Chapter 4. Sediment Characteristics

INTRODUCTION

Soft bottom ocean sediments provide important habitat to benthic invertebrate and demersal fishes. Sediment conditions can influence the distribution of benthic invertebrates by affecting the ability of various species to burrow, build tubes or feed (Gray 1981, Snelgrove and Butman 1994). In addition, many demersal fishes are associated with specific sediment types that reflect the habitats of their preferred prey (Cross and Allen 1993). Both natural and anthropogenic processes affect the distribution, stability, and composition of sediments.

Natural factors that may affect the distribution and stability of sediments on the continental shelf include bottom currents, wave exposure, the presence and abundance of calcareous organisms, and proximity to river mouths, sandy beaches, submarine basins, canyons, and hills (Emery 1960). The analysis of various sediment parameters (e.g., particle size, sorting coefficient, percentages of sand, silt, and clay) can provide useful information relevant to these processes. The geological history of an area can shape the chemical composition of sediments. For example, erosion from cliffs and shores, and discharges from bays, rivers, and streams can contribute various metals and sedimentary detritus to a given area (Emery 1960). Similarly, primary productivity in nearshore waters, as well as terrestrial plant debris originating from bays, estuaries, and rivers greatly affects the organic content of sediments (Mann 1982, Parsons et al. 1990). Finally, sediment particle size influences concentrations of various constituents within sediments. For example, the levels of organic materials and trace metals within ocean sediments generally rise with increasing amounts of fine particles (Emery 1960, Eganhouse and Vanketesan 1993).

Ocean outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of sediments through the discharge of wastewater and the subsequent deposition of a wide variety of organic and inorganic compounds. Some of the most commonly detected compounds in municipal wastewater discharges include various organic compounds, trace metals, and pesticides (Anderson et al. 1993). Additionally, the physical structure of large outfall pipes can alter the hydrodynamic regime affecting sediment transport and the subsequent substrate composition in the immediate area (see Shepard 1973). Consequently, monitoring sediment conditions is important to understand natural and anthropogenic impacts to the sediments in the region surrounding the Point Loma Ocean Outfall (PLOO).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2006 at stations surrounding the PLOO. The major goals are to (1) assess impact of the wastewater discharge on sediment quality in the region by analyzing spatial and temporal patterns of various grain size and chemistry parameters, and (2) determine the presence or absence of sedimentary or chemical footprints near the discharge site.

MATERIALS AND METHODS

Sediment samples were collected at 22 stations in the PLOO region (**Figure 4.1**). These stations are located along the 88, 98, and 116-m depth contours, and include 17 “E” stations located within 8 km of the outfall, and 5 “B” stations located greater than 11 km north of the outfall. Each sample was collected from one grab of a double chain-rigged 0.1 m^2 Van Veen grab sampler; the other grab sample was used for macrofaunal community analysis (see Chapter 5). Sub-samples for various analyses were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

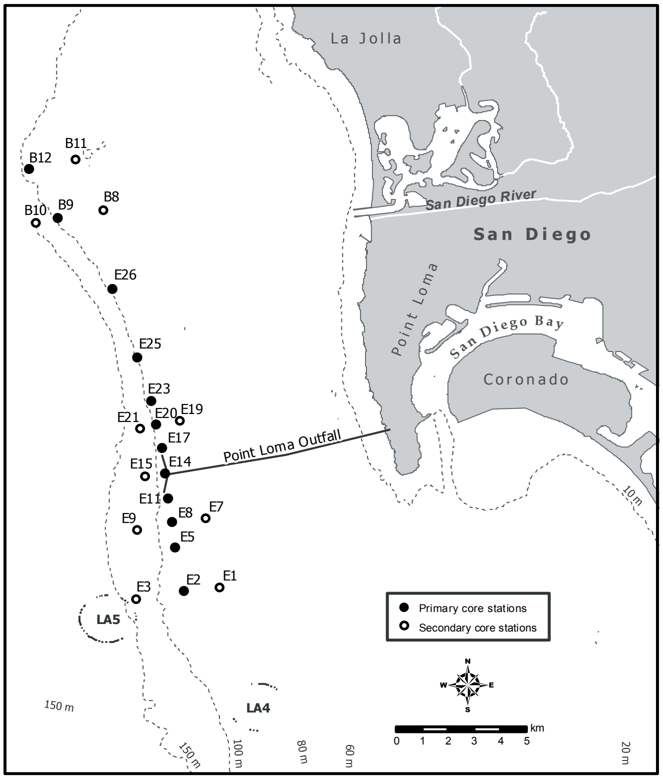

Figure 4.1
Benthic sediment station locations sampled for the Point Loma Ocean Outfall Monitoring Program.

