CHAPTER 5. SEDIMENT CHEMISTRY

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I. INTRODUCTION

The City of Los Angeles's Terminal Island Treatment Plant (TITP) discharges filtered secondary effluent into the Outer Los Angeles Harbor. The TITP NPDES permit mandates monitoring of receiving water throughout the Outer Los Angeles Harbor to determine the impact, if any, from the discharged secondary effluent from the Plant. The Plant's current NPDES permit became effective in March 1993. The program included chemical and physical characterization of sediments of the Outer Los Angeles Harbor stations to assess the accumulation of wastewater-related pollutants in the vicinity of TITP's outfall (EMD 1993 to 2001).

The TITP's NPDES mandated receiving water monitoring program including the sampling stations was modified several times during the period of 1994 -1995 (see Table 1-1 in Chapter 1). The modifications during this period were necessary to accommodate the continuous construction activities within the Outer Los Angeles Harbor associated with the construction of Pier 400, and changes in the configuration of the Plant's outfall.

By late July 1996, the new extended TITP outfall was in place and began discharging secondary effluent into the Outer Los Angeles Harbor near the southwest corner of Pier 400. At this time, the rock like construction enclosing the Increment 2 phase of Pier 400 created a new configuration for the Outer Los Angeles Harbor. These changes made necessary a complete re-evaluation of the TITP's entire receiving water monitoring program to better assess environmental impacts that could result from the TITP outfall discharge at its new terminus location. To address this, the Plant's marine monitoring program was redesigned. The new program was submitted to the Regional Water Quality Control Board (RWQCB) in July 1996, and the Post-Pier 400 Monitoring Program was implemented in August 1996.

Since 1996, with the exception of the 1998 summer survey, the Los Angeles Harbor Annual Assessment Report (CLA, EMD 1996 to 2001, and this report) is based on the Post-Pier 400 Monitoring Program. In 1998, the City participated in the Bight '98 Regional Survey. To be able to participate in the Bight '98 Program, the City gained approval from the RWQCB to resource exchange a major portion of the Plant's NPDES permit required samples from the 1998 summer survey. Only two sampling stations from the existing program were retained as compliance stations to maintain continuity with historical data in 1998.

Under the current NPDES mandated receiving water monitoring program, sediment collected from the thirteen receiving water stations in the Harbor are analyzed for grain size, total organic carbon, (TOC), dissolved sulfide, total organic halides (TOX), and selected inorganic and organic priority pollutants (nine metals, cyanide, and 89 organic compounds).

In this chapter, results of these analyses on the sediment samples collected during the summer of 2002 are presented. The data were examined for spatial patterns of contamination around the Plant's discharge of the TITP outfall. Finally, wherever possible, historical trends were reviewed to assess temporal changes of pollutant levels in the vicinity of the City's outfalls and in the reference areas.

II. MATERIALS AND METHODS

A. FIELD SAMPLING

The grab samples of sediment from 12 stations inside the Harbor (HM1-HM12) and 1 station (HM13) outside the Harbor (Figure 5-1) were collected in the summer of 2002 survey. Details of sample collection, preservation, and storage are described in Appendix C along with precise descriptions of all analytical procedures. Only general procedures are mentioned below.

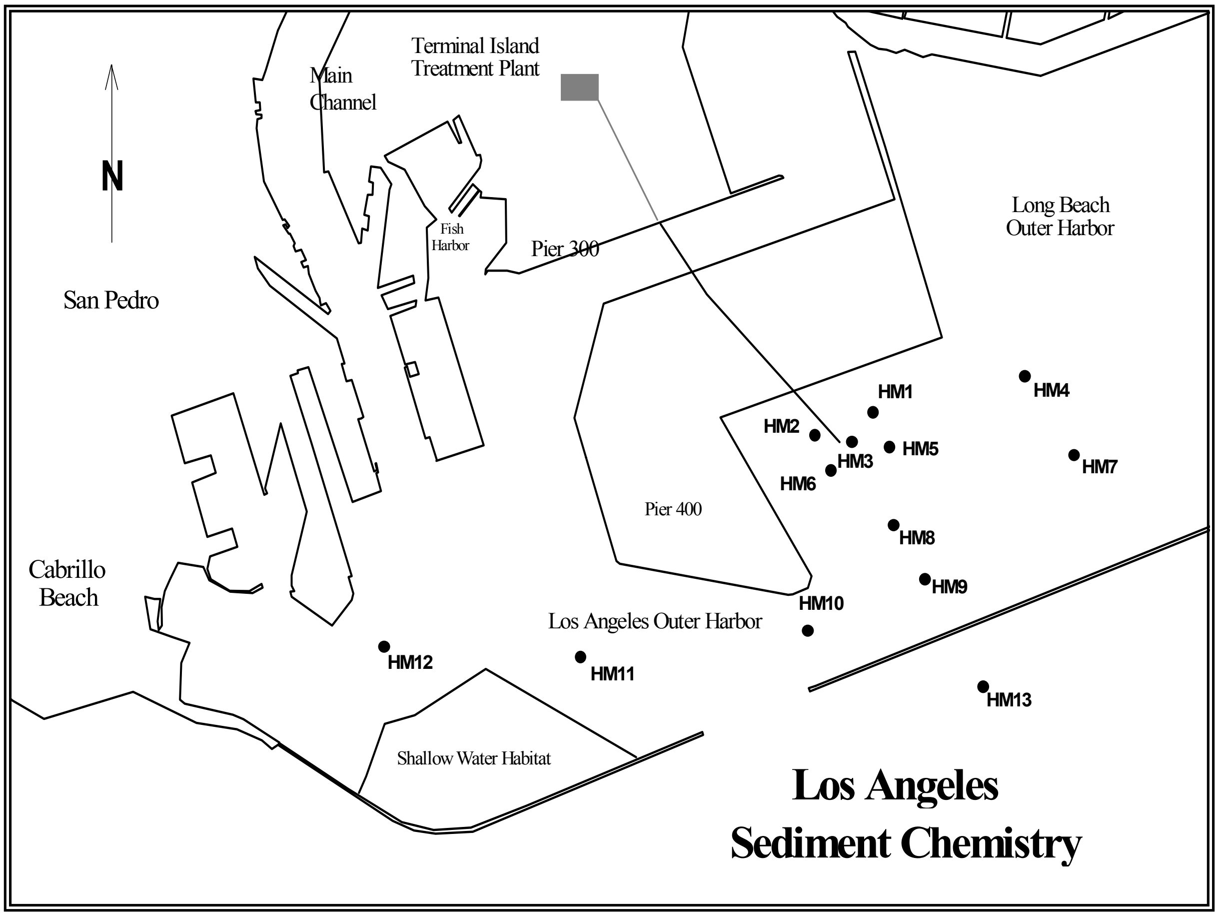

Figure 5-1. Sediment chemistry sampling stations in Los Angeles Harbor**.**

B. LABORATORY PROCEDURES

Sediment grain size was measured by a Coulter (Fluid Module) L5230 particle size distribution analyzer.

