

Post-Depositional Distribution of Organic Contaminants Near the Hyperion 7-Mile Outfall in Santa Monica Bay

Contaminants in ocean sediments can be recycled into the water column and atmosphere (Larsson 1985, Salomons *et al.* 1987) causing toxic effects (Burgess *et al.* 1993). The possibility that buried contaminants may be available to marine organisms complicates the disposal of wastes in the ocean. To evaluate the impact of contaminated sediments, we need to understand the fate of contaminants after deposition, including transport mechanisms within the sediment column and across the sediment/water interface.

The Hyperion Treatment Plant (City of Los Angeles) discharged sewage sludge into Santa Monica Bay through a 7-mile outfall from 1957 to November 1987 (Figure 1). On average, four million gallons of sludge were discharged each day in 100 m of water creating a sludge field of ~50 km² that is high in organic materials. The termination of sludge discharge created a unique opportunity to study recovery and the effects of contaminated sediments for years to come. In the three years following termination of discharge from the 7-mile outfall, the concentrations of sulfide, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and trace metals decreased in the surface sediments, and the abundance and diversity of benthic species increased, in the sludge field (SCCWRP 1992a).

In a contract with the Environmental Monitoring Division (EMD) of the City of Los Angeles, we investigated the distributions of PCBs, chlorinated pesticides (DDTs), and linear alkylbenzenes (LABs) in sediment cores collected near the Hyperion 7-mile outfall in Santa Monica Bay. The objective of the study was to characterize the post-depositional distribution of organic compounds in the sediment column, particularly the distribution of individual PCB congeners.

MATERIALS AND METHODS

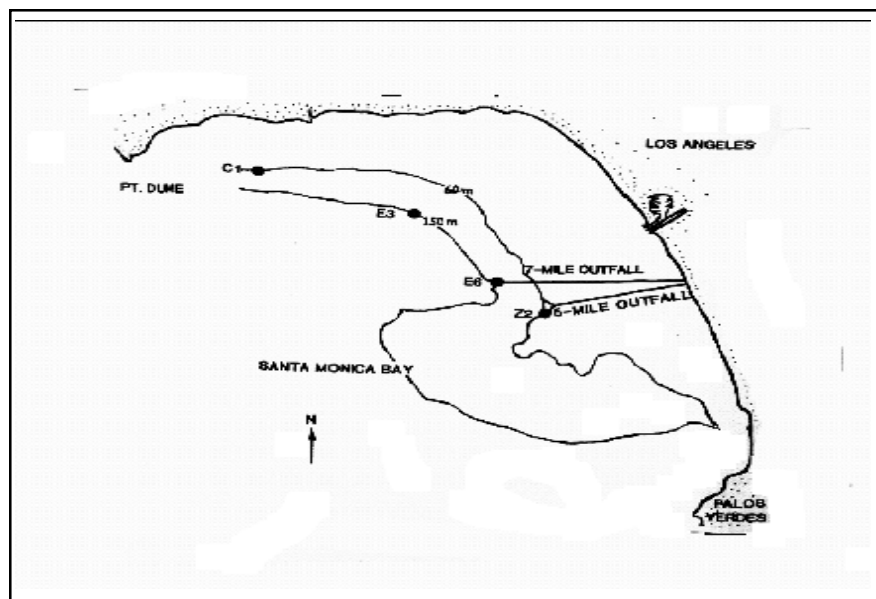
Sample Collection

Sediment cores were collected in June 1994 with the SCCWRP gravity corer (SCCWRP 1982). Four sites in

Santa Monica Bay (Figure 1) were selected based on historical concentrations of PCBs and other organic contaminants (City of Los Angeles 1993).

A 96 cm core was taken at E6 near the end of the 7-mile sludge outfall at a depth of 150 m (33°55.7N/118°33.34W). The sediments were black sludge with strong H₂S odor; natural sediments occurred at a depth of about 80 cm. A 32 cm core was taken at E3 (33°58.3N/

FIGURE 1. Location of coring stations in Santa Monica Bay.



118°36.75W) at 150 m. A 24 cm core was taken at Z2 (33°54.45N/118°31.5W) near the 5-mile sewage outfall at a depth of 60 m. The sediments had a slight H₂S odor. A 30 cm core was taken at C1 (34°00.01N/118°42.96W) a relatively unaffected station. The cores were sliced into 2 cm sections. In this paper, the sections are defined by the depth of the upper edge. For example, a depth of 2 cm means a section from 2-4 cm down the core. The samples were frozen in the field and transported to the laboratory.

Sample Preparation

The sediments were thawed and homogenized with a glass rod. About 40 g of each sample were centrifuged in a 250-mL glass bottle (excess water was removed) and mixed with approximately 50 g of anhydrous sodium

sulfate. Surrogate standards were spiked into the sample and 100 mL methylene chloride were added. The sample bottle was rolled on a roller table for 16 h. The solvent was filtered through a long-stemmed glass funnel plugged with baked glass wool and 2 g anhydrous sodium sulfate. The extract was collected in a 500-mL glass flat bottom flask. The sample was extracted two more times for 6 and 16 h, and the extracts were combined in the flat bottom flask. The extract volume was reduced to about 3 mL using a rotary evaporator at 30°C and 650 mm Hg vacuum pressure. Ten milliliters of hexane were added to the extract, which was concentrated again to approximately 3 mL (solvent-exchanged to hexane). Activated copper granules were added to the extract (overnight in the dark) to remove sulfur. Total lipid was determined by weighing.

An appropriate portion (depending on the lipid content) of the extract was concentrated to 1 mL under gentle nitrogen flow and applied to a 1:2 alumina/silica gel glass column. The second fraction, which contained PCBs, DDTs, and LABs, was collected by eluting 5 mL dry hexane and 30 mL of a 30/70 mixture of methylene chloride and hexane through the alumina/silica column. This fraction was concentrated to approximately 1 mL using the rotary evaporator, solvent-exchanged to hexane, and further concentrated to 0.5 mL under gentle nitrogen flow. An internal standard was added to the final sample before instrumental analysis.

GC/ECD Analysis

PCBs and DDTs were measured by an HP 5890 II GC equipped with a ^{63}Ni ECD detector and a 60 m x 0.25 mm ID (0.25 μm film thickness) DB-5 capillary column (J&W Scientific, Folsom, CA). Additional confirmation was provided using a second column, 60 m x 0.25 mm ID (0.25 μm film thickness) DB-1701, connected to a second ECD detector. The column temperature was started at 90°C, followed increases to 180°C at 6°C/min and to 290°C at 1°C/min. The injector and detector temperatures were maintained at 280°C. The carrier gas (He) flow rate was 2 mL/min at 90°C. Data were acquired and processed by a PE Nelson 2700 (Turbochrom 3) running on an IBM compatible PC.

