Recent Changes and Long Term Trends in the Combined Mass Emissions Discharged into the Southern California Bight

Mass emissions and contaminant concentrations of municipal wastewater effluent discharged into the Southern California Bight in 1988 by six of the largest municipal wastewater dischargers[a] were collected by Henry Schafer from the Southern California Coastal Water Research Project. These data were analyzed and compared with annual emissions data from 1971-1987. Wastewater outflow from these six wastewater treatment plants constitutes over 90% of the municipal effluents discharged directly into Southern California marine waters. The locations of these six facilities are mapped in Figure 1.

Comparisons of effluent constituents revealed that annual contaminant and mass emissions levels decreased considerably between 1987 and 1988. Reductions in contaminants and emissions were a result of the termination of sludge discharge from the Hyperion outfall, improved basic sewage treatment, improved source control, and increased secondary treatment. These reductions extend the long-term trend of decreasing emissions into the Southern California Bight from municipal discharges.

Methods

Wastewater contaminant data for 1988 were obtained from the National Pollution Discharge Elimination System (NPDES) analyses that are required by the Re-

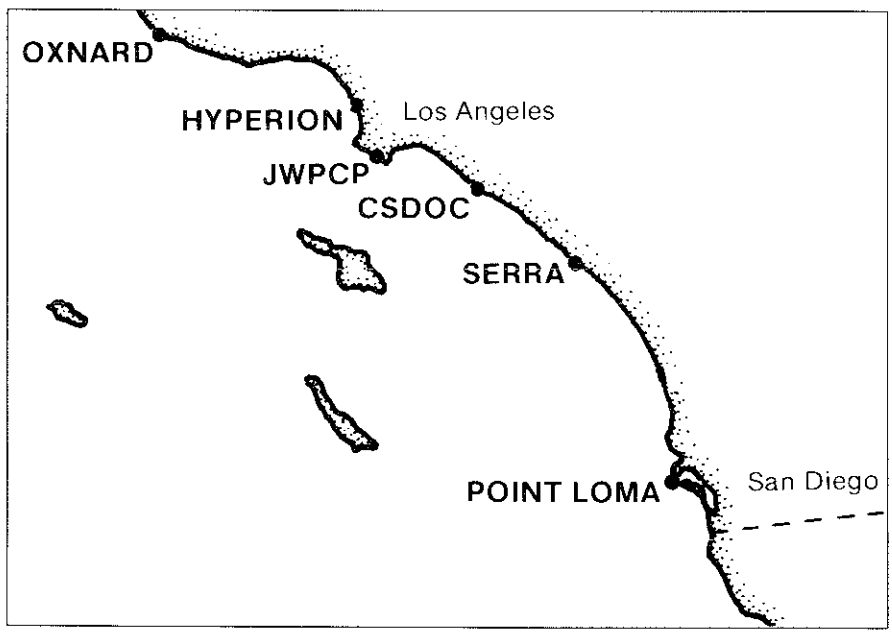


Figure 1. Locations of six municipal wastewater treatment facilities.[a]

[a] City of Los Angeles Hyperion Treatment Plant (Hyperion), County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant (JWPCP), County Sanitation Districts of Orange County (CSDOC), City of San Diego Point Loma Treatment Plant (Point Loma), City of Oxnard Perkins Wastewater Treatment Plant, and the South East Regional Reclamation Authority (SERRA).

gional Water Quality Control Boards and reported by each discharging agency. Annual mass emissions were calculated by multiplying the annual volume of effluent discharged by the mean annual concentrations of constituents. Seventeen years of comparable emissions monitoring and special studies data are available and have been used in this report to show long-term trends.

Results

Treatment and flow information for six of the largest municipal wastewater discharging plants are summarized with pertinent outfall information in Table 1. Flows from the four largest treatment facilities are much larger than flows from the other municipal outfalls in southern California. Hyperion and JWPCP each discharged about 370 million gallons per day (mgd); CSDOC and Point Loma discharged about 70% and 50% as much respectively; Oxnard and SERRA, discharged less than 5% of the flow volumes discharged by Hyperion and JWPCP. Only minor changes in the use of advanced primary and secondary treatment were reported between 1987 and 1988; most notable was an increase in the volume of secondary treatment at Hyperion in 1988.