Dissolved sulfide was measured colorimetrically using the methylene blue method (APHA 1992, part 4500-S2-D). Cyanide was measured by the method described in SW-846 (1986, 3rd Edition; Method 9013). TOC was analyzed using a TOC analyzer after persulfate digestion (APHA 1992, Part 5310 D).

Total organic halides (TOX) were analyzed by Mitsubishi TOX analyzer using EPA Method 9020.

For metal analysis the sediments were first digested in acids and then analyzed using ICP and Electrothermal Atomic Absorption Spectrophotometer.

For organic priority pollutants, the sediments were solvent-extracted and concentrated prior to instrument analysis. Base/neutral and acid extractable organic compounds (BNA's) were analyzed by Gas Chromatograph/Mass Spectrometer (GC/MS). Organochlorine pesticides and polychlorinated biphenyls (PCB's) were analyzed using a Gas Chromatograph (GC) equipped with electron capture detectors (ECD).

C. DATA ANALYSIS

Metals and organic contaminants have a greater affinity for finer grained sediments like silts and clays. Increased levels of fine sediments could correspondingly have higher levels of contaminants; to compensate for this, sediment chemistry data were normalized using methods described by NOAA (1988) in their National Status and Trends Program. Following this technique, raw data were normalized by dividing the raw concentrations by the weight of silt and clay (particles less than 64 µm in diameter). Data are not normalized when the silt and clay fraction of the sediment was less than 20%. This was done to prevent misleadingly high values in sandy samples (NOAA 1988). In the summer survey, the silt and clay fraction of sediments from all thirteen stations were above 20%.

III. RESULTS

A. GRAIN SIZE

Results of grain size analysis in this report are expressed as percentages of four components, gravel (particles >2 mm), sand (particles 2 mm - 64 µm), silt (particles 63-4 µm), and clay (particles <4 µm).

As shown by the data, the sediments in the Los Angeles Harbor were heterogeneous, comprising of different levels of gravel, sand, silt and clay (Table 5-1 and Figure 5-2). Fine grained sediments, the sum of silt and clay, were predominant at all 12 stations inside the Harbor. However, the percentage of fine grains among these stations varied between 56.6% at HM8 to 94.3 % at HM12. Sand

(74.2%) was dominant and fine grains (25.8%) were the lowest at station HM13 outside of the breakwater. The biggest change occurred on station HM6 with the fine grains percentage increasing from 49.3% in 2001 to 89.8% in 2002.

Table 5-1. Grain size distribution of sediments in Los Angeles Harbor Surveyed in summer 2002.

PERCENT COMPOSITION				
STATION	**GRAVEL**	**SAND**	**SILT**	**CLAY**
HM1	0.0	22.4	61.0	16.5
HM2	0.0	35.6	52.5	11.9
HM3 (outfall)	0.0	16.8	65.8	17.4
HM4	0.0	26.3	58.1	15.5
HM5	0.0	23.2	60.2	16.6
HM6	0.0	10.2	71.5	18.3
HM7	0.0	39.8	46.6	13.6
HM8	0.0	43.4	44.1	12.5
HM9	0.0	25.0	59.7	15.2
HM10	0.0	24.2	59.1	16.7
HM11	0.0	12.4	67.3	20.3
HM12	0.0	5.70	70.9	23.4
HM13 (outside Breakwater)	0.0	74.2	20.3	5.50

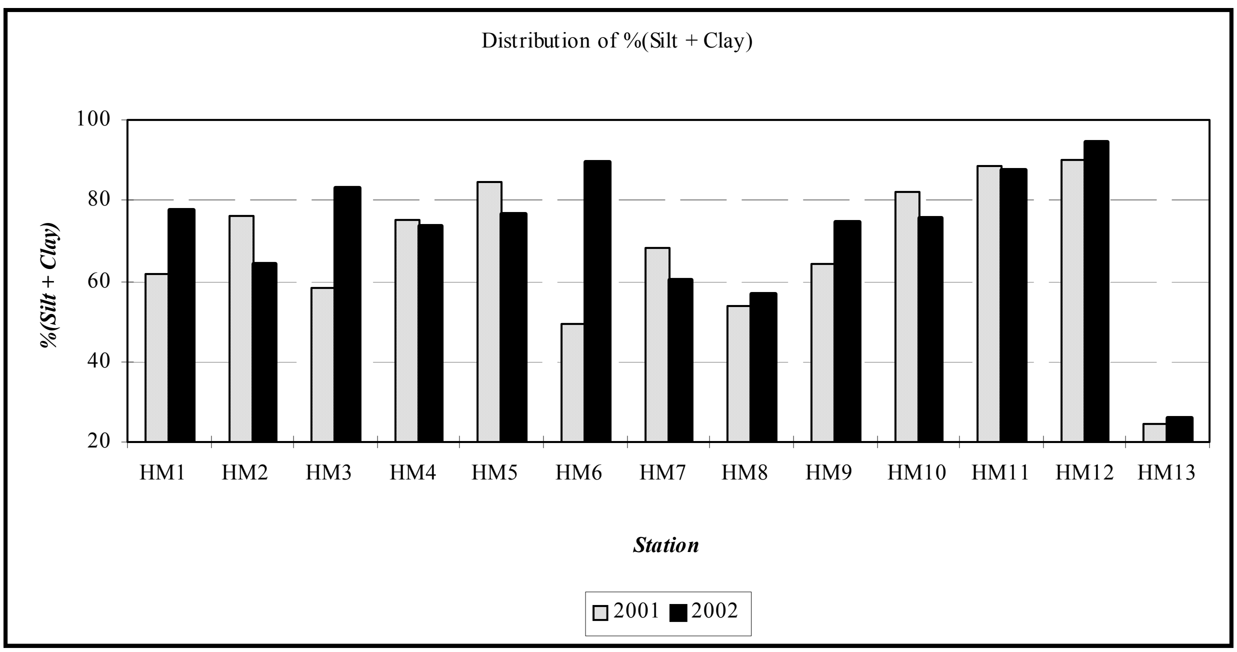

Figure 5-2. Distribution of % fine grains (Silt + Clay) in the sediments of Los Angeles Harbor in 2001 and 2002