Calibration of the GC/ECD for PCBs was done using a mixture of Aroclors 1242, 1248, 1254, and 1260 (1:1:1:1) prepared in six concentration levels with hexane (SCCWRP 1993a). Analyses of DDTs were performed simultaneously. Surrogate standards were tetrachloro-m-xylene and PCB 209. The internal standard was 2,2',4,4',5,5'-hexabromobiphenyl. Total PCBs were the sum of individual PCB congeners. DDTs were the sum of o,p'-DDE, p,p'-DDE, and p,p'-DDD.

GC/MS Analysis

Detailed quantitation procedures for measuring linear alkylbenzenes (LABs) are provided in *Measurements of Linear Alkylbenzenes by GC/MS and GC/FID* in this volume. Briefly, calibration standards were prepared by diluting a characterized LAB mixture to 2, 5, 20, 50, and 200 $\mu\text{g/mL}$. Since the LAB mixture contained no C_{10} -LABs, measurements of this isomer group in the sediment samples were based on the relative response factor of 6-phenylundecane (C_{11} -LAB-6). Phenanthrene- d_{10} was the surrogate standard and the internal standard was p-terphenyl- d_{14} .

The degree of degradation for LABs was estimated from the ratio of internal to external isomers (I/E ratio; Takada and Ishiwatari 1990):

$$\text{I/E} = \Sigma(6\text{- and }5\text{-phenyldodecane}) / \Sigma(4\text{-, }3\text{-, and }2\text{-phenyldodecane})$$

A large I/E means a high degree of degradation due to preferential biodegradation of external LAB isomers compared to internal isomers.

CHN Analysis

The method for measurements of TOC and TN was described elsewhere (SCCWRP 1992b) and slightly modified recently (SCCWRP 1993b).

Moisture Measurements

Approximately 10-15 g of sample were transferred to a tared aluminum pan and weighed with an electronic balance (accuracy ~0.5 mg). The sample was dried at 60°C for 24 h, cooled in a dessicator, and weighed. The moisture data were used to calculate the dry-weight based concentrations for the samples.

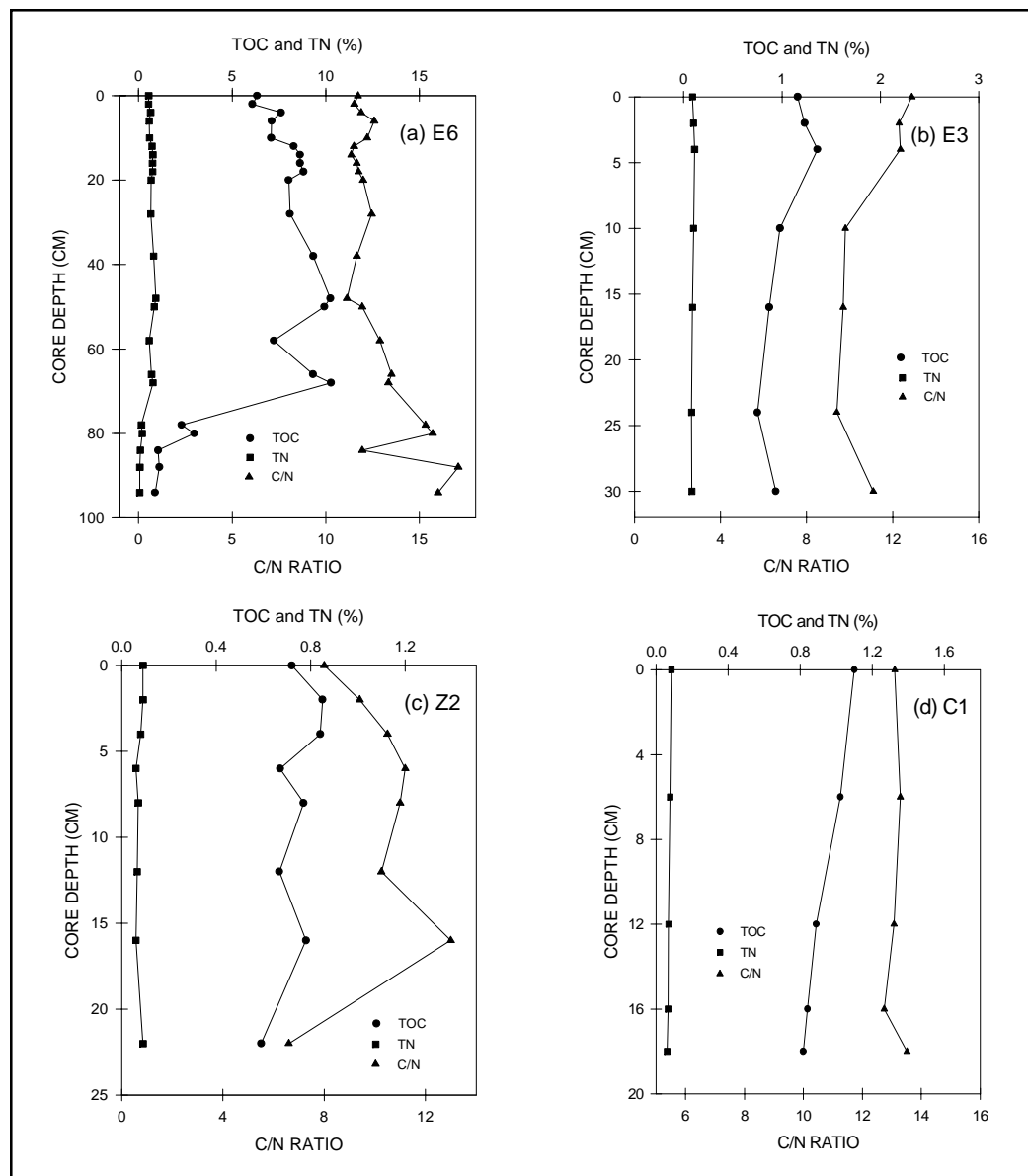
Data Presentation

TOC and TN are reported in weight percent of the dry sample weight, and C/N is a simple ratio of TOC to TN. Dry samples were prepared by placing wet samples into an oven at 60°C overnight. The amount of a sample used was weighed with a microbalance. The concentrations of LABs, PCBs, and DDTs are expressed on a dry sample weight, which is the weight of a wet sample (used for extraction) less the moisture content.