All sediment chemistry and grain size analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory. Particle size analysis was performed using a Horiba LA-920 laser scattering particle analyzer, which measures particles ranging in size from 0.00049 to 2.0 mm (i.e., -1 to 11 phi). Coarser sediments (e.g., very coarse sand, gravel, shell hash) were removed prior to analysis by screening the samples through a 2.0 mm mesh sieve. These data were expressed as the percent "Coarse" of the total sample sieved.

Data output from the Horiba particle size analyzer was categorized as follows: sand was defined as particles from >0.0625 to 2.0 mm in size, silt as particles from 0.0625 to 0.0039 mm, and clay as particles <0.0039 mm (see **Table 4.1**). These data were standardized and incorporated with a sieved coarse fraction containing particles >2.0 mm in diameter to obtain a distribution of coarse, sand, silt, and clay totaling 100%. The coarse fraction was included with the ≥2.0 mm fraction in the calculation of various particle size parameters, which were determined using a normal probability scale (see Folk 1968). The parameters included mean and median particle size in millimeters, phi size, standard deviation of phi (sorting coefficient), skewness, kurtosis, and percent sediment type (i.e., coarse, sand, silt, clay).

Chemical parameters analyzed for each sediment sample included total organic carbon (TOC), total nitrogen (TN), total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl compounds (PCBs) (see **Appendix B.1**). These data were generally limited to values above the method detection limit (MDL). However, concentrations below the MDL were reported as "estimated" values if their presence could be verified by mass-spectrometry (i.e., spectral peaks confirmed), or as "not detected" (i.e., null) if not confirmed. Zeroes were substituted for all null values when calculating mean values. Annual mean concentrations are reported as the mean ± the standard deviation of station-quarter values.

Concentrations of the sediment constituents detected in 2006 were compared to average results from previous years. In addition, values for trace metals, TOC, TN, and pesticides (i.e., DDT) were compared to median values for the Southern California Bight (SCB). These medians were based on the cumulative distribution function (CDF) calculated for each parameter using data from the SCB region-wide survey in 1994 (see Schiff and Gossett 1998). They are presented as the 50% CDF in the tables included herein. Levels of contamination were further evaluated by comparing the results of this study to the Effects-Range-Low (ERL) sediment quality guideline of Long et al. (1995). The National Status and Trends Program of the National Oceanic and Atmospheric Administration originally calculated the ERL to provide a means for interpreting monitoring data. The ERL represents chemical concentrations below which adverse biological effects were rarely observed.

Table 4.1

A subset of the Wentworth scale representative of the sediments encountered in the SBOO region. Particle size is presented in phi, microns, and millimeters along with the conversion algorithms. The sorting coefficients (standard deviation in phi units) are based on categories described by Folk (1968).

Wentworth scale				Sorting coefficient	
Phi size	Microns	Millimeters	Description	Standard deviation	Sorting
-2	4000	4	Pebble	Under 0.35 phi	very well sorted
-1	2000	2	Granule	0.35–0.50 phi	well sorted
0	1000	1	Very coarse sand	0.50–0.71 phi	moderately well sorted
1	500	0.5	Coarse sand	0.71–1.00 phi	moderately sorted
2	250	0.25	Medium sand	1.00–2.00 phi	poorly sorted
3	125	0.125	Fine sand	2.00–4.00 phi	very poorly sorted
4	62.5	0.0625	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31	0.0310	Coarse silt		
6	15.6	0.0156	Medium silt		
7	7.8	0.0078	Fine Silt		
8	3.9	0.0039	Very fine silt		
9	2.0	0.0020	Clay		
10	0.98	0.00098	Clay		
11	0.49	0.00049	Clay		