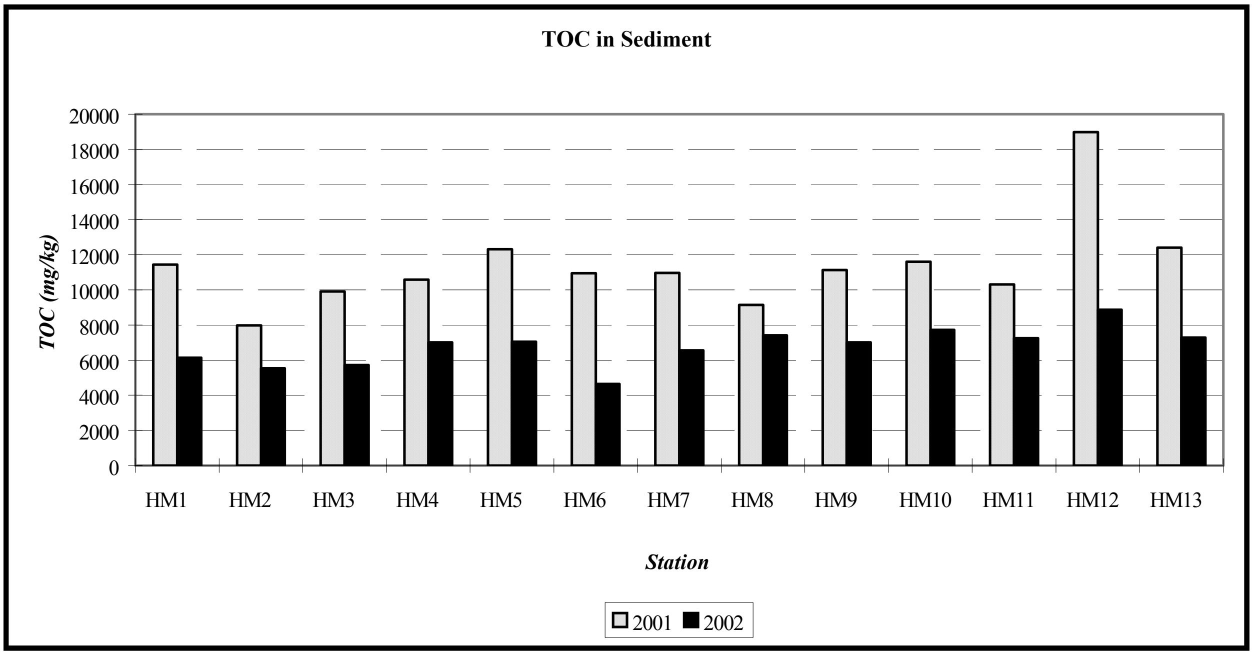

Figure 5-3. TOC in the sediments of Los Angeles Harbor in 2001 and 2002.

B. TOTAL ORGANIC CARBON, CYANIDE, AND DISSOLVED SULFIDE

Total organic carbon (TOC) was present at all stations in the Harbor (Table 5-2 and Figure 5-3) with highest concentration at station HM12, second highest concentration at HM10, and lowest concentration at HM6. Cyanide and dissolved sulfide were not detected in sediment samples collected in summer 2002 (Tables 5-2).

C. TOTAL ORGANIC HALIDES

Total organic halides (TOX) were detected in sediments at all stations surveyed in the summer of 2002 (Table 5-2 and Figure 5-4). The highest TOX (30.2 mg/kg) was found at HM13 and lowest one (4.31 mg/kg) at HM12 which had the highest TOC level at all stations.

Table 5-2. Cyanide, Dissolved Sulfide, TOC and TOX in sediments collected from Los Angeles Harbor in summer 2002. Concentrations normalized against fine grain fraction.

STATION	Cyanide mg/kg	Dissolved Sulfide mg/kg	TOC mg/kg	TOX mg/kg
HM1	ND	ND	6135	6.31
HM2	ND	ND	5536	8.28
HM3(outfall)	ND	ND	5724	7.02
HM4	ND	ND	7010	7.32
HM5	ND	ND	7057	5.83
HM6	ND	ND	4648	7.67
HM7	ND	ND	6555	6.21
HM8	ND	ND	7420	4.98
HM9	ND	ND	7012	7.92
HM10	ND	ND	7718	6.00
HM11	ND	ND	7258	4.67
HM12	ND	ND	8865	4.31
HM13	ND	ND	7279	30.2

