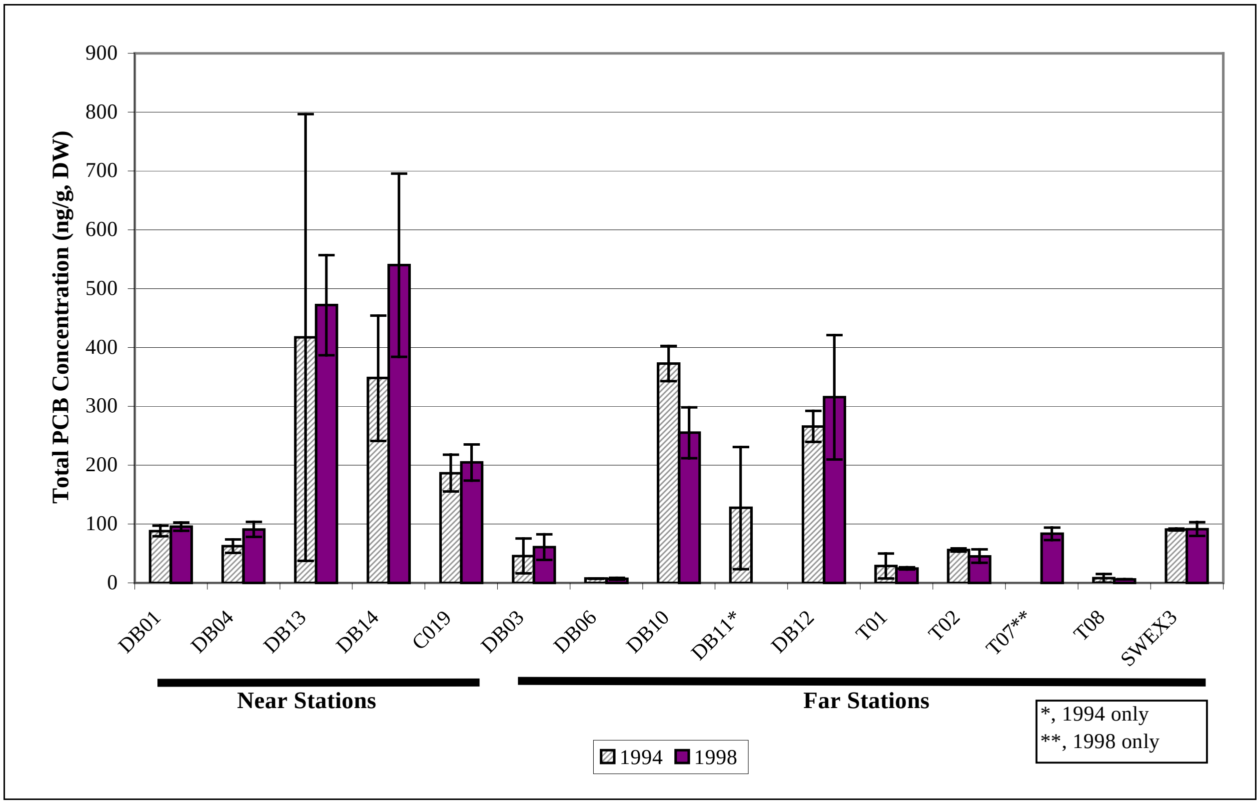


Figure 3-9. Total PCB Concentrations in Sediment in 1990, 1994, and 1998 Samples. Error Bars Are One Standard Deviation.

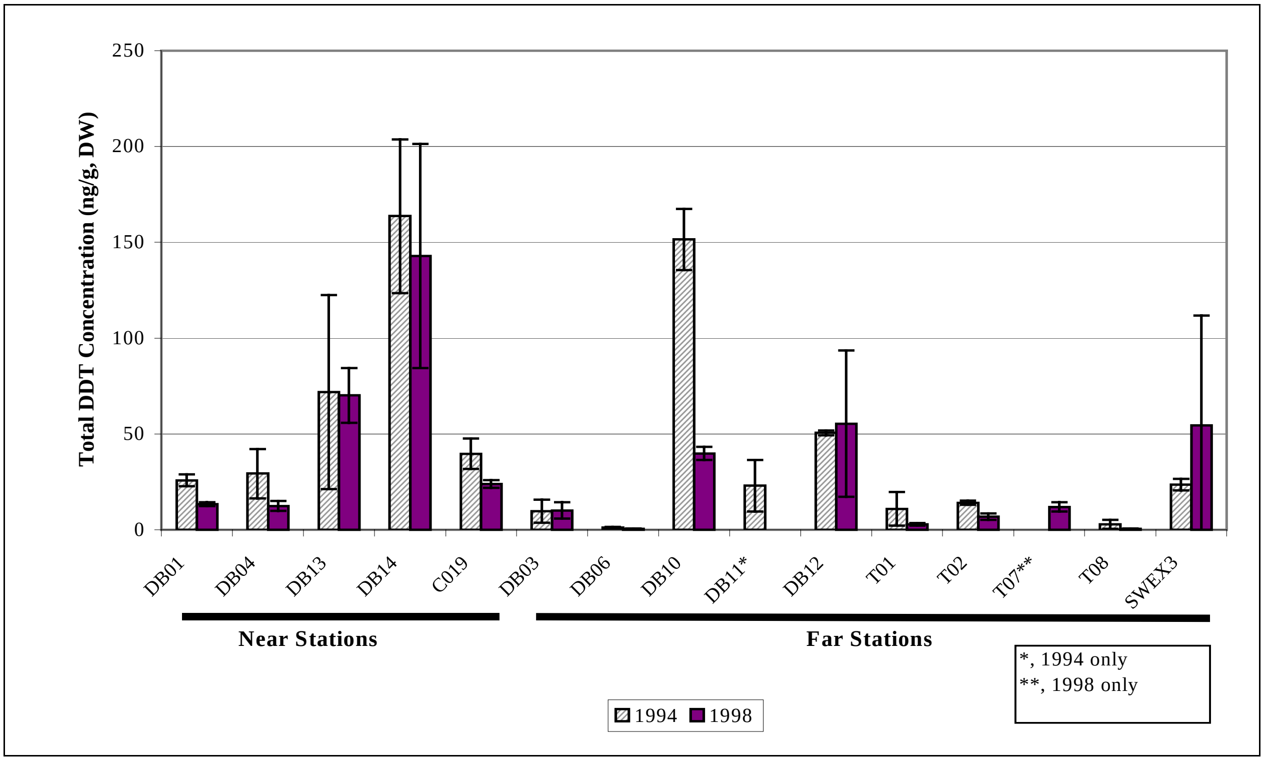


Figure 3-10. Total DDT Concentrations in Sediment in 1990, 1994, and 1998 Samples. Error Bars Are One Standard Deviation.

3.2.3 Sewage Tracer Results (LABs, Coprostanol, *Clostridium perfringens*)

3.2.3.1 LABs and Coprostanol

Linear alkyl benzenes (LABs) are the aromatic compound by-products produced during industrial synthesis of LAB sulfonates, which are widely used anionic surfactants in detergents. Sources of LABs in Boston Harbor include waste from industrial production, and household and commercial cleaning activities. LABs were determined as the five major environmentally relevant LAB groups: phenyldecanes (C_{10}-LAB), phenylundecanes (C_{11}-LAB), phenyldodecanes (C_{12}-LAB), phenyltridecanes (C_{13}-LAB), and phenyltetradecanes (C_{14}-LAB). The individual phenyl-substituted alkanes in each LAB group were determined together as one analyte and reported as one value for the LAB group. The total LABs, defined as the sum of the C_{10}-, C_{11}-, C_{12}-, C_{13}-, and C_{14}-LAB, was also calculated.

Coprostanol is a sterol that is found in human feces and can be used as an indicator of sewage-derived organic material. It is particularly useful as a tracer because its concentration is generally unaffected by chlorination and aeration, and because it persists in anoxic sediments. The coprostanol data represent the total concentration of two coprostanol isomers, coprostanol (5β-cholestan-3β-ol) and epicoprostanol (5β-cholestan-3α-ol).

The LAB and coprostanol concentrations measured in 1990, 1994, and 1998 are summarized in Table 3-5 and are shown in Figure 3-11 and Figure 3-12, respectively. Results normalized to TOC are presented in Appendix B. As shown in Figure 3-11, the non-normalized total LAB concentrations measured in sediments in 1998 ranged from approximately 53.5 (at Station DB06) to 3,690 ng/g (at DB13). All five LAB groups were identified in most samples. Compared to previous sampling years, the concentrations of total LABs measured in 1998 decreased at all stations, except for Stations DB13 (“Near” Fox Point CSOs) and DB06 (“Far” Old Harbor), where concentrations appeared to increase. In previous years, the highest concentrations of sediment LABs were observed at Station DB14.

As shown in Figure 3-12, coprostanol concentrations measured in 1998 ranged from 148 (at DB06) to 378,000 ng/g (at DB13). The coprostanol concentrations measured in 1998 were lower than those measured in either 1990 or 1994 at all stations, except Stations DB13 and DB14. The concentrations measured at Station DB13 were variable and much higher than any measurements made in the study area during the past 10 years.

The LAB/coprostanol ratios for 1998 ranged from 0.01 (at DB13) to 0.61 (at DB10) [Figure 3-13]. This range is much wider than observed in 1994, when ratios were between 0.08 and 0.27. Most LAB/coprostanol ratios were similar to those measured in previous years. However, marked increases in the ratios were noted at Stations DB06 and DB10. The increase at Station DB06 is not very meaningful because the LAB concentrations were almost non-detectable in the 1998 study. The increase at Station DB10 is due to one anomalously low coprostanol measurement in one replicate, without a corresponding drop in the LAB concentration. The resulting ratio is elevated compared to 1994. Interestingly, the ratio measured in 1994 also reflected high variability in replicate results. Although this station is not directly adjacent to a CSO, it is near a major storm drain.

Sediment LABs were also measured in 1997 as part of the MWRA Harbor Benthic Survey (Blake *et al.* 1998). Total LAB concentrations were determined for Stations T01 (414 ng/g), T02 (1106 ng/g), and T08 (222 ng/g), as well as for Station T04 (1263 ng/g), which corresponds to Station DB13 for this CSO study. LAB concentrations at Stations T01, T02, and T08 were similar to measurements made in 1994, and somewhat higher than concentrations measured in 1998. The concentration of LABs at Station T04, however, was more than 30 percent lower than the concentration measured in 1994. The increase observed in 1998 at this station was, therefore, not representative of the general decline in LAB concentrations observed since 1990.

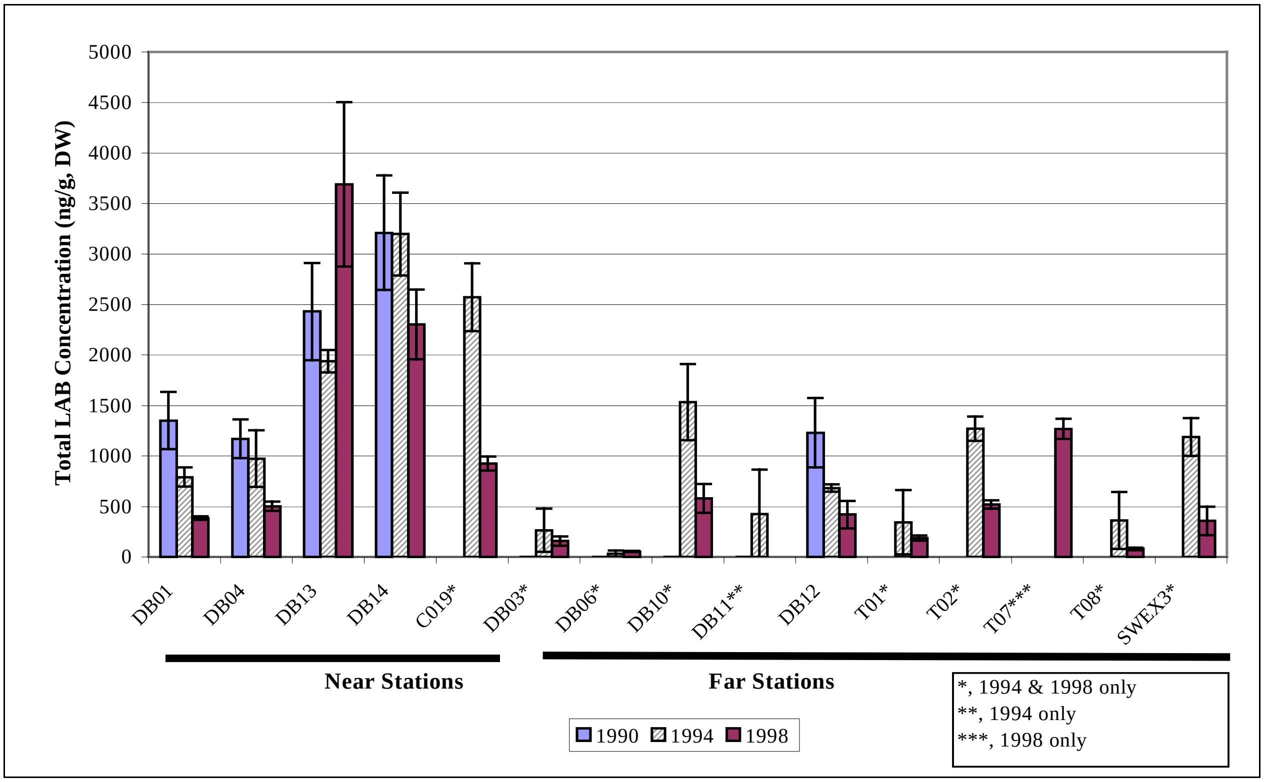


Figure 3-11. LAB Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

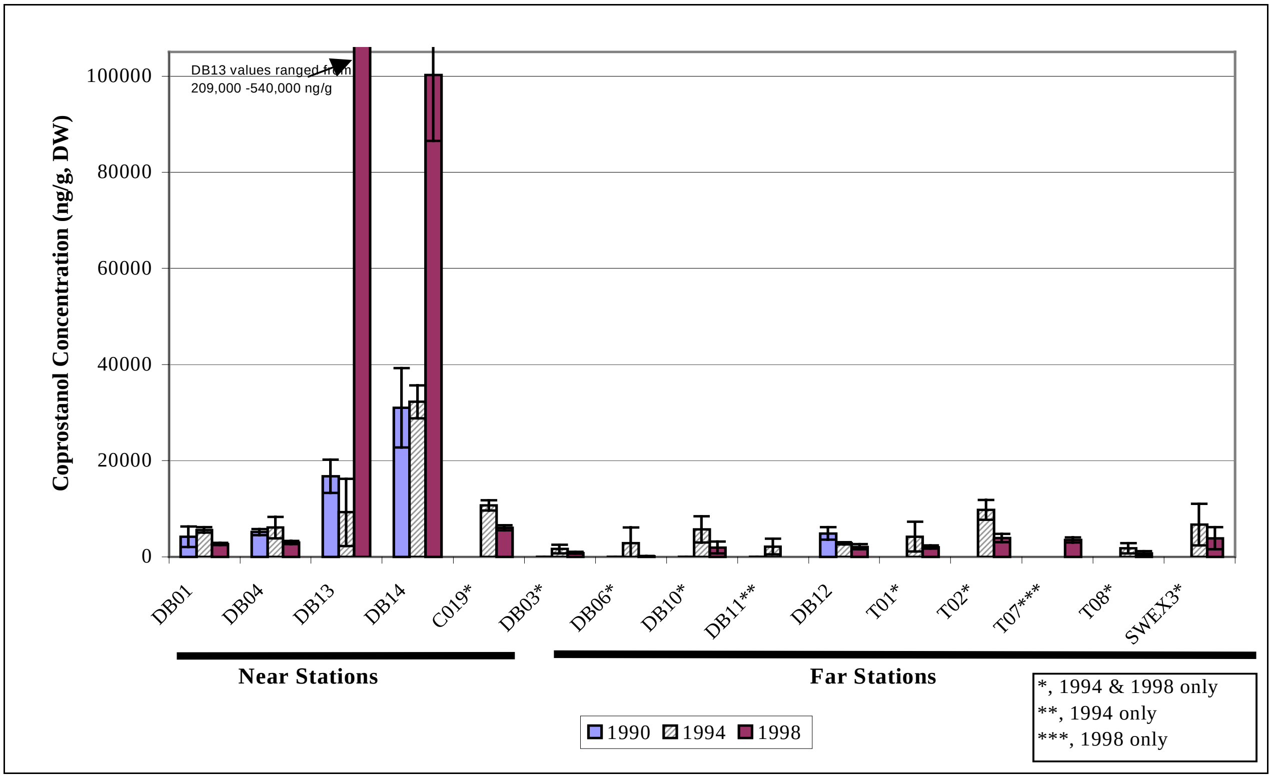


Figure 3-12. Coprostanol Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

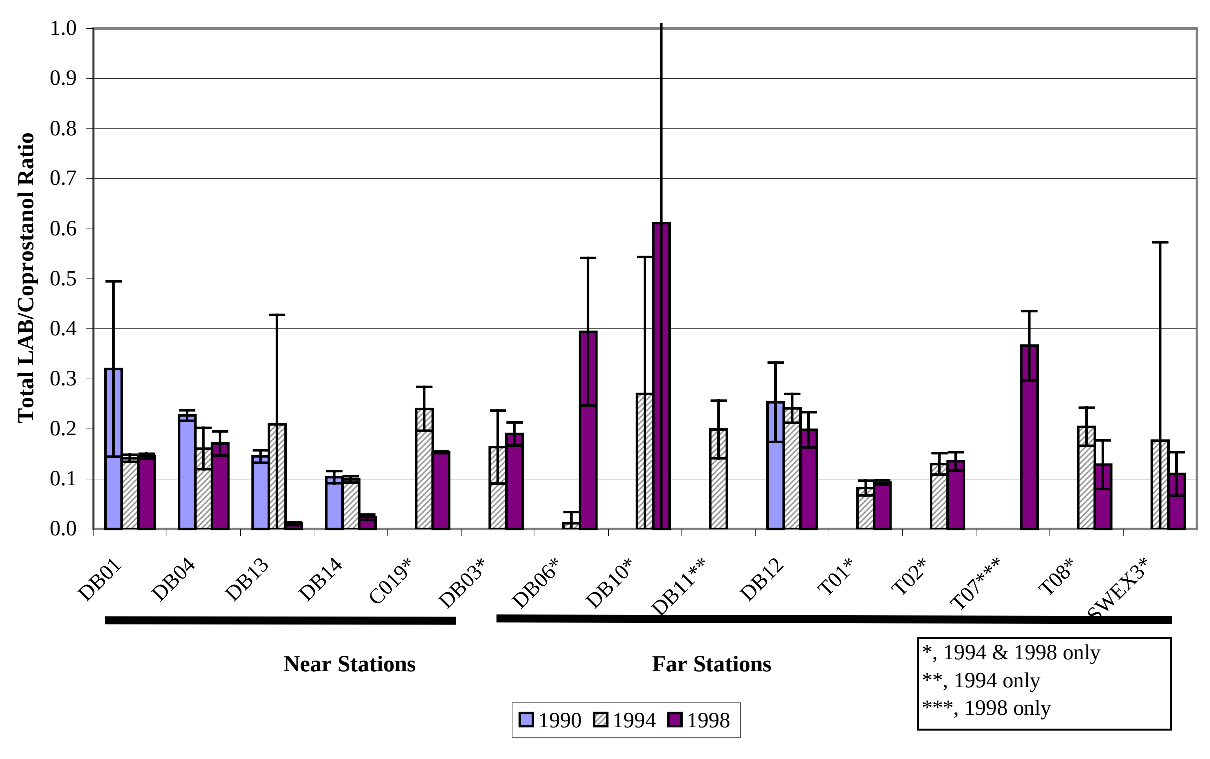


Figure 3-13. LAB/Coprostanol Ratios for 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

The general decline in both LAB and coprostanol concentrations at all “Far” stations and at most “Near” stations is probably due to reduced sewage influx to Boston Harbor as a result of facility improvements at the Deer and Nut Island treatment plants, as well as at local CSOs. The increases observed at the Fox Point and Commercial Point CSOs (BOS-88, BOS-89, and BOS-90) may be a result of localized inputs from major storm events in June 1998, rather than due to chronic inputs at these locations.

3.2.3.2 Clostridium perfringens *Densities*

Clostridium perfringens data for all samples collected since 1990 as part of the CSO monitoring program are presented in Table 3-5 and are illustrated in Figure 3-14. Data normalized to percent TOC are presented in Appendix B. The *C. perfringens* data were also $\log_{10}$-transformed for data analysis and interpretation.

The data are presented non-transformed in Figure 3-14(a) as well as log-transformed in Figure 3-14(b), although for evaluating relative differences in microbiological pollution, log-transformed data are more commonly used. The density of *C. perfringens* spores measured in 1998 ranged from a low value of 397 at Station DB06 to a high value of 15,100 (at CO19) colony forming units (referred to as spores) per gram dry weight of sediment. The densities of *C. perfringens* spores are lower than those measured in 1994 at all “Far” stations, a trend that represents a continued decline from the 1990 measurements. Densities measured at “Near” stations in 1998 were generally similar to 1994 measurements. However, all 1994 and 1998 measurements are lower than those made in 1990. Although not statistically significant (Table 3-6), highest densities were generally found at the “Near” stations, as well as at Stations DB10 and DB12, which is consistent with previous findings. The lowest densities overall were found at Station DB06 in all three study years.

Since 1990, *C. perfringens* densities declined at all stations, and concentrations within the last five years (1994 and 1998) were similar at most stations. The largest declines overall were observed at Stations DB14 (near BOS-90, the Commercial Point CSO), DB13 (near BOS-89, the Fox Point CSO), and DB04 (near the BOS-83 CSO).

Since 1993, additional *C. perfringens* data have been collected in April and August as part of other studies at selected Boston Harbor sites (Blake *et al.* 1998, Kropp *et al.* 1999). Four of these stations correspond to stations also sampled in this study (T01, T02, T04/DB13, and T08). There is no clear pattern in the differences between April and August sampling events as shown in Figures 3-15(a) and (b). Comparison of data generated during the current CSO study (1998) with results from the Harbor Benthic Monitoring Program surveys in August show that 1994 Benthic Monitoring results are similar, while 1998 Benthic Monitoring results are generally higher (by approximately a factor of two) than those found in the current CSO study. Densities of *C. perfringens* spores in the intervening years appear elevated at Stations T02 and T04/DB13, relative to 1998 CSO study densities.