Conversions for diameter in phi to millimeters: $D(mm) = 2^{-phi}$

Conversions for diameter in millimeters to phi: $D(phi) = -3.3219\log_{10}D(mm)$

RESULTS AND DISCUSSION

Particle Size Distribution

During 2006, ocean sediments collected off Point Loma were predominantly composed of very fine sand and coarse silt with a mean particle size of 0.079 mm or 3.9 phi (**Table 4.2**). Fine sediments (silt and clay fractions combined) averaged about 39% of the sediments overall, while sands accounted for approximately 58%. Coarser materials such as shell hash and gravel comprised the remaining 3%. The sorting coefficients (standard deviation) were greater than 1.0 phi at every station, indicating that sediments within the survey area were poorly sorted (i.e., consisted of particles of varied sizes; see Table 4.1). These results are typical of the mid-shelf and reflect the multiple origins of sediments in the region (see Emery 1960, City of San Diego 2007). This also suggests that these sites are subject to slow moving currents, reduced water motion, or some type of disturbance (e.g., storm surge, rapid suspension/deposition of materials). For example, 17 of the 44 samples collected in 2006 contained some measure of both coarse materials and fine particles (silt and clay), while 4 others included observations of rock, gravel, or coarse sand within the sample (see **Appendix B.2**). Mean particle size at all but 3 stations was ≤0.08 mm in diameter. Generally, finer sediments occurred along the 88-m contour, with more coarse sediments along the 98 and 116-m contours (**Figure 4.2**). The smallest particles (mean 0.039 mm) occurred at the north station B8 located along the 88-m depth contour, while the coarsest sediments (>0.1 mm) occurred at stations near the PLOO (E14) and southward (E2 and E9). Each of these stations averaged over 12% coarse materials, with station E14 averaging about 25%. Stations along the 98 and 116-m contours, from E17 southward to E2, were composed of sandy sediments that were slightly more coarse than the surrounding area. In addition, observations of the field samples collected at stations E9, E14, and E15 revealed the presence of coarse, black sand used as stabilizing

Table 4.2

Summary of particle size parameters and organic loading indicators at PLOO sediment stations during 2006. Data are expressed as annual means. CDF=cumulative distribution functions (see text); na=not available. Area mean=mean for 2006. Values that exceed the median CDF are in bold type.

		Particle size						Organic indicators				
Station	Depth (m)	Mean (mm)	Mean (phi)	SD (phi)	Coarse (%)	Sand (%)	Fines (%)	BOD (mg/kg)	Sulfides (ppm)	TN (wt%)	TOC (wt%)	TVS (wt%)
North reference stations												
B11	88	0.055	4.2	2.0	2.0	52.7	**45.4**	517	0.7	**0.102**	**2.870**	3.94
B8	88	0.039	4.7	1.6	0.0	40.9	**59.2**	475	3.0	**0.086**	**0.995**	3.87
B12	98	0.075	3.8	1.9	1.1	65.6	33.4	516	1.0	**0.063**	**3.600**	3.45
B9	98	0.059	4.1	1.8	2.0	58.4	**39.6**	342	1.5	**0.060**	**0.979**	3.13
B10	116	0.068	3.9	1.6	1.5	69.5	29.0	411	1.6	**0.053**	**1.585**	3.14
Stations north of the outfall												
E19	88	0.054	4.3	1.5	0.6	54.9	**44.6**	368	3.6	**0.063**	**0.740**	2.67
E20	98	0.062	4.0	1.4	0.0	63.7	36.4	339	3.2	**0.051**	**0.612**	2.25
E23	98	0.057	4.2	1.5	0.0	59.6	**40.4**	360	3.5	**0.054**	**0.647**	2.40
E25	98	0.059	4.1	1.6	0.0	61.7	38.4	469	1.7	**0.055**	**0.766**	2.38
E26	98	0.053	4.3	1.5	0.0	57.0	**43.1**	371	1.6	**0.060**	**0.768**	2.77
E21	116	0.062	4.0	1.5	0.0	66.3	33.8	288	1.2	0.050	**0.647**	2.30
Outfall stations												
E11	98	0.073	3.8	1.4	0.0	69.1	31.0	242	16.2	0.049	**0.613**	2.11
E14	98	0.283	2.4	1.8	24.9	42.8	32.4	418	5.9	0.048	**0.652**	1.85
E17	98	0.065	4.0	1.5	0.0	66.4	33.6	294	6.6	0.049	**0.655**	2.09
E15	116	0.064	4.0	1.5	0.0	67.3	32.8	339	3.9	0.048	**0.835**	2.38
Stations south of the outfall												
E1	88	0.057	4.2	1.9	2.0	53.9	**44.1**	357	2.4	**0.059**	**0.659**	2.38
E7	88	0.057	4.1	1.5	0.0	59.2	**40.8**	342	0.7	**0.061**	**0.662**	2.35
E2	98	0.150	3.1	1.9	12.5	44.5	**43.0**	282	5.6	**0.053**	**0.777**	2.42
E5	98	0.067	3.9	1.5	1.0	65.9	33.2	256	1.0	0.049	**0.627**	2.27
E8	98	0.066	4.0	1.5	0.2	66.9	33.0	270	1.3	0.050	**0.687**	2.20
E3	116	0.080	3.7	2.1	2.8	62.3	34.9	323	2.9	0.040	0.515	2.14
E9	116	0.144	2.8	1.8	14.8	26.0	**59.3**	303	0.9	**0.061**	**1.510**	2.50
Area mean		0.079	3.9	1.6	3.0	57.9	39.1	358	3.2	0.057	1.018	2.59
50% CDF							38.5	na	na	0.050	0.597	na

material for the outfall pipe, suggestive of the potential spread of this ballast material (see Appendix B.2).