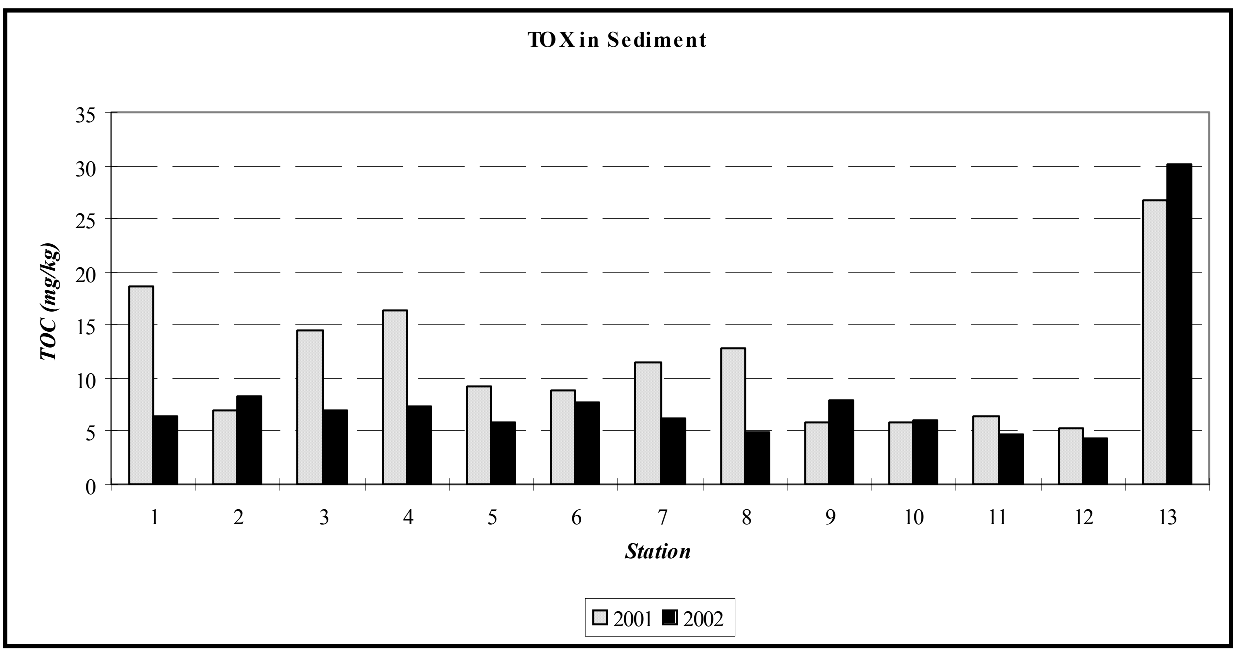

Figure 5-4. TOX in the sediments of Los Angeles Harbor in 2001 and 2002.

D. PRIORITY POLLUTANTS METALS AND ORGANICS

All sediment samples were analyzed for ninety-eight priority pollutants including nine heavy metals and eighty-nine organic compounds. A complete list of priority pollutants analyzed is presented in Appendix D.

1. Metals

Out of 9 priority pollutant metals tested, seven were detected in all sediments from 13 stations during the summer of 2002 (Table 5-3, 5-3A, and 5-3B). Silver was not detected in the samples from any site. Arsenic was detected at 11 stations except HM7 and HM13.

The metals detected were cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), zinc (Zn) and arsenic (As). Among the detected metals, average concentration of Zn (109.9 mg/kg) in the Harbor was the highest, followed by Cr, Cu, Ni, Pb, As, Cd, and Hg (Table 5-3). Maximum concentrations of metals As, Cd, Cr, Cu, Ni, and Zn were found in sediment at station HM12 which has the highest fine grain percentage in the L.A. Harbor (Tables 5-3a, 5-3b and Figures 5-5, 5-6). Minimum concentrations of all detected metals were found in sediment at station HM13.

Table 5-3. Metals in sediments of Los Angeles Harbor in summer 2002 and at a Dana Point Reference Site surveyed from 1984 - 1987. Concentrations were normalized against fine grain fraction.

POLLUTANTS	No. Station Detected	L.A. Harbor Average*	L.A. Harbor Range	Dana Point** Reference
Metals (mg/kg):				
Arsenic	11	9.60	6.5 -13.8	29.75
Cadmium	13	4.52	2.50 -5.69	1.37
Chromium	13	48.8	26.1 -75.6	141.1
Copper	13	52.2	13.0 -136.8	30.2
Lead	13	21.3	10.4 - 39.1	51.4
Mercury	13	0.295	0.066 – 1.183	0.63
Nickel	13	28.7	12.9 – 41.8	25.45
Silver	0	ND	ND	1.87
Zinc	13	109.9	55.4 – 170.3	169

ND= Not detected
*** Average of 13 stations. Concentrations below detection limit were taken as zero.**
**** 1984-1987 Reference Site Survey (NOAA 1988)**

Table 5-3A. Metals detected in sediments at stations HM1 - HM6 of the Los Angeles Harbor, summer 2002. Concentrations normalized against fine grain size.

	STATIONS					
Metals (mg/kg):	**HM1**	**HM2**	**HM3**	**HM4**	**HM5**	**HM6**
Arsenic	11.2	10.2	14.0	9.5	12.5	14.0
Cadmium	5.75	5.43	6.72	5.64	6.08	7.20
Chromium	61.0	51.3	69.5	59.3	67.0	67.5
Copper	58.5	46.2	71.1	62.8	65.7	73.6
Lead	24.9	17.4	27.9	29.2	30.3	24.3
Mercury	0.300	0.215	0.295	0.351	0.341	0.297
Nickel	34.8	31.8	41.1	34.4	36.4	44.4
Silver	ND	ND	ND	ND	ND	ND
Zinc	138.0	119.7	157.9	146.7	147.7	153.8

