Characteristics of effluents from large municipal wastewater treatment facilities between 1998 and 2000

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ABSTRACT - Nineteen publicly owned treatment works (POTWs) discharge treated wastewater directly to the coastal ocean within the SCB. Four of these facilities (large POTWs) are characterized by discharges greater than 100 million gallons per day (mgd). The large POTWs have historically been the leading point source of contaminants to the SCB. This study characterized the effluents from the large POTWs for the years 1998 through 2000, and compared annual discharges among the individual facilities. In addition, ongoing trends in large POTW discharges were evaluated using annual estimates dating back to 1971. From 1998 to 2000, mass emissions for the majority of constituents decreased 7% or more, and over half of these showed decreases of greater than 25%. The most significant reductions in constituent mass emissions occurred in effluent from the Hyperion Treatment Plant (HTP), which converted to full secondary treatment in December 1998. From 1998 to 2000, general constituent mass emissions at HTP decreased by an average of 63%, and combined metal mass emissions decreased by approximately 30%. Since 1971, despite increases in cumulative effluent flows from large POTWs, the majority of constituent emissions have declined significantly. For most constituents, declines in mass emissions occurred gradually until the late 1980s, and did not change dramatically following 1990. In 1999-2000, however, this plateau seems to have ended, with notable decreases from 1998 values of several constituent emissions such as BOD (28%) and suspended solids (14%). These changes in historical trends are attributable, in large part, to changes in emissions from HTP.

INTRODUCTION

The coastal ocean within the Southern California Bight (SCB) is an important recreational and economic resource. As home to almost 17 million people (U.S. Census Bureau 2002), southern California is one of the most densely populated coastal regions in the U.S. (Culliton *et al.* 1990). More than 175 million beach-goer days occur annually, helping to drive a tourism industry that generates an estimated $9 billion in ocean-related activities each year (Schiff *et al.* 2002). The significance of the coastal ocean as a recreational resource is mitigated by its necessity for other purposes, many of which result in the discharge of pollutants to coastal waters. Among these sources of contaminants are treated municipal wastewater, industrial effluents, stormwater runoff, and discharges from power generating stations, oil platforms, and dredging projects.

Nineteen municipal wastewater treatment facilities discharge treated wastewater directly to the SCB. Four of these are the large POTWs, each of which discharges more than 100 mgd. These facilities include the Hyperion Treatment Plant (HTP), operated by the City of Los Angeles; the Joint Water Pollution Control Plant (JWPCP), operated by the Los Angeles County Sanitation District; Treatment Plant No. 2, operated by the Orange County Sanitation District (OCSD); and Point Loma Wastewater Treatment Facility (PLWTP), operated by the City of San Diego (Figure 1). Historically, these facilities have been the leading source of contaminants to the SCB from point source discharges (Raco-Rands and Steinberger 2001). Although constituent emissions from large POTWs have generally decreased over the past 30 years, continued assessments enable managers to measure the effectiveness of previous management actions and determine the relative loads from large POTWs compared to other potential pollutant sources.

Each large POTW facility is individually regulated by separate Regional Water Quality Control Boards (Los Angeles RWQCB, Santa Ana RWQCB, and San Diego RWQCB), which conduct regulatory assessments on a per-facility basis. Comparisons among facilities and regional-level assessments of impact are not a part of the standard regulatory framework. As a result, the conduct of regional-scale assessments is hindered by the lack of a standard monitoring and