Organic Indicators

Generally, the distribution of organic indicators in PLOO sediments during 2006 was similar to that seen prior to discharge (see City of San Diego 1995a). The north reference stations had higher concentrations of organic indicators than most stations farther south (Table 4.2). For example, the north reference sites included the 3 highest values of TOC, TN, BOD, and TVS, and all 5 sites contained TOC values of ~1.0% or higher and TVS above 3.0%. In contrast, just one southern station (E9) had comparable TOC values. Concentrations of organic indicators at sites within the vicinity of the PLOO (i.e., E11, E14, E15, E17) were relatively low; however, TOC concentrations at these sites were above the median CDF. In addition, station E11 had elevated sulfides (16.2 ppm) and stations E14 and E25 had slightly elevated BOD values (418 and 469 mg/kg, respectively).

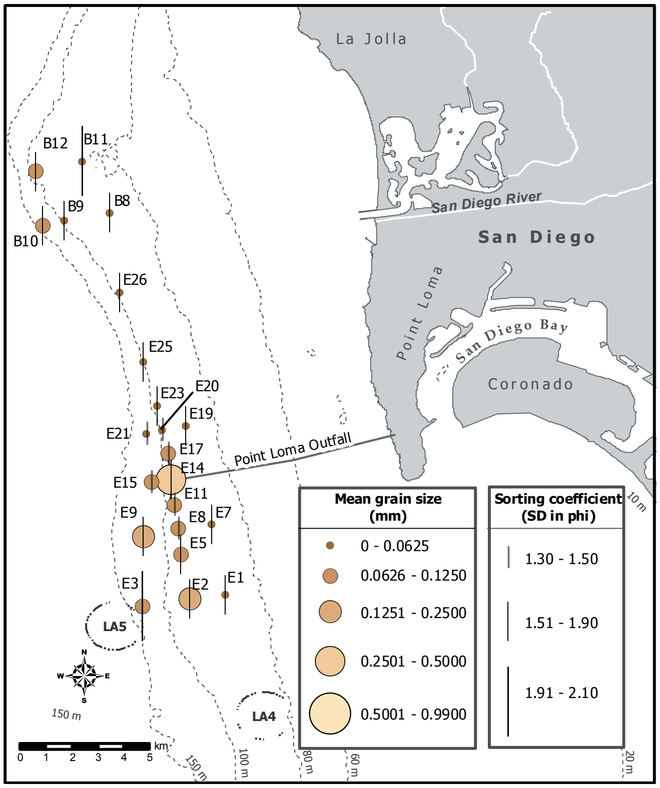

Figure 4.2
Annual mean particle size (mm) distribution and sorting coefficient (standard deviation in phi units) for PLOO sediment stations sampled during 2006.

Overall, these patterns are consistent with the spatial pattern observed in historical data from stations along the 98-m contour (**Figure 4.3**). Conversely, average TOC concentrations increased by over 50% in 2006 (see **Appendix B.3**). This change was not due to the relatively high values at stations B10, B11, B12, and E9; similarly high values have been encountered previously at these stations (see City of San Diego 1995b–1997). Instead, the high 2006 area mean is consistent with a region-wide increase in TOC values (see City of San Diego 2007). Mean BOD also reached a maximum value in 2006, but, in contrast to TOC, BOD values have been consistently higher during the entire post-discharge period (**Figure 4.4**). Overall, the concentrations of organics in sediments surrounding the PLOO during 2006 were within range of those found regionally for the mid-shelf strata (see City of San Diego 2007).