ND= Not detected

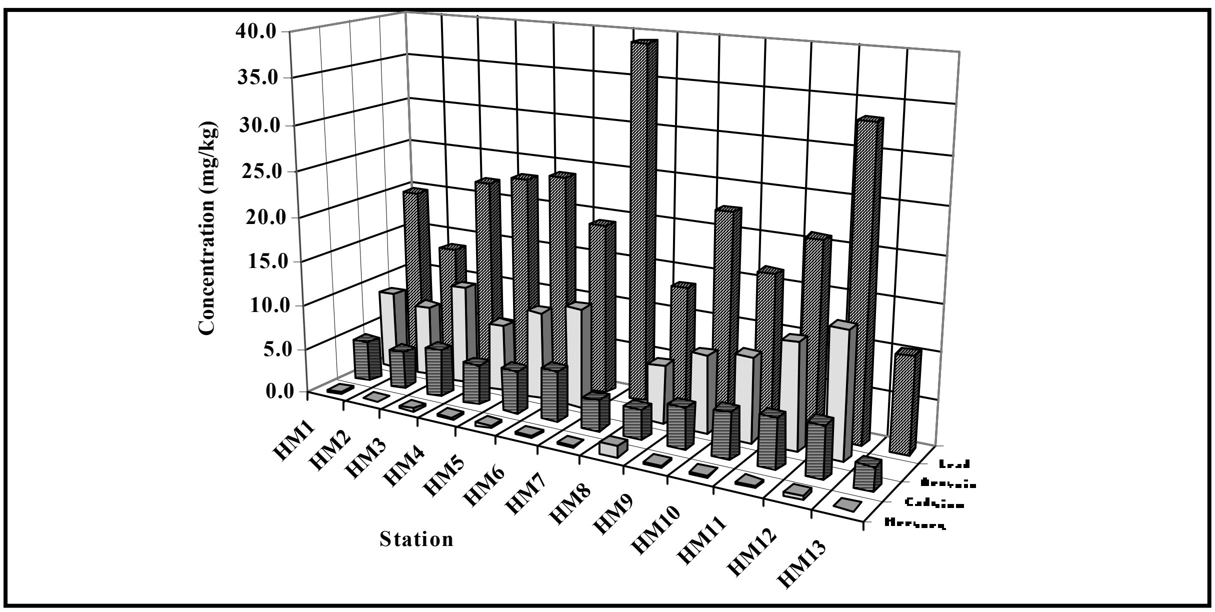

Figure 5-5. Mercury, cadmium, arsenic, and lead in the sediments of Los Angeles Harbor in 2002. Concentrations are normalized against fine grain size.

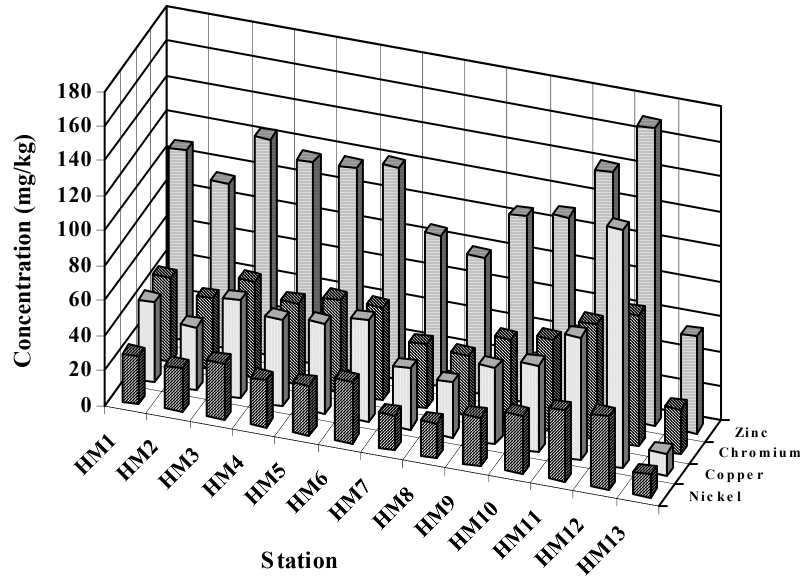

Figure 5-6. Nickel, copper, chromium, and zinc in the sediments of Los Angeles Harbor in 2002. Concentrations are normalized against fine grain size.

Table 5-3B. Metals detected in sediments at stations HM7 - HM13 of the Los Angeles Harbor, summer 2002. Concentrations normalized against fine grain size.

	STATIONS						
Metals (mg/kg):	**HM7**	**HM8**	**HM9**	**HM10**	**HM11**	**HM12**	**HM13**
Arsenic	ND	8.2	10.8	11.8	14.8	17.5	ND
Cadmium	4.30	4.23	5.66	6.33	6.97	7.23	3.18
Chromium	46.2	43.8	61.1	66.9	83.4	96.1	33.1
Copper	44.3	39.5	56.4	63.8	89.7	173.8	16.6
Lead	49.7	17.2	28.5	21.1	26.6	42.3	13.3
Mercury	0.203	1.503	0.203	0.249	0.298	0.530	0.084
Nickel	25.9	25.6	35.7	42.5	51.8	53.1	16.3
Silver	ND	ND	ND	ND	ND	ND	ND
Zinc	110.2	99.7	135.1	140.5	178.7	216.4	70.3

ND= Not detected

2. Organic Compounds

The sediment samples were analyzed for fifty-eight base/neutral acid extractable compounds and nineteen pesticides compounds. Only four compounds were detected in the sediments (Tables 5-4, 5-4A, and 5-4B). Of the four compounds, one compound (p,p'-DDD) was found only at two stations (HM5 and HM9); two compounds (Di-n-butylphthalate and o,p'-DDE) were found at five stations; p,p'-DDE was found at all 13 stations. No PCBs were detected in the Harbor. The highest total DDT (84.9 µg/kg) was found at station HM13 and the lowest at HM4.