NPDES analyses of concentrations of effluent constituents are listed in Table 2. Differences in effluent concentrations between facilities are due to a combination of factors, including the sources of sewage (eg. domestic vs. industrial), the volumes of water extracted upstream for reclamation and inland discharge, source control, efficiency of basic sewage treatment, and the degree of treatment (ie. primary, advanced primary, secondary, or tertiary treatments). The six treatment facilities have large differences in the factors listed above, however, the concentrations of most constituents are similar, and few constituents have ranges greater than a factor of 10.

The calculated annual mass emissions are listed in Table 3. The four large wastewater treatment facilities dominate mass emissions inputs because they had greater flow volumes and larger concentrations of constituents in their outflows.

The long-term combined mass emissions data

Table 1. Wastewater treatments and flow volumes (million gallons per day), and outfall information for six wastewater treatment plants.

Plant	Treatment		Total Flow	Distance of Discharge Offshore (m)	Discharge Depth (m)
	Advanced Primary	Secondary			
JWPCP	179	196	375	3,660	60
				2,400	60
Hyperion[a]	213	150	363	11,200	95
				8,300	57
CSDOC	120	134	254	7,250	60
Point Loma	186		186	4,000	60
Oxnard		17	17	1,860	15
SERRA		17	17	3,300	31

[a] Hyperion seven-mile outfall discharge was terminated in November 1987.

Table 2. Mean annual mass emissions concentrations in 1988.

Constituent	JWPCP	Hyperion-5	CSDOC	Point Loma	Oxnard	SERRA
Flow (1×10^9/yr)	518	501	351	257	24	23
(mgd)	375	363	254	186	17	17
Susp. Solids (mg/l)	70	49	51	70	23	12
Settl. Solids (ml/l)	0.2	0.38	0.4	0.4	0.02	<0.3
BOD (mg/l)	112	108	75	116	24	10
Oil & Grease (mg/l)	14	14	14	24	3	2
NH3-N (mg/l)	35	22	25	24	22	15
Organic-N (mg/l)	8	6			5	
Total P (mg/l) PO_4	8	5		2.36	7	
MBAS[a] (mg/l)	4 (LAS[b])			5	27	
Cyanide (mg/l)	0.03	0.018	<0.02	0.004	0.015	0.015
Phenol (mg/l)	2.04			0.008		
Turbidity (NTU[c])	57	40	29	73	15	4
Toxicity (TU[d])	2.4	1.1	0.5	1.5	0.2	
Ag (μg/l)	7	7	9	3	4	<25
As (μg/l)	6	8	2	4	2	<5
Cd (μg/l)	3	1	3	1	7	<10
Cr (μg/l)	36	6	17	5	8	<20
Cu (μg/l)	37	49	58	46	32	<25
Hg (μg/l)	0.5	0.1	0.2	0.2	<1	<1.5
Ni (μg/l)	51	46	37	<20	23	<30
Pb (μg/l)	36	45	17	10	11	40
Se (μg/l)	12			2		
Zn (μg/l)	140	79	59	70	35	68
Total DDT (μg/l)	0.04	ND[e]	<0.05	0.019	<0.03	ND
Total PCB (μg/l)	ND	ND	<0.3	ND	<0.1	ND

[a] MBAS = methylene blue active substances
[b] LAS = linear alkylbenzene sulfonate
[c] NTU = nephelometric turbidity units
[d] TU = toxicity units
[e] ND = not detected

presented in Table 4 show a 30% mean increase in flow since 1971, however they indicate less than a 3% increase in combined flow between 1985 and 1987, and no increase between 1987 and 1988. Increased upstream treatment and reclamation were the most important causes of reduced discharge flows, although the drought conditions experienced in the region in recent years may also have had some temporary effects.

Long-term flow data for six of the largest dischargers is summarized in Figure 2 and reveals JWPCP and Hyperion flows increased 1% and 7% respectively during the past 18 years, while the CSDOC and Point Loma outfall flows doubled during that period. These changes in flow can be partly accredited to upstream water reclamation and changes in population growth in southern California. In the last decade the County Sanitation Districts of Los Angeles County (CSDLAC) and the City of Los Angeles have expanded their upstream treatment facilities, which has removed some water from the sewage system and the marine discharge system.