Materials

Supplies for TOC and TN measurements were described previously (SCCWRP 1993b). Internal standards for LABs were purchased from AccuStandard, Inc.; surrogate standards were purchased from Ultra Scientific, Inc. Individual LAB standards were manufactured by Supelco, Inc. (Bellefonte, PA). Aroclors 1242, 1248,

FIGURE 2. Profiles of TOC and TN concentrations, and the C/N ratio in sediment cores collected at stations: a) E6, b) E3, c) Z2, and d) C1 in Santa Monica Bay.



oxygen filters; O₂ was purified with moisture and hydrocarbon filters.

RESULTS

Organic Carbon and Nitrogen

The organic content of sediments in the core from E6 was elevated above background levels in the upper 80 cm (Figure 2). The TOC and TN contents increased rapidly above 80 cm, peaked at 48 cm (~11 % TOC and ~1% TN), and then decreased gradually. The surface sediments contained relatively high TOC (~6 %) and TN (0.5 %) compared to the bottom section at 94-96 cm (0.9% TOC and 0.06% TN). The C/N ratio ranged from 11 to 14 between 0 and 68 cm; the lower sections (80-94 cm) had higher C/N ratios.

Sediments in the core from E3 contained about 1% TOC and 0.1% TN (Figure 2). The TOC was maximum at 4 cm and the C/N ratios ranged from 9.5 to 13.5. Sediments in the core from Z2 had the lowest TOC content (~0.5-0.85%) among the four stations. The TN content ranged from 0.06 to 0.09%

and the C/N ratios varied between 7 and 12.5. In the C1 core, the profiles of TOC (0.8-1.1%), TN (0.06-0.085%), and C/N (12.5-13.5) were uniform throughout the sediment column.

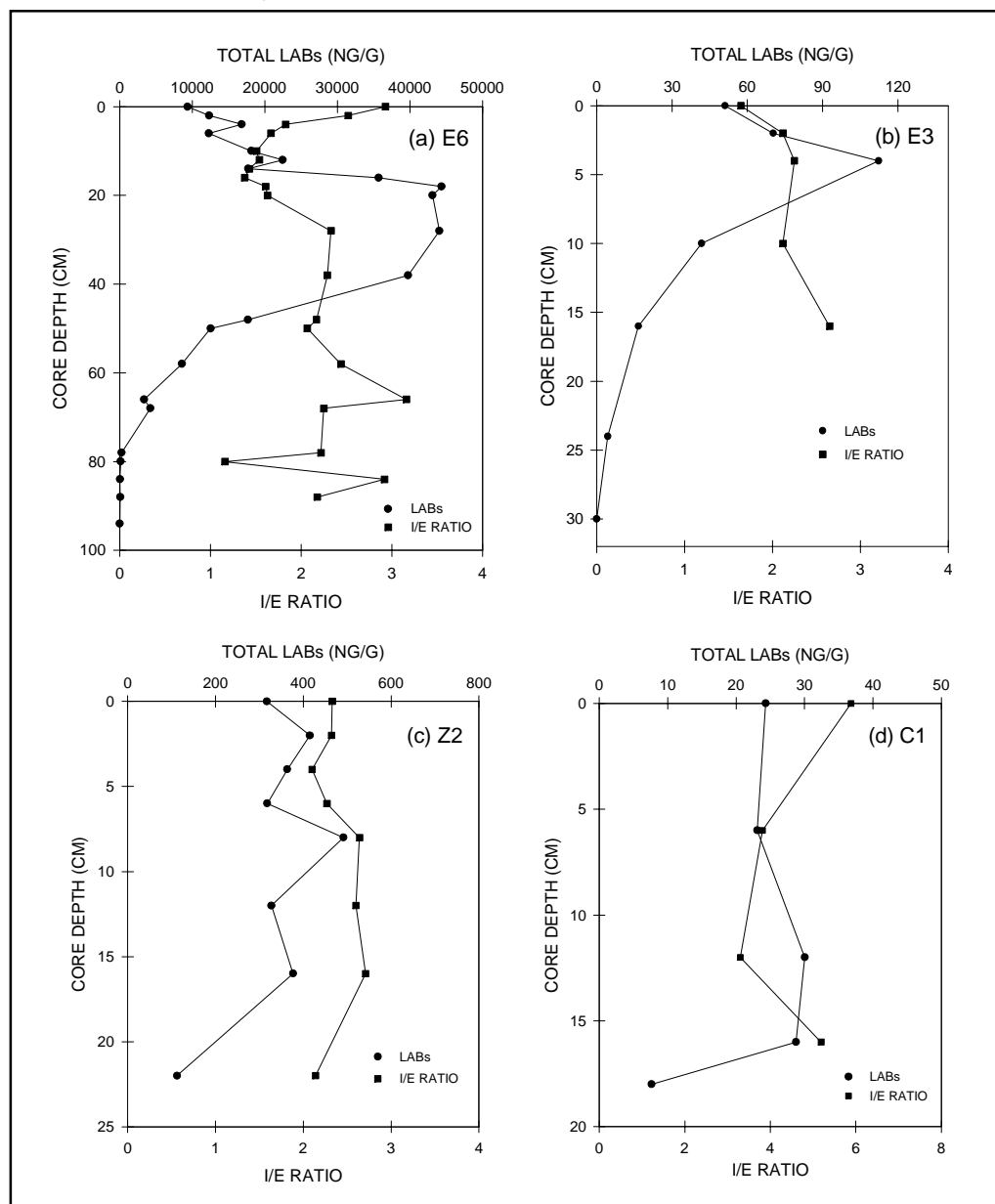
Linear Alkylbenzenes

Linear alkylbenzenes were found in all sediment cores (Figure 3); the concentrations were highest at E6, followed by Z2, E3, and C1. The concentration of total LABs in the E6 core increased rapidly above background levels at 80 cm to a plateau at 18 to 38 cm. Above 18 cm, LAB concentrations dropped quickly, although concentrations at the surface were relatively high.

1254, and 1260 were obtained from Supelco, Inc. PCB reference materials used as quality control standards were obtained from NIST and Ultra Scientific, Inc. Some of the DDTs were custom-made by AccuStandard, Inc. The remaining DDTs, and surrogate standards for both PCBs and DDTs, were made by AccuStandard, Inc. Ultra resins-analyzed grade hexane and methylene chloride were obtained from J.T. Baker Inc. (Phillipsburg, NJ). All standards were prepared in hexane.