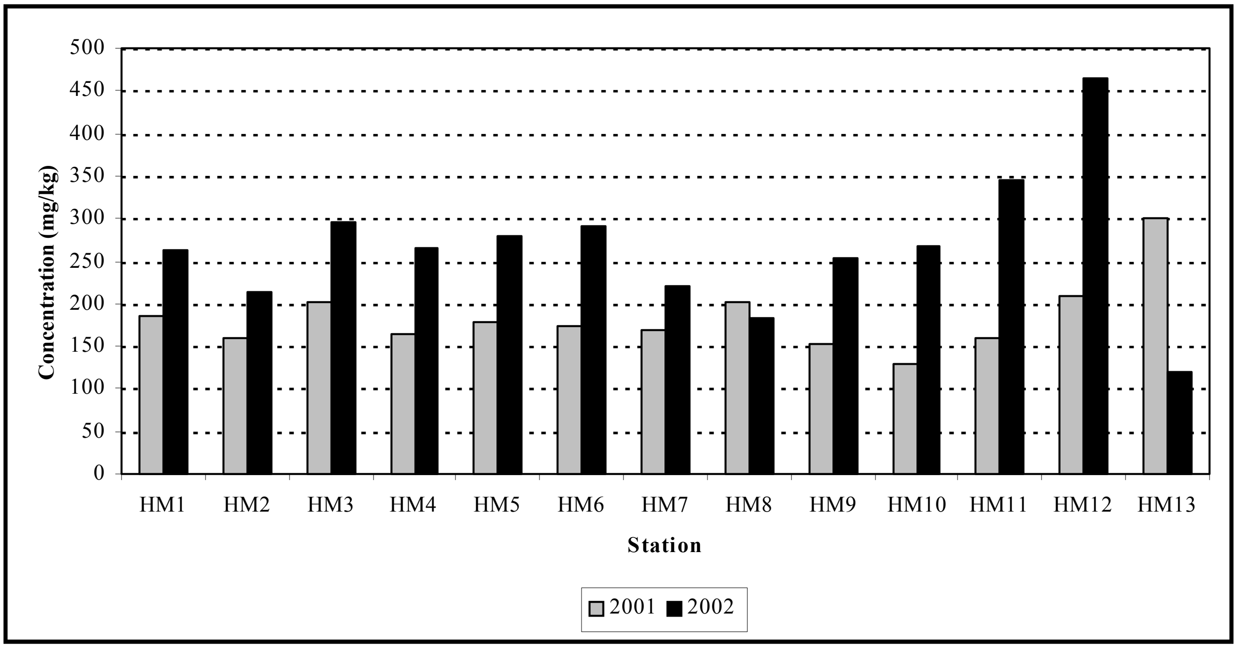

Figure 5-7. Total metals in the sediment of Los Angeles Harbor in 2001 and 2002. Concentrations are normalized against fine grain size.

Table 5-4. BNA and Petsticides detected in sediments of Los Angeles Harbor, summer 2002, and at a Dana Point Reference Site surveyed from 1984 - 1987. Concentrations were normalized against fine grain fraction.

POLLUTANTS	No. Station Detected	L.A. Harbor Average*	L.A. Harbor Range	Dana Pt** Reference
Base Neutral Acids (mg/kg):				
Di-n-Butylphthalate	5	0.645	0.400–0.916	NA
Pesticides (µg/kg):				
o,p' – DDE* **	5	12.0	9.5 – 19.6	NA
p,p' – DDE	13	41.2	26.5 – 55.1	NA
p,p' – DDD	2	3.6	3.15 – 3.94	NA

NA Not available ; ND= Not detected
*** Average of 13 stations. Concentrations below detection limit were taken as zero.**
**** 1984-1987 Reference Site Survey (NOAA 1988)**
***** Not a priority pollutant**

Table 5-4A. BNA and Petsticides detected in sediments at stations HM1 - HM6 of the Los Angeles Harbor in summer 2002. Concentrations normalized against fine grain size.

	STATIONS					
POLLUTANTS	**HM1**	**HM2**	**HM3**	**HM4**	**HM5**	**HM6**
Base Neutral Acids (mg/kg):						
Di-n-Butylphthalate	0.426	ND	0.649	0.965	0.404	ND
Pesticides (μg/kg):						
o,p' – DDE*	<0.30	9.88	<0.30	<0.30	<0.30	8.15
p,p' – DDE	33.2	58.4	31.7	27.9	49.5	47.6
p,p' - DDD	<0.30	<0.30	<0.30	<0.30	3.97	<0.30

* Not a priority pollutant

Table 5-4B. BNA and Petsticides detected in sediments at stations HM7 - HM13 of the Los Angeles Harbor in summer 2002. Concentrations normalized against fine grain size.

	STATIONS						
POLLUTANTS	**HM7**	**HM8**	**HM9**	**HM10**	**HM11**	**HM12**	**HM13**
Base Neutral Acids (mg/kg):							
Di-n-Butylphthalate	1.01	ND	ND	ND	ND	ND	ND
Pesticides (μg/kg):							
o,p' – DDE*	<0.30	15.1	<0.30	<0.30	17.4	8.40	<0.30
p,p' – DDE	37.7	58.0	35.9	32.1	57.8	33.4	84.9
p,p' - DDD	<0.30	<0.30	3.26	<0.30	<0.30	<0.30	<0.30

*: Not a priority pollutant

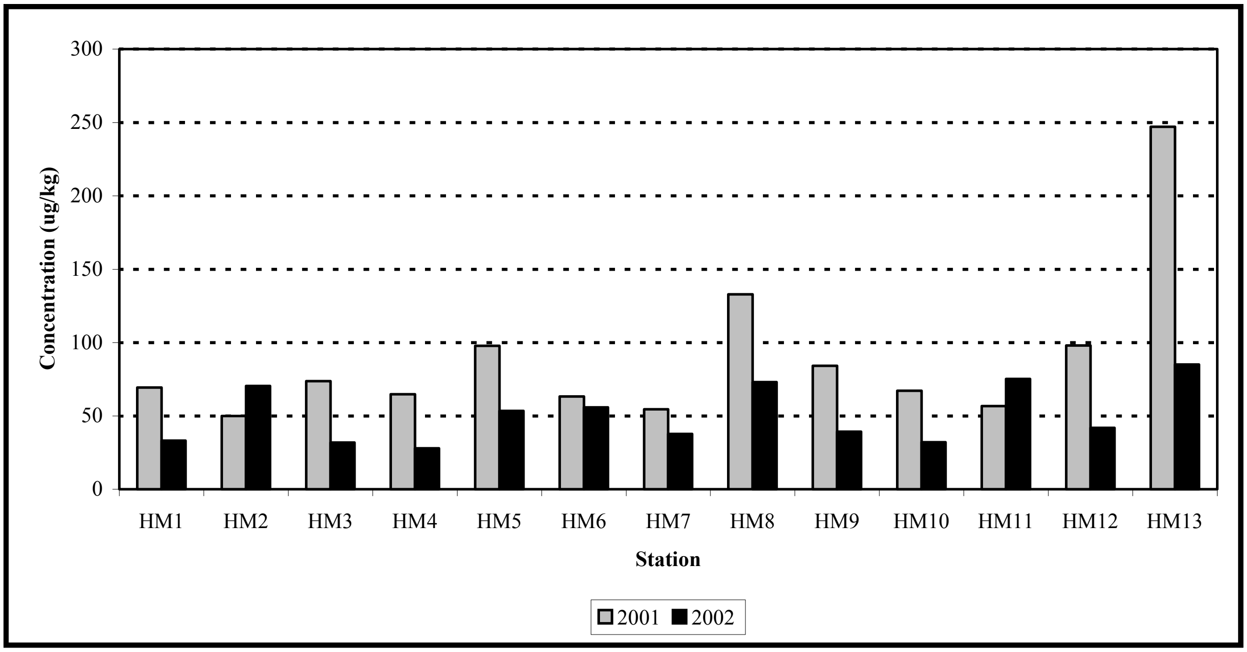

Figure 5-8. Total DDT in the sediment of Los Angeles Harbor in 2001 and 2002. Concentrations are normalized against fine grain size.