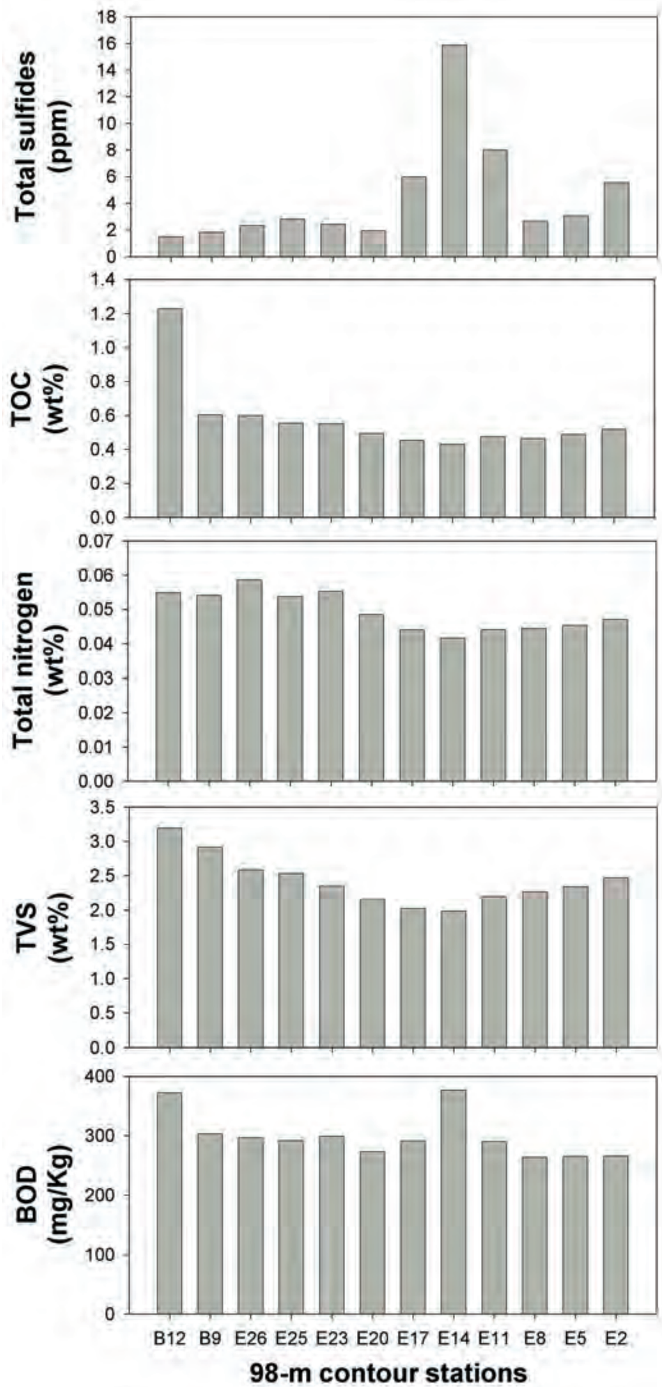

Figure 4.3
Means of organic indicators for 98-m contour stations, 1991–2006, listed from north to south (left to right).

Trace Metals

Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, tin, and zinc were detected at concentrations above their MDLs in all sediments off Point Loma (**Table 4.3**). Silver was detected in

Table 4.3

Annual mean concentrations of trace metals (ppm) detected at each PLOO sediment station during 2006. CDF=cumulative distribution function; ERL=effects range-low-threshold value; nd=not detected; na=not available. Bolded values exceed the CDF value. Area mean=mean for 2006. See Appendix A.1 for metal names represented by the periodic table symbols.