Ultra high purity gases (He, N₂, H₂, and O₂) were supplied by Oxygen Service Company (Orange, CA). Compressed air was generated by an air generator manufactured by Balston Inc. (Haverhill, MA). Before use, He, N₂, and H₂ were purified with moisture, hydrocarbon, and

FIGURE 3. Profiles of total LAB concentrations and the ratio of internal/external LAB isomers (I/E) in sediment cores collected at stations: a) E6, b) E3, c) Z2, and d) C1 in Santa Monica Bay.



The LAB profile in E3 had a peak at about 4 cm (Figure 3), which was approximately 400 times lower than the concentration in the E6 core. The LAB concentrations dropped to background levels at 30 cm. In contrast, there was little trend in LAB concentration in the Z2 and C1 cores. The LAB concentration in the core taken near the 5-mile outfall (Z2) was about 100 times lower than the LAB concentration in the core taken near the 7-mile outfall (E6).

The I/E ratios for cores from stations E6, E3, and Z2 (Figure 3) varied within a narrow range (1.38-2.93), which corresponds to 30-55% degradation (Takada and Ishiwatari 1990). The I/E ratios in core C1, the site farthest from the

7-mile outfall, were relatively high indicating more complete degradation.

PCBs and DDTs

The profiles of PCBs and DDTs were similar in all of the cores (Figure 4). Sediments in the E6 core had the highest concentrations of PCBs and DDTs; there were only trace amounts of PCBs (<150 ng/g) and DDTs (<10 ng/g) below 84 cm. Above 84 cm, the concentrations rose quickly and reached maxima at 68 cm (~14 µg/g PCB and 1.8 µg/g DDT). The concentrations dropped rapidly above 68 cm, but decreased more slowly from 50 cm to the surface. There was another drop of about 50% in the concentration of PCBs and DDTs at 16-18 cm. At the surface, the concentrations of PCBs were ~800-1000 ng/g and the concentrations of DDTs were ~100-200 ng/g.

The E3 and Z2 cores contained similar and relatively low concentrations of PCBs and DDTs (Figure 4). In the E3 core, PCB and DDT concentrations peaked at about 24 cm and were higher at the surface than at the bottom. In the Z2 core, PCB and DDT concentrations peaked at 16 cm. The PCB concentration at

the bottom of Z2 core was higher than that at the surface, while the DDT concentrations were similar at the top and bottom. The C1 core contained the lowest concentrations of PCBs and DDTs (10-50 ng/g).

DISCUSSION

Sedimentation History

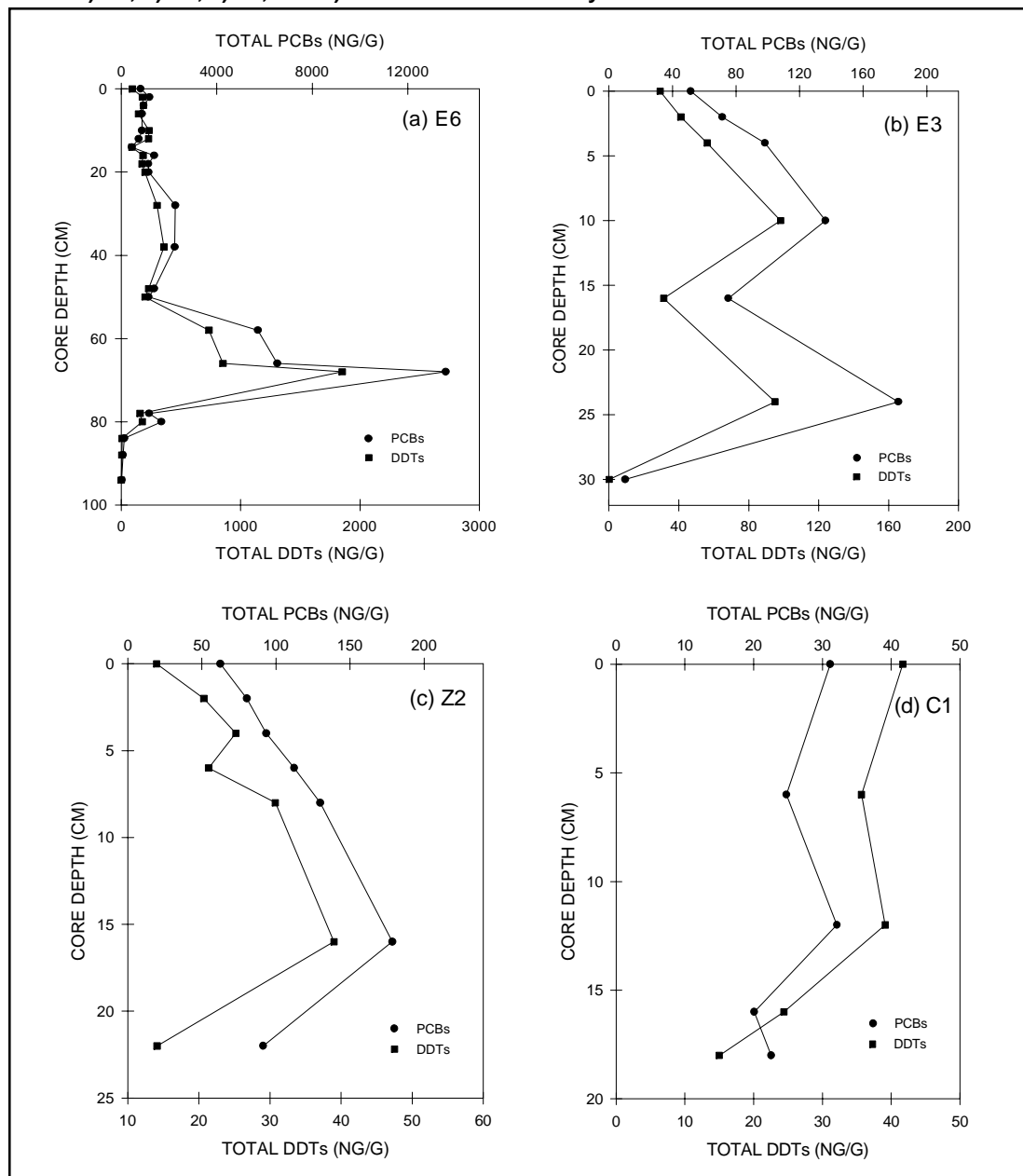
The depositional histories of the sediment cores can be reconstructed with the profiles of LABs, PCBs, DDTs, and TOC. The presence of LABs in the environment is an indication of domestic waste inputs (Eganhouse *et al.* 1983, Ishiwatari *et al.* 1983, Takada and Ishiwatari 1987, Eganhouse *et al.* 1988). LABs are used to synthesize

linear alkylbenzenesulfonate (LAS) surfactants that serve as raw materials for the manufacture of detergents. Residual LABs occur in detergents as a result of incomplete sulfonation during production. If the LAB residues survive the waste treatment process, they can be discharged into aquatic environments through sewage outfalls, river runoff, or ocean sludge dumping. The use of LASs in detergent production in the US began about 1963-65 and replaced tetrapropylene-based alkylbenzenes (TABs).