Despite increasing human populations in southern California and the resulting effluent flows, the combined suspended solids emissions have been reduced by 66% since 1971 (Table 4; Figure 3). Combined solids emissions have declined

Table 3. Calculated annual mass emissions in 1988.[a]

Constituent	JWPCP	Hyperion-5	CSDOC	Point Loma	Oxnard	SERRA
Flow ($l \times 10^9$/yr)	518	501	351	257	24	23
(mgd)	375	363	254	186	17	17
Suspended Solids	36300	24500	17800	17800	550	270
BOD	58000	54200	26400	29800	560	240
Oil & Grease	7150	6850	4770	6040	77	48
NO_3-N	220	250		140	150	
NO_2-N						
NH_3-N	18200	11000	8670	6240	510	360
Organic-N	4040	2960			110	
Total P	3950	2340		1860	165	
MBAS	1870			1360	640	
Cyanide	16	8.9		1.1	0.4	0.3
Phenol	1100			ND[b]		
Ag	3.6	3.5	3.1	0.8	0.1	<0.6
As	3.1	4.0	0.8	1.0	0.06	<0.1
Cd	1.6	0.7	1.1	0.3	0.2	<0.2
Cr	19	3.2	6.1	1.3	0.2	<0.5
Cu	19	25	20	12	0.8	<0.6
Hg	0.3	0.05	0.08	0.05	0.01	<0.03
Ni	26	23	13	3.3	0.6	<0.7
Pb	19	23	5.9	2.6	0.3	0.9
Se	6.2			0.4		
Zn	73	40	21	18	0.8	1.6
Total DDT (kg/yr)	21	ND	ND	5	ND	ND
Total PCB (kg/yr)	ND	ND	ND	ND	ND	ND

[a] Measurements are listed in metric tons per year, except as noted.
[b] ND = not detected

steadily since 1971 as a result of major improvements at the individual treatment facilities. Temporary increases occurred during periods of major treatment plant construction and during abnormally wet years. Reductions of solids emissions by JWPCP and Hyperion (Figure 4) have been responsible for over 90% of this decline. Treatment improvements implemented at JWPCP accounted for 65% of the combined effluent reductions of solids from 1971 through 1988. Termination of the Hyperion seven-mile outfall, which discharged 59,000 t in 1987, reduced the combined solids

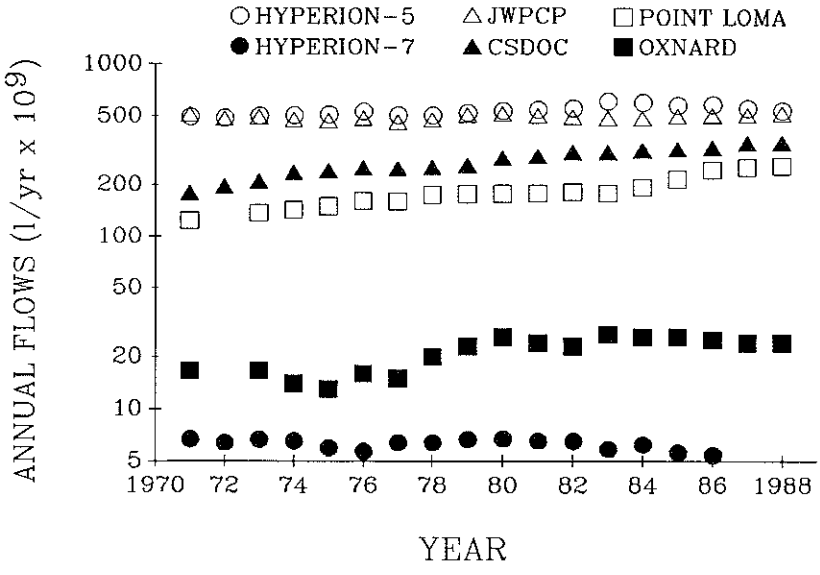


Figure 2. Annual outfall flow volumes, 1971-1988.