Station	Depth	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
North reference stations																			
B-11	88	**9820**	**0.3**	4.21	50.2	0.10	0.11	23.6	8.4	**20400**	10.3	120	0.028	9.5	0.00	**0.32**	nd	0.6	24.4
B-8	88	**11700**	**0.3**	4.32	53.6	0.07	0.08	22.5	**12.9**	**17100**	11.5	129	**0.047**	10.6	**0.29**	**0.67**	nd	1.0	25.8
B-12	98	7110	**0.7**	**5.04**	27.1	0.11	0.16	25.5	4.0	**22900**	9.6	70	0.016	6.9	0.14	nd	nd	0.8	20.1
B-9	98	9025	**0.5**	3.54	54.3	0.11	0.12	22.6	8.0	**19350**	8.4	107	0.024	8.0	nd	**0.28**	nd	0.7	23.6
B-10	116	7440	0.2	2.51	31.7	0.05	0.10	17.6	7.4	13850	6.9	73	0.022	6.0	nd	**0.21**	0.19	0.5	19.0
Stations north of the outfall																			
E-19	88	**9990**	0.1	3.14	48.2	0.05	0.10	18.7	8.5	13950	9.7	111	**0.046**	8.7	nd	**0.52**	0.10	0.9	19.9
E-20	98	8105	0.2	2.37	35.0	0.04	0.11	15.5	6.4	11400	7.4	88	0.025	7.0	nd	**0.33**	0.19	0.7	17.0
E-23	98	8415	**0.3**	3.11	37.2	0.05	0.11	16.1	6.4	12350	7.8	93	0.023	7.6	nd	**0.40**	nd	0.7	16.5
E-25	98	8180	**0.3**	2.90	35.1	0.05	0.10	15.9	5.9	12100	7.8	90	0.027	7.3	0.17	**0.30**	nd	0.9	15.5
E-26	98	8370	0.2	2.46	38.3	0.05	0.09	16.3	6.8	12350	8.0	96	0.028	7.6	0.00	**0.45**	nd	0.6	18.9
E-21	116	6945	0.2	2.78	27.9	0.04	0.12	14.3	4.9	10600	6.9	75	0.022	6.6	0.14	**0.22**	nd	0.8	13.7
Outfall stations																			
E-11	98	6715	**0.4**	2.97	28.5	0.04	0.11	13.2	4.7	9790	6.3	69	0.026	6.0	nd	**0.22**	0.18	0.8	15.0
E-14	98	6990	**0.4**	3.79	32.4	0.03	0.16	14.5	7.0	11100	6.2	93	0.019	8.0	0.14	**0.20**	0.16	0.6	16.7
E-17	98	7610	**0.3**	3.81	32.9	0.04	0.12	14.9	4.9	11450	7.1	83	0.022	7.0	0.12	**0.36**	0.19	0.9	15.3
E-15	116	7050	**0.4**	2.32	27.9	0.04	0.12	14.6	5.2	10445	6.8	72	0.025	6.5	0.13	**0.30**	0.20	0.8	15.2
Stations south of the outfall																			
E-1	88	**9690**	**0.3**	3.10	52.0	0.08	0.08	16.5	9.9	13650	7.8	101	**0.054**	7.4	0.07	nd	nd	1.3	26.9
E-7	88	8890	**0.3**	3.22	42.4	0.05	0.10	16.7	6.7	12450	8.7	94	0.027	8.0	0.12	**0.45**	0.26	0.9	17.6
E-2	98	**10700**	**0.4**	2.23	53.8	0.08	0.07	17.6	**14.5**	14850	6.6	108	**0.041**	7.4	nd	nd	nd	1.2	27.3
E-5	98	7025	0.2	2.58	31.0	0.04	0.05	13.5	6.5	10500	6.6	73	0.028	5.9	nd	**0.32**	0.36	0.7	14.2
E-8	98	7000	0.2	2.66	29.2	0.04	0.07	14.0	5.0	10350	6.1	72	0.024	6.2	nd	**0.29**	0.21	1.0	14.4
E-3	116	**9375**	**0.4**	2.24	68.8	0.07	0.08	15.2	**13.2**	13650	9.4	106	**0.051**	5.8	nd	nd	nd	1.5	27.5
E-9	116	7905	**0.5**	3.63	32.5	0.05	0.13	18.1	9.6	13550	8.7	80	0.028	7.1	nd	**0.32**	nd	0.8	24.6
Area mean		8366	0.3	3.13	39.5	0.06	0.10	17.1	7.6	13552	7.9	91	0.029	7.3	0.06	0.30	0.10	0.8	19.5
Detection (%)		100	100	100	100	100	100	100	100	100	100	100	100	100	41	82	45	100	100
50% CDF		9400	0.2	4.80	na	0.26	0.29	34.0	12.0	16800	na	na	0.040	na	0.29	0.17	na	na	56.0
ERL		na	na	8.2	na	na	1.2	81	34	na	46.7	na	0.2	20.9	na	1.0	na	na	150

Table 4.4

Annual mean concentrations for pesticides (ppt), total PCBs (ppt), and total PAHs (ppb) in PLOO sediments during January and July 2006. CN=*cis*-Non-achlor; CDF=cumulative distribution function (see text); nd=not detected; na=not available; ERL=Effects-range-low threshold value. Bolded values exceed the CDF value.

	Pesticides					
Station	**CN**	**HCB**	**Total DDT**	**Total PAH**	**No. PAH**	**Total PCB**
North reference stations						
B-11	nd	nd	**31790**	182	13	nd
B-8	nd	nd	nd	191	10	nd
B-12	1000	nd	285	112	7	nd
B-9	nd	nd	nd	114	7	nd
B-10	nd	nd	nd	103	6	nd
Stations north of the outfall						
E-19	nd	nd	nd	159	9	nd
E-20	nd	nd	nd	133	8	nd
E-23	nd	nd	nd	138	9	nd
E-25	nd	nd	205	140	9	nd
E-26	nd	nd	nd	123	7	nd
E-21	nd	nd	nd	124	7	nd
Outfall stations						
E-11	nd	nd	nd	103	5	nd
E-14	nd	nd	nd	111	6	nd
E-17	nd	228	nd	123	8	nd
E-15	nd	nd	nd	112	7	nd
Stations south of the outfall						
E-1	nd	nd	612	190	13	535
E-7	nd	nd	230	93	7	nd
E-2	nd	nd	252	146	9	**2715**
E-5	nd	nd	215	92	6	nd
E-8	nd	nd	180	126	6	nd
E-3	nd	nd	nd	255	12	**3769**
E-9	nd	nd	nd	140	9	**9355**
CDF	na	na	10000	na		2600
ERL			1580	4022		22700

82% of the samples and selenium and thallium were detected in just over 40% of the samples.