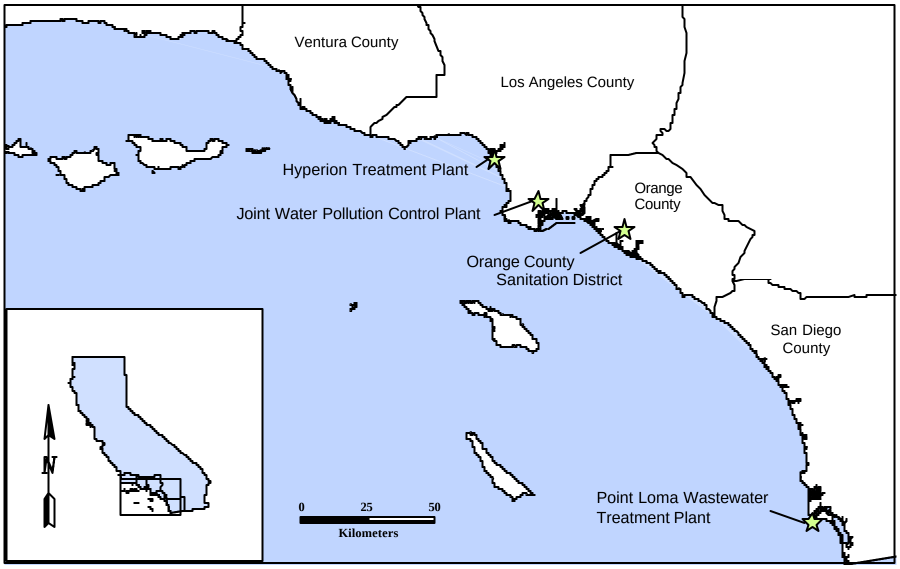

Figure 1. Locations of the four large publicly owned treatment works in the SCB.

reporting system among facilities. While this may not impair the assessment of short-term trends and the direct regulation of large POTWs, it poses a considerable challenge when trying to understand the long-term trends in cumulative large POTW discharges, which is essential to developing environmentally and economically sound policies, on a regional scale, regarding these point source facilities.

The purpose of this study was to compile monitoring information and characterize effluent emissions from the four large POTWs for the years 1998-2000. This information then allowed us to assess pollutant loading from large POTWs on a regional scale during this time period, and to evaluate trends in large POTW discharges since 1971. These objectives were accomplished by (1) developing a unified data management system so that effluent characterizations could be determined for each facility using a standardized method; (2) calculating the average flows, concentrations, and mass emissions for each large POTW facility for 1998, 1999, and 2000; and (3) comparing characterizations among facilities and to previous years.

METHODS

Effluent data were obtained from monthly, quarterly, and annual discharge monitoring reports from the individual POTWs. Analytical methods (Appendix I), reporting levels (Appendix II), and measurement frequencies (Appendix III) were obtained from laboratory reports, discharge monitoring reports, or personnel at the individual facilities. Analysis frequency was assumed to be the minimum frequency required by the National Pollution Discharge Elimination System (NPDES) permit, in the case that the actual frequency was not noted.

The constituents chosen for this assessment did not represent the entirety of wastewater analysis conducted by the individual agencies. Specific parameters were chosen based on the existence of data for consistent historical comparisons and based on the known influence of these constituents in the marine environment. Since this assessment was first made in 1973, several constituents, or categories of constituents, have been added based on an increase in scientific understanding of their impacts. This report continued this level of assessment, which included the analysis of various metals, nutrients, DDTs, PAHs, PCBs, toxicity bioassays, and general constituents such as suspended solids, BOD, and oil and grease.

Annual average effluent concentration and mass emission estimates were calculated for the 1998-2000 calendar years. In order to perform these calculations, the chemistry data were standardized to monthly time steps. For constituents analyzed at a frequency greater than once per month, this entailed calculation of an arithmetic mean of all samples in a given month. Where the frequency of constituent analysis was less than monthly, an arithmetic average of available data within the given year was calculated. This average was then used to populate months for which no data existed. This latter manipulation was based on the assumption that the given constituent concentrations were temporally consistent for any given month in the year. Furthermore, constituent measurements below the reporting level (RL) were assigned a value of zero for calculating average effluent concentrations.