Table 4. Combined mass emissions for six municipal outfalls, 1971-1988.[a]

Constituent	1971	1972	1973	1974	1975	1976	1977	1978
Flow (1×10^9/yr)	1286	1274	1319	1336	1361	1419	1335	1402
(mgd)	931	922	955	967	985	1027	966	1015
Suspended Solids	288000	279000	270000	264000	287000	288000	244000	256000
BOD[d]	283000	250000	217000	222000	237000	259000	244000	237000
Oil & Grease	63500	60600	57400	54700	57400	59100	49000	49000
NH_3-N	56600	39900	45900	37000	36600	37400	41200	39500
Ag	18	21	29	22	26	20	34	32
As				21	12	11	14	15
Cd	57	34	49	55	50	45	42	45
Cr	676	673	695	690	580	593	366	280
Cu	559	485	509	575	511	507	412	417
Hg				3	2	3	3	2
Ni	339	273	318	314	124	307	264	320
Pb	243	226	180	199	196	191	152	219
Se[e]				18	17	22	23	23
Zn	1880	1210	1360	1320	1142	1064	837	905
Total DDT(kg/yr)[f]	21700	6600	4120	2120	1990	1670	920	1110
Total PCB (kg/yr)[f]	8730	9830	4620	9390	6010	4310	2180	2510

[a] Measurements listed in metric tons per year except as noted.
[b] SERRA data first included in 1982.
[c] Discharge from Hyperion seven-mile outfall was terminated in November 1987.
[d] Hyperion seven-mile outfall data excluded.

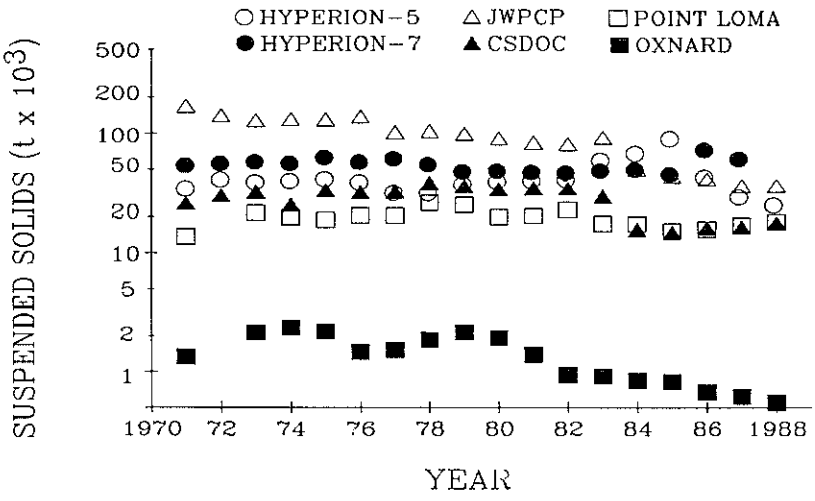


Figure 3. Suspended solids emissions, 1971-1988.

emissions 40% in 1988, and recent improvements in primary and secondary treatment at Hyperion also reduced the five-mile outfall emissions significantly.

Combined biochemical oxygen demand (BOD) emissions only declined 5% between 1971 and 1982 (Table 4; Figure 3), but were reduced 37% between 1982 and 1987 due to additional advanced treatment by several facilities. BOD remained virtually unchanged between 1987 and 1988 because the Hyperion seven-mile outfall values were not included in past estimates and because there was little change in treatment during 1988 that would have reduced BOD levels.

Emissions of oil and

1979	1980	1981	1982[b]	1983	1984	1985	1986	1987[c]	1988
1456	1516	1516	1548	1591	1602	1623	1666	1674	1673
1054	1097	1097	1120	1152	1160	1175	1206	1212	1212
243000	233000	226000	227000	247000	198000	205000	187000	162000	97400
246000	260000	264000	269000	256000	230000	255000	184000	169000	169000
45000	39000	37000	31900	36300	30200	34300	29300	26600	24900
41200	42000	41000	44000	40600	40800	44200	43900	45600	45000
42	31	28	26	26	25	27	22	15	11
15	11	12	9	10	18	15	12	12	9
42	40	33	21	24	16	17	15	10	4
237	275	187	203	164	140	110	88	60	30
359	336	339	284	246	252	240	204	135	77
3	2	2	1	1	1	1	1	<1	<1
256	224	167	169	165	134	120	129	78	66
223	175	130	123	98	94	120	106	64	51
8	11	15	9	10	9	13	8	7	7
724	730	540	546	502	372	376	342	276	153
760	640	470	290	220	310	58	50	53	26
1190	1130	1250	860	1440	1340	<320	<99	<104	ND

[e] Data include only JWPCP, Hyperion five-mile and seven-mile outfalls, and Point Loma.
[f] Values for 1971-75 are from SCCWRP's final report to the U.S. Environmental Protection Agency for Grant No. 801153 and R803707.

grease decreased by 38,600 t/yr since 1971 (Table 4). During this time period JWPCP reduced its oil and grease emissions by about 30,000 t/yr. Although a significant amount of solids was discharged from the Hyperion seven mile outfall, the effluent contained a relatively small proportion of the total oil and grease discharged into the Bight, and overall, oil and grease levels only declined 5% in 1988 after termination of the seven-mile outfall.