Enteroccocus and fecal coliform data were measured in 1990 and 1998 (Table 3-5). Direct comparison of the results from 1990 and 1998 is difficult due to the use of different methodologies between years. However, current *Enterococcus* and fecal coliform results seem to suggest that elevated concentrations may reflect proximity to outfalls.

3.2.4 Metal Contaminant Results

Sediment samples were analyzed for silver (Ag), aluminum (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn). Results are presented in Table 3-6 as µg/g dry sediment. Al and Fe results are presented on a percent dry weight basis. Concentrations of metals normalized to percent fines and Al are provided in Appendix B. The non-normalized metals data for all stations are provided in Figure 3-16 through Figure 3-23. Although, empirically, normalization may help in identifying and interpreting metal concentrations above regional background concentrations (*e.g.*, concentration increases that are due to anthropogenic activity), statistically, normalization did not affect the analysis of the data reported here. Normalization of 1994 data to percent fines appeared to reduce the variability of the data and resulted in consistent elevations of Pb and Zn at Station DB14. Review of normalized data from all years (Appendix B) does not clearly show elevated concentrations at any one station or group of stations. Therefore, all discussion that follows will involve non-normalized data.

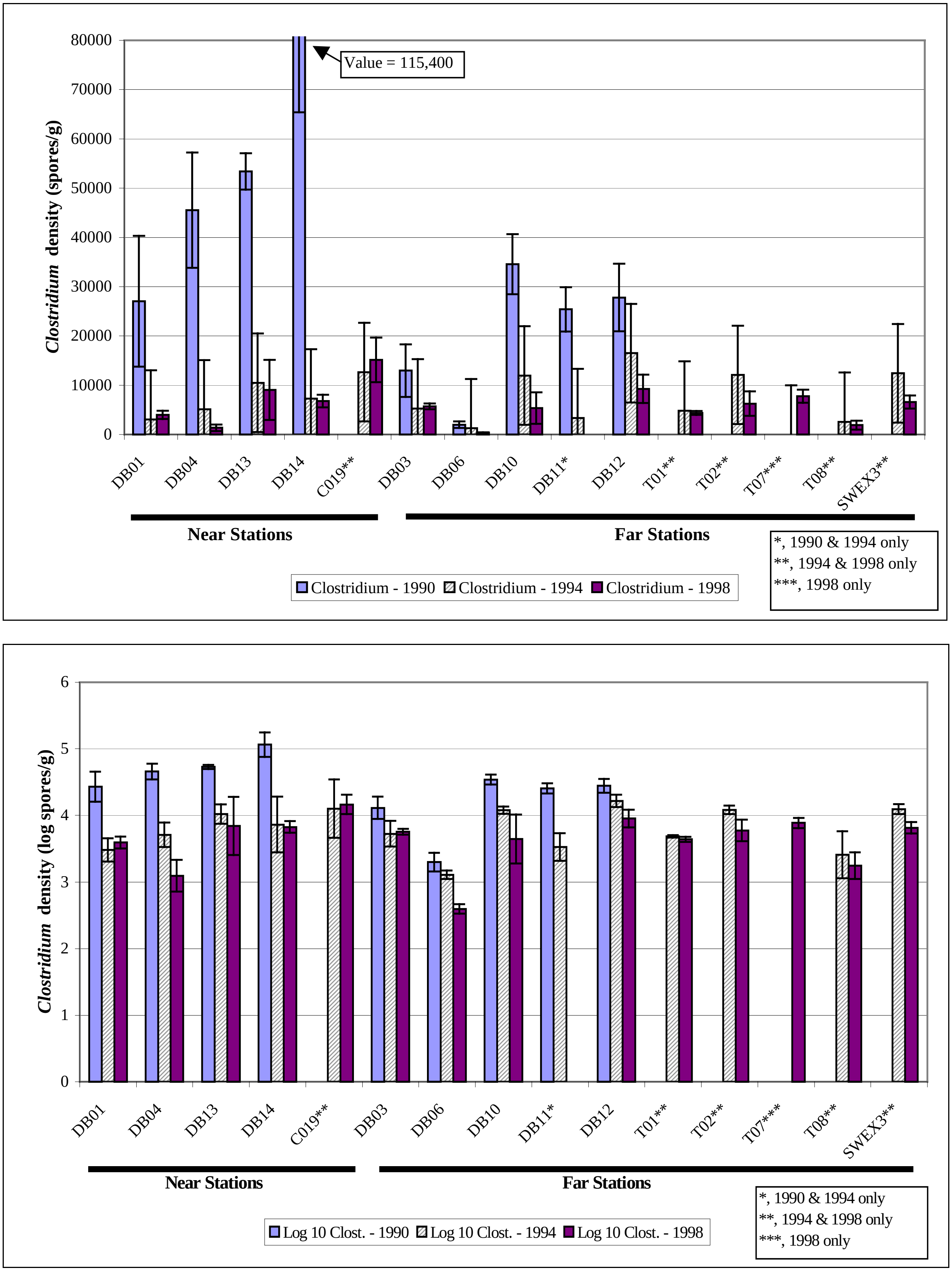


Figure 3-14. Densities of *Clostridium perfringens* in 1990, 1994, and 1998 Sediment Samples; (a) Spores/g Sediment; (b) Log$_{10}$-transformed. Error Bars Are One Standard Deviation.

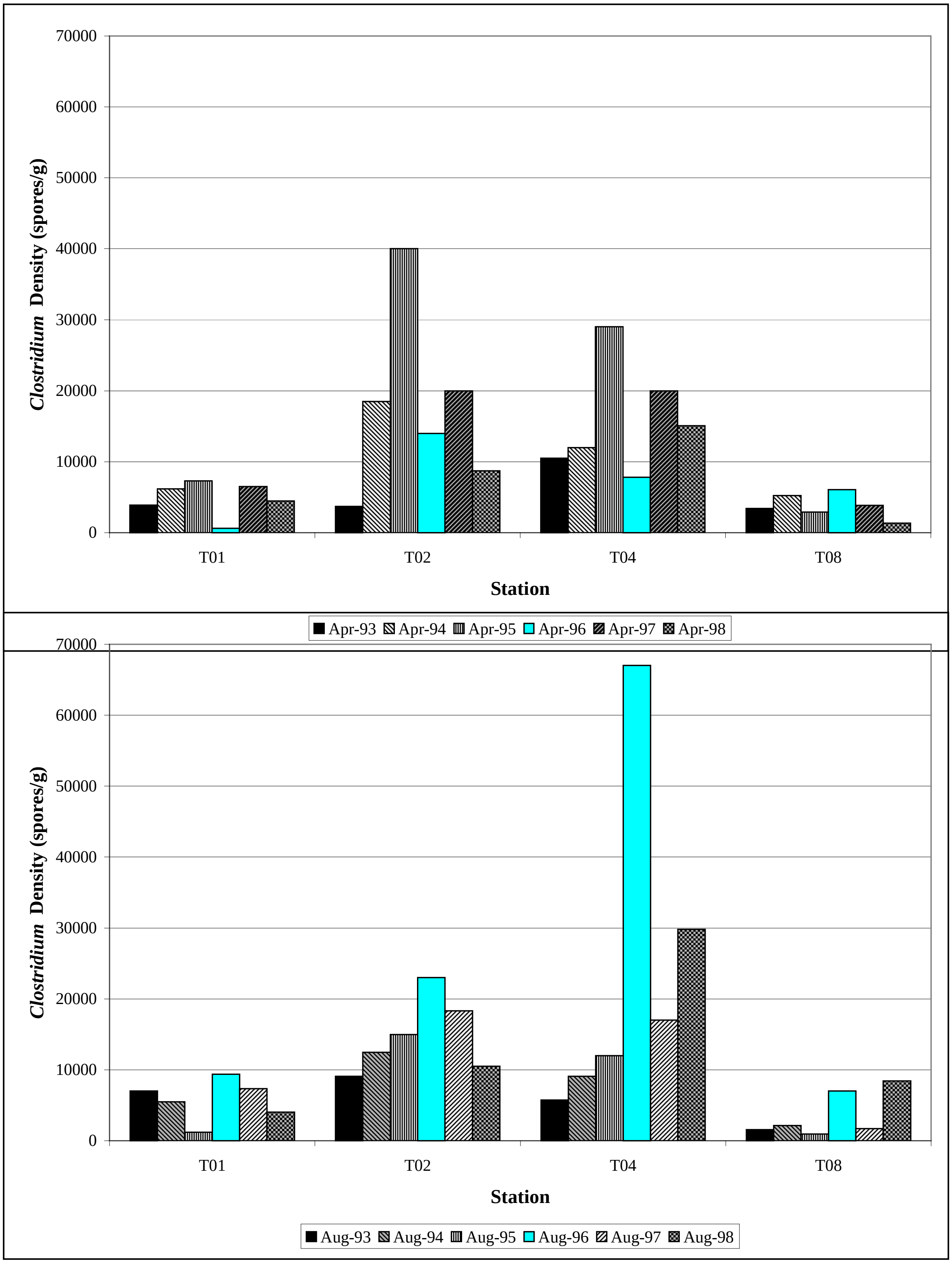


Figure 3-15. Densities of *Clostridium perfringens* in Sediment Samples Collected for the Harbor Benthic Monitoring Program in (a) April 1993 - 1998 and (b) in August 1993 - 1998.

Table 3-6. Comparison of Metal Contaminants in 1998, 1994, and 1990 Sediment Samples. Raw Data Are Not Normalized.

	Not normalized (:g/g, dry weight)									
Station	**Ag**	**Al[1]**	**Cd**	**Cr**	**Cu**	**Fe[1]**	**Hg**	**Ni**	**Pb**	**Zn**	**%Fines[2]**
1998											
DB01	2.47	6.69	0.757	142	117	3.84	0.583	31.6	146	220	85.4
DB03	0.713	4.62	0.35	68	33.4	2.1	0.183	15	56.4	83.9	19.1
DB04	2.85	6.56	0.737	151	103	4.11	0.597	36.3	125	192	89.7
DB06	0.303	3.9	0.07	26.4	17.8	1.3	0.0667	9.93	29.2	36.5	5.87
DB10	3.13	5.89	1.37	142	288	4.16	1.03	36	423	351	54.1
DB12	2.74	5.4	1.62	162	88	3.04	0.65	28.8	116	164	43.5
DB13	3.48	5.85	2.1	164	193	3.97	2.29	38.7	389	435	78.3
DB14	1.84	5.28	2.2	117	170	3.54	1.07	34.9	719	507	53.6
T01	0.71	5.19	0.32	58.9	33.6	2.3	0.17	19.7	50.8	71.8	25
T02	1.8	5.91	0.417	105	52.9	3.05	0.31	24.6	62.9	108	53
T07	5.56	6.1	0.943	165	99	3.38	0.827	32.5	110	147	57.4
T08	0.41	3.89	0.123	29	16.9	1.71	0.08	12.2	27.5	44.1	5.43
CO19	4.03	7.4	1.09	205	148	4.78	0.79	44.8	150	234	96.7
SWEX3	2.59	6.58	0.347	154	80.3	3.93	0.697	35	90.8	142	66.4
1994											
DB01	3.48	5.7	0.844	157	134	3.72	0.741	34.5	152	233	74.4
DB03	0.885	4.63	0.228	65.2	27.9	1.99	1.35	15.3	54.6	69.5	18.6
DB04	2.97	5.47	0.82	139	87	2.94	0.617	28.2	159	168	60.8
DB06	0.359	3.64	0.0651	34.8	12.1	1.35	0.075	9.1	28.4	33.3	7.43
DB10	5.05	6.17	1.69	218	198	4.22	1.18	37.8	182	273	87.9
DB11	1.2	4.19	0.585	77	41.2	1.95	0.402	13.5	63.5	95.5	39.6
DB12	3.76	5.33	1.13	209	98.5	3.14	0.81	33.9	130	172	45.6
DB13	5.59	6.71	2.12	254	158	3.79	1.24	37.1	199	266	85.7
DB14	2.18	4.25	1.48	119	126	2.84	0.771	25.5	347	344	51.9
T01	0.895	6.49	0.307	78.2	26.8	2.6	0.26	20.7	32.8	67.6	36.4
T02	2.5	5.66	0.485	126	59.2	2.63	0.373	23.2	63.1	101	37.9
T08	0.53	3.02	0.101	48.9	15.8	2.03	0.101	13.3	25.9	47.2	6.13
CO19	4.76	7.2	1.14	215	146	4.34	0.812	37.2	137	218	95.9
SWEX3	4.03	6.95	0.423	194	95.7	3.95	0.581	35.9	108	156	54
1990											
DB01	-	6.52	8.28	116	215	2.82	-	73.4	469	1470	30.1
DB03	-	5.31	0.6	82.8	48.5	2.09	-	19.3	59.7	97.6	18.5
DB04	-	7.44	1.5	196	156	3.7	-	47.9	150	275	63.8
DB06	-	5.11	0.25	34.2	18.6	1.39	-	13.8	36.7	46.7	6.1
DB10	-	7.14	2.29	218	215	4.62	-	51.5	427	473	62.7
DB12	-	6.44	1.06	168	103	3.07	-	34	110	156	44.1
DB13	-	7.41	2.01	212	182	4.01	-	44.3	192	342	77.7
DB14	-	6.97	2.46	160	183	3.7	-	44.3	523	433	64.1

[1] Al and Fe reported as percent dry weight.

[2] Percent Fines is the sum of percent silt and percent clay.