The concentration of LABs in core E6 began to rise above background levels at about 78 cm (~1963) and reached a plateau at 40 cm (Figure 5). The concentration began to drop at about 18 cm (termination of discharge from 7-mile outfall in 1987). These estimates assume that the post-deposition degradation of LABs was similar throughout the sediment column, a span of about 30 yr. This is supported by the relatively small variation (1.2-3.2) in I/E ratio (Figure 3a). The range of I/E corresponds to 30-60% LAB degradation (Takada and Ishiwatari 1990), which should not change the LAB profile significantly.

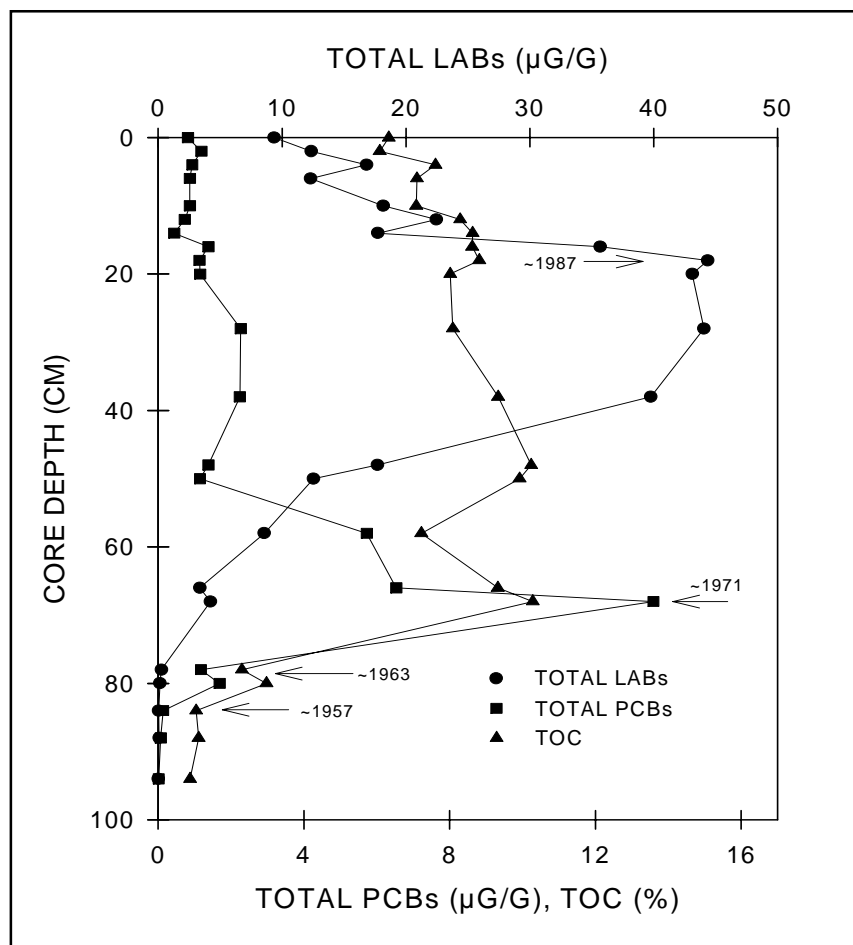
Sludge discharge from the 7-mile outfall, which began in 1957, caused the elevated concentrations of PCBs and TOC above about 80 cm (Figure 5). The year 1957 was placed at a depth with a non-zero concentration of PCBs under the assumption that contaminants deposited on the sediment surface diffused into the subsurface sediments (Brown and Wagner 1990, Sanders *et al.* 1992). Based on the LAB profile, 1963 was placed at about 76 cm, although significant amounts of LABs were found below that depth.

FIGURE 4. Profiles of total PCB and DDT concentrations in sediment cores collected at stations: a) E6, b) E3, c) Z2, and d) C1 in Santa Monica Bay.



The rapid rise in LAB concentrations above 76 cm was probably the result of increasing detergent production. The concentration of PCBs increased dramatically when discharge from the 7-mile outfall began. The peak concentration of 13 $\mu\text{g/g}$ at 68 cm probably corresponds to 1971 when the discharge of chlorinated hydrocarbons was banned. The decline in the concentration of PCBs above 68 cm indicates decreasing amounts of PCB residues in the waste treatment system. The 50% decrease in the concentrations of PCBs, DDTs, and LABs at 16-18 cm in the E6 core presumably was related to termination of discharge from the 7-mile outfall in 1987.

FIGURE 5. Profiles of total LABs, PCBs and TOC concentrations in sediment core collected at station E6.



The technique used for the E6 core did not work for the other sediment cores. For example, the total LABs in E3 peaked at 4 cm, which corresponded to termination of discharge from the 7-mile outfall (Figure 3b). The maximum concentration of PCBs occurred at 24 cm (Figure 4b), which was probably 1971. This gave a net particle sedimentation rate of about 0.5 cm/yr. Since the sediment core was sliced every 2 cm, every datum in the E3 core represents about four years of sedimentation. Because the concentrations of organic contaminants in E3 were relatively low, variations in concentration due to the historical events would be smoothed. The problem was more critical at stations Z2 and C1 (Figures 3c,d and 4c,d) where no trends were present. Therefore, no attempt was made to date the E3, Z2, and C1 cores.

Distribution of Organic Contaminants

Station E6

All of the measured parameters were at background levels at the bottom of the E6 core indicating that they were deposited before the 7-mile outfall began operation in 1957. The profiles of TOC, LABs, and PCBs provided

reasonable dates for the core (Figure 5) from which the particle sedimentary rate was estimated at about 2.2 cm/yr. Assuming a sediment density of 1.5 g/cm³ (Kennish 1994), the accumulation rate was approximately 50-350 mg C/cm²/yr from 1957 to 1994. By comparison, the accumulation rates range from 0.06 to 2.8 mg C/cm²/yr in the basins and on the continental slope in the Southern California Bight (Eganhouse and Venkatesan 1993).