The concentrations and mass emissions of most trace metals has steadily declined since monitoring began in the early 1970s. The mean mass emissions of combined trace metals reported in 1988 was about one-ninth of the amount

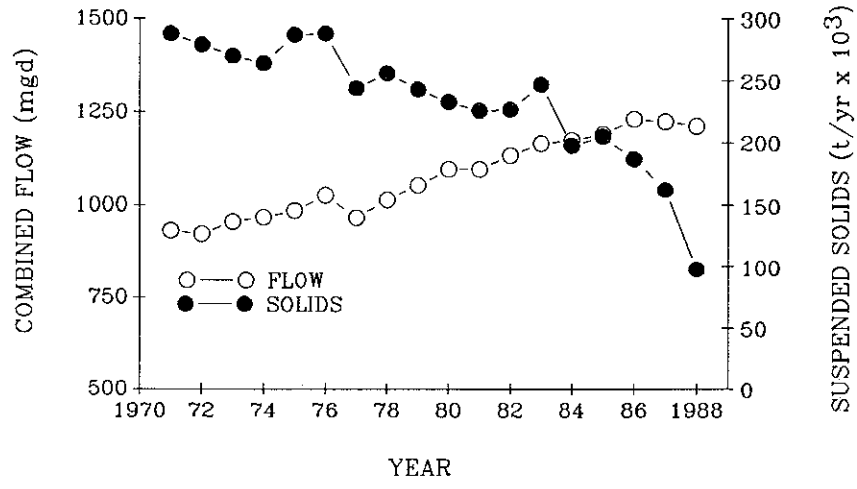


Figure 4. Combined flow and suspended solids from six outfalls, 1971-1988.

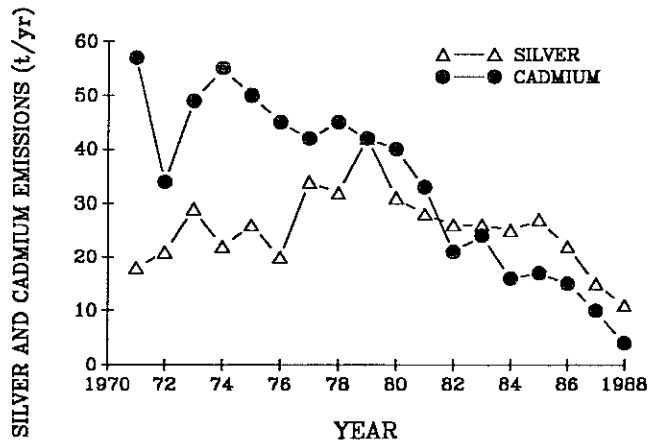


Figure 5a. Silver and cadmium emissions from six dischargers, 1971-1988.

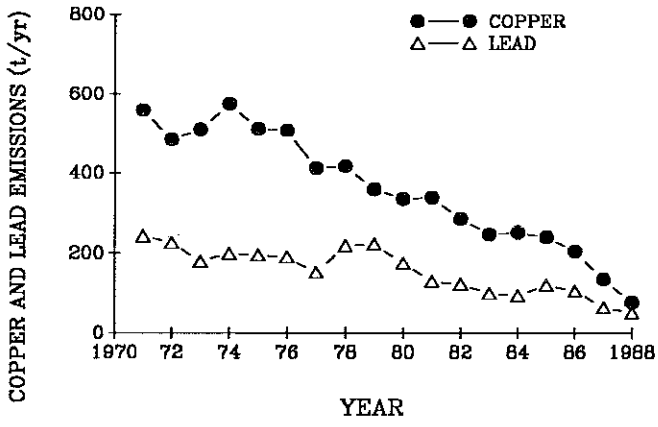


Figure 5b. Copper and lead emissions from six dischargers, 1971-1988.