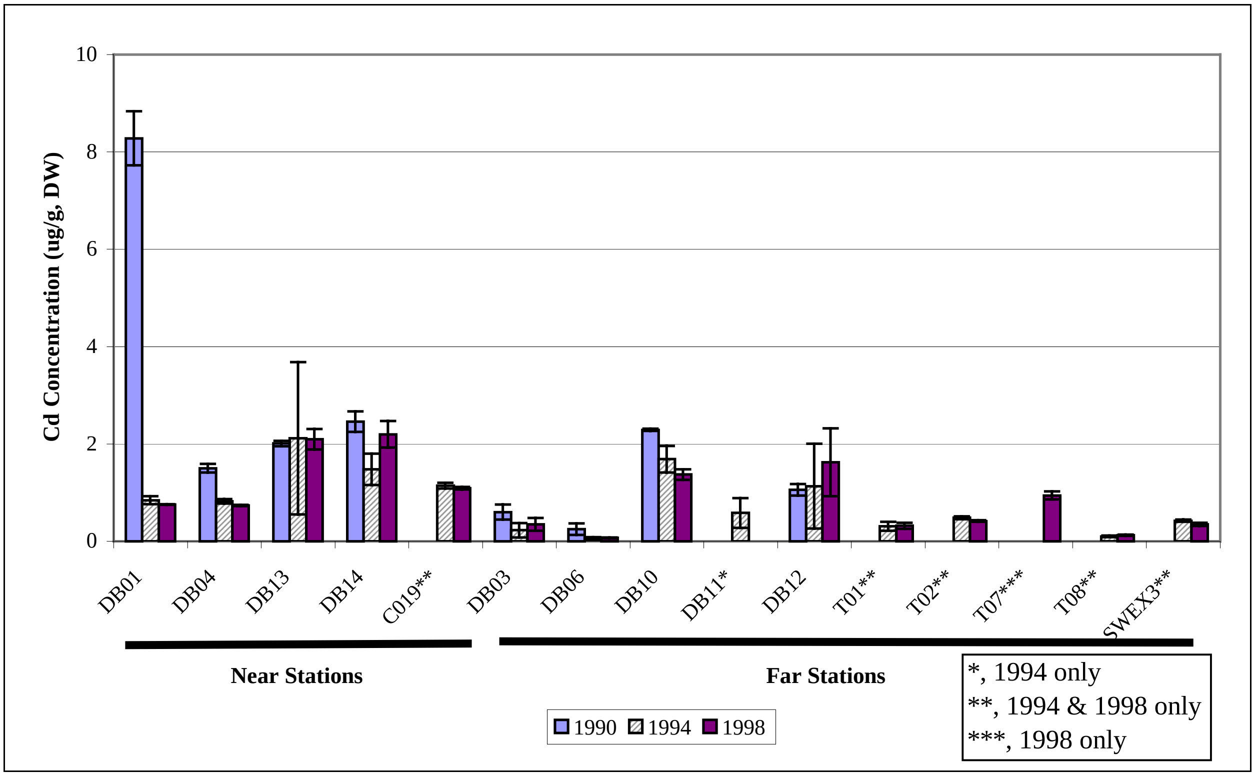


Figure 3-16. Cadmium Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

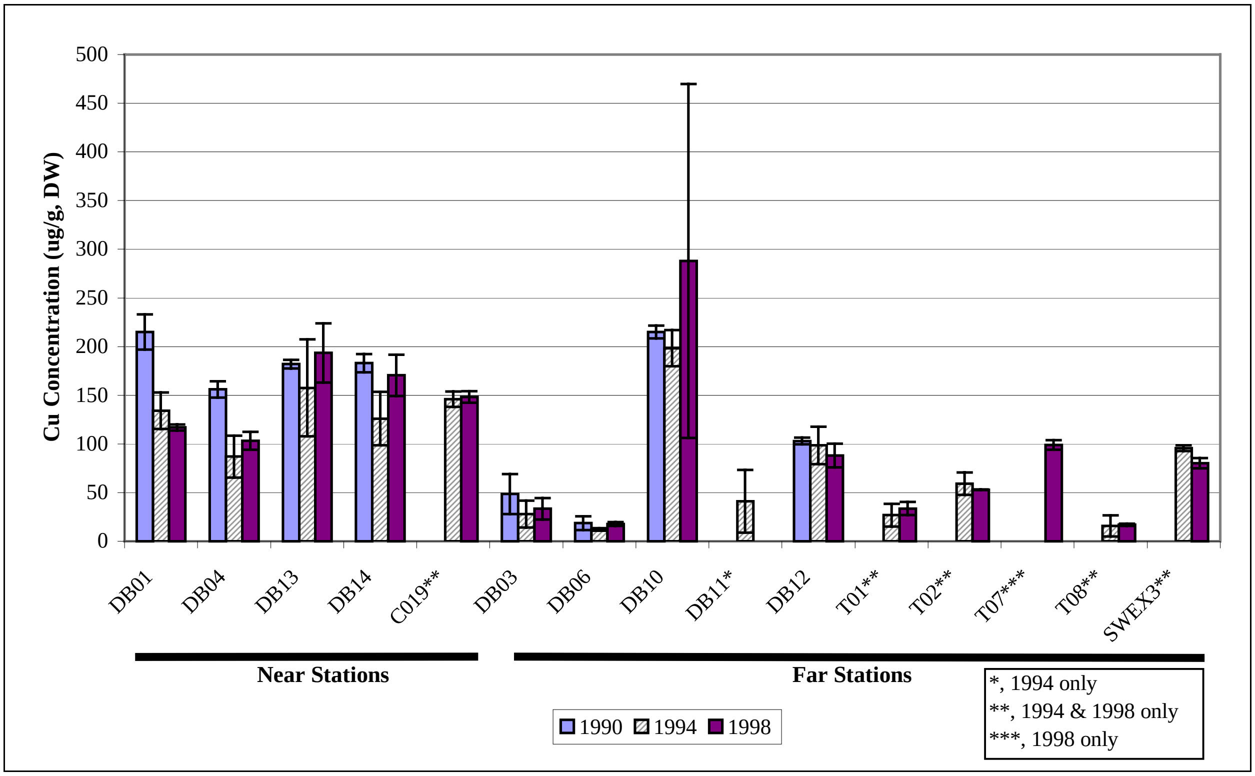


Figure 3-17. Copper Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

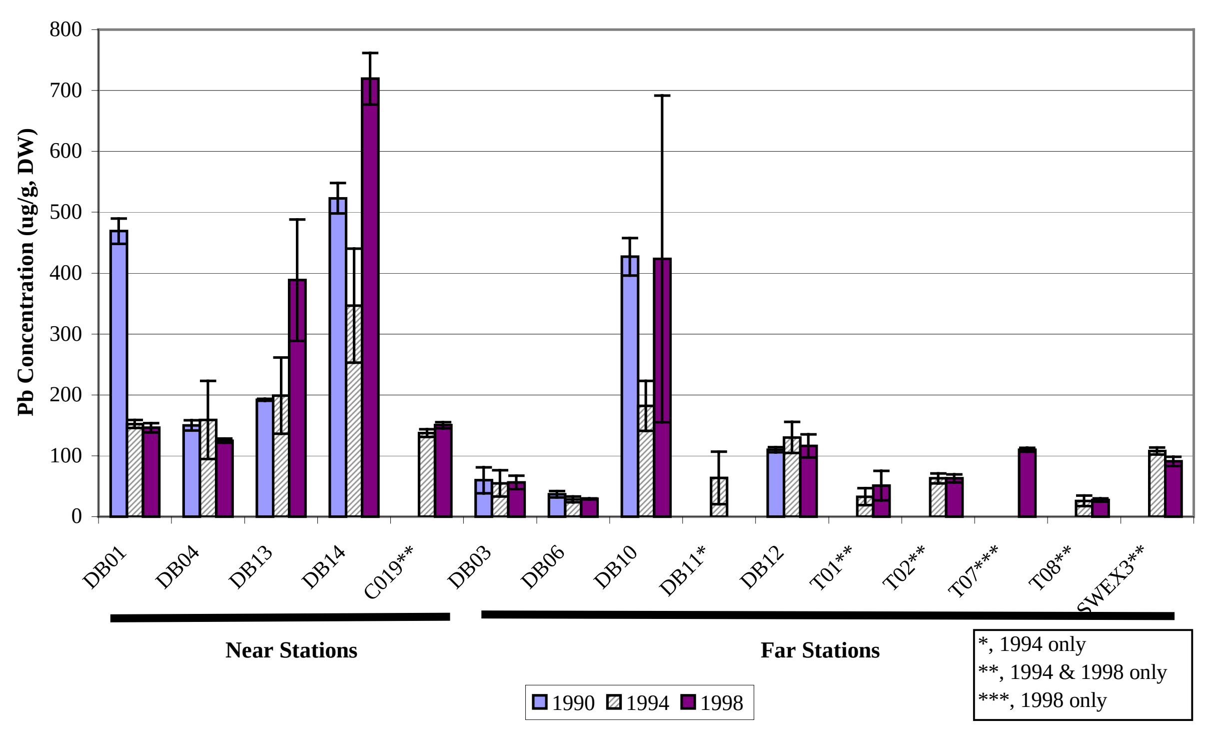


Figure 3-18. Lead Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

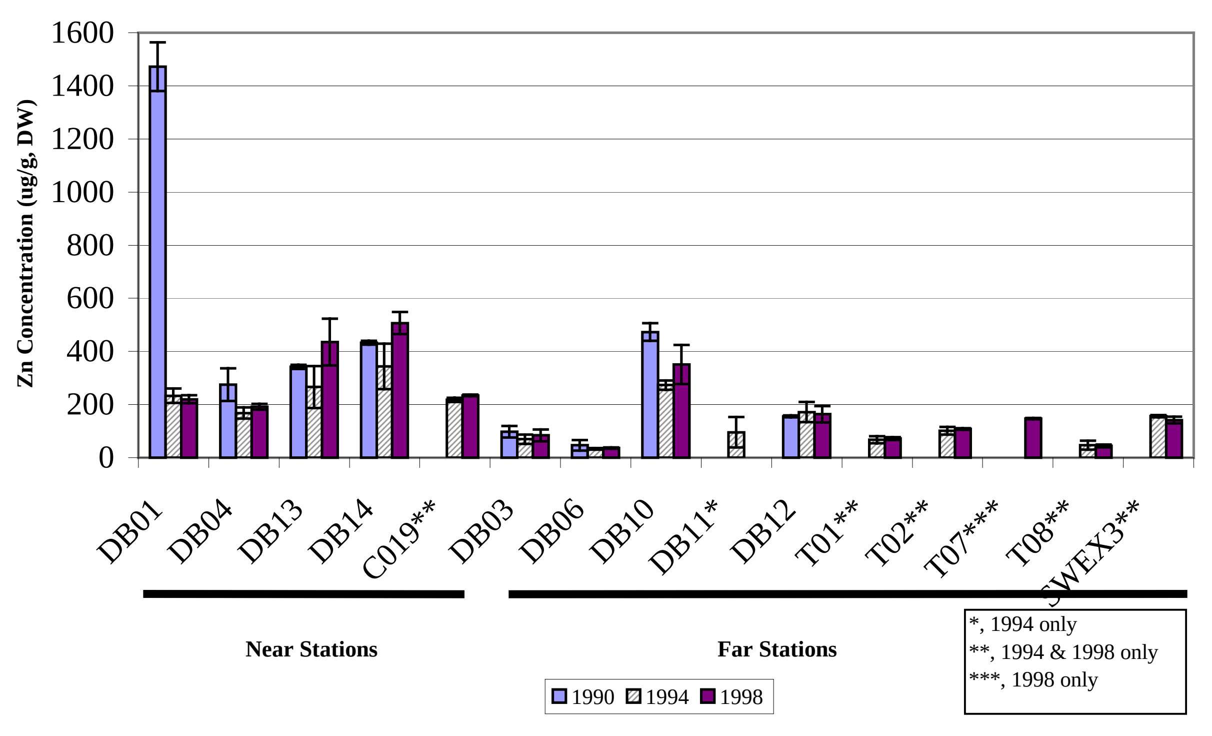


Figure 3-19. Zinc Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

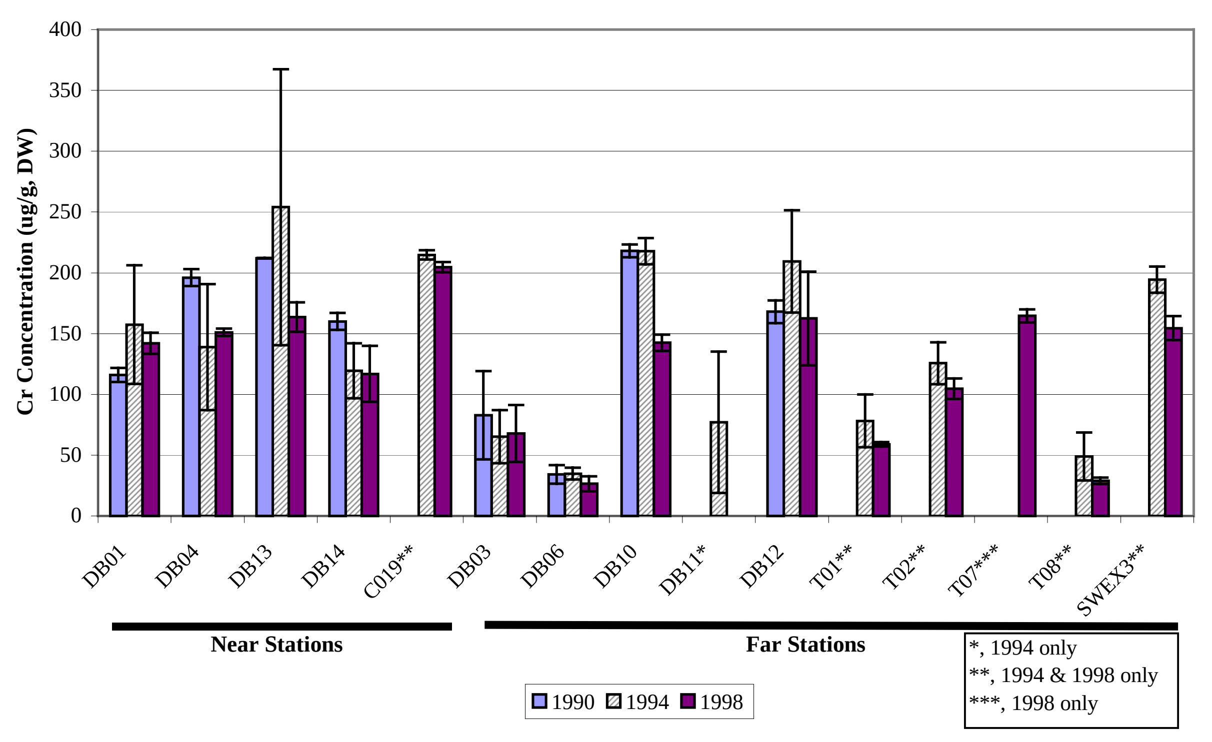


Figure 3-20. Chromium Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

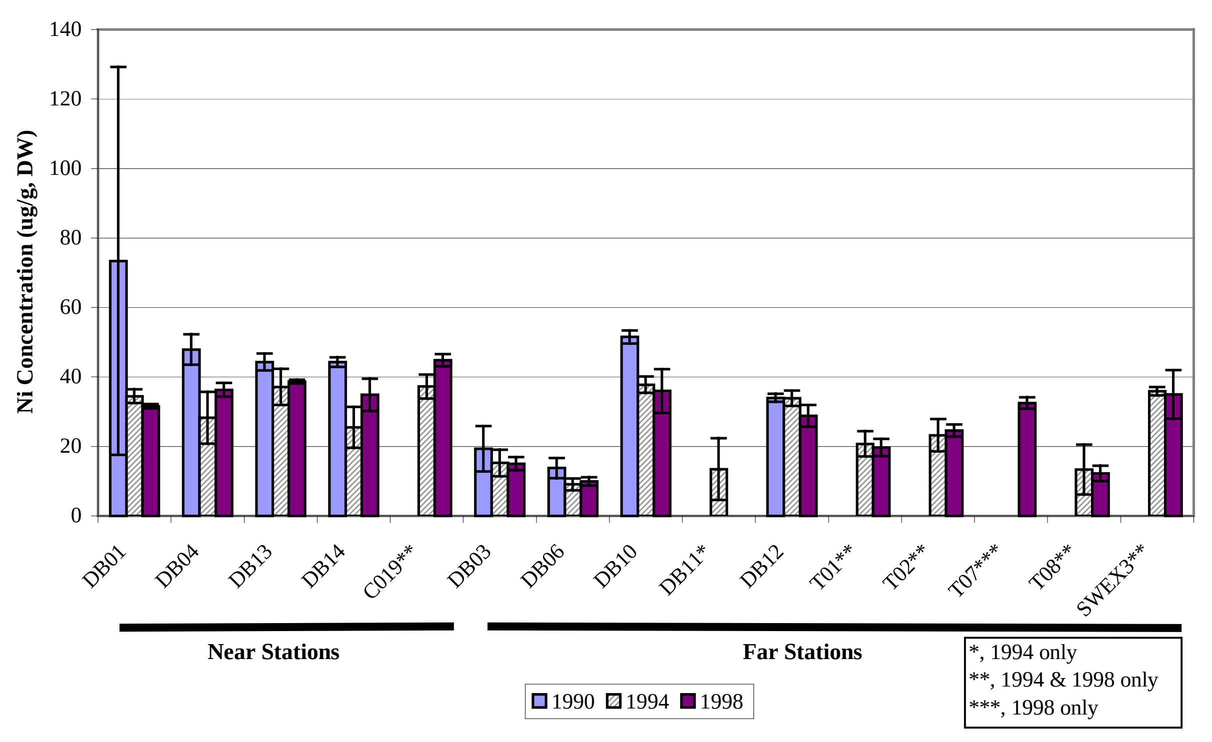


Figure 3-21. Nickel Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

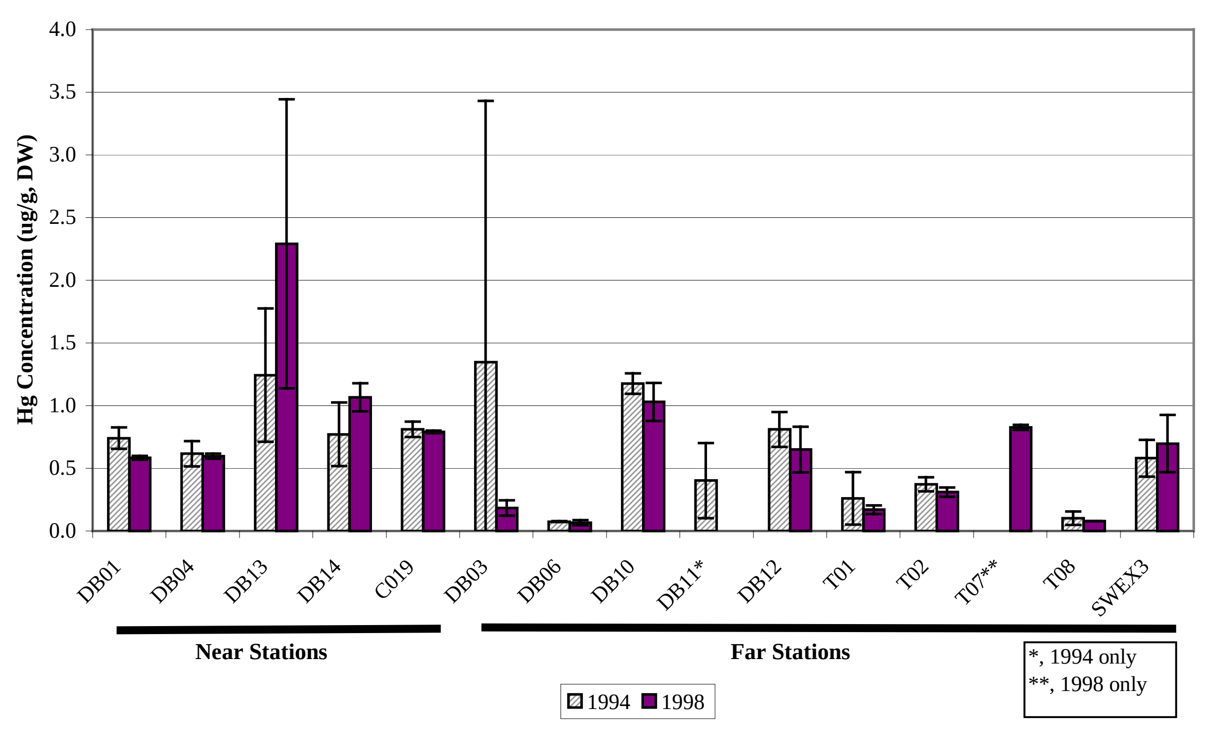


Figure 3-22. Mercury Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

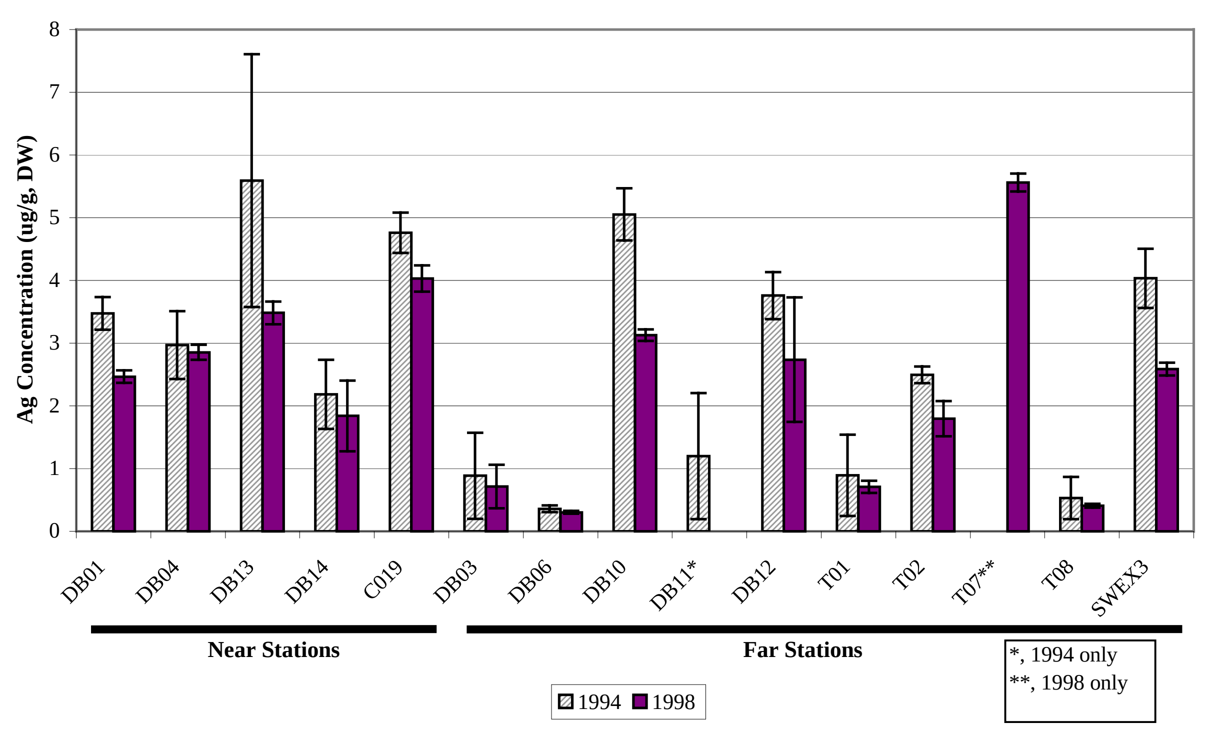


Figure 3-23. Silver Concentrations in 1990, 1994, and 1998 Sediment Samples. Error Bars Are One Standard Deviation.

3.2.4.1 Cadmium, Copper, Lead and Zinc

Cd, Cu, Pb, and Zn are the four primary metals of concern that probably have anthropogenic sources (Durell 1995). Results from the 1994 study indicated that BOS-90 ("Near" Station DB14) may have contributed Pb and Zn. Results from the 1998 study appear to support these conclusions; the highest concentrations of Cd, Cu, Pb, and Zn were found at Stations DB10, DB13, and DB14. In general, the concentrations of these metals in sediments collected at stations near the CSOs were higher compared to levels in sediments collected at stations far from the CSOs (Figures 3-16 through 3-19). Over time, the concentrations of these four metals have generally been similar. Since 1990, a slight decrease in concentration was observed for all metals at Station DB04 and a particularly large decrease was observed at Station DB01 between 1990 and 1994, with the 1998 results similar to those for 1994. These stations represent the Old Harbor area.

3.2.4.2 Chromium, Nickel, Mercury, and Silver

Concentrations of Cr and Ni are relatively similar at all stations, although concentrations at stations near the CSOs are generally slightly higher than at the "Far" stations. Since 1990, concentrations have also remained fairly constant, with only slight decreases observed at Stations DB04, DB10, DB13, and DB14. Statistical testing described in Section 3.3 evaluates the significance of these observations.

Ag and Hg were only measured as part of the 1994 and 1998 studies. Since 1994, concentrations of Ag remained about the same or decreased slightly (Stations DB01, DB10, T02 and SWEX3). Concentrations of Hg in 1998 samples were similar to those in 1994 samples from all stations. Concentrations of both Hg and Ag were generally higher at stations near the CSOs.

3.3 Analysis of 1990, 1994, and 1998 Data for Temporal and Spatial Trends

Statistical analysis of the data generated from 1990 through 1998 was performed using a one-way nested ANOVA test to see if the stations designated as "Near" and "Far" were significantly different from each other by year. The sources of variance were examined to estimate the magnitude of error at the various stages of the study. Correlation analyses were then performed on the individual parameters versus TOC and percent fines to determine if these parameters could be used to explain variability in the data. Temporal trends in data collected since 1990 were evaluated using the one-way ANOVA test. Additional data collected in 1994 and 1998 were compared for "Near"/"Far" significance using a correlation analysis. Parameters and stations common between 1994 and 1998 were also evaluated using a student t- test to determine significant differences between the years and parameters. Station T07, added in 1998, was also evaluated to see if it fit in as a "Near" or "Far" station using a Wilcoxon Rank Sum test. Results of these analyses are presented below.

3.3.1 One-Way Nested ANOVA to Test for Near/Far Differences

One-way nested ANOVAs were performed to determine if the grouping of stations as "Near" or "Far" would actually result in the ability to discriminate these stations as different. The nesting in this case is by year and the designation of "Near" or "Far" is nested within the main group of year. Year has three levels –1990, 1994, and 1998. This type of ANOVA assumes that all subordinate groups are randomly distributed, which is not entirely the case for the station grouping in this study. The "Near" and "Far" grouping was based on the physical distance between a CSO discharge and the sampling station. Thus, this may partially contraindicate the use of a nested ANOVA in this way. However, only the physical distance is being statistically evaluated. These analyses were intended to determine if the "Near" and "Far" classification was relevant.

Table 3-7 contains the results of these analyses for all common data (stations and parameters) from 1990 through 1998. No significant differences were observed when comparing all measurements between the three study years. However, significant differences were observed when comparing measurements grouped as "Near" or "Far." Nesting of "Near" vs. "Far" within the treatment level of year was significant for all parameters ($p< 0.05$) except chromium ($p> 0.05$).

Table 3-7. One-Way Nested ANOVA for "Near" and "Far" Stations Using 1990, 1994, and 1998 Results.

Parameter	Treatment = Year		Nesting = "Near"/ "Far"	
	F-statistic	P-value	F-statistic	P-value
C. perfringens spores*	6.10	0.088	4.17	0.0091
Percent fines*	0.02	0.981	11.52	0.0001
Percent TOC*	0.05	0.954	12.91	0.0001
PAH-24*	0.06	0.943	12.03	0.0001
Al	2.00	0.28	5.33	0.0024
Cd*	0.68	0.573	8.82	0.0001
Cr	0.57	0.615	2.45	0.0716
Cu	0.34	0.737	3.79	0.0143
Fe	0.08	0.927	7.34	0.0002
Ni*	0.49	0.654	9.19	0.0001
Zn*	0.21	0.81	13.26	0.0001

*Indicates parameters that required transformation prior to testing. Log_{10} transformation was sufficient to induce a normal distribution (determined by the method of Box and Cox) in the samples, as well as homogeneity of variance between samples. Total number of observations for each variable was 72. F-statistic for the treatment level year is based on 2 and 3 degrees of freedom, while the F-statistic for the nested factor was based on 3 and 66 degrees of freedom.

3.3.2 Variance Components of the One-Way Nested ANOVA Test

Variance was examined to estimate the magnitude of error at various stages of the study. Nesting the "Near" and "Far" groups within years allows estimation of the amount of error associated with sampling near or far from a CSO discharge site. Grouping the stations as either "Near" or "Far" allowed estimation of the amount of error associated with sampling individual stations (*i.e.*, variance between replicate samples at individual stations).

Table 3-8 presents variance components (in percent of total) for the analytical parameter indicated arising from the data arranged as a nested ANOVA. The unexplained error component is due to the grouping of stations as "Near" or "Far." These values represent the error between measurements on each grouping and are an indication of the amount of variability that is not explained by the ANOVA. Table 3-8 shows that 46.5 to 89.3 percent of the variability in the data represents the residual error. This residual error represents the variability in the parameter of interest from replicate to replicate (*i.e.*, stations and samples collected within stations) within the subgroup of "Near" or "Far." This error arises because of the high degree of variability in the data. The variability is due to pooling of the stations and indicates that there is a high degree of variability in the sediment, whether it is designated "Near" or "Far." Among years, the variance between "Near" and "Far" represents 12.3-50.5 percent of the total variance. The variance between years is generally low. As shown in Table 3-8, the only parameters with a detectable variance over time were Al and *C. perfringens* spores. Generally, the largest variance occurs at the replication level and this leads to difficulty in demonstrating significant changes over the years.

Tables 3-9 and 3-10 present the error variance components of the ANOVA test when the measurements are broken down into the "Near" or "Far" groups within the years. This reduces the variability due to the "Near"/ "Far" grouping in the previous analyses. Table 3-9 shows the variance component analysis for the "Far" grouping and indicates that variation over the years is generally not significant. The unexplained error component is due to the sample replication at individual stations and is an indication of the variability of sediment samples at the same station. The error component is much lower and represents 1.0 to 40.6 percent of the variance. This indicates that replication is generally good (except for Al and Cu) between samples from any one station. The most significant portion of the variance arises at the level of station within years (50.2 to 99.0 percent). This represents the error component as well as the added portion due to the differences between stations and indicates that the stations are significantly different from each other.

The variance components in Table 3-10 represent the "Near" group and show the same general trends noted for the "Far" group. However, the error component is generally higher than for the "Far" group, indicating that the replicate sediment samples at stations near a CSO discharge are more highly variable. The stations within years variance component ranges from 2.3 to 83.8 percent, a much broader range than for the "Far" group. The variance between years is more significant in the "Near" group and indicates more change at these stations between sampling years.

Table 3-8. Variance Components (in Percent of Total) Arising from the Data Arranged as a Nested ("Near"/ "Far" Grouping) ANOVA.

Parameter	Variance Component (Percent of Total)		
	Year	"Near"/ "Far" (Year)	Error
Percent Fines*	0	46.7	53.3
Percent TOC	0	49.9	50.2
C. perfringens spores*	41.2	12.3	46.5
PAH-24*	0	47.9	52.1
Al	14.01	22.8	63.2
Cd*	0	39.5	60.6
Cr	0	10.8	89.3
Cu	0	18.9	81.1
Fe	0	33.5	66.5
Ni*	0	40.6	59.4
Zn*	0	50.5	49.5

*Parameters analyzed as log-transformed variables.

Table 3-9. Variance Components (in Percent of Total) Arising from the Data Arranged as a Nested ("Far" Grouping) ANOVA.