Mass emission estimates (ME) were calculated from the product of the mean daily flow, the constituent concentration, the number of days in the given month, and a unit conversion factor. Mass emissions were calculated for each constituent for each month, and then summed over all months in the year to obtain an annual estimate:

$$ME_{const} = \sum_{i=1}^{12} \mu\,(F_i * C_i * D_i)$$

where

ME_{const} = Mass emissions of a particular constituent
F_i = Mean daily flow in month *i*
C_i = Constituent concentration for month *i*
D_i = Number of days of discharge in month *i*
μ = Unit conversion factor (varies depending on units of concentration measurement)

Annual average flow-weighted concentrations (FWC) were calculated by dividing the annual mass emission for a given constituent by the total annual volume of effluent. This calculation was then corrected by a unit conversion factor to obtain the proper units for the specific parameter:

$$FWC_{const} = \mu * \frac{ME_{const}}{AEV}$$

where

FWC_{const} = Flow-weighted concentration of a particular constituent
μ = Unit conversion factor (varies depending on units of concentration measurement)
ME_{const} = Mass emissions of a particular constituent
AEV = Annual effluent volume

Effluent volume was the product of the month-averaged mean daily flow (provided by the agencies) and the number of days of discharge in the given month. Annual effluent volumes were then a sum of these monthly volumes:

$$AEV = \sum_{i=1}^{12} \mu\,(F_i * D_i)$$

where

AEV = Annual effluent volume
F_i = Mean daily flow in month *i*
D_i = Number of days of discharge in month *i*
μ = Unit conversion factor

This scheme for estimating FWC resulted in levels below the RL for constituents that had one or more non-detected results; these FWC were reported as calculated. The FWC calculations that resulted in a zero value for a specific constituent were reported as less than the RL provided by the facility during that year for the given constituent.

Reporting levels varied among facilities for individual constituents. When more than one RL was used during the year for a given constituent and facility, all were reported; the greatest RL was used for reporting non-detectable values in annual average concentrations. Method detection limits (MDL) were used in place of RLs whenever RLs were not available. From 1998 to 2000, HTP only reported MDLs, as opposed to RLs. For all years, PLWTP predominantly reported MDLs, and in 1999-2000, OCSD only reported MDLs. Significant figures were retained in reporting the detection levels used by the facilities, and/or their contract laboratories, for effluent chemical analyses.

Total effluent volumes and estimated mass emissions calculated for this study period were appended to existing historical information in order to establish ongoing trends in large POTW emissions. Mass emission estimates for the individual years 1998 and 2000 were then statistically compared using a parametric one sample paired t-test to determine significant increases or decreases in the emissions between the two years. A non-parametric Wilcoxon-Sign rank test was performed in those cases where the assumptions for the paired t-test were questionable. The years 1998 and 2000 were chosen because they represent the time period immediately preceding and one year after HTP's conversion to a full secondary treatment system.

RESULTS

Effluent Flows and Volume

Facility flow rates ranged from 174 mgd to 368 mgd between 1998 and 2000 (Table 1). HTP and JWPCP consistently had flow rates greater than 300 mgd, OCSD flows were below 260 mgd for all three years, and PLWTP had flow rates consistently less than 200 mgd. The greatest combined flow rate during this time period was observed in 1998 (1,159 mgd), which resulted in the discharge of 1,602 x 10^9 liters (L) of treated effluent to the SCB from large POTWs (Table 2). Between 1998 and 1999, the combined effluent volume from the four large POTWs decreased approximately 7% and stayed at this level through 2000.

Table 1. Flow rates of municipal wastewater discharged to the SCB by the large POTWs between 1998 and 2000.

	1998			1999			2000		
Facility	Advanced Primary (mgd)	Advanced Secondary (mgd)	Total Flow (mgd)	Advanced Primary (mgd)	Advanced Secondary (mgd)	Total Flow (mgd)	Advanced Primary (mgd)	Advanced Secondary (mgd)	Total Flow (mgd)
OCSD	128	128	255	117	117	233	121	121	241
HTP	172	197	368	0	337	337	0	325	325
JWPCP	154	188	342	136	194	329	134	200	334
PLWTP	194	0	194	175	0	175	174	0	174
Combined	647	512	1,159	427	647	1,075	429	646	1,075

mgd = Million gallons per day.