IV. DISCUSSION

A. GRAIN SIZE, TOC, and TOX

The comparisons of grain size, TOC, and TOX between 2001 and 2002 sampling years are shown in Figures 5-2, 5-3, and 5-4, respectively. The fine grains (silt + clay) had mixed variations from 2001 to 2002. TOC levels were significantly reduced in 2002 at all stations. Lower TOX levels were found in 2002 at 8 stations except HM2, HM9, HM10, and HM13. The biggest reduction of TOC level was at HM13 which had slight increase in fine grains.

B. SPATIAL PATTERN OF METALS AND ORGANIC

Concentrations of metals, organics and other contaminants detected in Outer Los Angeles Harbor during the summer 2002, were variable (Tables 5-1, 5-2, 5-3A, 5-3B, 5-4A, 5-4B, and 5-5; Figures 5-2, 5-3, 5-4, 5-5, 5-6, 5-7, and 5-8). Station HM12 (inside the Harbor) had highest level of total metals detected while HM13 (outside breakwater) had the lowest level. Station HM4 had the highest concentration of Di-n-butylphthalate (0.916 mg/kg). Only p,p'-DDE was detected at all stations with the highest level (65.3 μg/kg) at HM11 and the lowest (20.5 μg/kg) at HM4. The DDT derivatives may have been transported to San Pedro Bay on contaminated sediment originating from the Palos Verdes Shelf, and their presence may be attributed to coastal water movement to the east from the area of the White Point outfall toward the Harbor (HEP 1980). Another source of DDT in the Harbor could be the Dominguez and Cerritos Channels. Prior to being banned, DDT may have spilled during loading of ships or flowed from storm drains entering these channels from the Montrose Chemical Corporation, a former large producer of DDT.

An increasing pattern of total metals from station HM8 to station HM12 was shown in Figure 5-7 but total DDT levels did not follow the same pattern (Figure 5-8). The positions of HM8 to HM12 were from the vicinity of the outfall following along the westward curve of Pier 400 toward Cabrillo Pier. Overall, no other distinct spatial patterns for either metals or organic pollutants were observed in the sediments of Outer Los Angeles Harbor. The lack of any spatial pattern in sediments of the Harbor could be due to past dredging activities and construction of Pier 400 in the Harbor, which is likely to disturb the surface sediments of the Harbor. Since the contaminants are deposited in the surface sediments, and samples are collected from the surface, any disturbance in the surface sediment at the sampling sites would affect its contaminant level.

Table 5-5 shows the comparison pollutant levels at LA Harbor in 2002 with the average levels in ports at Southern California Bight in 1998 (SCCWRP 2003). Except cadmium, nickel, and total DDT, all other metals and PCBs detected at LA Harbor in 2002 were lower than the average levels of pollutants found in ports at Southern California Bight of 1998.

Table 5-5. Concentration of metals and organic pollutants in sediments of Los Angeles Harbor, summer 2002, with comparison to concentrations in ports of Southern California Bight (SCB).

	LA Harbor (2002)	**Ports at SCB (1998)**
Metals (mg/kg)		
As	9.6	10.1
Cd	4.52	0.40
Cr	48.8	51.8
Cu	52.2	107
Hg	0.295	0.39
Pb	21.3	44.9
Ni	28.7	21.5
Ag	ND	1.10
Zn	110	180
Total DDT (μg/kg)	50.5	30.8
PCBs (μg/kg)	ND	38.3

C. TEMPORAL PATTERNS

Data collected at TITP outfall (HM3) in 2001 and 2002 are shown on Table 5-6. Silver and PCBs were not detected at any station in both sampling years. The levels of other eight metals increased significantly from 2001 to 2002. However, total DDT level was down more than 50% from 73.4 μg/kg in 2001 to 34.1 μg/kg in 2002.

In an attempt to assess the Harbor's relative degree of contamination with respect to reference sites in the Southern California Bight, pollutant levels in 2002 at TITP outfall were compared with the station (Z2) near Hyperion Treatment Plant (HTP) 5-Mile outfall and reference site (C1) in Santa Monica Bay (SMB). The data are presented in Table 5-6. The concentrations of metals (except arsenic and cadmium) and total DDT at TITP outfall were lower than the levels at Z2 but had mixed variations with the reference site C1.

Total DDT data collected at stations HM3 (TITP outfall) and HM13 (outside breakwater of Los Angeles Harbor) from 1999 – 2002 are shown in Table 5-7. Total DDT concentrations showed the decreasing trend over the past four years at the outfall. At HM13, total DDT level had no significant change during 1999 to 2001 period but decreased about three-fold from 2001 to 2002. It may indicate that DDT contamination outside breakwater of the Harbor may not be from effluent discharge.

Generally, the concentrations of metals and total DDT in LA Harbor have been declining over the last ten years (Figure 5-9). The only exception is that cadmium and lead levels increased in 2002. The construction of Pier 400 and the change of outfall did not have any impact on the declining trend of pollutant levels from 1993 to 1997.

D. CONTAMINATION ASSESSMENT OF THE LOS ANGELES HARBOR

To assess the biological impact of the sediment contaminants of the Los Angeles Harbor, the metals, DDTs and PCBs levels of the sediments were compared with the Effective Range- Low (ER-L), and the Effective Range-Median (ER-M) values (Long et al 1995). The ER-L, and ER-M values correspond, respectively, to bulk sediment concentrations below which effects to benthic organisms are rarely observed (ER-L) and levels above which effects are frequently observed or expected (ER-M). As shown in Table 5-8, the average concentrations of all metals and the organics except total DDT were consistently below the corresponding ER-M values. Average concentration of total DDTs in the Harbor sediments were above both ER-L and ER-M values. At the outfall station HM3, the concentrations of metals and organics were all bellow the corresponding ER-M values. However, the average concentrations of arsenic, cadmium, copper, mercury, nickel, and total DDT from all stations were above their ER-L values.