Parameter	Variance Component (Percent of Total)		
	Year	Station (Year)	Error
Percent Fines*	0	89.3	10.7
Percent TOC	0	95.8	4.2
C. perfringens spores*	3.4	89.8	6.8
PAH-24*	0	94.7	5.3
Al	9.2	50.2	40.6
Cd*	0	84.3	15.7
Cr	0	92.9	7.1
Cu	0	75.9	24.2
Fe	0	82.5	17.5
Ni*	0	93.6	6.4
Zn*	0	99.0	1.0

*Parameters analyzed as log-transformed variables.

Table 3-10. Variance Components (in Percent of Total) Arising from the Data Arranged as a Nested ("Near" Grouping) ANOVA.

Parameter	Variance Component (Percent of total)		
	Year	Station (Year)	Error
Percent Fines	0	73.6	26.4
Percent TOC	0	83.8	16.2
C. perfringens spores	75.2	13.7	11.1
PAH-24	0	91.2	8.8
Al	33.1	23.4	43.5
Cd	24.4	66.9	8.7
Cr	0	46.2	53.8
Cu	29.3	46.0	24.8
Fe	8.4	45.6	46.0
Ni	46.9	2.3	50.8
Zn	15.8	77.4	6.9

3.3.3 Correlation of Parameters to TOC and Fines for "Near" and "Far" Stations

Percent TOC and percent fines are often higher in nearshore locations and organics and metals have been found to preferentially bind to these smaller, highly organic particles. Pearson product moment correlations were calculated using the sample means normalized to percent fines and percent TOC for all sampling periods between 1990 and 1998 to determine if TOC or percent fines controlled sediment contaminant loads. Tables 3-11 and 3-12 present the correlation coefficients and p-values between contaminant concentrations in the CSO sediment data, and the percent TOC and percent fines.

Table 3-11(a). Correlation Coefficients for Metal Contaminants and TOC and Fines at "Far" Stations.

	TOC	Al	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Percent Fines	0.95 (0.0001)	0.80 (0.0018)	0.90 (0.0001)	0.93 (0.0001)	0.85 (0.0005)	0.96 (0.0001)	0.90 (0.0001)	0.70 (0.012)	0.83 (0.001)
Percent TOC		0.84 (0.0006)	0.96 (0.0001)	0.94 (0.0001)	0.87 (0.0003)	0.93 (0.0001)	0.96 (0.0001)	0.81 (0.0014)	0.92 (0.0001)

n = 12 for all calculations.

Table 3-11(b). Correlation Coefficients for Organic Contaminants and TOC and Fines at "Far" Stations.

	C. perfringens spores	PAH-24	Total LABs	Coprostanol
Percent Fines	0.58 (0.0475)	0.71 (0.0092)	0.89 (0.0013)	0.75 (0.021)
Percent TOC	0.67 (0.0172)	0.76 (0.0043)	0.81 (0.008)	0.66 (0.054)

n = 12 for all, except Total LABs and coprostanol where n= 9 due to data missing for three stations during 1990.

Table 3-12(a). Correlation Coefficients for Metal Contaminants and TOC and Fines at "Near" Stations.

	TOC	**Al**	**Cd**	**Cr**	**Cu**	**Fe**	**Ni**	**Pb**	**Zn**
Percent Fines	ns	ns	-0.71 (0.01)	0.57 (0.048)	ns	0.84 (0.0006)	ns	-0.59 (0.042)	-0.75 (0.005)
Percent TOC		ns	ns	ns	0.73 (0.007)	ns	ns	0.83 (0.0008)	0.61 (0.034)

ns – not significant.
n = 12 for all.

Table 3-12(b). Correlation Coefficients for Organic Contaminants and TOC and Fines at "Near" Stations.

	***C. perfringens* spores**	**PAH-24**	**Total LAB**	**Coprostanol**
Percent Fines	ns	-0.64 (0.025)	ns	ns
Percent TOC	ns	0.79 (0.002)	0.70 (0.012)	0.67 (0.017)

ns – not significant.
n = 12 for all.

As shown in Tables 3-11(a) and 3-11(b), strong positive correlations were observed between all contaminants (metals and organics) and percent TOC in sediments from the "Far" stations. At the "Near" stations, however, the only metals that showed a positive correlation to TOC were Cu, Pb, and Zn (Table 3-12a). Although total LAB and coprostanol parameters indicated some correlation with TOC in sediments from the "Near" stations, the correlations were not as strong as for samples collected from the "Far" stations

Strong positive correlations were also observed between all contaminants (metals and organics) and the fine fraction of sediment samples from the "Far" stations (Tables 3-11a and 3-11b). At the "Near" stations, there were no positive correlations between organic contaminants and the fine sediment fraction (Table 3-12b), and only two metals indicated some positive correlation. Fe and, to a lesser degree, Cr were positively correlated to the fine sediment fraction at "Near" stations (Table 3-12a). Significant negative correlations with the fine fraction at "Near" locations were observed for the metals Cd, Pb, and Zn, and for the organic parameter, PAH-24 (Tables 3-12a and 3-12b).

While normalization reduced the range of contaminant concentrations overall, it did not reduce the variability in the data and did not have an effect on the results of statistical analyses performed on the data. Correlation analyses showed a significant (positive slope) correlation of contaminant parameters with sediment fines and TOC content of samples collected at stations "Far" from the CSOs. This is not surprising because organic contaminants and many metals bind strongly to fine, organic-rich material. However, these correlations diminish or disappear when the analyses are conducted on sediments collected at "Near" stations, especially for many of the metals versus the sediment fines. The low or negative correlation coefficients with the fine sediment fraction and with TOC imply that other factors are affecting the normally observed covariance in these parameters, especially near the CSO discharge sites. CSOs are likely the cause for these differences because the concentrations of contaminants in the "Near" samples are higher than in the "Far" samples. The difference between the behavior of the metals and organics in the "Near" sediments most likely reflects the geochemical processes which account for the binding of contaminants to sediment particles. These processes are partially controlled by the increase in the TOC and percent fines at these locations. At the "Near" sites, it is possible that the shift from a positive to a low or negative correlation of metals with percent fines and TOC may be due to high concentrations of sulfides (reduced sediment), which help to bind the metals.

3.3.4 One-Way ANOVAs to Determine Temporal Trends for 1990, 1994, and 1998 Data.

One-way ANOVAs were used to determine if metal concentrations in sediments differed significantly with year. Table 3-13(a) presents the results of these analyses for metals in sediments from stations common to all three study years. The corresponding p-values are listed in Table 3-13(b). The letters in Tables 3-13(a) and 3-14(a) represent the study year (A = 1990, B = 1994, and C = 1998). Parentheses indicate those years that are not significantly different from each other and the order of the letters indicates decreasing concentration values from left to right. For example, Cu at Station DB01 is A(BC), which indicates that 1990 had the highest Cu concentration, 1994 and 1998 were equivalent but significantly different from 1990. Table 3-14(a) presents results for common organic parameters and Table 3-14(b) shows the corresponding p-values.

Table 3-13(a). One-Way ANOVA Results for Non-normalized Metal Concentrations of Sediments Collected in 1990, 1994, and 1998. A=1990, B=1994, and C=1998.

Station	Al	Cd	Cr	Cu	Fe	Ni	Pb	Zn
DB01	(CAB)	A(BC)	(BCA)	A(BC)	(CAB)	(ABC)	A(BC)	A(BC)
DB03	(ABC)	(AC) (CB)	(ACB)	(ACB)	(ABC)	(ABC)	(ACB)	(ACB)
DB04	(AC) (CB)	A(BC)	(ABC)	A(CB)	(CAB)	(AC)(CB)	(BAC)	(AC)(CB)
DB06	(ACB)	A(CB)	(BAC)	(ACB)	(ABC)	(ACB)	(ACB)	(ACB)
DB10	A(BC)	(ACB)	(AB)C	(CAB)	(BCA)	A(BC)	(ACB)	A(CB)
DB12	(ACB)	(CBA)	(BAC)	(ABC)	(BAC)	(ABC)	(BCA)	(BCA)
DB13	(AB)(BC)	(BCA)	(BAC)	(CAB)	(ACB)	(ACB)	C(BA)	(CAB)
DB14	(AC)(CB)	(AC)B	(ABC)	(AC)(CB)	(ACB)	(AC)(CB)	CAB	(CA)(AB)

Table 3-13(b). The p-Values Corresponding to One-Way ANOVA Results for Non-normalized Metal Concentrations of Sediments Collected in 1990, 1994, and 1998.

Station	Al	Cd	Cr	Cu	Fe	Ni	Pb	Zn
DB01	0.2612	0.0001	0.2862	0.0005	0.0171	0.2828	0.0001	0.0001
DB03	0.1962	0.0516	0.7198	0.3153	0.8939	0.4697	0.9459	0.3242
DB04	0.0478	0.0001	0.1281	0.0025	0.0801	0.0095	0.5468	0.0318
DB06	0.1286	0.0284	0.2689	0.2209	0.8454	0.0624	0.0865	0.4079
DB10	0.0055	0.0545	0.0001	0.5744	0.7025	0.0061	0.1733	0.0063
DB12	0.4932	0.5434	0.2491	0.4170	0.9210	0.0545	0.4431	0.7869
DB13	0.0346	0.9885	0.3145	0.4607	0.4331	0.0847	0.0197	0.0623
DB14	0.0568	0.0112	0.0552	0.0335	0.0813	0.006	0.0009	0.0307

Table 3-14 (a). One-Way ANOVA Results for Non-normalized Percent Fine Fraction, TOC, *C. perfringens* Spores, and Organic Contaminant Concentrations of Sediments Collected in 1990, 1994, and 1998. A=1990, B=1994, and C=1998.

Station	Fines	TOC	*C. perfringens* spores	PAH-24	LABs	Coprostanol
DB01	CBA	A(BC)	A(CB)	A(BC)	A(BC)	(BAC)
DB03	(CBA)	(BAC)	ACB	(BAC)	(BC)	(BC)
DB04	(CAB)	ACB	A(BC)	(BCA)	(AB)(BC)	(BAC)
DB06	(BAC)	(ACB)	(AB)(BC)	(AB)(BC)	(CB)	(BC)
DB10	B(AC)	(AB)C	A(BC)	C(AB)	BC	(BC)
DB12	(BAC)	(BCA)	(AB)(BC)	(CB)A	A(BC)	(AB)(BC)
DB13	(BCA)	C(AB)	A(BC)	C(BA)	(CA)(AB)	C(AB)
DB14	(ACB)	C(BA)	A(BC)	(CB)A	(ABC)	C(BA)

Table 3-14(b). The p-Values Corresponding to One-Way ANOVA Results for Non-Normalized Percent Fine Fraction, TOC, *C. perfringens* Spores, and Organic Contaminant Concentrations of Sediments Collected in 1990, 1994, and 1998.

Station	Fines	TOC	*C. perfringens* spores	PAH-24	LABs	Coprostanol
DB01	0.0001	0.0048	0.0145	0.0026	0.0014	0.0777
DB03	0.9974	0.3110	0.0523	0.3661	0.4445	0.2125
DB04	0.1218	0.0002	0.0004	0.1836	0.0153	0.0775
DB06	0.1421	0.7617	0.0090	0.0225	0.2978	0.2316
DB10	0.0064	0.0024	0.0003	0.0088	0.0150	0.1012
DB12	0.9445	0.1744	0.0090	0.0243	0.0093	0.0149
DB13	0.2049	0.0076	0.0001	0.0077	0.0199	0.0051
DB14	0.2193	0.0063	0.0057	0.0004	0.0778	0.0002

The results of the ANOVAs suggest that the change in the sediment metal concentrations over the past 10 years is not statistically significant. For example, there has not been a significant change in the concentrations of any metals at Station DB12, and only minimal change in Cd and Al concentrations can be detected at Stations DB03 and DB06, respectively. These three stations are all in the “Far” group, where minor changes would be expected if no major geophysical or anthropogenic activity or long-term response had occurred over this period of time. Station DB10, also in the “Far” group, has shown a more significant decrease in the concentrations of metals over time than the other stations.

The percent fines parameter is relatively constant across years as well as across stations. This could be due to the large variability in this parameter and the inability of this small sample set to detect differences in means.

3.3.5 Comparison of 1994 and 1998 Results

Using only the 1994 and 1998 results allows comparison of a larger set of data, both in terms of stations as well as parameters (includes total PCBs, DDTs, Ag, and Hg). Twelve stations were common to these two sampling years. It should be noted that T07 was a new station added in 1998 and that data for Station DB11 were not available for 1998. Tests used to analyze the 1994 and 1998 data sets included correlation analyses of “Near” and “Far” groupings and the student t-test comparing individual stations. Data from the new station (T07), added in 1998, were also evaluated.

3.3.5.1 Correlation Between “Near”/ “Far” Groupings of 1994 and 1998 Data

For both “Near” and “Far” stations, a correlation analysis was conducted to determine if chemical concentrations in sediments are correlated with the physical parameters of the sediment (% fines and TOC). Data from 1994 and 1998 were pooled and mean sediment chemical/physical parameter concentrations calculated and compared using a pearson product moment correlation. Tables 3-15(a) and (b) present correlation results of metals and organics, respectively, for “Far” stations and Tables 3-16(a) and (b) present similar results for “Near” stations. In all tables, the pearson product moment correlation coefficient is presented along with the significance level of the correlation. The results are similar to the results for the correlation analysis using all three sampling years. However, the results using only 1994 and 1998 data contain more metal and organic contaminant parameters. Again, the “Far” station grouping shows highly significant positive correlations for most parameters. The “Near” station group does not show as many differences when compared to the previous analysis (Section 3.2.2.3). The additional organic parameters measured for these years show that the “Far” station group has varying positive correlations with the fine fraction or with TOC, while the “Near” station group shows strong positive correlations to TOC and strong negative correlations with percent fines (for variables that do correlate).

Table 3-15(a). Correlation Coefficients for Metal Contaminants and TOC and Fines at "Far" Stations Sampled in 1994 and 1998.

	TOC	**Al**	**Ag**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Ni**	**Pb**	**Zn**
Fines	0.88 (0.0001)	0.83 (0.0001)	0.85 (0.0001)	0.72 (0.0009)	0.89 (0.0001)	0.71 (0.001)	0.92 (0.0001)	0.64 (0.004)	0.90 (0.0001)	0.55 (0.018)	0.77 (0.0002)
TOC		0.73 (0.0006)	0.83 (0.0001)	0.83 (0.0001)	0.90 (0.0001)	0.80 (0.0001)	0.91 (0.0001)	0.69 (0.002)	0.92 (0.0001)	0.66 (0.003)	0.85 (0.0001)

n=18 for "Far" group.

Table 3-15(b). Correlation Coefficients for Organic Contaminants and TOC and Fines at "Far" Stations Sampled in 1994 and 1998.

	***C. perfringens* spores**	**PAH 48**	**PAH 24**	**Petrogenic**	**Pyrogenic**	**Total LAB**	**Coprostanol**	**Total PCB**	**Total DDT**
Fines	0.66 (0.003)	0.54 (0.021)	0.52 (0.027)	0.51 (0.030)	0.54 (0.020)	0.75 (0.0004)	0.54 (0.022)	0.69 (0.002)	0.76 (0.0002)
TOC	0.73 (0.0006)	0.71 (0.0009)	0.69 (0.002)	0.72 (0.0007)	0.71 (0.001)	0.73 (0.0006)	ns	0.81 (0.0001)	0.81 (0.0001)

Table 3-16(a). Correlation Coefficients for Metal Contaminants and TOC and Fines at "Near" Stations Sampled in 1994 and 1998.

	TOC	**Al**	**Ag**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Ni**	**Pb**	**Zn**
Fines	ns	0.95 (0.0001)	0.66 (0.036)	ns	0.73 (0.018)	ns	0.89 (0.0006)	ns	0.73 (0.016)	0.66 (0.039)	ns
TOC		ns	ns	0.81 (0.005)	ns	0.74 (0.015)	ns	0.75 (0.013)	ns	0.88 (0.001)	0.97 (0.0001)

n=10 for "Near" group.

Table 3-16(b). Correlation Coefficients for Organic Contaminants and TOC and Fines at "Near" Stations Sampled in 1994 and 1998.

	***C. perfringens* spores**	**PAH 48**	**PAH 24**	**Petrogenic**	**Pyrogenic**	**Total LAB**	**Coprostanol**	**Total PCB**	**Total DDT**
Fines	ns	-0.83 (0.003)	-0.83 (0.003)	-0.81 (0.005)	-0.84 (0.003)	ns	ns	ns	-0.73 (0.016)
TOC	ns	0.83 (0.003)	0.82 (0.003)	0.85 (0.002)	0.81 (0.004)	0.79 (0.007)	0.81 (0.005)	0.87 (0.001)	0.74 (0.014)

3.3.5.2 Student t-Test Comparing 1994 and 1998 Results

Results for parameters and stations, common to the 1994 and 1998 sample collections, were compared using a student t-test. Table 3-17 presents the results of this t-test. Assumptions of a normal distribution prior to the t-test were checked and those station-parameter data combinations marked with an asterisk were either transformed prior to analysis or a non-parametric test (two-sample t-test, median scores) was used to assess the equality of the samples' measure of location between the two time periods. A "+" or "-" sign indicates whether the 1998 values were significantly higher or lower, respectively, than the 1994 measurements.

The results of the t-tests support the temporal trends described in Section 3.3.4. In general, significant changes were consistent for most parameters within a site. Of the five "Near" stations, three showed a consistent increase in a number of organic contaminants and two showed a consistent decrease. Metals concentrations at "Near" stations did not appear to change much. Concentrations of both organics and metals at "Far" stations generally decreased or remained unchanged relative to 1994 results. At Station DB10, however, PAH and Pb concentrations increased significantly in comparison to concentrations of other organic compounds and metals, which decreased or remained unchanged.

Table 3-17. Results of t-Test Comparing Variables Between 1994 and 1998 at Individual Stations.

	STATION												
Variable	**DB01 "Near"**	**DB04 "Near"**	**DB13 "Near"**	**DB14 "Near"**	**CO19 "Near"**	**DB03 "Far"**	**DB06 "Far"**	**DB10 "Far"**	**DB12 "Far"**	**T01 "Far"**	**T02 "Far"**	**T08 "Far"**	**SWXE3 "Far"**
Fines	+0.0253*	ns	ns	ns	ns	ns	ns	–0.0144	ns	-0.024	+0.0353	ns	ns
TOC	- 0.0402	ns	+ 0.0192	+0.0441	ns	ns	ns	–0.0052	ns	ns	ns	ns	–0.0375
Spores	ns	+0.0316	ns	ns	ns	ns	-0.0015	– 0.0307	ns	ns	–0.0305	ns	–0.0165
Tot-PAH	–0.0087	ns	+0.0346	ns	–0.0139	ns	ns*	+0.0192	ns	ns	ns	–ns	–ns
24-PAH	–0.0115	ns	+0.0346	ns	ns	ns	ns	+ 0.0445	ns	ns	ns	ns	ns
Petro-PAH	–0.0058	ns	+0.0317	ns	–0.0021	ns	ns	+0.0253*	ns	ns	ns	ns	–0.026
Pyro-PAH	–0.0103	ns	+0.0368	ns	–0.0253*	ns	ns	ns	ns	ns	ns	ns	ns
Coprostanol	– 0.0253*	ns	+0.0185	+0.0116	–0.0024	ns	–0.0253*	ns	ns	ns	+ 0.0109	ns	ns
Tot-PCB	ns	+0.0253*	ns	ns	ns*	ns	ns	– 0.0181	ns	ns	ns	ns	ns
Tot-DDT	– 0.0027	ns	ns	ns	–0.028	ns	–0.0145	– 0.0003	ns	–0.0253*	–0.0037	ns	ns*
Ag	–0.0033	ns	–0.0253*	ns	–0.03	ns	ns	–0.0015	ns	ns	–0.0173	ns	–0.0066
Al	ns	ns	ns	ns	ns*	ns	ns	ns	ns	0.0087	ns	ns	ns
Cd	– 0.0253*	– 0.0253*	ns*	ns	ns	ns	ns	ns	ns	ns	0.0251	ns*	– 0.0263
Cr	ns	ns	ns	ns	–0.037	ns	ns	–0.0005	ns	ns	ns	ns	–0.0253*
Cu	ns	ns*	ns	ns	ns	ns	+0.0142	ns*	ns	ns*	ns	ns	– 0.0117
Fe	ns	ns	ns	ns	+ 0.0012	ns	ns	ns	ns	ns	ns	ns	ns
Hg	–0.0361	ns	ns*	ns	ns	ns	ns	ns	ns	ns*	ns	ns*	ns
Ni	ns	ns	ns	ns	+ 0.0269	ns	ns	ns	ns	ns	ns	ns	ns
Pb	ns	ns	+0.0492	+0.0116	+0.0472	ns	ns	+0.0253*	ns*	ns*	ns	ns	–0.0253*
Zn	ns	ns*	ns*	ns	+0.0253*	ns	ns	ns	ns	ns	ns	ns*	ns

*Non-parametric test
ns = not significant

▨ Shading indicates parameter or station exclusive to 1994 and 1998 only.

3.3.5.3 Evaluation of Data from 1998 New Station T07

An additional station was added to the sampling regime in 1998 (Quincy Bay, Station T07). Based on its location, this station is considered in the “Far” group, removed from CSO influences. A Wilcoxon Rank Sum Test was used to determine if sediment concentrations at this site (n=3) were significantly different from sediment concentrations at the other “Far” sites (n=30). The Wilcoxon Rank Sum Test was used because data could not be transformed to meet the assumption of normality. The results indicated that all parameters were equivalent with each other across the “Far” station grouping and Station T07, except for the parameters Ag (p=0.006) and Cr (p = 0.023), which were significantly different between Station T07 and the “Far” grouping.

3.3.6 Summary of Statistical Analyses

In general, the most significant statistical finding of the analyses of data made since 1990 is that, for most paramete0rs, differences in concentrations can be explained by proximity to a CSO. Contaminant concentrations in sediments from stations near CSOs are statistically higher than contaminant concentrations at stations far from the CSOs. Differences between years were more difficult to detect, primarily due to the variability in replicate analyses at each station and the small data set available. Some statistically significant findings pertinent to individual parameters and stations are summarized below.