The four POTWs provided varying levels of treatment on effluent discharged to the SCB between 1998 and 2000 (Table 2). One hundred percent of the discharge from PLWTP received advanced primary treatment for all three years, while OCSD consistently discharged a 1:1 ratio of advanced primary and secondary treated effluent. JWPCP consistently discharged a blend of advanced primary and secondary treated effluent. In 1998, 55% of the effluent from JWPCP received secondary treatment; 59% in 1999, and 60% in 2000. Fifty-four percent of the effluent from HTP received secondary treatment in 1998; the remaining fraction of wastewater was treated by advanced primary methods. In December of 1998, HTP completed conversion to a full secondary treatment facility. As a result, in 1999 and 2000, 100% of the effluent discharged by HTP had undergone full secondary treatment.

Mass Emissions

Combined facility emissions of all metals decreased from 1998 to 1999, but increased again in 2000 for most metals (Table 2). The 1998-1999 decreases ranged from 16% to 73%, except in the case of selenium, which decreased 1%. The increases in trace metal mass emissions that occurred between 1999 and 2000 were on the order of 5% to 36%, with lead increasing 88%. Cadmium emissions showed an overall decrease of 87% from 1998 to 2000. Combined mercury emissions were the same for 1999 and 2000 (0.02 mt), 33% lower than emission levels in 1998 (0.03 mt).

Combined mass emissions of general constituents (i.e., BOD, suspended solids, oil/grease) decreased from 1998 to 2000, with the exception of all nitrogen-containing compounds (i.e., ammonia-N, nitrate-N) and cyanide, which showed a net increase over this time period (Table 2). The PLWTP had the lowest total mass emissions of suspended solids, BOD, and oil/grease in 1998. In 1999 and 2000, following conversion to full secondary treatment, HTP exhibited the lowest mass emissions for suspended solids, BOD, and oil/grease, with net decreases of approximately 46%, 75%, and 68%, respectively, from 1998 to 2000.

Estimated mass emissions of organic compounds between 1998 and 2000 exhibited a net decrease for total DDT (63%), while emissions of all other organic compounds increased during this time (Table 2). Increases in phenolic compounds and total PAHs were the result of increases in emissions at JWPCP, since the other facilities that detected these compounds exhibited general decreases. In the case of total PAHs, with the exception of emissions from CSDOC in 1999, JWPCP was the only facility to discharge these compounds to the SCB between 1998 and 2000. The HTP only discharged 1.8 mt of non-chlorinated phenols in 1998; no other organic compounds were detected in HTP effluents during the study period. There were no emissions of total PCBs to the SCB from large POTWs between 1998 and 2000.

Annual Average Concentrations and Toxicity

Of ten trace metals included in this study, most were detected by all facilities for all years, with the exception of PLWTP, which detected only five of ten of metals in 1999 and 2000 (Table 3). During the three-year time period, the highest concentrations of cadmium (0.8 ug/L), chromium (13 ug/L), nickel (46 ug/L), selenium (14.9 ug/L), and silver (7 ug/L) were discharged by JWPCP in 1998; the highest concen-

Table 2. Estimated constituent mass emissions from the large POTWs between 1998 and 2000.