Significant amounts of TOC, TN, LABs, PCBs, and DDTs were found in the surface sediments at E6 despite the dramatic decline in municipal wastewater emissions since 1970 (SCCWRP 1993c) and termination of discharge from the 7-mile outfall in 1987. Transport of these compounds from the 5-mile outfall should have been insignificant, since their concentrations were higher in surface sediments at E6 than in surface sediments at Z2. These compounds were probably mixed to the surface of the sediment column by resuspension and reworking processes (Wheatcroft and Martin 1994). The low concentrations of TOC, TN, PCBs, and DDTs in the bottom of the E6 core represent pre-discharge conditions.

The declines in the concentrations of LABs, PCBs, and DDTs in the E6 core occurred at two rates: an initial exponential decline after discharge ceased (Figures 3a and 4a) and a nearly linear decrease thereafter. Detectable amounts of these contaminants will be present in surface sediments for years to come because of sediment resuspension and reworking processes.

Station E3

Station E3 was located about 8 km northwest of E6. The impact of discharge from the 7-mile outfall on E3 appeared more significant than the discharge from the 5-mile outfall. The profiles of TOCs and LABs were similar and had a maximum at 4 cm that can be related to the termination of the 7-mile outfall in 1987 (Figures 2b and 3b). In addition, the concentrations of DDTs were higher in the E3 core than in the Z2 core (Figures 4b and 4c). LABs, PCBs, and DDTs were not detected in the bottom section of the E3 core (Figures 3b and 4b), which represents pre-discharge sediments.

FIGURE 6. Composition of PCBs at various horizons in sediment cores collected at stations: a) E6, b) E3, c) Z2, and d) C1 in Santa Monica Bay.

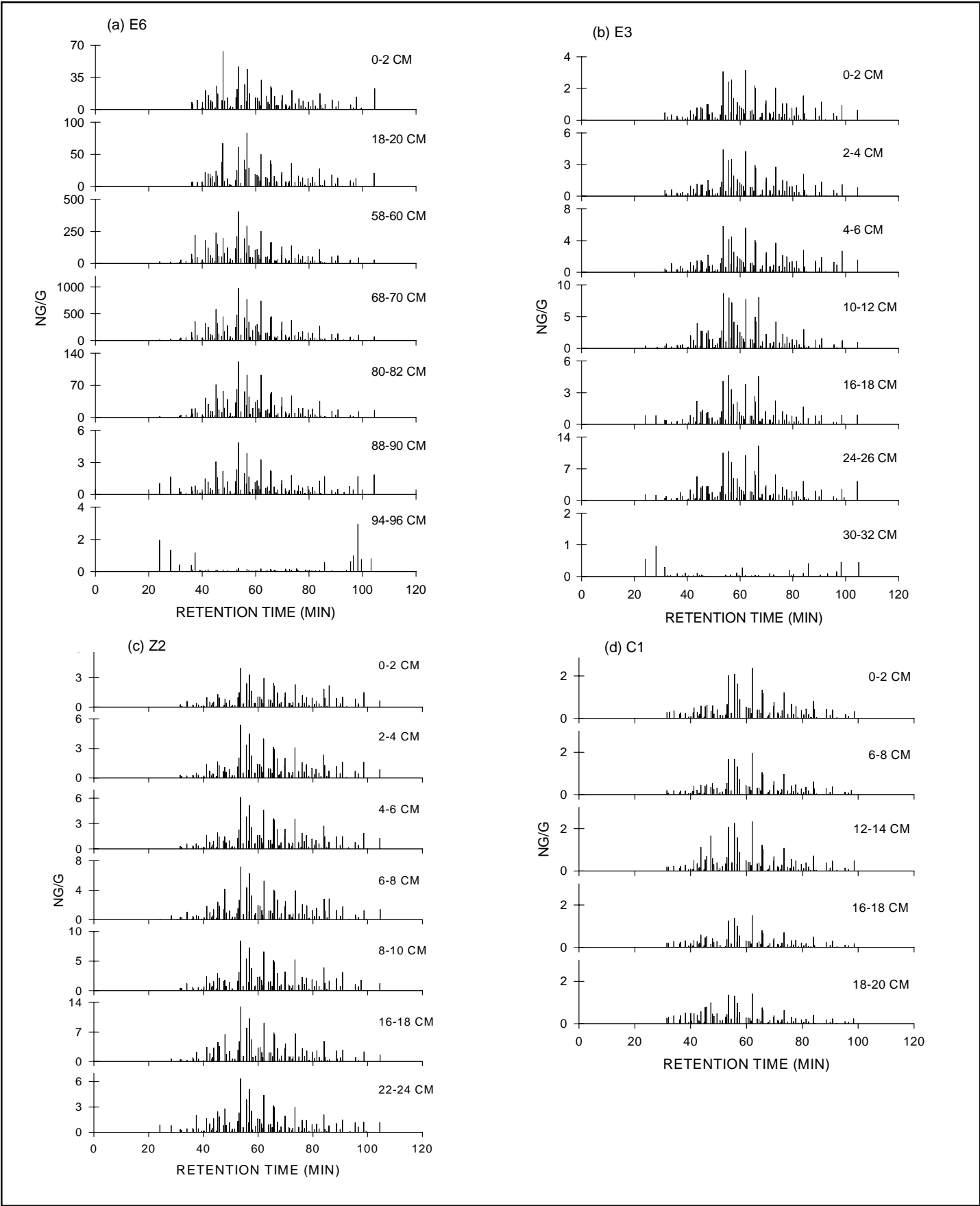


FIGURE 7. Level of chlorination of PCBs at various horizons in sediment cores collected at stations: a) E6, b) E3, c) Z2, and d) C1 in Santa Monica Bay.