Total 24-PAH concentrations at Stations DB10, DB13, and DB14 increased significantly since 1994 (Table 3-15). Statistical analyses using a t-test (Table 3-15) indicated that most PAH-24 concentrations in sediments from the remaining stations sampled in 1998 were not statistically different from those collected in 1994. However, a more powerful one-way ANOVA test, using data from all three study years, detected significant decreases between 1994 and 1998 at Stations DB01, DB03, and DB04 (Table 3-14a). This same trend was evident for the extended list of Total PAHs measured in 1994 and 1998 (Figure 3-5, Table 3-15)

In most locations, the percent pyrogenic PAHs increased slightly in 1998, compared to 1994, except at Stations DB13, DB14 and DB06, where the amount of petrogenic PAHs increased in 1998. These changes were only statistically significant at Stations DB01, DB10, DB13, CO19, and SWEX3 (Table 3-15). The increase in petrogenic PAHs at these stations during 1998 may be attributed to additional petroleum inputs and, given that these stations are all near CSOs (except DB10, which is near a large storm drain), it is possible that nearby CSOs are sources for this type of contamination.

The t-test (Table 3-15) comparing means at each site, between 1994 and 1998, indicates that total PCB concentrations were not significantly different at any stations, except Station DB04, where concentrations increased slightly in 1998 and at Station DB10, where concentrations decreased by approximately 30 percent in 1998. Total DDTs decreased significantly at a number of stations in 1998, including Stations DB01, DB06, DB10, T01, T02, and C019.

Since 1990, statistically significant declines in *Clostridium perfringens* spore densities were observed at all stations (Table 3-14a, 3-14b). At most stations, however, the differences between densities measured in 1994 and 1998, though significantly lower than in 1990, were generally not significantly different from each other (Table 3-15). The largest declines, overall, were observed at Stations DB14 (near BOS-90, the Commercial Point CSO), Station DB13 (near BOS-89, the Fox Point CSO), and Station DB04 (near the BOS-83 CSO).

Compared to 1994 and 1990, concentrations of total LABs measured in 1998 decreased at all stations, except at Station DB13, where concentrations increased. In previous years, the highest concentrations of LABs were observed at Station DB14.

Coprostanol concentrations measured in 1998 ranged from 148 (at DB06) to 378,000 ng/g (at DB13). The coprostanol values measured in 1998 were lower than those measured in either 1990 or 1994 at all stations, except Stations DB13 and DB14. The concentrations measured at DB13 in 1998 were highly variable and significantly higher than other coprostanol measurements made in the study area during the past 10 years.

Concentrations of metals have remained fairly constant since 1990 at most stations. The slight decreases observed were primarily associated with stations in the Old Harbor area. At Station DB04, a small, though statistically significant decrease, in concentration of Cd, Cu, Ni, and Zn was observed since 1990. A relatively large decrease in these metals was observed at Station DB01 between 1990 and 1994, with 1998 results similar to those measured in 1994. Concentrations of Cr, Ni, and Zn also decreased slightly since 1990 at Station DB10. Ag was only measured in 1994 and 1998, and showed significant decreases between those years at Stations DB01, DB10, DB13, T02, SWEX3, and CO19. Concentrations of Hg were similar in both 1994 and 1998 at all stations, except at Station DB10, where the concentration decreased slightly.

4.0 CONCLUSIONS

Comparison of sediment contaminant concentrations measured during the last three CSO studies indicates that, overall, the largest differences were detected between stations “near” and “far” from CSOs. Concentrations are statistically higher at “Near” stations, although an overall decrease in sewage tracer compounds (*Clostridium perfringens* spores, LABs, and coprostanol) suggests that the documented improvement in sewage effluent quality, and reduction in CSO discharge volume and frequency, are being reflected in the sediment quality. The largest declines in *C. perfringens* spores, one of the best indicators of the presence of raw sewage, were observed at Stations DB14 (near BOS-90, the Commercial Point CSO), Station DB13 (near BOS-89, the Fox Point CSO), and Station DB04 (near the BOS-83 CSO). The general decline in both LABs and coprostanol at all “Far” stations and at most “Near” stations also reflects the reduced influx of sewage to Boston Harbor.

The increase in concentrations of LAB and coprostanol, observed in sediments near the major CSOs (Fox Point BOS-88, -89 and Commercial Point BOS-90) in South Dorchester Bay in August 1998 may have been due to localized inputs from major storm events of June 1998, rather than due to chronic inputs at these locations. Comparison of the 1998 data to data obtained from the same stations in 1997 (Blake *et al.* 1998) and earlier (Durell *et al.* 1991, Durell 1995) suggests an overall decline in most sewage tracer compounds until 1998. In 1997, concentrations measured near Station DB13 (Station T04) were much lower than those measured in 1998, and were more consistent with the overall declines observed in this area since 1990. Concentrations of sewage tracers at stations not adjacent to the CSOs (*i.e.,* Station DB10) and at “Far” stations did not show a corresponding increase in 1998. In fact, concentrations of sewage tracers measured at Station DB10, located south of the CSOs, decreased in 1998. Only PAH concentrations increased at Station DB10 in 1998, which is probably due to an increase in localized street runoff from an adjacent storm drain. These results are an indication that impacts to sediment quality, due to localized inputs from CSOs, may be isolated in the areas adjacent to the CSOs. A decline in the general use of certain contaminants (*e.g.,* PCBs and DDTs) has most likely also contributed to improved sediment quality.

On the average, slightly higher concentrations of contaminants were found in the South Dorchester Bay area than in the Old Harbor area, an observation also made in a previous investigation (Durell 1995). Past studies have concluded that the available data were insufficient to attribute the increased concentrations of organic and metal contaminants in this area strictly to the CSOs. The observed contamination is most likely due to a combination of sources. In South Dorchester Bay, for example, most CSO pipes serve as storm drains as well as combined outfalls, and discharge separate stormwater and combined sewage flows. Therefore, it is not entirely possible to attribute the higher concentrations of contaminants to combined sewage discharges alone. However, locations where high concentrations of coprostanol and *Clostridium* spores were detected are probably being impacted by sewage.

In general, the reduced concentrations of sewage tracers and, to some extent, metals and other organic constituents throughout Dorchester Bay and Boston Harbor are due, in part, to improved treatment of sewage at the Deer Island and Nut Island facilities, as well as to reductions in discharges at individual CSOs. In the future, CSOs will be eliminated in South Dorchester Bay when separate sewer/storm drains are built; however, stormwater discharges to this area will then increase. While a significant reduction in discharge of sewage tracers is likely, contaminants associated with street runoff are expected to remain the same or increase. In North Dorchester Bay (Old Harbor area), MWRA’s CSO Plan calls for eliminating the CSOs as well as most stormwater runoff. Future sampling studies will help to determine the effects of eliminating CSOs, reducing stormwater runoff, and in increasing stormwater discharges on the overall sediment quality in Dorchester Bay.

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APPENDICES

APPENDIX A: 1998 ANALYTICAL RESULTS
APPENDIX B: NORMALIZED MEAN DATA 1990, 1994 AND 1998

Note: Appendices are not available on-line. To order a printed copy, please call the MWRA Environmental Quality Department at 617-788-4700

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Table A-1. HC981 Grain-Size and TOC Data

		Phi Classification						GRAVEL	SAND	SILT	CLAY	TOC	%Fines[1]
		<-1	-1 - 0	0 - 1	1-2	2-3	3-4						
Station	Sample_ID	PCT	PCT	PCT	PCT	PCT	PCT	PCT	PCT	PCT	PCT	PCT	PCT
C019*	HC981067	0.00	0.09	0.37	0.41	0.46	0.78	0.00	2.10	47.03	50.87	2.74	97.90
C019	HC981068	0.00	0.07	0.29	0.52	0.74	2.14	0.00	3.80	45.20	51.10	2.84	96.30
C019	HC981069	0.00	0.08	0.08	0.49	1.63	1.87	0.00	4.10	39.70	56.10	3.02	95.80
	Mean	0.00	0.08	0.25	0.47	0.94	1.60	0.00	3.33	43.98	52.69	2.87	96.67
	STD	0.00	0.01	0.15	0.06	0.61	0.72	0.00	1.08	3.82	2.96	0.14	1.10
DB01	HC98102D	0.00	0.38	1.88	1.77	1.23	11.37	0.00	16.60	54.30	29.10	2.39	83.40
DB01	HC98102E	0.00	1.03	1.21	1.32	0.82	9.22	0.00	13.60	64.20	22.20	2.05	86.40
DB01	HC98102F	0.00	1.24	1.97	1.09	0.57	8.81	0.00	13.70	54.30	32.10	2.52	86.40
	Mean	0.00	0.88	1.69	1.39	0.87	9.80	0.00	14.63	57.60	27.80	2.32	85.40
	STD	0.00	0.45	0.42	0.35	0.33	1.38	0.00	1.70	5.72	5.08	0.24	1.73
DB03	HC981051	11.31	9.63	21.10	29.53	8.11	4.99	11.30	73.40	8.20	7.20	0.48	15.40
DB03	HC981052	8.90	5.54	13.33	32.17	8.72	6.07	8.90	65.80	12.80	12.50	0.74	25.30
DB03	HC981053	7.57	7.44	20.53	34.32	8.26	5.31	7.60	75.90	8.70	7.90	0.40	16.60
	Mean	9.26	7.54	18.32	32.01	8.36	5.46	9.27	71.70	9.90	9.20	0.54	19.10
	STD	1.90	2.05	4.33	2.40	0.32	0.55	1.88	5.26	2.52	2.88	0.18	5.40
DB04	HC981028	0.00	0.00	0.90	1.42	1.35	6.07	0.00	9.70	64.10	26.20	2.62	90.30
DB04	HC981029	0.07	0.37	1.11	1.99	1.40	5.82	0.10	10.70	56.80	32.50	2.67	89.30
DB04	HC98102A	0.00	0.00	0.77	1.89	1.40	6.51	0.00	10.60	58.50	30.90	2.56	89.40
	Mean	0.02	0.12	0.93	1.77	1.38	6.13	0.03	10.33	59.80	29.87	2.62	89.67
	STD	0.04	0.21	0.17	0.30	0.03	0.35	0.06	0.55	3.82	3.27	0.06	0.55
DB06	HC981032	0.00	0.14	7.96	49.42	34.09	3.18	0.00	94.80	2.60	2.60	0.27	5.20
DB06	HC981034	0.02	0.03	5.36	49.21	35.56	3.43	0.00	93.60	3.50	2.90	0.23	6.40
DB06	HC981035	0.05	0.15	5.71	46.88	37.18	4.05	0.10	94.00	3.00	3.00	0.22	6.00
	Mean	0.02	0.11	6.34	48.50	35.61	3.55	0.03	94.13	3.03	2.83	0.24	5.87
	STD	0.03	0.07	1.41	1.41	1.55	0.45	0.06	0.61	0.45	0.21	0.03	0.61
DB10	HC981038	19.96	5.03	5.18	6.61	8.97	4.99	20.00	30.80	28.50	20.80	3.12	49.30
DB10	HC981039	10.76	2.23	1.80	3.40	5.67	6.53	10.80	19.60	43.70	25.90	3.15	69.60
DB10	HC98103A	25.69	4.83	6.68	7.73	7.01	4.71	25.70	31.00	24.20	19.10	2.61	43.30
	Mean	18.80	4.03	4.55	5.91	7.22	5.41	18.83	27.13	32.13	21.93	2.96	54.07
	STD	7.53	1.56	2.50	2.25	1.66	0.98	7.52	6.52	10.25	3.54	0.30	13.78
DB12	HC98104C	23.12	4.47	3.66	6.48	8.03	11.50	23.10	34.10	22.60	20.20	3.27	42.80
DB12	HC98104D	12.57	3.43	2.79	3.84	7.01	15.33	12.60	32.40	30.80	24.20	2.35	55.00
DB12	HC98104E	18.69	7.05	9.46	10.14	7.66	14.39	18.70	48.70	19.60	13.10	1.89	32.70
	Mean	18.13	4.98	5.30	6.82	7.57	13.74	18.13	38.40	24.33	19.17	2.50	43.50
	STD	5.30	1.86	3.63	3.16	0.52	2.00	5.27	8.96	5.80	5.62	0.70	11.17
DB13	HC981047	0.11	0.76	1.51	4.32	8.65	10.59	0.10	25.80	41.60	32.40	8.47	74.00
DB13	HC981048	0.10	0.39	2.05	3.52	8.99	10.16	0.10	25.10	43.60	31.10	7.82	74.70
DB13	HC981049	0.00	0.14	1.72	3.66	4.31	4.09	0.00	13.90	53.60	32.50	5.13	86.10
	Mean	0.07	0.43	1.76	3.83	7.32	8.28	0.07	21.60	46.27	32.00	7.14	78.27
	STD	0.06	0.31	0.27	0.43	2.61	3.64	0.06	6.68	6.43	0.78	1.77	6.79

Table A-2. HC 981 Sewage Tracer Data LABs, Coprostanol, and *C. perfringens*

	Station	C019	C019	C019	C019	C019	DB01	DB01	DB01	DB01	DB01
	Sample_ID	HC981067	HC981068	HC981069			HC98102D	HC98102E	HC98102F		
	Units	Value	Value	Value	Mean	Stdev	Value	Value	Value	Mean	Stdev
Phenyl Decanes	ng/g, dry wt.	77.54	85.13	66.05	76.24	9.61	31.61	39.05	39.50	36.72	4.43
Phenyl Undecanes	ng/g, dry wt.	278.31	277.25	247.78	267.78	17.33	98.59	104.00	106.68	103.09	4.12
Phenyl Dodecanes	ng/g, dry wt.	327.35	283.01	260.54	290.30	34.00	100.91	89.56	100.71	97.06	6.50
Phenyl Tridecanes	ng/g, dry wt.	203.32	186.97	189.80	193.36	8.74	84.58	87.43	95.57	89.19	5.70
Phenyl Tetradecanes	ng/g, dry wt.	106.42	93.51	92.42	97.45	7.79	53.18	59.09	61.03	57.76	4.09
Total LAB	ng/g, dry wt.	992.94	925.87	856.58	925.13	68.18	368.87	379.13	403.48	383.82	17.78
Coprostanol	ng/g, dry wt.	6572.92	6016.99	5543.75	6044.55	515.14	2521.44	2529.82	2895.38	2648.88	213.51
Total LAB/Coprostanol Ratio		0.15	0.15	0.15	0.15	0.00	0.15	0.15	0.14	0.15	0.01
Clostridium	units/g, dry wt.	9900.00	17900.00	17600.00	15133.33	4534.68	3590.00	4960.00	3400.00	3983.33	851.14
Log 10 Clostridium		4.00	4.25	4.25	4.16	0.15	3.56	3.70	3.53	3.59	0.09

	Station	DB03	DB03	DB03	DB03	DB03	DB04	DB04	DB04	DB04	DB04
	Sample_ID	HC981051	HC981052	HC981053			HC981028	HC981029	HC98102A		
	Units	Value	Value	Value	Mean	Stdev	Value	Value	Value	Mean	Stdev
Phenyl Decanes	ng/g, dry wt.	14.39	27.59	26.91	22.97	7.43	54.04	52.92	53.71	53.56	0.58
Phenyl Undecanes	ng/g, dry wt.	26.76	47.27	48.67	40.90	12.26	129.68	155.78	164.92	150.13	18.29
Phenyl Dodecanes	ng/g, dry wt.	25.16	41.75	40.35	35.75	9.20	120.98	131.68	115.09	122.58	8.41
Phenyl Tridecanes	ng/g, dry wt.	22.00	32.61	42.27	32.29	10.14	101.28	131.23	99.58	110.70	17.80
Phenyl Tetradecanes	ng/g, dry wt.	17.35	30.29	30.08	25.91	7.41	53.93	78.96	63.14	65.34	12.66
Total LAB	ng/g, dry wt.	105.67	179.51	188.27	157.82	45.38	459.91	550.57	496.44	502.31	45.61
Coprostanol	ng/g, dry wt.	586.24	1038.22	870.40	831.62	228.47	3137.81	3213.50	2553.22	2968.18	361.35
Total LAB/Coprostanol Ratio		0.18	0.17	0.22	0.19	0.02	0.15	0.17	0.19	0.17	0.02
Clostridium	units/g, dry wt.	5540.00	6380.00	5240.00	5720.00	590.93	690.00	1340.00	2050.00	1360.00	680.22
Log 10 Clostridium		3.74	3.80	3.72	3.76	0.04	2.84	3.13	3.31	3.09	0.24

Total LAB is the sum of target LABs

[a] Not detected

Table A-2: HC 981 Sewage Tracer Data LABs, Coprostanol, and *C. perfringens* (cont'd)

	Station	DB13	DB13	DB13	DB13	DB13	DB14	DB14	DB14	DB14	DB14
	Sample_ID	HC981047	HC981048	HC981049			HC981042	HC981043	HC981044		
	Units	Value	Value	Value	Mean	Stdev	Value	Value	Value	Mean	Stdev
Phenyl Decanes	ng/g, dry wt.	588.48	572.57	376.42	512.49	118.10	399.36	455.85	307.62	387.61	74.81
Phenyl Undecanes	ng/g, dry wt.	1471.73	1432.69	971.63	1292.01	278.15	765.74	722.43	695.87	728.01	35.27
Phenyl Dodecanes	ng/g, dry wt.	1338.42	1283.00	805.45	1142.29	293.02	789.28	702.30	505.82	665.80	145.21
Phenyl Tridecanes	ng/g, dry wt.	633.23	608.22	445.60	562.35	101.88	417.17	381.40	277.60	358.72	72.50
Phenyl Tetradecanes	ng/g, dry wt.	194.92	194.35	153.82	181.03	23.57	213.64	141.44	129.84	161.64	45.41
Total LAB	ng/g, dry wt.	4226.77	4090.82	2752.91	3690.17	814.53	2585.20	2403.43	1916.74	2301.79	345.62
Coprostanol	ng/g, dry wt.	541531.89	381872.50	209262.21	377555.53	166176.90	106356.16	84466.48	109937.11	100253.25	13788.49
Total LAB/Coprostanol Ratio		0.01	0.01	0.01	0.01	0.00	0.02	0.03	0.02	0.02	0.01
Clostridium	units/g, dry wt.	13900.00	11000.00	2200.00	9033.33	6092.89	7820.00	7200.00	5340.00	6786.67	1290.63
Log 10 Clostridium		4.14	4.04	3.34	3.84	0.44	3.89	3.86	3.73	3.83	0.09

	Station	SWEX3	SWEX3	SWEX3	SWEX3	SWEX3	T01	T01	T01	T01	T01
	Sample_ID	HC981058	HC981059	HC98105A			HC98106C	HC98106D	HC98106E		
	Units	Value	Value	Value	Mean	Stdev	Value	Value	Value	Mean	Stdev
Phenyl Decanes	ng/g, dry wt.	28.98	45.05	44.08	39.37	9.01	12.29	14.74	20.52	15.85	4.22
Phenyl Undecanes	ng/g, dry wt.	48.90	128.29	122.38	99.86	44.23	53.01	59.52	68.21	60.25	7.63
Phenyl Dodecanes	ng/g, dry wt.	51.71	132.68	101.92	95.43	40.87	52.00	51.42	68.54	57.32	9.72
Phenyl Tridecanes	ng/g, dry wt.	38.56	100.44	93.70	77.57	33.95	38.80	36.32	42.70	39.27	3.22
Phenyl Tetradecanes	ng/g, dry wt.	29.02	57.93	49.89	45.62	14.92	14.80	13.45	16.99	15.08	1.78
Total LAB	ng/g, dry wt.	197.18	464.39	411.97	357.84	141.59	170.90	175.45	216.96	187.77	25.38
Coprostanol	ng/g, dry wt.	1232.88	5506.40	4808.17	3849.15	2292.50	1852.80	1792.13	2450.56	2031.83	363.90
Total LAB/Coprostanol Ratio		0.16	0.08	0.09	0.11	0.04	0.09	0.10	0.09	0.09	0.00
Clostridium	units/g, dry wt.	5400.00	8000.00	6370.00	6590.00	1313.89	3940.00	4490.00	4690.00	4373.33	388.37
Log 10 Clostridium		3.73	3.90	3.80	3.81	0.09	3.60	3.65	3.67	3.64	0.04

Total LAB is the sum of target LABs

[a]Not detected

Table A-3. HC981 PAH DATA.