Sediments at most stations contained concentrations of metals below their respective CDF and ERL values. For example, only antimony and silver frequently occurred in concentrations above the median CDF. Generally, metal concentrations were highest in 2 general locations: (1) at the north reference stations, particularly B8 and B11, and (2) at the 3 southernmost stations located east of the LA-5 dredge disposal site (i.e., E1, E2, E3). The highest values for aluminum, barium, copper, lead, manganese, mercury, nickel, selenium, silver, tin, and zinc were collected at one or more of these stations. Several of these stations, along with station E19 located northeast of the PLOO, also included concentrations of 3 or more metals above the CDF. Some of the lowest metal concentrations actually occurred at the 4 stations surrounding the PLOO discharge area (i.e., E11, E14, E15, E17). The high levels of barium, copper, mercury, and zinc at the southern stations near LA-5 may be related to the deposition of dredged sediments that originated from San Diego Bay, where such metals are known to occur in high concentrations (see City of San Diego 2003).

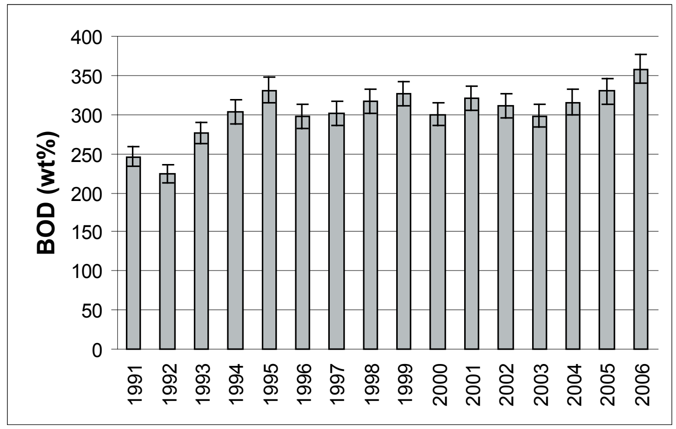

Figure 4.4

Annual mean concentrations of BOD (1991–2006) with 95% confidence limit.

Overall, the average concentrations of trace metals in local sediments decreased in 2006 relative to prior years (**Appendix B.4**). In particular, the 2006 levels of aluminum, beryllium, iron, and manganese detected in Point Loma sediments were much lower than 2005, when increased runoff and sedimentation resulting from record rainfall increased concentrations of these metals region-wide (City of San Diego 2006). Reduced runoff and drought conditions that persisted throughout much of 2006 may have contributed to the decline in metals contamination found region-wide (see City of San Diego 2007).

Pesticides, PCBs, and PAHs

Three chlorinated pesticides were detected at 9 PLOO sediment stations in 2006: cis-Nonachlor, hexachlorobenzene (HCB), and DDT (the sum of several metabolites) (**Table 4.4**). Cis-Nonachlor was found in the sediments from station B12, along with low levels of DDT, while low concentrations of HCB were detected at station E17. In contrast, DDT was detected as its final metabolic degradation product (p,p-DDE) at stations E1, E2, E5, E7, E8, E25, B11, and B12. All but one of these samples were collected in January. Sediments at station E1 contained similar concentrations of p,p-DDE in January and July. The extraordinarily high mean concentration at station B11 (31,790 ppt) — a result of the January sample with a concentration of 63,580 ppt and a non-detect in July — exceeded the median CDF for the SCB (10,000 ppt) and the ERL (1580 ppt). Similarly high values (e.g., >40,000 ppt) have been found only twice before, once at station B9 and once at E2 (see City of San Diego 1996, 2000). The previous high total DDT concentration at station B11 was 6400 ppt in 1996 (City of San Diego 1997). Pesticide contamination along the San Diego shelf appears to result from sources unrelated to the PLOO discharge. For example, region-wide total DDT concentrations peaked in 1993, just 2 years into a 7-yr period when 10 large dredging projects disposed contaminated sediments from San Diego Bay at the LA-5 disposal site (Steinberger et al. 2003, City of San Diego 2006). Similarly, discharges from Mission Bay and the San Diego River during periods of heavy rainfall may affect those more northern sites (e.g., B9, B11).