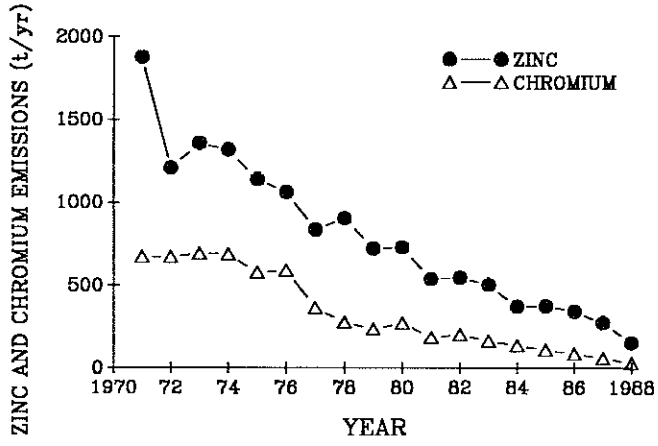


Figure 5c. Zinc and chromium emissions from six dischargers, 1971-1988.

reported in 1971. Silver, which has been reduced by 60%, is the only metal not reduced by at least a factor of five during the 18 yr period (Table 4).

Combined trace metals were reduced a mean of 56% from 1986 to 1988. Cadmium, chromium, copper, and zinc were reduced by approximately 50%, while silver, nickel, and lead were reduced by 15% to 20% (Table 4; Figures 5a,b, and c). Although the termination of the Hyperion seven-mile sludge outfall reduced metal emissions, approximately equivalent reductions in emissions were achieved in the other effluents by increased source control and improved treatment.

DDT concentrations in effluents have been reduced to less than 0.1 μg/l, which is near the limits of detection for approved methods. Calculated mass emissions are down from 50 kg/yr in 1987 to 40 kg/yr in 1988 (Figure 6). During the 1950s and 1960s large quantities of DDT were discharged from the largest manufacturer of DDT in the world - Montrose Chemcial Corporation. Until 1971, Montrose waste passed through the JWPCP facility and was discharged at the Palos Verdes outfall. After termination of Montrose DDT waste discharge, measurements of JWPCP effluent indicated that about 20 t of DDT were discharged in 1971 (Table 4), mostly due to residual waste in the sewer lines. By 1975 the combined effluent of the four largest municipal dischargers contained less than 2 t/yr, and by 1985 the amount was less than 0.1 t/yr.

Emissions of PCBs, which have exceeded DDT emissions since 1971, dropped from about 10 t/yr in the early 1970s to about 1 t/yr in the late 1970s. Reported estimates for the combined effluents remained at about 1 t/yr through 1985. In 1988, PCB levels were below detection limits.

Since 1985 there has been some uncertainty about the last 18 years of PCB emissions estimates to the Bight when CSDOC (the largest reported source of outfall PCBs in the last 10 years) discovered major differences between the CSDOC laboratory results and other labs' analyses of effluent PCBs. CSDOC was using a unique method that was considered more rigorous in extracting PCBs from effluent than the standard EPA-recommended method. However, after an extensive investigation, it was concluded that problems with the extraction method and an airborne source of contamination in the CSDOC laboratory resulted in overestimates of PCB concentrations in the effluent. From 1985 until the discovery of the source of airborne contamination, only outside laboratories' PCB test results were considered reliable, but since July 1988 CSDOC PCB tests have been reliable with only minimal contamination noted in monthly tests conducted by an outside lab. Thus, annual mean PCB concentrations in CSDOC effluent have been corrected as follows: 1985 = <1 mg/l (was 2.8 mg/l), 1986 = <0.3 mg/l (was 1.4 mg/l), 1987 = <0.3 mg/l (was 0.7 mg/l). The PCB values in Table 4 have been adjusted to