	Station	C019	C019	C019	C019	C019
	Sample_ID	HC981067	HC981068	HC981069		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	370	339	363	357	16.6
C1-NAPHTHALENES	ng/g, dry wt.	125	119	160	135	22.4
C2-NAPHTHALENES	ng/g, dry wt.	113	110	115	112	2.4
C3-NAPHTHALENES	ng/g, dry wt.	104	106	111	107	3.6
BIPHENYL	ng/g, dry wt.	43.9	39.1	37.9	40.3	3.2
ACENAPHTHYLENE	ng/g, dry wt.	136	134	155	142	11.3
DIBENZOFURAN	ng/g, dry wt.	87.2	84.9	88.0	86.7	1.6
ACENAPHTHENE	ng/g, dry wt.	67.0	65.7	69.7	67.5	2.0
FLUORENE	ng/g, dry wt.	92.3	94.3	96.5	94.4	2.1
C1-FLUORENES	ng/g, dry wt.	54.7	60.6	63.6	59.6	4.5
C2-FLUORENES	ng/g, dry wt.	105	130	113	116	12.7
C3-FLUORENES	ng/g, dry wt.	203	222	219	215	10.0
ANTHRACENE	ng/g, dry wt.	292	250	299	280	26.4
PHENANTHRENE	ng/g, dry wt.	795	763	814	791	25.7
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	451	426	490	456	32.1
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	390	347	407	381	30.8
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	247	219	247	238	16.3
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	69.9	68.2	70.7	69.6	1.26
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	79.7	75.8	83.6	79.7	3.87
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	136	135	138	136	1.48
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	166	154	169	163	8.01
FLUORANTHENE	ng/g, dry wt.	1495	1294	1424	1404	102
PYRENE	ng/g, dry wt.	1395	1160	1327	1294	121
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	859	712	873	815	89.1
BENZ(A)ANTHRACENE	ng/g, dry wt.	857	807	867	844	32.2
CHRYSENE	ng/g, dry wt.	1146	1019	1102	1089	64.7
C1-CHRYSENES	ng/g, dry wt.	527	501	546	525	22.8
C2-CHRYSENES	ng/g, dry wt.	295	275	315	295	20.0
C3-CHRYSENES	ng/g, dry wt.	123	116	142	127	13.6
C4-CHRYSENES	ng/g, dry wt.	a	a	a		
BENZO(B)FLUORANTHENE	ng/g, dry wt.	1271	1181	1327	1259	73.4
BENZO(K)FLUORANTHENE	ng/g, dry wt.	1025	1007	991	1008	17.0
BENZO(E)PYRENE	ng/g, dry wt.	964	920	975	953	29.3
BENZO(A)PYRENE	ng/g, dry wt.	1198	996	1247	1147	133
PERYLENE	ng/g, dry wt.	302	279	317	299	19.3
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	943	967	1030	980	44.8
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	240	244	259	248	10.2
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	851	854	908	871	32.2
Totals						
Total 24 PAH	ng/g, dry wt.	14276	13172	14485	13978	706
Total PAH	ng/g, dry wt.	17618	16271	17961	17283	893
Petro-PAH	ng/g, dry wt.	4127	3942	4311	4127	184
Pyro-PAH	ng/g, dry wt.	13491	12329	13650	13157	721
%Pyro-PAH of Total PAH	%	76.6%	75.8%	76.0%	76.1%	0.4%

Table A-3. HC981 PAH DATA (cont'd)

	Station	DB03	DB03	DB03	DB03	DB03
	Sample_ID	HC981051	HC981052	HC981053		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	26.0	46.0	47.5	39.8	12.0
C1-NAPHTHALENES	ng/g, dry wt.	18.3	28.3	29.2	25.3	6.0
C2-NAPHTHALENES	ng/g, dry wt.	21.2	34.4	31.6	29.1	7.0
C3-NAPHTHALENES	ng/g, dry wt.	20.0	32.1	31.9	28.0	7.0
BIPHENYL	ng/g, dry wt.	4.86	9.70	9.7	8.08	2.8
ACENAPHTHYLENE	ng/g, dry wt.	15.0	38.2	34.3	29.2	12.4
DIBENZOFURAN	ng/g, dry wt.	8.47	15.7	16.2	13.5	4.3
ACENAPHTHENE	ng/g, dry wt.	7.23	9.94	13.3	10.2	3.0
FLUORENE	ng/g, dry wt.	11.0	16.5	18.8	15.5	4.1
C1-FLUORENES	ng/g, dry wt.	10.6	15.7	16.6	14.3	3.2
C2-FLUORENES	ng/g, dry wt.	24.4	31.3	41.7	32.5	8.7
C3-FLUORENES	ng/g, dry wt.	24.0	35.8	43.8	34.5	9.9
ANTHRACENE	ng/g, dry wt.	33.1	57.1	54.0	48.1	13.1
PHENANTHRENE	ng/g, dry wt.	106	155	172	144	34.0
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	75.3	121	119	105	25.6
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	65.1	103	106	91.3	22.7
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	34.6	62.2	62.1	53.0	15.9
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	9.50	15.7	16.94	14.1	4.0
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	13.3	23.7	23.86	20.3	6.0
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	19.2	36.9	32.23	29.5	9.2
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	18.1	46.1	41.05	35.1	14.9
FLUORANTHENE	ng/g, dry wt.	159	224	238	207	42.5
PYRENE	ng/g, dry wt.	163	283	282	242	69.1
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	111	201	191	168	49.7
BENZ(A)ANTHRACENE	ng/g, dry wt.	97.4	163	173	145	41.2
CHRYSENE	ng/g, dry wt.	122	207	225	185	54.8
C1-CHRYSENES	ng/g, dry wt.	74.9	153	157	128	46.4
C2-CHRYSENES	ng/g, dry wt.	44.0	103	99.4	82.3	33.2
C3-CHRYSENES	ng/g, dry wt.	17.8	44.3	42.7	34.9	14.9
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	111	218	230	186	65.7
BENZO(K)FLUORANTHENE	ng/g, dry wt.	110	222	219	184	64.1
BENZO(E)PYRENE	ng/g, dry wt.	98.2	202	204	168	60.6
BENZO(A)PYRENE	ng/g, dry wt.	122	241	234	199	66.6
PERYLENE	ng/g, dry wt.	31.0	61.9	60.9	51.3	17.6
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	98.8	210	214	174	65.4
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	25.4	56.1	56.1	45.8	17.7
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	88.9	185	193	156	57.9
Totals						
Total 24 PAH	ng/g, dry wt.	1564	2821	2889	2425	747
Total PAH	ng/g, dry wt.	2038	3709	3780	3176	986
Petro-PAH	ng/g, dry wt.	566	934	961	820	221
Pyro-PAH	ng/g, dry wt.	1473	2776	2819	2356	765
%Pyro-PAH of Total PAH	%	72.3%	74.8%	74.6%	73.9%	1.4%

Table A-3. HC981 PAH DATA (cont'd)

	Station	DB06	DB06	DB06	DB06	DB06
	Sample_ID	HC981032	HC981034	HC981035		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	5.21	5.17	5.15	5.18	0.03
C1-NAPHTHALENES	ng/g, dry wt.	3.62	4.15	4.45	4.07	0.42
C2-NAPHTHALENES	ng/g, dry wt.	a	2.66	a	na	na
C3-NAPHTHALENES	ng/g, dry wt.	a	a	a	na	na
BIPHENYL	ng/g, dry wt.	a	a	a	na	na
ACENAPHTHYLENE	ng/g, dry wt.	2.16	2.89	2.84	2.63	0.41
DIBENZOFURAN	ng/g, dry wt.	1.79	1.84	1.85	1.83	0.03
ACENAPHTHENE	ng/g, dry wt.	1.81	1.29	2.38	1.83	0.55
FLUORENE	ng/g, dry wt.	1.55	1.63	2.14	1.77	0.32
C1-FLUORENES	ng/g, dry wt.	a	a	a	na	na
C2-FLUORENES	ng/g, dry wt.	a	a	a	na	na
C3-FLUORENES	ng/g, dry wt.	a	a	a	na	na
ANTHRACENE	ng/g, dry wt.	4.94	4.90	5.98	5.28	0.61
PHENANTHRENE	ng/g, dry wt.	20.9	19.0	26.9	22.3	4.1
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	2.05	12.4	16.1	10.2	7.3
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	19.4	15.8	17.8	17.6	1.8
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	1.55	1.36	2.21	1.71	0.44
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	1.11	1.61	2.34	1.69	0.61
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	4.95	a	a	4.95	na
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	a	a	a	na	na
FLUORANTHENE	ng/g, dry wt.	40.7	40.1	47.1	42.6	3.89
PYRENE	ng/g, dry wt.	36.8	36.8	45.2	39.6	4.85
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	17.8	28.7	30.0	25.5	6.69
BENZ(A)ANTHRACENE	ng/g, dry wt.	14.6	15.3	17.7	15.8	1.62
CHRYSENE	ng/g, dry wt.	22.0	22.6	26.9	23.8	2.65
C1-CHRYSENES	ng/g, dry wt.	10.4	9.9	12.7	11.0	1.49
C2-CHRYSENES	ng/g, dry wt.	5.67	6.58	7.39	6.55	0.86
C3-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	18.34	20.79	22.41	20.5	2.05
BENZO(K)FLUORANTHENE	ng/g, dry wt.	20.6	22.9	24.9	22.8	2.12
BENZO(E)PYRENE	ng/g, dry wt.	17.5	17.5	19.1	18.0	0.91
BENZO(A)PYRENE	ng/g, dry wt.	18.3	21.7	22.4	20.8	2.18
PERYLENE	ng/g, dry wt.	5.06	5.19	6.48	5.58	0.78
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	15.9	18.7	20.2	18.3	2.18
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	3.37	5.03	4.53	4.31	0.85
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	15.4	17.4	18.7	17.2	1.68
Totals						
Total 24 PAH	ng/g, dry wt.	271	298	342	303	35.7
Total PAH	ng/g, dry wt.	334	364	416	371	41.6
Petro-PAH	ng/g, dry wt.	71.0	74.7	90.1	78.6	10.1
Pyro-PAH	ng/g, dry wt.	263	289	326	292	31.7
%Pyro-PAH of Total PAH	%	78.7%	79.5%	78.3%	78.8%	0.6%

Table A-3. HC981 PAH DATA (cont'd)

	Station	DB12	DB12	DB12	DB12	DB12
	Sample_ID	HC98104C	HC98104D	HC98104E		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	172	160	193	175	16.8
C1-NAPHTHALENES	ng/g, dry wt.	134	87.3	121	114	23.9
C2-NAPHTHALENES	ng/g, dry wt.	222	110	142	158	57.4
C3-NAPHTHALENES	ng/g, dry wt.	239	94	132	155	75.6
BIPHENYL	ng/g, dry wt.	42.5	39.1	44.1	41.9	2.55
ACENAPHTHYLENE	ng/g, dry wt.	161	118	101	127	31.3
DIBENZOFURAN	ng/g, dry wt.	77.8	58.9	275	137	120
ACENAPHTHENE	ng/g, dry wt.	79.5	56.9	272	136	118
FLUORENE	ng/g, dry wt.	135	70.2	273	159	104
C1-FLUORENES	ng/g, dry wt.	135	59.6	98.9	97.9	37.8
C2-FLUORENES	ng/g, dry wt.	254	138	175	189	59.4
C3-FLUORENES	ng/g, dry wt.	223	139	227	196	49.9
ANTHRACENE	ng/g, dry wt.	422	234	496	384	135
PHENANTHRENE	ng/g, dry wt.	978	617	2645	1413	1082
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	831	505	1023	786	262
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	762	487	593	614	139
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	372	262	229	288	74.9
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	86	58	248	131	103
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	135	90	141	122	28.0
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	186	147	140	157	24.7
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	166	137	106	136	30.3
FLUORANTHENE	ng/g, dry wt.	1258	963	2723	1648	943
PYRENE	ng/g, dry wt.	1414	1174	2663	1751	800
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	1120	888	1108	1039	131
BENZ(A)ANTHRACENE	ng/g, dry wt.	875	710	1379	988	348
CHRYSENE	ng/g, dry wt.	1062	837	1523	1140	350
C1-CHRYSENES	ng/g, dry wt.	706	576	691	658	70.8
C2-CHRYSENES	ng/g, dry wt.	437	325	295	352	75.2
C3-CHRYSENES	ng/g, dry wt.	194	133	114	147	41.9
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	1027	799	1403	1076	305
BENZO(K)FLUORANTHENE	ng/g, dry wt.	725	688	1081	832	217
BENZO(E)PYRENE	ng/g, dry wt.	794	685	1057	846	191
BENZO(A)PYRENE	ng/g, dry wt.	1049	902	1402	1118	257
PERYLENE	ng/g, dry wt.	253	215	355	274	72.4
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	812	701	1136	883	226
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	209	185	307	234	65
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	689	602	909	733	158
Totals						
Total 24 PAH	ng/g, dry wt.	13584	10552	21382	15172	5587
Total PAH	ng/g, dry wt.	18438	14050	25822	19436	5949
Petro-PAH	ng/g, dry wt.	5814	3666	7675	5718	2006
Pyro-PAH	ng/g, dry wt.	12625	10384	18146	13718	3995
%Pyro-PAH of Total PAH	%	68.5%	73.9%	70.3%	70.9%	2.8%

Table A-3. HC981 PAH DATA (cont'd)

	Station	DB14	DB14	DB14	DB14	DB14
	Sample_ID	HC981042	HC981043	HC981044		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	803	803	907	838	60
C1-NAPHTHALENES	ng/g, dry wt.	726	961	985	891	143
C2-NAPHTHALENES	ng/g, dry wt.	1194	1877	1752	1608	364
C3-NAPHTHALENES	ng/g, dry wt.	2434	2811	3126	2790	346
BIPHENYL	ng/g, dry wt.	106	153	158	139	29
ACENAPHTHYLENE	ng/g, dry wt.	219	270	339	276	60
DIBENZOFURAN	ng/g, dry wt.	615	786	772	725	95
ACENAPHTHENE	ng/g, dry wt.	1002	1343	1331	1225	194
FLUORENE	ng/g, dry wt.	1048	1518	1469	1345	258
C1-FLUORENES	ng/g, dry wt.	639	896	931	822	159
C2-FLUORENES	ng/g, dry wt.	1522	2214	2618	2118	555
C3-FLUORENES	ng/g, dry wt.	2319	3906	3773	3333	881
ANTHRACENE	ng/g, dry wt.	2538	3095	2961	2865	291
PHENANTHRENE	ng/g, dry wt.	13393	16948	17834	16058	2350
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	6223	7984	8668	7625	1262
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	4940	6433	6806	6060	987
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	2865	3919	4238	3674	718
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	820	1048	1091	986	146
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	830	1123	1208	1053	198
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	1544	2083	2385	2004	426
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	1374	1861	2044	1760	346
FLUORANTHENE	ng/g, dry wt.	16235	19374	20974	18861	2410
PYRENE	ng/g, dry wt.	14725	18275	19558	17519	2504
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	4873	6351	6928	6050	1060
BENZ(A)ANTHRACENE	ng/g, dry wt.	5671	6653	7741	6688	1035
CHRYSENE	ng/g, dry wt.	7080	8031	9227	8113	1076
C1-CHRYSENES	ng/g, dry wt.	2810	3427	3883	3374	539
C2-CHRYSENES	ng/g, dry wt.	1262	1451	1694	1469	216
C3-CHRYSENES	ng/g, dry wt.	534	591	700	608	84.2
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	5734	6528	7272	6511	769
BENZO(K)FLUORANTHENE	ng/g, dry wt.	5624	6119	6685	6142	531
BENZO(E)PYRENE	ng/g, dry wt.	4344	4768	5237	4783	447
BENZO(A)PYRENE	ng/g, dry wt.	5872	6543	7131	6515	630
PERYLENE	ng/g, dry wt.	1448	1602	1713	1587	133
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	4623	4736	4018	4459	386
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	1037	1097	921	1018	89
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	4152	4047	3186	3795	530
Totals						
Total 24 PAH	ng/g, dry wt.	106231	125535	133193	121653	13894
Total PAH	ng/g, dry wt.	133178	161624	172265	155689	20208
Petro-PAH	ng/g, dry wt.	47153	62032	65397	58194	9708
Pyro-PAH	ng/g, dry wt.	86025	99592	106868	97495	10579
%Pyro-PAH of Total PAH	%	64.6%	61.6%	62.0%	62.8%	1.6%

Table A-3. HC981 PAH DATA (cont'd)

	Station	T01	T01	T01	T01	T01
	Sample_II	HC98106C	HC98106D	HC98106E		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	48.8	31.1	40.0	40.0	8.82
C1-NAPHTHALENES	ng/g, dry wt.	68.5	27.5	76.4	57.5	26.3
C2-NAPHTHALENES	ng/g, dry wt.	182	53.6	101.7	112.4	64.8
C3-NAPHTHALENES	ng/g, dry wt.	170	63.8	82.5	105.5	56.8
BIPHENYL	ng/g, dry wt.	19	6.97	22.0	15.9	7.93
ACENAPHTHYLENE	ng/g, dry wt.	29	16.5	19.3	21.4	6.29
DIBENZOFURAN	ng/g, dry wt.	29	13.4	17.0	19.9	8.34
ACENAPHTHENE	ng/g, dry wt.	28	11.5	16.4	18.6	8.33
FLUORENE	ng/g, dry wt.	78	25.5	38.8	47.6	27.6
C1-FLUORENES	ng/g, dry wt.	124	32.9	48.9	68.5	48.5
C2-FLUORENES	ng/g, dry wt.	186	76.7	88.7	117	59.9
C3-FLUORENES	ng/g, dry wt.	123	67.5	58.5	82.9	34.8
ANTHRACENE	ng/g, dry wt.	130	55.6	68.2	84.5	39.7
PHENANTHRENE	ng/g, dry wt.	458	201	241	300	139
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	484	211	243	312	149
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	356	175	184	238	102
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	126	79.3	77.5	94.4	27.7
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	48	16.8	21.9	29.0	16.9
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	99	34.4	40.4	57.9	35.6
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	103	44.7	45.5	64.3	33.2
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	54	32.4	32.9	39.8	12.3
FLUORANTHENE	ng/g, dry wt.	519	294	317	376	124.0
PYRENE	ng/g, dry wt.	445	264	277	329	100.8
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	364	225	235	275	77.5
BENZ(A)ANTHRACENE	ng/g, dry wt.	297	166	182	215	71.7
CHRYSENE	ng/g, dry wt.	339	201	215	251	75.8
C1-CHRYSENES	ng/g, dry wt.	225	135	136	165	51.4
C2-CHRYSENES	ng/g, dry wt.	120	79.0	82.2	93.8	22.9
C3-CHRYSENES	ng/g, dry wt.	44	29.1	30.4	34.4	8.12
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	242	149	169	187	48.7
BENZO(K)FLUORANTHENE	ng/g, dry wt.	257	170	177	202	48.3
BENZO(E)PYRENE	ng/g, dry wt.	199	129	142	157	37.2
BENZO(A)PYRENE	ng/g, dry wt.	262	151	181	198	57.5
PERYLENE	ng/g, dry wt.	65.2	40.4	47.1	50.9	12.8
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	192	124	136	151	36.4
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	60	36.4	40.2	45.7	12.9
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	172	111	120	134	33.0
Totals						
Total 24 PAH	ng/g, dry wt.	4744	2540	2952	3412	1172
Total PAH	ng/g, dry wt.	6745	3581	4051	4792	1708
Petro-PAH	ng/g, dry wt.	2943	1277	1564	1928	891
Pyro-PAH	ng/g, dry wt.	3802	2304	2487	2864	817
%Pyro-PAH of Total PAH	%	56.4%	64.3%	61.4%	60.7%	4.0%

Table A-3. HC981 PAH DATA (cont'd)

	Station	T07	T07	T07	T07	T07
	Sample_Id	HC981079	HC98107C	HC98107D		
	Units	Value	Value	Value	Mean	Stdev
NAPHTHALENE	ng/g, dry wt.	74.0	73.2	72.7	73.3	0.679
C1-NAPHTHALENES	ng/g, dry wt.	50.7	62.1	55.0	56.0	5.77
C2-NAPHTHALENES	ng/g, dry wt.	44.1	53.6	43.4	47.0	5.71
C3-NAPHTHALENES	ng/g, dry wt.	35.0	49.1	42.0	42.0	7.06
BIPHENYL	ng/g, dry wt.	12.7	21.5	12.1	15.4	5.31
ACENAPHTHYLENE	ng/g, dry wt.	35.7	38.9	34.3	36.3	2.34
DIBENZOFURAN	ng/g, dry wt.	22.2	28.4	22.6	24.4	3.48
ACENAPHTHENE	ng/g, dry wt.	17.0	27.1	17.7	20.6	5.64
FLUORENE	ng/g, dry wt.	25.4	37.3	26.9	29.9	6.52
C1-FLUORENES	ng/g, dry wt.	20.2	23.5	22.3	22.0	1.65
C2-FLUORENES	ng/g, dry wt.	48.1	59.1	54.2	53.8	5.53
C3-FLUORENES	ng/g, dry wt.	58.3	63.6	63.9	61.9	3.18
ANTHRACENE	ng/g, dry wt.	69.1	82.9	68.9	73.6	7.99
PHENANTHRENE	ng/g, dry wt.	243	297	245	262	30.6
C1-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	164	179	160	167	9.87
C2-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	151	156	141	149	7.78
C3-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	80.9	81.8	85.6	82.8	2.50
C4-PHENANTHRENES/ANTHRACENES	ng/g, dry wt.	a	a	a	na	na
DIBENZOTHIOPHENE	ng/g, dry wt.	21.3	25.1	21.3	22.6	2.21
C1-DIBENZOTHIOPHENES	ng/g, dry wt.	30.4	34.5	27.5	30.8	3.53
C2-DIBENZOTHIOPHENES	ng/g, dry wt.	47.3	45.9	43.8	45.7	1.77
C3-DIBENZOTHIOPHENES	ng/g, dry wt.	48.4	50.7	44.4	47.8	3.16
FLUORANTHENE	ng/g, dry wt.	447	461	449	452	7.50
PYRENE	ng/g, dry wt.	411	426	397	411	14.8
C1-FLUORANTHRENES/PYRENES	ng/g, dry wt.	251	260	242	251	9.25
BENZ(A)ANTHRACENE	ng/g, dry wt.	236	237	232	235	2.47
CHRYSENE	ng/g, dry wt.	308	310	300	306	5.17
C1-CHRYSENES	ng/g, dry wt.	155	162	153	157	4.97
C2-CHRYSENES	ng/g, dry wt.	94.2	98.4	93.0	95.2	2.80
C3-CHRYSENES	ng/g, dry wt.	40.4	44.0	39.4	41.3	2.40
C4-CHRYSENES	ng/g, dry wt.	a	a	a	na	na
BENZO(B)FLUORANTHENE	ng/g, dry wt.	296	306	306	303	6.11
BENZO(K)FLUORANTHENE	ng/g, dry wt.	311	321	297	310	12.3
BENZO(E)PYRENE	ng/g, dry wt.	263	275	262	267	7.37
BENZO(A)PYRENE	ng/g, dry wt.	333	329	326	329	3.41
PERYLENE	ng/g, dry wt.	86.3	86.6	82.7	85.2	2.18
INDENO(1,2,3-C,D)PYRENE	ng/g, dry wt.	267	285	272	275	9.09
DIBENZO(A,H)ANTHRACENE	ng/g, dry wt.	67.2	70.6	68.4	68.7	1.72
BENZO(G,H,I)PERYLENE	ng/g, dry wt.	248	263	252	254	7.96
Totals						
Total 24 PAH	ng/g, dry wt.	4044	4292	4022	4119	150
Total PAH	ng/g, dry wt.	5113	5426	5076	5205	192
Petro-PAH	ng/g, dry wt.	1299	1490	1304	1364	109
Pyro-PAH	ng/g, dry wt.	3814	3936	3771	3840	85.3
%Pyro-PAH of Total PAH	%	74.6%	72.5%	74.3%	73.8%	1.1%

Table A-4. HC981 PCB, Pesticide DATA

	Station	C019	C019	C019	C019	C019
	Sample_ID	HC981067	HC981068	HC981069		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	2.19	2.17	2.20		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	1.19	1.16	1.14		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	4.15	4.80	5.16		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	a	8.70	9.48		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	11.68	12.39	13.11		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	26.19	25.90	31.32		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	6.95	6.17	6.69		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	5.96	6.54	5.88		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	34.36	36.97	41.52		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	21.85	27.03	27.86		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	14.64	15.28	14.79		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	2.49	1.36	1.15		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	25.10	29.73		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	7.46	5.93	7.40		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	8.02	7.96	9.50		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	6.98	9.96	7.23		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	11.62	12.17	8.71		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	2.34	a	2.59		
DECACHLOROBIPHENYL	ng/g, dry wt.	2.65	3.86	4.53		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	a	4.78	5.04		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	a	a	a		
P,P-DDD	ng/g, dry wt.	10.47	10.25	11.87		
P,P-DDE	ng/g, dry wt.	7.59	7.72	8.12		
P,P-DDT	ng/g, dry wt.	3.69	2.46	a		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	1.67	1.33	1.57		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	0.96	1.92	1.63		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	a		
Totals						
Total PCB	ng/g, dry wt.	170.72	213.45	229.98	204.72	30.58
Total DDT	ng/g, dry wt.	21.74	25.20	25.03	23.99	1.95