The distribution of contaminants in the Outer Harbor will change due to natural processes coupled with any resumption of dredge and fill operations. Though the dredge and fill projects were completed in April 2000 in the vicinity of the TITP outfall, the recovery process for the marine communities would take place gradually. As the effluent discharge continues, it will take long-term monitoring surveys to document any changes that may occur in sediment chemistry at and around the outfall due to the effluent discharge.

Table 5-6. Temporal pattern of Contaminants levels at TITP outfall and reference sites. Concentrations (mg/kg for metals and µg/kg for organics) normalized against fine grain fraction.

	L.A. Harbor		SMB	
	TITP Outfall*		Z2[a]	C1
Contaminants	**2001**	**2002**		
Metals (mg/kg):				
As	6.34	9.6	ND	ND
Cd	ND	4.52	ND	3.12
Cr	34.8	48.8	135	60.4
Cu	32.6	52.2	72.8	15.2
Hg	0.136	0.295	0.513	0.129
Pb	14.4	21.3	30.5	9.51
Ni	20.7	28.7	35.9	31.9
Ag	ND	ND	ND	ND
Zn	74.8	110	147	79.7
Pesticides & PCB (µg/kg):				
Total DDTs	73.7	50.5	60.9	75.9
PCBs	ND	ND	ND	ND

ND = Not detected NA = Not Analyzed
* TITP Outfall Station HM3
a Hyperion Treatment Plant Outfall : Z2 Station. Reference : C1 station. Summer 2002 (CLA, EMD 2002)
b 1984-1987 Reference Site Survey (NOAA 1988)

Table 5-7. Temporal pattern of total DDTs concentration at HM13 (outside breakwater of the Harbor) and HM3 (outfall). Concentrations (mg/kg for metals and µg/kg for organics) normalized against fine grain fraction.

	HM13 Outside breakwater				HM3 TITP Outfall			
	1999	**2000**	**2001**	**2002**	**1999**	**2000**	**2001**	**2002**
Pesticides & PCB (µg/kg):								
Total DDT	231	198	247	84.9	113	102	73.7	31.7

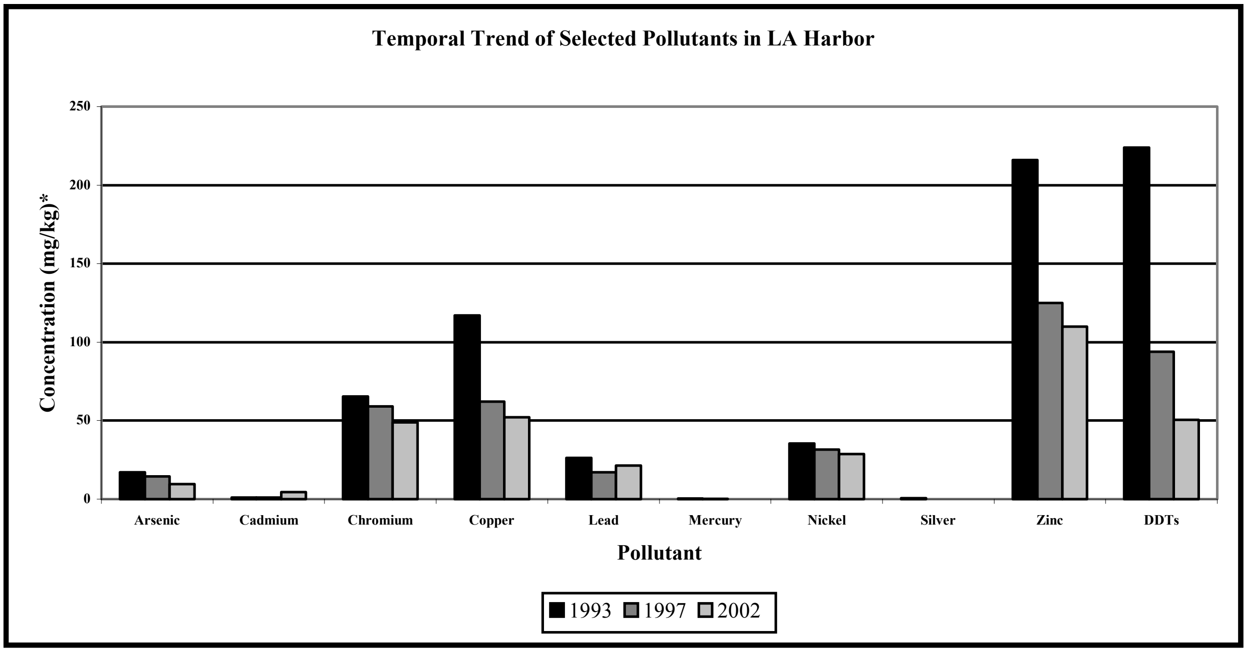

Figure 5-9. Temporal trend of average concentrations of pollutants in the sediment of Los Angeles Harbor of 1993, 1997, and 2002. Concentrations of DDTs are in µg/kg. All concentrations are normalized against fine grain size.

Table 5-8. Concentration of metals and organic pollutants in sediments of Los Angeles Harbor, summer 2002, with comparison to Effective Levels* (ER-L and ER-M). Concentrations in dry weight.

DETECTED POLLUTANTS	No. Station Detected	L.A. Harbor Average	HM3	ER-L*	ER-M*
Metals (mg/kg):					
Arsenic	11	9.60	11.0	8.2	70.0
Cadmium	13	4.52	5.29	1.2	9.6
Chromium	13	48.8	54.7	81.0	370
Copper	13	52.2	56.0	34.0	270
Lead	13	21.3	21.9	46.7	218
Mercury	13	0.0295	0.232	0.15	0.7
Nickel	13	28.7	32.4	20.9	51.6
Silver	0	ND	ND	1.0	3.7
Zinc	13	110	124	150	410
PAHs:	0	ND	ND	4,022	44,792
Pesticides and PCB (µg/kg):					
Total DDT	13	50.5	31.7	1.58	46.1
AR 1254	0	ND	ND	22.7	180

NA= Not available ND= Not detected
* Source: Long et.al. (1995).

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