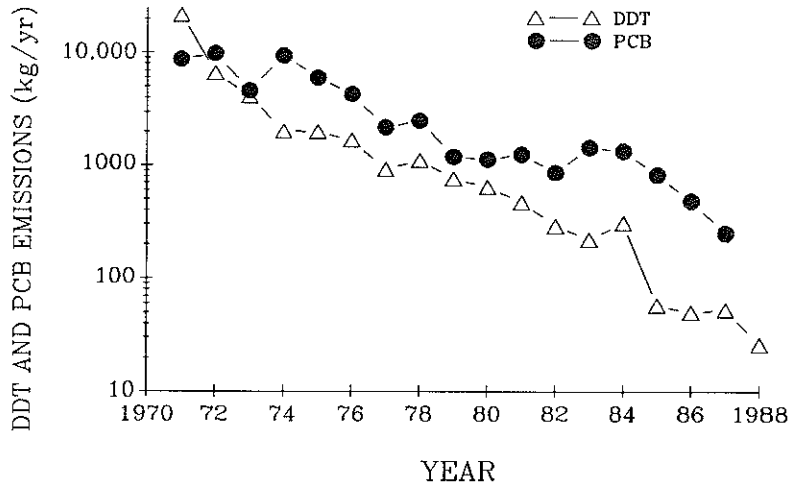
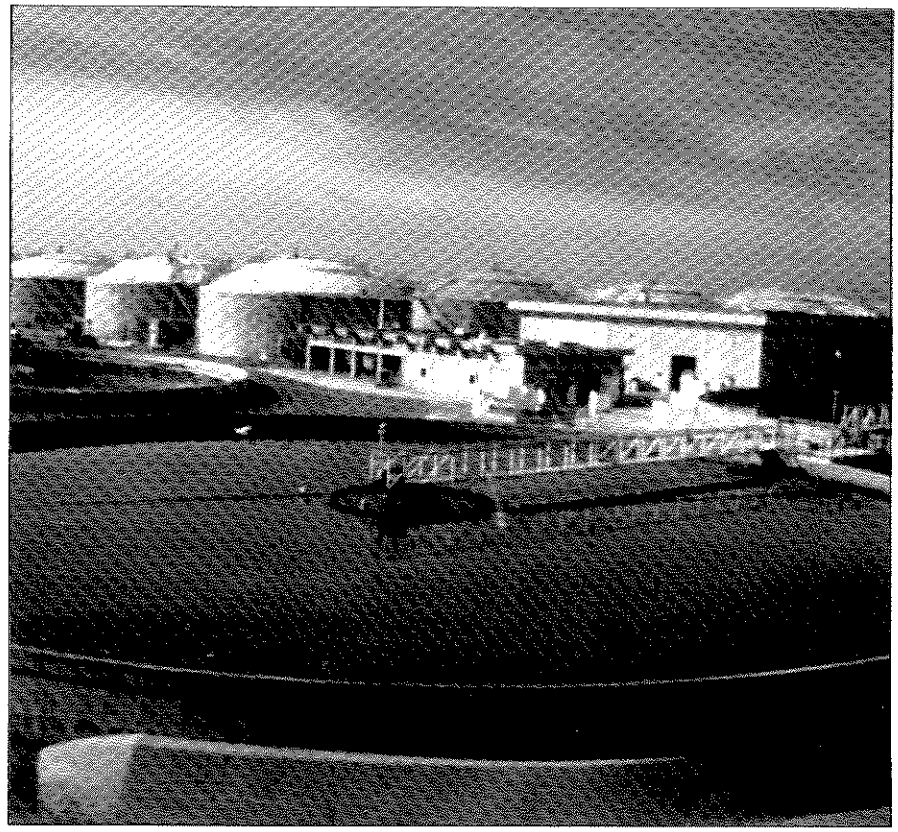


Figure 6. DDT and PCB inputs from six dischargers, 1971-1988.