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT
[a] Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	DB03	DB03	DB03	DB03	DB03
	Sample_ID	HC981051	HC981052	HC981053		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	0.47	0.94	1.14		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	0.34	0.72	0.75		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.96	2.21	2.08		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	1.07	2.33	2.21		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	2.35	4.53	4.38		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	6.84	13.36	12.59		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	1.15	2.50	2.35		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.83	1.81	1.62		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	3.86	9.39	8.45		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	3.89	8.24	7.70		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	1.54	3.66	3.40		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	0.40	0.63	0.66		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	5.06	10.32	9.69		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	1.43	2.72	3.29		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	2.05	4.24	4.04		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	0.93	1.69	2.17		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	1.42	2.52	2.13		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.57	1.07	0.84		
DECACHLOROBIPHENYL	ng/g, dry wt.	0.45	1.74	1.70		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	0.82	2.23	1.92		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	0.09	a	0.11		
P,P-DDD	ng/g, dry wt.	2.07	5.93	5.17		
P,P-DDE	ng/g, dry wt.	1.76	4.21	4.03		
P,P-DDT	ng/g, dry wt.	0.51	0.72	0.95		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	a	a	0.21		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	0.22	0.21	0.30		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	0.37		
Totals						
Total PCB	ng/g, dry wt.	35.62	74.59	71.17	60.46	21.58
Total DDT	ng/g, dry wt.	5.25	13.10	12.19	10.18	4.29

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT
[a]Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	DB06	DB06	DB06	DB06	DB06
	Sample_ID	HC981032	HC981034	HC981035		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	a	0.09	0.42		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	a	0.13	0.12		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	a	0.27	0.12		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	a	a	0.15		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.43	0.40	0.35		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	3.86	1.11	0.95		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.19	0.20	0.22		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	a	0.09	0.10		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	0.60	0.65	0.57		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	0.61	0.52	0.72		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.33	0.34	0.35		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	a	0.11	0.11		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	1.96	0.71	0.65		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.27	0.27	a		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	0.24	0.21	0.21		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	a	a	0.47		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	a	0.61	0.54		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
DECACHLOROBIPHENYL	ng/g, dry wt.	a	0.08	a		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	0.09	0.11	a		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	a	a	a		
P,P-DDD	ng/g, dry wt.	0.29	0.25	0.20		
P,P-DDE	ng/g, dry wt.	0.21	0.20	0.13		
P,P-DDT	ng/g, dry wt.	0.09	0.14	0.08		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	0.25	0.18	0.12		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	a	a	a		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	a		
Totals						
Total PCB	ng/g, dry wt.	8.48	5.78	6.06	6.77	1.48
Total DDT	ng/g, dry wt.	0.69	0.70	0.41	0.60	0.16

Total PCB is the sum of target PCBs

Total DDT is the sum of target DDT

[a] Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	DB12	DB12	DB12	DB12	DB12
	Sample_ID	HC98104C	HC98104D	HC98104E		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	3.55	3.08	2.31		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	2.86	2.47	1.67		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	7.95	8.62	8.20		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	13.05	12.64	3.79		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	17.70	18.03	8.15		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	66.02	67.56	24.02		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	10.00	10.64	4.17		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	9.12	13.93	7.06		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	52.02	45.69	23.44		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	45.79	48.18	15.32		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	22.71	25.94	10.11		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	3.62	4.58	3.61		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	60.67	59.77	19.54		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	11.05	17.49	12.09		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	23.09	23.68	8.83		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	4.81	4.56	2.74		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	8.48	12.90	9.29		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	3.11	a	5.18		
DECACHLOROBIPHENYL	ng/g, dry wt.	4.68	3.08	23.93		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	10.03	8.44	1.98		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	0.88	0.36	a		
P,P-DDD	ng/g, dry wt.	32.45	25.00	9.69		
P,P-DDE	ng/g, dry wt.	15.86	17.37	5.65		
P,P-DDT	ng/g, dry wt.	35.55	1.48	1.35		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	1.18	a	1.72		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	12.31	0.55	0.39		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	1.52		
Totals						
Total PCB	ng/g, dry wt.	370.26	382.84	193.45	315.52	105.90
Total DDT	ng/g, dry wt.	94.77	52.65	18.67	55.37	38.12

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT

[a] Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	DB14	DB14	DB14	DB14	DB14
	Sample_ID	HC981042	HC981043	HC981044		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	a	3.83	8.06		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	39.74	57.85	35.84		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	a	a	12.98		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	35.87	36.74	54.12		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	146.00	167.63	199.52		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	7.06	6.62	11.54		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	9.88	11.06	20.22		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	17.26	26.82	76.52		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	21.65	a	28.39		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	19.31	14.84	29.77		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	13.05	13.78	14.85		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	25.36	24.02	47.70		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	19.28	16.43	25.41		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	8.50	10.52	17.25		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	19.92	9.45	32.42		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	22.69	21.90	31.29		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	13.49	9.68	73.89		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	23.15	26.76	a		
DECACHLOROBIPHENYL	ng/g, dry wt.					
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	7.31	22.41	26.66		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	a	2.57	8.74		
P,P-DDD	ng/g, dry wt.	54.50	66.31	100.67		
P,P-DDE	ng/g, dry wt.	19.00	21.46	36.86		
P,P-DDT	ng/g, dry wt.	14.28	12.86	35.10		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	9.40	13.29	20.67		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	33.92	3.93	2.27		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	a		
Totals						
Total PCB	ng/g, dry wt.	442.21	457.93	719.78	539.97	155.92
Total DDT	ng/g, dry wt.	95.09	125.61	208.03	142.91	58.42

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT

[a] Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	T01	T01	T01	T01	T01
	Sample_ID	HC98106C	HC98106D	HC98106E		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	0.38	0.40	0.24		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	a	0.09	0.09		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.40	0.32	0.38		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	1.27	1.09	1.01		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.86	0.79	0.90		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	1.85	1.96	2.45		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	0.68	0.75	0.72		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.97	0.95	0.93		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	3.37	2.91	3.43		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	3.12	2.31	2.90		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.94	1.15	1.24		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	a	0.71	0.34		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	2.82	1.48	1.85		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	0.98	0.86	0.78		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	1.28	0.85	1.05		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	2.70	2.21	1.97		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	4.56	2.62	3.24		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	a	0.48	0.48		
DECACHLOROBIPHENYL	ng/g, dry wt.	a	0.60	0.86		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	0.68	0.71	0.78		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	a	a	a		
P,P-DDD	ng/g, dry wt.	0.63	0.64	a		
P,P-DDE	ng/g, dry wt.	1.20	a	1.22		
P,P-DDT	ng/g, dry wt.	0.22	2.23	0.48		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	0.26	0.21	0.33		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	0.73	0.64	0.71		
LINDANE	ng/g, dry wt.	0.30	a	a		
MIREX	ng/g, dry wt.	a	a	a		
Totals						
Total PCB	ng/g, dry wt.	26.19	22.55	24.86	24.53	1.84
Total DDT	ng/g, dry wt.	2.73	3.57	2.49	2.93	0.57

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT
[a] Not detected

Table A-4. HC981 PCB, Pesticide DATA (cont'd)

	Station	T07	T07	T07	T07	T07
	Sample_ID	HC981079	HC98107C	HC98107D		
	Units	Value	Value	Value	Mean	Stdev
PCBs						
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	ng/g, dry wt.	0.83	1.31	0.68		
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	ng/g, dry wt.	0.50	0.54	0.47		
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	ng/g, dry wt.	1.48	1.80	1.41		
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	ng/g, dry wt.	3.34	3.77	2.83		
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	ng/g, dry wt.	4.72	4.26	3.55		
2,2',3,4,4',5-HEXACHLOROBIPHENYL	ng/g, dry wt.	9.94	12.69	9.41		
2,2',3,4,5,5',6-HEPTACHLOROBIPHENYL	ng/g, dry wt.	2.78	3.73	3.12		
2,2',3,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	2.16	2.78	2.64		
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	ng/g, dry wt.	13.77	17.16	11.98		
2,2',4,5,5'-PENTACHLOROBIPHENYL	ng/g, dry wt.	8.46	10.02	8.54		
2,2',5,5'-TETRACHLOROBIPHENYL	ng/g, dry wt.	2.89	4.30	3.58		
2,2',5-TRICHLOROBIPHENYL	ng/g, dry wt.	1.06	1.40	0.32		
2,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	10.07	9.61	7.62		
2,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	3.80	4.13	4.38		
2,3,3',4,4'-PENTACHLOROBIPHENYL	ng/g, dry wt.	3.65	3.80	3.26		
2,4'-DICHLOROBIPHENYL	ng/g, dry wt.	3.13	4.24	3.16		
2,4,4'-TRICHLOROBIPHENYL	ng/g, dry wt.	4.08	6.08	4.44		
3,3',4,4',5-PENTACHLOROBIPHENYL	ng/g, dry wt.	a	a	a		
3,3',4,4'-TETRACHLOROBIPHENYL	ng/g, dry wt.	a	1.41	a		
DECACHLOROBIPHENYL	ng/g, dry wt.	3.95	1.74	2.70		
DDTs (pesticides)						
O,P-DDD	ng/g, dry wt.	2.96	2.40	1.63		
O,P-DDE	ng/g, dry wt.	a	a	a		
O,P-DDT	ng/g, dry wt.	a	a	a		
P,P-DDD	ng/g, dry wt.	4.41	4.70	3.10		
P,P-DDE	ng/g, dry wt.	5.45	5.66	3.67		
P,P-DDT	ng/g, dry wt.	0.64	0.68	0.68		
Pesticides						
ALDRIN	ng/g, dry wt.	a	a	a		
DIELDRIN	ng/g, dry wt.	1.21	1.25	1.50		
ENDRIN	ng/g, dry wt.	a	a	a		
HEXACHLOROBENZENE	ng/g, dry wt.	0.62	a	0.66		
LINDANE	ng/g, dry wt.	a	a	a		
MIREX	ng/g, dry wt.	a	a	a		
Totals						
Total PCB	ng/g, dry wt.	80.60	94.80	74.08	83.16	10.59
Total DDT	ng/g, dry wt.	13.46	13.43	9.09	11.99	2.52

Total PCB is the sum of target PCBs
Total DDT is the sum of target DDT
[a] Not detected

Table A-5. HC981 Metals Data

	Station:	DB03	DB03	DB03	DB03	DB03	DB03
	Sample:	HC981051	HC981052	HC981053			
	Bottle:	HC981051CM1	HC981052CM1	HC981053CM1	Mean	Stdev	RSD
Not normalized	UNITS						
Cadmium	ug/g	0.22	0.48	0.35	0.35	0.130	37.1%
Mercury	ug/g	0.13	0.25	0.17	0.18	0.061	33.3%
Silver	ug/g	0.41	1.09	0.64	0.71	0.346	48.5%
Chromium	ug/g	51.7	94.8	57.4	67.97	23.412	34.4%
Copper	ug/g	23.6	45.5	31.1	33.40	11.130	33.3%
Lead	ug/g	55.5	67.9	45.8	56.40	11.077	19.6%
Nickel	ug/g	13.5	17.1	14.5	15.03	1.858	12.4%
Zinc	ug/g	69	109.9	72.9	83.93	22.572	26.9%
Aluminum	PCTDRYWT	4.46	5.07	4.33	4.62	0.395	8.6%
Iron	PCTDRYWT	1.923	2.39	2	2.10	0.250	11.9%
%Fines		15.4	25.3	16.6	19.10	5.403	28.3%
Normalized to %Fines	Stations:	DB03	DB03	DB03	Mean	Stdev	RSD
	UNITS						
Cadmium	ug/g/%Fines	0.01429	0.01897	0.02108	0.018	0.003	19.2%
Mercury	ug/g/%Fines	0.00844	0.00988	0.01024	0.010	0.001	10.0%
Silver	ug/g/%Fines	0.02662	0.04308	0.03855	0.036	0.009	23.6%
Chromium	ug/g/%Fines	3.35714	3.74704	3.45783	3.521	0.202	5.7%
Copper	ug/g/%Fines	1.53247	1.79842	1.87349	1.735	0.179	10.3%
Lead	ug/g/%Fines	3.60390	2.68379	2.75904	3.016	0.511	16.9%
Nickel	ug/g/%Fines	0.87662	0.67589	0.87349	0.809	0.115	14.2%
Zinc	ug/g/%Fines	4.48052	4.34387	4.39157	4.405	0.069	1.6%
Aluminum	%/g/%Fines	0.28961	0.20040	0.26084	0.250	0.046	18.2%
Iron	%/g/%Fines	0.12487	0.09447	0.12048	0.113	0.016	14.5%
Normalized to Aluminum	Stations:	DB03	DB03	DB03	Mean	Stdev	RSD
	UNITS						
Cadmium	ug/g/%aluminum	0.04933	0.09467	0.08083	0.07	0.023	31.0%
Mercury	ug/g/%aluminum	0.02915	0.04931	0.03926	0.04	0.010	25.7%
Silver	ug/g/%aluminum	0.09193	0.21499	0.14781	0.15	0.062	40.7%
Chromium	ug/g/%aluminum	11.59193	18.69822	13.25635	14.52	3.717	25.6%
Copper	ug/g/%aluminum	5.29148	8.97436	7.18245	7.15	1.842	25.8%
Lead	ug/g/%aluminum	12.44395	13.39250	10.57737	12.14	1.432	11.8%
Nickel	ug/g/%aluminum	3.02691	3.37278	3.34873	3.25	0.193	5.9%
Zinc	ug/g/%aluminum	15.47085	21.67653	16.83603	17.99	3.261	18.1%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.43117	0.47140	0.46189	0.45	0.021	4.6%

Table A-5. HC981 Metals Data (cont'd)

	Station:	C019	C019	C019	C019	C019	C019
	Sample:	HC981067	HC981068	HC981069			
	Bottle:	HC981067CM1	HC981068CM1	HC981069CM1	Mean	Stdev	RSD
Not normalized	UNITS						
Cadmium	ug/g	1.07	1.12	1.08	1.09	0.026	2.4%
Mercury	ug/g	0.79	0.78	0.8	0.79	0.010	1.3%
Silver	ug/g	3.94	3.88	4.27	4.03	0.210	5.2%
Chromium	ug/g	200	206	208	204.67	4.163	2.0%
Copper	ug/g	142.6	148	154.4	148.33	5.907	4.0%
Lead	ug/g	150.9	145	155	150.30	5.027	3.3%
Nickel	ug/g	43.1	46.6	44.7	44.80	1.752	3.9%
Zinc	ug/g	231	236	236	234.33	2.887	1.2%
Aluminum	PCTDRYWT	7.28	7.64	7.28	7.40	0.208	2.8%
Iron	PCTDRYWT	4.82	4.78	4.74	4.78	0.040	0.8%
%Fines		97.9	96.3	95.8	96.67	1.097	1.1%
Normalized to %Fines	Stations:	C019	C019	C019	Mean	Stdev	RSD
Cadmium	ug/g/%Fines	0.01093	0.01163	0.01127	0.011	0.000	3.1%
Mercury	ug/g/%Fines	0.00807	0.00810	0.00835	0.008	0.000	1.9%
Silver	ug/g/%Fines	0.04025	0.04029	0.04457	0.042	0.002	6.0%
Chromium	ug/g/%Fines	2.04290	2.13915	2.17119	2.118	0.067	3.2%
Copper	ug/g/%Fines	1.45659	1.53686	1.61169	1.535	0.078	5.1%
Lead	ug/g/%Fines	1.54137	1.50571	1.61795	1.555	0.057	3.7%
Nickel	ug/g/%Fines	0.44025	0.48390	0.46660	0.464	0.022	4.7%
Zinc	ug/g/%Fines	2.35955	2.45067	2.46347	2.425	0.057	2.3%
Aluminum	%/g/%Fines	0.07436	0.07934	0.07599	0.077	0.003	3.3%
Iron	%/g/%Fines	0.04923	0.04964	0.04948	0.049	0.000	0.4%
Normalized to Aluminum	Stations:	C019	C019	C019	Mean	Stdev	RSD
Cadmium	ug/g/%aluminum	0.14698	0.14660	0.14835	0.15	0.001	0.6%
Mercury	ug/g/%aluminum	0.10852	0.10209	0.10989	0.11	0.004	3.9%
Silver	ug/g/%aluminum	0.54121	0.50785	0.58654	0.55	0.039	7.2%
Chromium	ug/g/%aluminum	27.47253	26.96335	28.57143	27.67	0.822	3.0%
Copper	ug/g/%aluminum	19.58791	19.37173	21.20879	20.06	1.004	5.0%
Lead	ug/g/%aluminum	20.72802	18.97906	21.29121	20.33	1.206	5.9%
Nickel	ug/g/%aluminum	5.92033	6.09948	6.14011	6.05	0.117	1.9%
Zinc	ug/g/%aluminum	31.73077	30.89005	32.41758	31.68	0.765	2.4%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.66209	0.62565	0.65110	0.65	0.019	2.9%

Table A-5. HC981 Metals Data (cont'd)

	Station:	DB06	DB06	DB06	DB06	DB06	DB06
	Sample:	HC981032	HC981034	HC981035			
	Bottle:	HC981032CM1	HC981034CM1	HC981035CM1	Mean	Stdev	RSD
Not normalized	UNITS						
Cadmium	ug/g	0.06	0.08	0.07	0.07	0.010	14.3%
Mercury	ug/g	0.05	0.09	0.06	0.07	0.021	31.2%
Silver	ug/g	0.28	0.3	0.33	0.30	0.025	8.3%
Chromium	ug/g	22.5	33.6	23.2	26.43	6.216	23.5%
Copper	ug/g	18.7	15.5	19.1	17.77	1.973	11.1%
Lead	ug/g	29.8	28.3	29.5	29.20	0.794	2.7%
Nickel	ug/g	10.5	10.7	8.6	9.93	1.159	11.7%
Zinc	ug/g	34.3	39.3	35.9	36.50	2.553	7.0%
Aluminum	PCTDRYWT	3.88	4.43	3.38	3.90	0.525	13.5%
Iron	PCTDRYWT	1.234	1.384	1.293	1.30	0.076	5.8%
%Fines		5.2	6.4	6	5.87	0.611	10.4%
Normalized to %Fines	Stations:	DB06	DB06	DB06	Mean	Stdev	RSD
Cadmium	ug/g/%Fines	0.01154	0.01250	0.01167	0.012	0.001	4.4%
Mercury	ug/g/%Fines	0.00962	0.01406	0.01000	0.011	0.002	21.9%
Silver	ug/g/%Fines	0.05385	0.04688	0.05500	0.052	0.004	8.5%
Chromium	ug/g/%Fines	4.32692	5.25000	3.86667	4.481	0.704	15.7%
Copper	ug/g/%Fines	3.59615	2.42188	3.18333	3.067	0.596	19.4%
Lead	ug/g/%Fines	5.73077	4.42188	4.91667	5.023	0.661	13.2%
Nickel	ug/g/%Fines	2.01923	1.67188	1.43333	1.708	0.295	17.2%
Zinc	ug/g/%Fines	6.59615	6.14063	5.98333	6.240	0.318	5.1%
Aluminum	%/g/%Fines	0.74615	0.69219	0.56333	0.667	0.094	14.1%
Iron	%/g/%Fines	0.23731	0.21625	0.21550	0.223	0.012	5.6%
Normalized to Aluminum	Stations:	DB06	DB06	DB06	Mean	Stdev	RSD
Cadmium	ug/g/%aluminum	0.01546	0.01806	0.02071	0.02	0.003	14.5%
Mercury	ug/g/%aluminum	0.01289	0.02032	0.01775	0.02	0.004	22.2%
Silver	ug/g/%aluminum	0.07216	0.06772	0.09763	0.08	0.016	20.4%
Chromium	ug/g/%aluminum	5.79897	7.58465	6.86391	6.75	0.898	13.3%
Copper	ug/g/%aluminum	4.81959	3.49887	5.65089	4.66	1.085	23.3%
Lead	ug/g/%aluminum	7.68041	6.38826	8.72781	7.60	1.172	15.4%
Nickel	ug/g/%aluminum	2.70619	2.41535	2.54438	2.56	0.146	5.7%
Zinc	ug/g/%aluminum	8.84021	8.87133	10.62130	9.44	1.019	10.8%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.31804	0.31242	0.38254	0.34	0.039	11.5%

Table A-5. HC981 Metals Data (cont'd)

	Station:	DB12	DB12	DB12	DB12	DB12	DB12
	Sample:	HC98104C	HC98104D	HC98104E			
	Bottle:	HC98104CCM1	HC98104DCM1	HC98104ECM1	Mean	Stdev	RSD
Not normalized	UNITS						
Cadmium	ug/g	1.68	2.29	0.9	1.62	0.697	42.9%
Mercury	ug/g	0.55	0.86	0.54	0.65	0.182	28.0%
Silver	ug/g	2.2	3.88	2.13	2.74	0.991	36.2%
Chromium	ug/g	166	199	122.3	162.43	38.474	23.7%
Copper	ug/g	87.1	100.6	76.4	88.03	12.127	13.8%
Lead	ug/g	127.1	126.9	94.5	116.17	18.764	16.2%
Nickel	ug/g	27.6	32.4	26.5	28.83	3.137	10.9%
Zinc	ug/g	182.3	180.3	127.9	163.50	30.847	18.9%
Aluminum	PCTDRYWT	5.32	6.11	4.77	5.40	0.674	12.5%
Iron	PCTDRYWT	3.05	3.3	2.77	3.04	0.265	8.7%
%Fines		42.8	55	32.7	43.50	11.166	25.7%
Normalized to %Fines	Stations:	DB12	DB12	DB12	Mean	Stdev	RSD
Cadmium	ug/g/%Fines	0.03925	0.04164	0.02752	0.036	0.008	20.9%
Mercury	ug/g/%Fines	0.01285	0.01564	0.01651	0.015	0.002	12.8%
Silver	ug/g/%Fines	0.05140	0.07055	0.06514	0.062	0.010	15.8%
Chromium	ug/g/%Fines	3.87850	3.61818	3.74006	3.746	0.130	3.5%
Copper	ug/g/%Fines	2.03505	1.82909	2.33639	2.067	0.255	12.3%
Lead	ug/g/%Fines	2.96963	2.30727	2.88991	2.722	0.362	13.3%
Nickel	ug/g/%Fines	0.64486	0.58909	0.81040	0.681	0.115	16.9%
Zinc	ug/g/%Fines	4.25935	3.27818	3.91131	3.816	0.497	13.0%
Aluminum	%/g/%Fines	0.12430	0.11109	0.14587	0.127	0.018	13.8%
Iron	%/g/%Fines	0.07126	0.06000	0.08471	0.072	0.012	17.2%
Normalized to Aluminum	Stations:	DB12	DB12	DB12	Mean	Stdev	RSD
Cadmium	ug/g/%aluminum	0.31579	0.37480	0.18868	0.29	0.095	32.5%
Mercury	ug/g/%aluminum	0.10338	0.14075	0.11321	0.12	0.019	16.3%
Silver	ug/g/%aluminum	0.41353	0.63502	0.44654	0.50	0.119	24.0%
Chromium	ug/g/%aluminum	31.20301	32.56956	25.63941	29.80	3.671	12.3%
Copper	ug/g/%aluminum	16.37218	16.46481	16.01677	16.28	0.237	1.5%
Lead	ug/g/%aluminum	23.89098	20.76923	19.81132	21.49	2.133	9.9%
Nickel	ug/g/%aluminum	5.18797	5.30278	5.55556	5.35	0.188	3.5%
Zinc	ug/g/%aluminum	34.26692	29.50900	26.81342	30.20	3.774	12.5%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.57331	0.54010	0.58071	0.56	0.022	3.8%