	OCSD			HTP			JWPCP			PLWTP			**TOTAL**		
Constituent	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
Volume (L x 10^9)	352	323	334	509	465	451	472	455	463	268	242	242	1,602	1,485	1,489
Suspended Solids (mt)	16,657	14,995	17,016	15,321	8,949	8,345	32,300	27,884	30,233	10,565	9,131	9,037	74,842	60,959	64,631
Settleable Solids (L x 10^3)	135,319	123,678	189,743	14,963	61,199	27,374	47,218	45,518	50,101	36,662	12,039	40,331	234,161	242,434	307,549
BOD (mt)	26,794	25,566	23,924	35,740	12,248	8,908	45,707	38,493	42,299	28,341	24,626	22,614	136,582	100,933	97,744
Oil/Grease (mt)	5,580	5,056	5,199	5,005	2,010	1,620	6,100	5,563	5,638	2,477	2,600	2,383	19,162	15,229	14,840
Ammonia-N (mt)	8,470	8,521	8,656	13,457	12,704	13,145	13,693	13,768	14,067	6,602	6,503	6,699	42,222	41,497	42,567
Nitrate-N (mt)	na	na	na	148	450	199	55	94	46	26	27	34	229	571	279
Nitrite-N (mt)	na	na	na	209	452	389	87	57	46	na	na	na	296	509	435
Organic-N (mt)	na	na	na	2,562	1,290	1,414	3,190	2,804	3,110	na	na	na	5,752	4,094	4,524
Total Phosphorus[a] (mt)	-	-	-	1,985	1,449	1,361	495	422	444	85	54	93	2,565	1,925	1,898
Phosphate	na	na	na	na	na	na	1,517	1,293	1,363	261	167	na	1,778	1,461	1,363
Phosphorus	na	na	na	1,985	1,449	1,361	na	na	na	na	na	na	1,985	1,449	1,361
ortho-Phosphate	na	na	na	na	na	na	na	na	na	na	na	285	0	0	285
Cyanide (mt)	nd	nd	nd	2.2	2.5	2.5	4.6	4.4	5.8	1.4	1.2	0.94	8.1	8.2	9.2
Arsenic (mt)	0.12	0.36	1.0	1.6	0.89	1.1	1.3	1.0	1.1	0.32	0.24	0.19	3.3	2.5	3.4
Cadmium (mt)	0.20	0.09	0.04	nd	nd	nd	0.39	0.08	0.04	0.04	nd	nd	0.6	0.16	0.08
Chromium (mt)	2.3	1.5	1.4	0.72	0.96	nd	6.1	1.3	3.4	0.20	nd	nd	9.3	3.8	4.8
Copper (mt)	13	12	13	17	6.9	5.0	12	11	13	13	15	21	55	46	51
Lead (mt)	0.11	0.32	0.64	0.14	nd	nd	0.39	nd	nd	0.42	nd	nd	1.1	0.32	0.6
Mercury (mt)	0.02	0.004	0.01	nd	nd	0.01	nd	0.02	nd	0.01	nd	nd	0.03	0.02	0.02
Nickel (mt)	8.1	7.4	9.0	4.8	5.0	2.4	22	15	20	0.19	nd	0.97	35	27	32
Selenium (mt)	0.09	1.03	1.97	nd	0.16	0.36	7.05	5.89	5.88	0.35	0.29	0.28	7.5	7.4	8.5
Silver (mt)	0.43	0.49	0.82	2.4	0.74	0.39	3.1	2.3	2.9	0.27	0.30	nd	6.2	3.9	4.1
Zinc (mt)	15	14	19	22	17	13	25	21	23	13	11	10	75	63	66
Phenols (mt)															
Chlorinated Phenols	0.15	0.09	0.05	nd	nd	nd	3.0	3.7	4.2	nd	nd	nd	3.1	3.8	4.2
Nonchlorinated Phenols	1.3	1.3	0.88	1.8	nd	nd	42	46	54	3.5	2.8	2.8	48	50	58
Total DDT (kg)	nd	nd	nd	nd	nd	nd	4.0	3.0	1.5	nd	nd	nd	4.0	3.0	1.5
Total PAH (kg)	nd	105	nd	nd	nd	nd	720	630	740	nd	nd	nd	720	735	740
Total PCB (kg)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0	0	0

[a] Total phosphorus is the sum of phosphorus, and the P component of phosphate and ortho-phosphate.

nd = Not detected.

na = Not analyzed.

Dash = Not applicable.

Table 3. Mean values and coefficients of variation (CV) of annually averaged constituent concentrations in effluent from the four large POTWs between 1998 and 2000.