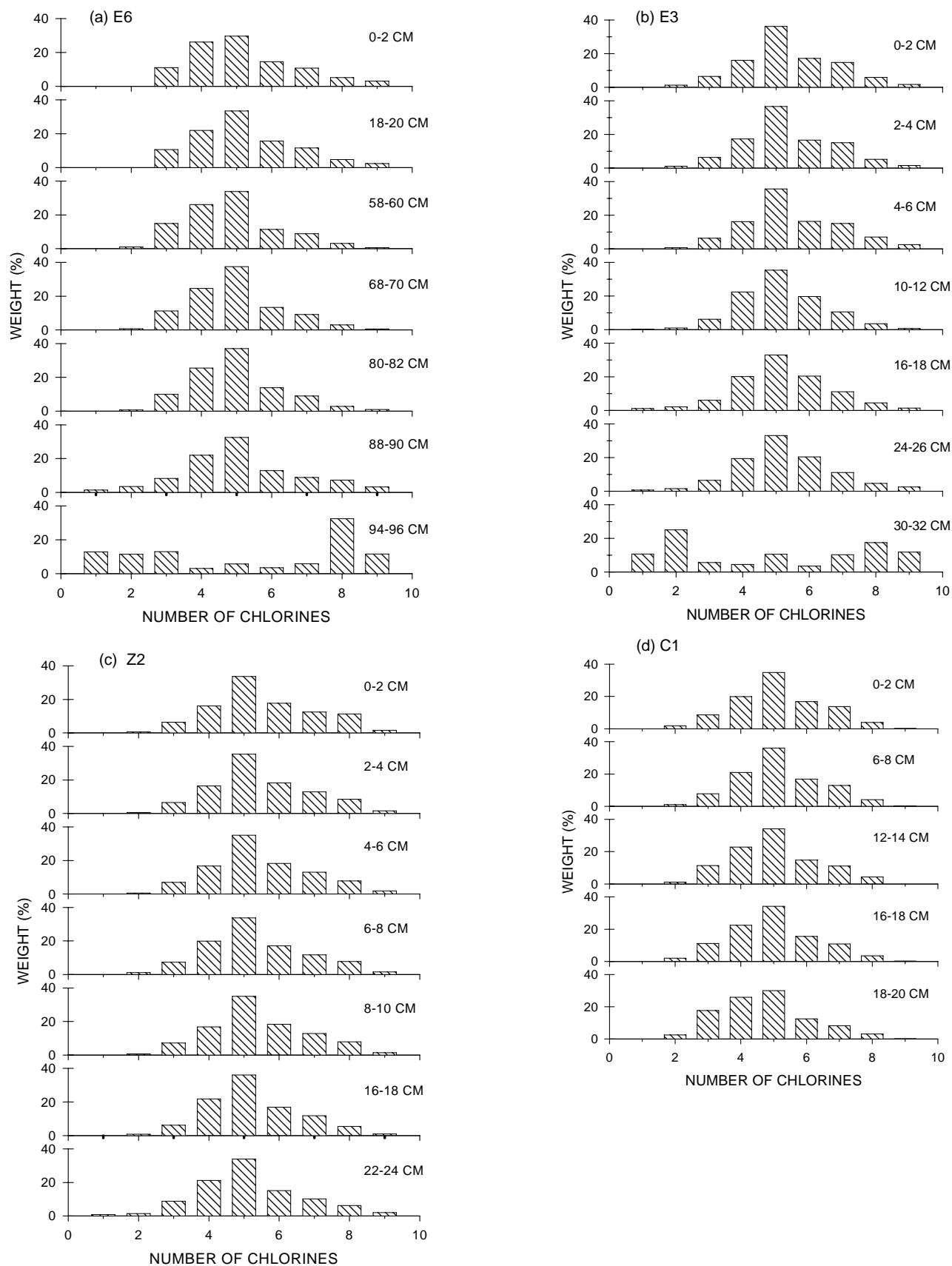
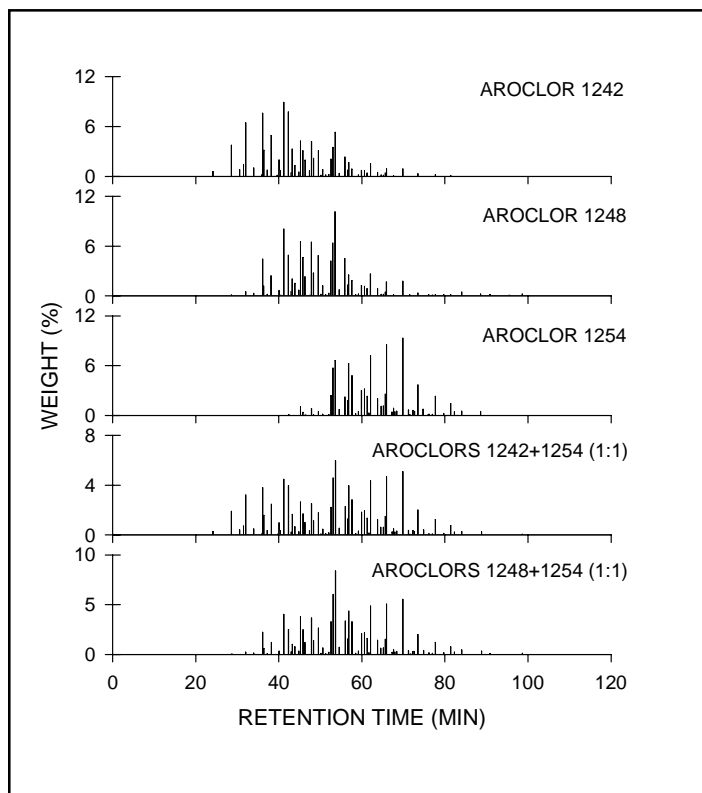


FIGURE 8. Composition of single Aroclors and 1:1 mixtures of Aroclors (Supelco, Inc.)



Station Z2

Station Z2 was located near the 5-mile outfall. Primary and secondary treated wastewater have been discharged through the 5-mile outfall since 1962. The concentration of suspended solid was much lower in treated wastewater (58 mg/L in 1987) than the concentration of total solids in sludge (12,600 mg/L in 1987) discharged from the 7-mile outfall from 1957 to 1987 (SCCWRP 1988). The low concentrations of PCBs, DDTs, and LABs in the Z2 core (Figures 3c and 4c), and the high concentrations in the E6 core (Figures 3a and 4a), are consistent with the hydrophobic nature of these compounds and the disparity in solids content of the effluents discharged from the 5-mile and 7-mile outfalls. The TOC and TN levels in the Z2 core were similar to background levels for marine sediments (~1% for TOC and ~0.1% for TN), which is probably due to effective dilution and mixing of effluent particles, and their transport away from the 5-mile outfall in the water column.

Station C1

Station C1 was the farthest from the outfalls. The profiles of TOC, TN, and C/N in the C1 core were flat and typical of uncontaminated marine sediments (Figure 2d). The concentrations of LABs, PCBs, and DDTs were substantially lower than concentrations in the other sedi-

ment cores, but higher than other reference sites in the Southern California Bight (e.g., R-61 off Point La Jolla in San Diego coast; SCCWRP, unpublished data). The highly degraded LABs (high I/E ratios; Figure 3d) suggest that the organic contaminants traveled a long time or distance before being incorporated into the sediments at C1.