PCBs were detected in sediments from only 4 stations in 2006, all of which are located south of the PLOO (Table 4.4). Three stations (E2, E3, E9) had values above the median CDF of 2600 ppt, but still well below the ERL of 22,700 ppt. Fifteen different congeners comprised the highest total PCB concentration (9355 ppt) at station E9, while 8 were detected at stations E2 and E3. PCBs 110 and 153/168 were detected at all 4 sites, while PCBs 52, 101, 118, and 149 were found at stations E2, E3, and E9. PCBs have historically occurred at these and other southern stations relatively near the LA-5 disposal site. In contrast, PAH compounds were detected in low concentrations at all stations in 2006 with no values exceeding the ERL of 4022 ppb (Table 4.4).

SUMMARY and CONCLUSIONS

Ocean sediments at stations surrounding the PLOO in 2006 were comprised primarily of very fine sands and coarse silt. Overall, these sediments were poorly sorted and consisted of particles of varied sizes. This suggests that the region was subject to low wave and current activity and/or physical disturbance. Stations containing the finest particles were found along the 88-m contour, while those with the coarsest particles were found along the 98-m and 116-m contours. Very coarse sediments were found at stations E14 located nearest the PLOO and stations E2 and E9 located southward of the outfall. Two stations located near the PLOO contained sand that was slightly more coarse than surrounding sites, and one site located between the outfall and LA-5 contained variable amounts of ballast sand, coarse particles, and shell hash. Generally, the region's sediment composition reflects multiple anthropogenic input (e.g., outfall construction, dredge materials disposal) and natural influences (e.g., Pleistocene and recent detrital deposits; see Emery 1960).

The overall distribution of organic indicators was generally similar to previous surveys; however the concentrations of TOC and BOD were generally high in 2006 than in the previous year. The highest concentrations of BOD, total nitrogen, total carbon, and total volatile solids occurred at sites north of the PLOO. Stations located south of the outfall and near the LA-5 disposal site generally had relatively low values of organic indicators with the exception of station E9. Sediments at station E14, nearest the outfall, had elevated TOC concentrations and relatively high BOD values, but very low sulfides compared to previous years. However, concentrations of organics in sediments surrounding the PLOO during 2006 were within range of those found regionally (see City of San Diego 2007).

Fifteen trace metals were detected frequently in sediments surrounding the PLOO during 2006, with the lowest concentrations occurring near the discharge site. Most metals were present at concentrations below median CDF values for the SCB and other sediment quality guidelines. Only antimony and silver occurred in concentrations frequently above median CDF values. Metal concentrations were highest at the north reference stations, particularly B8 and B11, and several stations located east of the LA-5 dredge disposal site (i.e., E1, E2, E3). The highest values for 11 different metals were collected at one or more of these 5 sites. Several metals detected at stations near LA-5 were also present in high concentrations in sediments collected from San Diego Bay (see City of San Diego 2003). Their presence at sites south of the PLOO and near LA-5 may be related to the disposal of materials dredged from the Bay. The lowest metal concentrations occurred at sites near the PLOO. Region-wide, average concentrations of trace metals decreased in 2006 relative to prior years. In particular, concentrations of metals associated with storm-related runoff in 2005 (e.g., aluminum, beryllium, iron, manganese) were significantly lower than in 2006.

PAH compounds were detected in low concentrations at all stations in 2006, and no value exceeded the ERL. In contrast, PCB values above the median CDF were detected in sediments from 3 stations south of the PLOO. The total PCB load at these stations included from 8 to 15 different PCB congeners, with 6 congeners common to each station. In general, concentrations of PAHs and PCBs have been higher at these southern stations than elsewhere off San Diego, and are most likely the result of misplaced deposits of dredged material that were originally destined for LA-5. Previous studies have attributed elevated levels of various contaminants such as PAHs, PCBs, trace metals, and DDT in this area to the deposits from LA-5 (see Anderson et al. 1993; City of San Diego 2003; Steinberger et al. 2003). In contrast, PAHs have not been detected in effluents from large municipal wastewater treatment facilities in southern California (Steinberger and Schiff 2003), and low concentrations near the discharge site are not unexpected. Three chlorinated pesticides were detected in PLOO sediments from 9 stations in 2006. An extraordinarily high concentration of DDT that exceeded both the median CDF and the ERL was collected at station B11 in January. Similarly high values were found only twice before (see City of San Diego 1996, 2000). Generally, pesticide contamination along the San Diego shelf has been low and appears to be the result of sources unrelated to the PLOO discharge.

Overall, data from the sediment composition and chemistry indicate that impact from the PLOO wastewater discharge appears to be limited to slight increases in mean sediment grain size and moderately elevated levels of BOD and sulfides in nearby sediments. Instead, natural events (e.g., storms and plankton blooms) and anthropogenic sources (e.g., pollution from stormwater discharge and dredging activities) are more likely than the PLOO to contribute measurable changes to sediments off Point Loma.

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