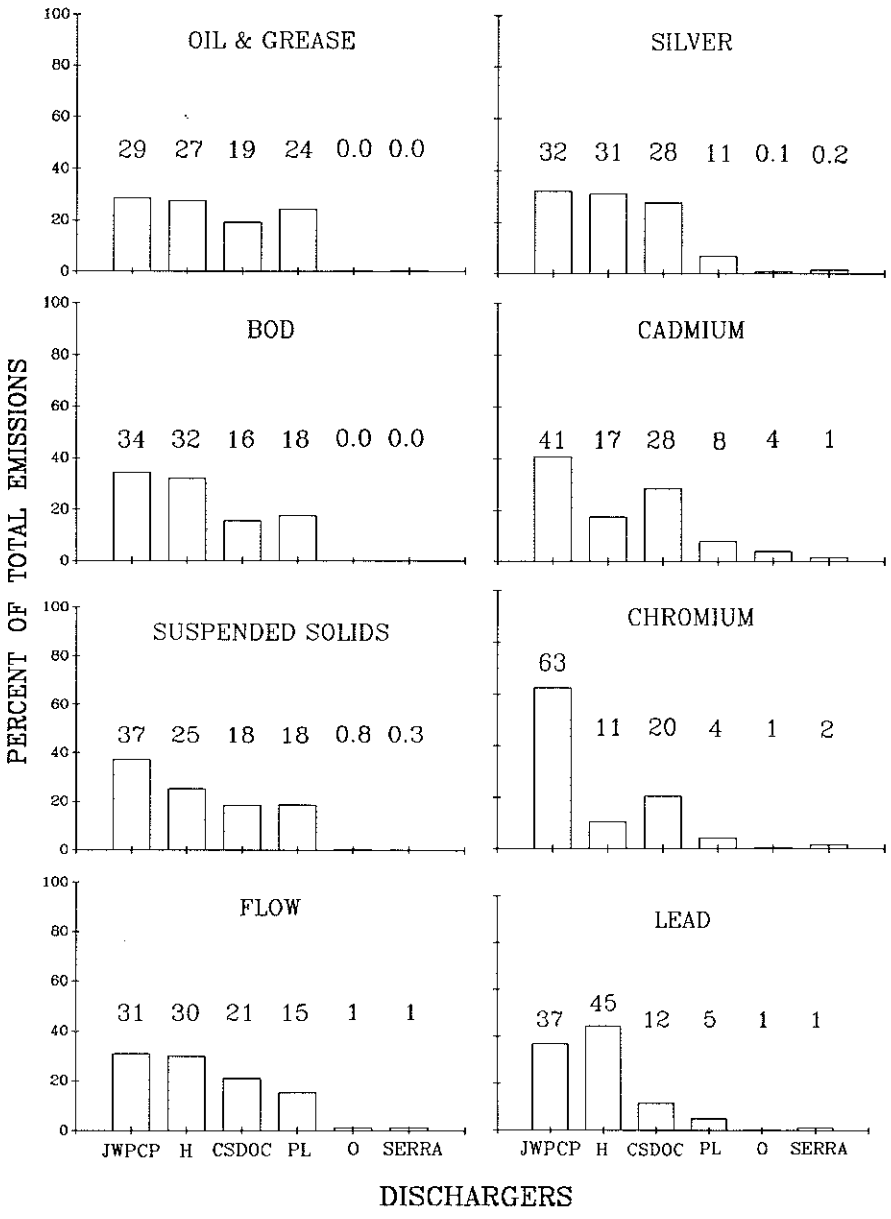


Figure 7. Percentages of total emissions for selected constituents from six municipal dischargers in 1988.

reflect these changes, however, PCB levels detected by CSDOC testing prior to 1985 should be viewed with caution, because the level of laboratory contamination cannot be ascertained.

Because the levels of DDT and PCB emissions are near or below the detection limits of recommended analytical methods, it will be necessary to use improved methods that can detect smaller concentrations to document future emissions trends. The most likely source of DDT and PCB contamination in today's marine biota are the reservoirs of these contaminants in the coastal sediments discharged from the 1940's to the 1970's.

The percentage of total emissions for selected constituents from the six dischargers in 1988 are compared in Figure 7. Each sanitation agency treats a unique mix of residential, commercial, and industrial effluents and some concentrated contaminants by removing a significant portion of their flow for reuse. Despite these differences, the emissions of constituents are generally proportional to the flow volume, although there are several exceptions. Suspended solids, BOD, and trace contaminants from the Point Loma facility (the only all-primary treatment facility) are roughly proportional to its flow, but its oil and grease emissions are more than 50% greater than predicted. Emissions of silver and cadmium from CSDOC exceeded its flow proportion by 50%. Chromium levels in JWPCP effluent were double the amount that would be predicted by its flow rate.

Discussion

Mass emissions levels and contaminant concentrations have been reduced over the last 18 years as a result of increased source control, improved sludge treatment and disposal, expanded wastewater treatment facilities, improved primary treatment, and increased secondary treatment. Mass emissions reductions in the next decade will not be as significant as they have been in the past decade because the majority of solids and contaminants have already been removed. However, reductions will continue on a smaller scale due to planned treatment increases, increases in upstream reclamation, and more effective source control.