Compositions of PCBs

Except for the bottom sections of cores E6 and E3, the PCB compositions of the sediment sections were similar (Figures 6 and 7). This suggests a single source of PCB inputs to Santa Monica Bay. The similar PCB patterns in the sediment column (e.g., E6) may be due to vertical mixing that brings the PCBs upward (Brown and Wagner 1990) and is consistent with the presence of historically deposited PCBs and DDTs in the surface sediments of Santa Monica Bay. Since E6 is close to the 7-mile outfall and E3 is close to the 5-mile outfall, the similar PCB patterns at these two sites suggest that PCBs partitioned similarly between sludge and sludge-derived effluent.

The different PCB patterns in the bottom sections of cores E6 and E3 (Figure 6) may reflect the refractory potential of PCB congeners in sediments. The bottom sections of these cores contained sediments deposited before sludge was discharged from the 7-mile outfall (Figure 5). Organic contaminants adsorbed to particles may have settled to the sea floor and penetrated into the subsurface by vertical mixing processes (e.g. diffusion, bioturbation; Brown and Wagner 1990). The PCB distributions in the bottom sections of cores E6 and E3 may indicate that PCB congeners with $N_{Cl}=4$ to 7 are less refractory in the sediments than other congeners. However, since the overall PCB, DDTs, and LAB concentrations in these sections were fairly low, downward mixing may not be significant.

Biodegradation of PCBs in aquatic sediments has been investigated extensively in the last few years (Brown *et al.* 1987a,b, Brown and Wagner 1990, Lake *et al.* 1992). The difference of PCB patterns in field sediments and original sources can be used to derive the biodegradation pathways, if the sources of PCB inputs are well defined. PCBs are also degraded in laboratory studies when sediments are inoculated with microorganisms extracted from specific types of sediments (Quensen *et al.* 1988, 1990, Sugiura 1992, Rhee *et al.* 1993).

Two types of microbes degrade PCBs. Anaerobic microorganisms reductively dechlorinate meta- and para-substituted PCBs (Rusling and Miaw 1989). While meta and para reductive dechlorination occurs in riverine and

estuarine sediments (Brown *et al.* 1987a,b, Brown and Wagner 1990, Lake *et al.* 1992), ortho, meta, and para dechlorination by anaerobes was observed in freshwater lake sediments (Brown 1987b) and confirmed in a laboratory study (Van Dort and Bedard 1991). Aerobic microbes, on the other hand, preferably metabolize lightly chlorinated PCBs, especially ortho-substituted congeners (Bedard *et al.* 1987, Fava *et al.* 1991, Harkness *et al.* 1993).

Since the sources of PCBs received by the Hyperion Treatment Plant are unknown, but were probably diverse, it is difficult to estimate the extent of PCB biodegradation in the sediments. The PCB compositions of all samples most closely resembled a 1:1 mixture of Aroclors 1248 and 1254 (Figure 8). Historically, PCBs in the Hyperion Treatment Plant effluent were measured using an Aroclor-based quantitation method and Aroclor 1242, 1254, or 1260 normally chosen as standards (City of Los Angeles 1993). If Aroclor 1248 did not occur in the effluent, the altered PCB composition in the sediments may indeed be due to reductive dechlorination. The difference between mixtures of Aroclors 1248 and 1254 (1:1), and of Aroclors 1242 and 1254 (1:1), is the composition in the lower portion of Aroclor 1242. The observed pattern of PCBs in the sediments near the outfalls may be a consequence of significant dechlorination of Aroclor 1242.

Due to low biological availability, higher chlorinated PCBs (e.g., Aroclors 1254 and 1260) are less subject to reductive biodegradation compared to Aroclor 1242 (Quensen *et al.* 1990). The large amount of H₂S present in the E6 sediment core provided an anaerobic environment for reductive dechlorination. Furthermore, lightly chlorinated PCBs (N_{Cl}=1 and 2) characteristic of Aroclor 1242 were absent from the upper sections (0-2 and 18-20 cm) of the E6 core (Figure 7a). It may indicate either aerobic biodegradation (Harkness *et al.* 1993) or transfer of the more soluble PCBs into the sediment pore water or water column by elution (Brown and Wagner 1990).

There is further evidence for degradation. Since the 68-cm depth at E6 represents the time (~1971) when the discharge of chlorinated hydrocarbons was banned, the majority of PCBs in the sediment column were discharged prior to 1971. PCBs below 68-70 cm were either discharged at a earlier date, or mixed downward after deposition. PCBs above 68 cm were mixed upward by resuspension and reworking of older deposits. The relative amount of N_{Cl}=5 PCBs peaked at 68-70 cm (Figure 7a) and decreased up and down the core. As the N_{Cl}=5 PCBs decreased, the relative amounts of N_{Cl}=8 and N_{Cl}=9 PCBs increased. This was also observed in cores E3 (Figure 7b) and Z2 (Figure 7c), although to a lesser extent. The evidence suggests that N_{Cl}=8 and N_{Cl}=9 PCBs (character-

istic of Aroclor 1260) were more persistent than N_{Cl}=5 PCBs (typically associated with Aroclor 1254).

CONCLUSIONS

Four sediment cores (E6, E3, Z2, and C1) were collected from the Santa Monica Bay and analyzed for LABs, PCBs, DDTs, TOC, and TN. The profiles of LABs, PCBs, and TOC concentrations in the E6 core corresponded to historical events associated with discharge from the 7-mile outfall and use of LABs and PCBs. Based on this dating, the accumulation rate of carbon from 1957 to 1994 was approximately 50-350 mg/cm²/yr — two to three orders of magnitude higher than in the nearby basins. Systematic variation in LABs, PCBs, and TOC was not as pronounced in the other cores because of low particle deposition rates and large core sub-sampling intervals.

The PCB compositions of the core sections were similar and most closely resembled a mixture of Aroclors 1248 and 1254 (1:1). The PCB pattern suggested that reductive dechlorination and/or aerobic biodegradation had occurred, especially if Aroclor 1248 had not been in the effluent discharged. Analyses of these sediments by the Aroclors method is not appropriate.

Detectable amounts of PCBs and DDTs were present in the surface sediments around the 7-mile and 5-mile outfalls, even though discharge of these chlorinated hydrocarbons was banned in early 1970s and concentrations in the effluent have been undetectable since 1990 (SCCWRP 1993c). It is likely that historically deposited PCBs and DDTs have been mixed upward in the sediment column by sediment resuspension and reworking processes. Extrapolating the trends of the PCB and DDT concentration profiles, these compounds will be present in the surface sediments in Santa Monica Bay for years to come.

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Collecting sediments.