Table A-5. HC981 Metals Data (cont'd)

		Using averagee of Lab Dup for metals					
	Station:	DB14	DB14	DB14	DB14	DB14	DB14
	Sample:	HC981042	HC981043	HC981044			
	Bottle:	HC981042CM1	HC981043CM1	HC981044CM1	Mean	Stdev	RSD
Not normalized	**UNITS**						
Cadmium	ug/g	2.07	2.01	2.51	2.20	0.273	12.4%
Mercury	ug/g	1.04	0.97	1.19	1.07	0.112	10.5%
Silver	ug/g	2.01	1.21	2.3	1.84	0.565	30.7%
Chromium	ug/g	124.6	90.95	135.1	116.88	23.064	19.7%
Copper	ug/g	164.1	153.3	194	170.47	21.084	12.4%
Lead	ug/g	698	692	768	719.33	42.253	5.9%
Nickel	ug/g	39.3	30	35.3	34.87	4.665	13.4%
Zinc	ug/g	499	470	552	507.00	41.581	8.2%
Aluminum	PCTDRYWT	5.38	4.895	5.55	5.28	0.340	6.4%
Iron	PCTDRYWT	3.56	3.02	4.04	3.54	0.510	14.4%
%Fines		54.4	44.7	61.7	53.60	8.528	15.9%
Normalized to %Fines	**Stations:**	**DB14**	**DB14**	**DB14**	**Mean**	**Stdev**	**RSD**
Cadmium	ug/g/%Fines	0.03805	0.04497	0.04068	0.041	0.003	8.5%
Mercury	ug/g/%Fines	0.01912	0.02170	0.01929	0.020	0.001	7.2%
Silver	ug/g/%Fines	0.03695	0.02707	0.03728	0.034	0.006	17.2%
Chromium	ug/g/%Fines	2.29044	2.03468	2.18963	2.172	0.129	5.9%
Copper	ug/g/%Fines	3.01654	3.42953	3.14425	3.197	0.211	6.6%
Lead	ug/g/%Fines	12.83088	15.48098	12.44733	13.586	1.652	12.2%
Nickel	ug/g/%Fines	0.72243	0.67114	0.57212	0.655	0.076	11.7%
Zinc	ug/g/%Fines	9.17279	10.51454	8.94652	9.545	0.848	8.9%
Aluminum	%/g/%Fines	0.09890	0.10951	0.08995	0.099	0.010	9.8%
Iron	%/g/%Fines	0.06544	0.06756	0.06548	0.066	0.001	1.8%
Normalized to Aluminum	**Stations:**	**DB14**	**DB14**	**DB14**	**Mean**	**Stdev**	**RSD**
Cadmium	ug/g/%aluminum	0.38476	0.41062	0.45225	0.42	0.034	8.2%
Mercury	ug/g/%aluminum	0.19331	0.19816	0.21441	0.20	0.011	5.5%
Silver	ug/g/%aluminum	0.37361	0.24719	0.41441	0.35	0.087	25.3%
Chromium	ug/g/%aluminum	23.15985	18.58018	24.34234	22.03	3.043	13.8%
Copper	ug/g/%aluminum	30.50186	31.31767	34.95495	32.26	2.371	7.3%
Lead	ug/g/%aluminum	129.73978	141.36874	138.37838	136.50	6.039	4.4%
Nickel	ug/g/%aluminum	7.30483	6.12870	6.36036	6.60	0.623	9.4%
Zinc	ug/g/%aluminum	92.75093	96.01634	99.45946	96.08	3.355	3.5%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.66171	0.61696	0.72793	0.67	0.056	8.3%

Table A-5. HC981 Metals Data (cont'd)

		Using averagee of Lab Dup for metals					
	Station:	**T01**	**T01**	**T01**	**T01**	**T01**	**T01**
	Sample:	**HC98106C**	**HC98106D**	**HC98106E**			
	Bottle:	**HC98106CCM1**	**HC98106DCM1**	**HC98106ECM1**	**Mean**	**Stdev**	**RSD**
Not normalized	**UNITS**						
Cadmium	ug/g	0.39	0.3	0.27	0.32	0.062	19.5%
Mercury	ug/g	0.15	0.21	0.15	0.17	0.035	20.4%
Silver	ug/g	0.6	0.77	0.76	0.71	0.095	13.4%
Chromium	ug/g	56.8	59.6	60.2	58.87	1.815	3.1%
Copper	ug/g	38.5	25.9	36.4	33.60	6.751	20.1%
Lead	ug/g	78.7	36.8	37	50.83	24.133	47.5%
Nickel	ug/g	17.8	18.75	22.5	19.68	2.485	12.6%
Zinc	ug/g	76.8	65.2	73.3	71.77	5.950	8.3%
Aluminum	PCTDRYWT	5.43	5.235	4.9	5.19	0.268	5.2%
Iron	PCTDRYWT	2.22	2.2	2.47	2.30	0.150	6.6%
%Fines		20.3	29.6	25.2	25.03	4.652	18.6%
Normalized to %Fines	**Stations:**	**T01**	**T01**	**T01**	**Mean**	**Stdev**	**RSD**
Cadmium	ug/g/%Fines	0.01921	0.01014	0.01071	0.013	0.005	38.1%
Mercury	ug/g/%Fines	0.00739	0.00709	0.00595	0.007	0.001	11.1%
Silver	ug/g/%Fines	0.02956	0.02601	0.03016	0.029	0.002	7.8%
Chromium	ug/g/%Fines	2.79803	2.01351	2.38889	2.400	0.392	16.3%
Copper	ug/g/%Fines	1.89655	0.87500	1.44444	1.405	0.512	36.4%
Lead	ug/g/%Fines	3.87685	1.24324	1.46825	2.196	1.460	66.5%
Nickel	ug/g/%Fines	0.87685	0.63345	0.89286	0.801	0.145	18.1%
Zinc	ug/g/%Fines	3.78325	2.20270	2.90873	2.965	0.792	26.7%
Aluminum	%/g/%Fines	0.26749	0.17686	0.19444	0.213	0.048	22.6%
Iron	%/g/%Fines	0.10936	0.07432	0.09802	0.094	0.018	19.0%
Normalized to Aluminum	**Stations:**	**T01**	**T01**	**T01**	**Mean**	**Stdev**	**RSD**
Cadmium	ug/g/%aluminum	0.07182	0.05731	0.05510	0.06	0.009	14.8%
Mercury	ug/g/%aluminum	0.02762	0.04011	0.03061	0.03	0.007	19.9%
Silver	ug/g/%aluminum	0.11050	0.14709	0.15510	0.14	0.024	17.3%
Chromium	ug/g/%aluminum	10.46041	11.38491	12.28571	11.38	0.913	8.0%
Copper	ug/g/%aluminum	7.09024	4.94747	7.42857	6.49	1.345	20.7%
Lead	ug/g/%aluminum	14.49355	7.02961	7.55102	9.69	4.167	43.0%
Nickel	ug/g/%aluminum	3.27808	3.58166	4.59184	3.82	0.688	18.0%
Zinc	ug/g/%aluminum	14.14365	12.45463	14.95918	13.85	1.277	9.2%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.40884	0.42025	0.50408	0.44	0.052	11.7%

Table A-5. HC981 Metals Data (cont'd)

	Station:	T07	T07	T07	T07	T07	T07
	Sample:	HC981079	HC98107C	HC98107D			
	Bottle:	HC981079CM1	HC98107CCM2	HC98107DCM3	Mean	Stdev	RSD
Not normalized	UNITS						
Cadmium	ug/g	1.03	0.93	0.87	0.94	0.081	8.6%
Mercury	ug/g	0.81	0.85	0.82	0.83	0.021	2.5%
Silver	ug/g	5.72	5.51	5.45	5.56	0.142	2.5%
Chromium	ug/g	166.2	158.4	168.9	164.50	5.453	3.3%
Copper	ug/g	93.4	102.3	101.4	99.03	4.899	4.9%
Lead	ug/g	106.7	112.8	110.8	110.10	3.110	2.8%
Nickel	ug/g	30.6	33.1	33.7	32.47	1.644	5.1%
Zinc	ug/g	145.2	145.5	150.2	146.97	2.804	1.9%
Aluminum	PCTDRYWT	5.91	5.58	6.81	6.10	0.637	10.4%
Iron	PCTDRYWT	3.37	3.29	3.47	3.38	0.090	2.7%
%Fines		54.6	54.9	62.6	57.37	4.535	7.9%
Normalized to %Fines	Stations:	T07	T07	T07	Mean	Stdev	RSD
Cadmium	ug/g/%Fines	0.01886	0.01694	0.01390	0.017	0.003	15.1%
Mercury	ug/g/%Fines	0.01484	0.01548	0.01310	0.014	0.001	8.5%
Silver	ug/g/%Fines	0.10476	0.10036	0.08706	0.097	0.009	9.5%
Chromium	ug/g/%Fines	3.04396	2.88525	2.69808	2.876	0.173	6.0%
Copper	ug/g/%Fines	1.71062	1.86339	1.61981	1.731	0.123	7.1%
Lead	ug/g/%Fines	1.95421	2.05464	1.76997	1.926	0.144	7.5%
Nickel	ug/g/%Fines	0.56044	0.60291	0.53834	0.567	0.033	5.8%
Zinc	ug/g/%Fines	2.65934	2.65027	2.39936	2.570	0.148	5.7%
Aluminum	%/g/%Fines	0.10824	0.10164	0.10879	0.106	0.004	3.7%
Iron	%/g/%Fines	0.06172	0.05993	0.05543	0.059	0.003	5.5%
Normalized to Aluminum	Stations:	T07	T07	T07	Mean	Stdev	RSD
Cadmium	ug/g/%aluminum	0.17428	0.16667	0.12775	0.16	0.025	16.0%
Mercury	ug/g/%aluminum	0.13706	0.15233	0.12041	0.14	0.016	11.7%
Silver	ug/g/%aluminum	0.96785	0.98746	0.80029	0.92	0.103	11.2%
Chromium	ug/g/%aluminum	28.12183	28.38710	24.80176	27.10	1.998	7.4%
Copper	ug/g/%aluminum	15.80372	18.33333	14.88987	16.34	1.784	10.9%
Lead	ug/g/%aluminum	18.05415	20.21505	16.27019	18.18	1.975	10.9%
Nickel	ug/g/%aluminum	5.17766	5.93190	4.94860	5.35	0.514	9.6%
Zinc	ug/g/%aluminum	24.56853	26.07527	22.05580	24.23	2.031	8.4%
Aluminum	%/g/%aluminum	1.00000	1.00000	1.00000	1.00	0.000	0.0%
Iron	%/g/%aluminum	0.57022	0.58961	0.50954	0.56	0.042	7.5%

Table B-1(a). Sediment metal contaminant comparisons – 1998, 1994, and 1990 samples; data normalized to %Fines.

	Normalized to %Fines (μg/g/%Fines)									
Station	Ag	Al[1]	Cd	Cr	Cu	Fe[1]	Hg	Ni	Pb	Zn
	1998									
DB01	0.0289	0.0784	0.00886	1.66	1.37	0.045	0.00683	0.37	1.71	2.57
DB03	0.0361	0.25	0.0181	3.52	1.73	0.113	0.00952	0.809	3.02	4.41
DB04	0.0318	0.0732	0.00822	1.68	1.15	0.0458	0.00665	0.405	1.39	2.14
DB06	0.0519	0.667	0.0119	4.48	3.07	0.223	0.0112	1.71	5.02	6.24
DB10	0.0602	0.113	0.0268	2.73	5.99	0.0805	0.0203	0.698	8.83	6.96
DB11	-[2]	-	-	-	-	-	-	-	-	-
DB12	0.0624	0.127	0.0361	3.75	2.07	0.072	0.015	0.681	2.72	3.82
DB13	0.0446	0.0748	0.0271	2.09	2.5	0.0508	0.0286	0.497	5.06	5.65
DB14	0.0338	0.0995	0.0412	2.17	3.2	0.0662	0.02	0.655	13.6	9.54
T01	0.0286	0.213	0.0134	2.4	1.41	0.0939	0.00681	0.801	2.2	2.96
T02	0.034	0.112	0.00792	1.98	1.01	0.0578	0.00585	0.465	1.19	2.05
T07	0.0974	0.106	0.0166	2.88	1.73	0.059	0.0145	0.567	1.93	2.57
T08	0.0756	0.721	0.0227	5.38	3.12	0.315	0.0148	2.24	5.06	8.11
CO19	0.0417	0.0766	0.0113	2.12	1.54	0.0494	0.00817	0.464	1.56	2.42
SWEX3	0.0396	0.1	0.00533	2.34	1.22	0.0596	0.011	0.545	1.37	2.14
	1994									
DB01	0.0467	0.0766	0.0113	2.11	1.8	0.05	0.00996	0.463	2.04	3.13
DB03	0.0477	0.249	0.0123	3.51	1.5	0.107	0.0726	0.822	2.94	3.74
DB04	0.0488	0.09	0.0135	2.28	1.43	0.0484	0.0101	0.464	2.62	2.76
DB06	0.0483	0.489	0.00876	4.68	1.63	0.182	0.0101	1.22	3.83	4.48
DB10	0.0575	0.0701	0.0192	2.48	2.26	0.048	0.0134	0.429	2.07	3.11
DB11	0.0303	0.106	0.0148	1.95	1.04	0.0492	0.0102	0.34	1.6	2.41
DB12	0.0825	0.117	0.0248	4.59	2.16	0.0689	0.0178	0.743	2.85	3.77
DB13	0.0652	0.0783	0.0247	2.96	1.84	0.0442	0.0145	0.433	2.32	3.1
DB14	0.0421	0.0819	0.0285	2.3	2.43	0.0548	0.0149	0.492	6.68	6.63
T01	0.0246	0.178	0.00844	2.15	0.736	0.0713	0.00714	0.57	0.901	1.86
T02	0.0659	0.149	0.0128	3.32	1.56	0.0694	0.00984	0.614	1.67	2.67
T07	-	-	-	-	-	-	-	-	-	-
T08	0.0864	0.492	0.0165	7.98	2.58	0.331	0.0165	2.17	4.22	7.7
CO19	0.0496	0.0751	0.0119	2.24	1.52	0.0452	0.00846	0.388	1.43	2.27
SWEX3	0.0747	0.129	0.00784	3.6	1.77	0.0733	0.0108	0.665	2	2.89
	1990									
DB01	-	0.217	0.275	3.85	7.14	0.0937	-	2.44	15.6	48.9
DB03	-	0.287	0.0324	4.48	2.62	0.113	-	1.04	3.23	5.28
DB04	-	0.117	0.0235	3.07	2.45	0.058	-	0.751	2.35	4.31
DB06	-	0.838	0.041	5.61	3.05	0.228	-	2.26	6.02	7.66
DB10	-	0.114	0.0365	3.48	3.43	0.0737	-	0.821	6.81	7.54
DB11	-	-	-	-	-	-	-	-	-	-
DB12	-	0.146	0.024	3.81	2.34	0.0696	-	0.771	2.49	3.54
DB13	-	0.0954	0.0259	2.73	2.34	0.0516	-	0.57	2.47	4.4
DB14	-	0.109	0.0384	2.5	2.85	0.0577	-	0.691	8.16	6.76

Table B-1(b). Sediment metal contaminant comparisons – 1998, 1994, and 1990 samples; data normalized to %Aluminum.

	Normalized to Aluminum (µg/g/%Al)									
Station	**Ag**	**Al[1]**	**Cd**	**Cr**	**Cu**	**Fe[1]**	**Hg**	**Ni**	**Pb**	**Zn**
	1998									
DB01	0.369	1	0.113	21.2	17.5	0.576	0.0873	4.73	21.8	33
DB03	0.152	1	0.0749	14.5	7.15	0.455	0.0392	3.25	12.1	18
DB04	0.436	1	0.113	23.1	15.8	0.628	0.0911	5.54	19.1	29.4
DB06	0.0792	1	0.0181	6.75	4.66	0.338	0.017	2.56	7.6	9.44
DB10	0.532	1	0.234	24.2	48.6	0.708	0.175	6.08	71.5	59.6
DB11	-[2]	-	-	-	-	-	-	-	-	-
DB12	0.498	1	0.293	29.8	16.3	0.565	0.119	5.35	21.5	30.2
DB13	0.596	1	0.361	28	33.3	0.679	0.384	6.64	67.4	75.3
DB14	0.345	1	0.416	22	32.3	0.669	0.202	6.6	136	96.1
T01	0.138	1	0.0614	11.4	6.49	0.444	0.0328	3.82	9.69	13.9
T02	0.304	1	0.0705	17.7	8.96	0.516	0.0524	4.16	10.6	18.3
T07	0.919	1	0.156	27.1	16.3	0.556	0.137	5.35	18.2	24.2
T08	0.107	1	0.0321	7.45	4.37	0.442	0.0207	3.2	7.1	11.4
CO19	0.545	1	0.147	27.7	20.1	0.646	0.107	6.05	20.3	31.7
SWEX3	0.393	1	0.0528	23.5	12.2	0.598	0.106	5.32	13.8	21.5
	1994									
DB01	0.61	1	0.148	27.6	23.5	0.652	0.13	6.04	26.7	40.9
DB03	0.191	1	0.0493	14.1	6.03	0.43	0.291	3.3	11.8	15
DB04	0.543	1	0.15	25.4	15.9	0.538	0.113	5.16	29	30.7
DB06	0.0986	1	0.0179	9.57	3.34	0.372	0.0206	2.5	7.82	9.17
DB10	0.819	1	0.274	35.3	32.2	0.684	0.191	6.12	29.5	44.3
DB11	0.286	1	0.14	18.4	9.83	0.465	0.0959	3.21	15.2	22.8
DB12	0.706	1	0.213	39.3	18.5	0.59	0.152	6.36	24.4	32.2
DB13	0.834	1	0.315	37.9	23.5	0.565	0.185	5.53	29.6	39.6
DB14	0.514	1	0.349	28.1	29.7	0.669	0.182	6	81.6	80.9
T01	0.138	1	0.0474	12.1	4.13	0.4	0.0401	3.2	5.06	10.4
T02	0.441	1	0.0857	22.2	10.5	0.464	0.0659	4.11	11.1	17.8
T07	-	-	-	-	-	-	-	-	-	-
T08	0.175	1	0.0335	16.2	5.23	0.673	0.0336	4.42	8.57	15.6
CO19	0.661	1	0.159	29.8	20.3	0.602	0.113	5.17	19	30.3
SWEX3	0.58	1	0.0609	28	13.8	0.569	0.0836	5.17	15.5	22.5
	1990									
DB01	-	1	1.27	17.8	33	0.433	-	11.3	71.9	226
DB03	-	1	0.113	15.6	9.13	0.394	-	3.63	11.2	18.4
DB04	-	1	0.202	26.3	21	0.497	-	6.44	20.2	37
DB06	-	1	0.0489	6.69	3.64	0.272	-	2.7	7.18	9.14
DB10	-	1	0.321	30.5	30.1	0.647	-	7.21	59.8	66.2
DB11	-	-	-	-	-	-	-	-	-	-
DB12	-	1	0.165	26.1	16	0.477	-	5.28	17.1	24.2
DB13	-	1	0.271	28.6	24.6	0.541	-	5.98	25.9	46.2
DB14	-	1	0.353	23	26.3	0.531	-	6.36	75	62.1
T01	-	-	-	-	-	-	-	-	-	-
T02	-	-	-	-	-	-	-	-	-	-
T07	-	-	-	-	-	-	-	-	-	-
T08	-	-	-	-	-	-	-	-	-	-
CO19	-	-	-	-	-	-	-	-	-	-
SWEX3	-	-	-	-	-	-	-	-	-	-

[1] Aluminum is unitless and iron reported as %/g/%Aluminum.

[3] Not applicable, sediment not collected at this station or analyzed for this parameter.

Table B-2. (continued)

	Normalized to TOC (ng/g/%TOC)							
Station	**Total PAH[1]**	**Total 24 PAH[2]**	**Petro-PAH[3]**	**Pyro-PAH[4]**	**Total PCB[5]**	**Total DDT[6]**	**Total LAB[7]**	**Coprostanol**
T01	-	-	-	-	-	-	-	-
T02	-	-	-	-	-	-	-	-
T07	-	-	-	-	-	-	-	-
T08	-	-	-	-	-	-	-	-
CO19	-	-	-	-	-	-	-	-
SWEX3	-	-	-	-	-	-	-	-

[1] Total PAH is the sum of all target PAH compounds (Table 2-2).
[2] Total 24 PAH is the sum of all asterisked (*) PAH compounds which were used to compare to the 1990, 1994, and 1998 CSO survey total PAH data (Table 2-2).
[3] Petro-PAH is the sum of petrogenic PAH compounds (Table 2-2; Naphthalene through C_3-Dibenzothiophenes).
[4] Pyro-PAH is the sum of pyrogenic PAH compounds (Table 2-2; Fluoranthene through Benzo(g,h,i)perylene).
[5] Total PCB is the sum of all target PCB congeners (Table 2-2).
[6] Total DDT is the sum of all target DDTs (Table 2-2).
[7] Total LAB is the sum of LAB compounds (Table 2-2).
[8] NA, not applicable. Sediment not collected at this station or analyzed for this parameter.