	OCSD						HTP						JWPCP						PLWTP					
	1998		1999		2000		1998		1999		2000		1998		1999		2000		1998		1999		2000	
Constituent	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)	mean	CV (%)
Flow (mgd)	255	6	233	2	241	2	368	5	337	2	325	4	342	5	329	2	334	3	194	11	175	2	174	2
Flow (million L/day)	965	6	882	2	912	2	1393	5	1276	2	1230	4	1294	5	1245	2	1264	3	734	11	662	2	659	2
Suspended Solids (mg/L)	47	7	46	5	51	4	30	11	19	16	19	10	68	8	61	9	65	7	39	32	38	10	37	9
Settleable Solids (mL/L)	0.4	15	0.4	10	0.6	20	0.03	237	0.1	240	0.1	213	0.1	0	0.1	0	0.1	27	0.1	49	0.05	104	0.17	69
BOD (mg/L)	965	6	882	2	912	2	1393	5	1276	2	1230	4	1294	5	1245	2	1264	3	734	11	662	2	659	2
Oil/Grease (mg/L)	15.8	8	15.7	10	15.6	11	9.8	28	4.3	53	4	28	13	10	12	10	12	11	9.2	15	10.8	20	9.9	21
Ammonia-N (mg/L)	24	6	26	3	26	5	26.4	9	27.3	6	29.2	7	29.0	6	30.2	4	30.4	5	24.6	8	26.9	4	27.7	3
Nitrate-N (mg/L)	na	-	na	-	na	-	0.3	122	0.97	130	0.4	93	0.12	58	0.21	41	0.10	36	0.10	188	0.11	111	0.14	178
Nitrite-N (mg/L)	na	-	na	-	na	-	0.41	106	0.97	82	0.86	45	0.18	79	0.13	18	0.10	45	na	-	na	-	na	-
Organic-N (mg/L)	na	-	na	-	na	-	5	22	2.8	30	3.1	30	6.76	5	6.16	13	6.7	10	na	-	na	-	na	-
Phosphate (mg/L)	na	-	na	-	na	-	na	-	na	-	na	-	3.21	9	2.84	13	2.94	11	0.97	59	0.69	70	na	-
Phosphorus (mg/L)	na	-	na	-	na	-	3.90	9	3.11	11	3.02	7	na	-	na	-	na	-	na	-	na	-	na	-
ortho-Phosphate (mg/L)	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	1.18	63
Cyanide (ug/L)	< 5	-	< 1.3	-	< 4.1	-	4.2	94	5.5	66	5.5	61	10	23	9.7	29	12	38	5.2	34	5.1	35	3.9	25
Turbidity	37	4	38	6	40	13	25	27	10	11	8	13	52	7	48	9	49	7	32	9	36	11	38	9
Acute Toxicity (TUa)																								
Pimephales promelas (survival)	0.93	44	1.2	31	1.0	24	0.3	115	0.10	181	0.36	116	0.9	16	0.7	60	1.1	37	1.2	16	1.1	13	1.3	10
Chronic Toxicity (TUc)																								
P. promelas/C. dubia (growth/reproduction)	na	-	na	-	na	-	na	-	22	131	41	55	na	-	na	-	na	-	na	-	na	-	na	-
Pimephales promelas (survival/growth)	na	-	na	-	na	-	37	56	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Haliotis rufescens (development)	44.05	28	69.2	78	104.20	67	na	-	na	-	na	-	na	-	na	-	na	-	64	0	64	0	64	0
Macrocystis pyrifera (germ tube length)	na	-	na	-	na	-	na	-	na	-	na	-	15	132	45.1	27	42	0	120	141	214	102	72	27
Macrocystis pyrifera (germination)	na	-	na	-	na	-	na	-	na	-	na	-	12	156	41.7	2	42	0	80	52	64	0	92	46
Arsenic (ug/L)	0.3	234	1	128	3.02	30	3.06	57	2	30	2	53	2.7	13	2.3	11	2.3	14	1.2	17	1.01	12	0.80	26
Cadmium (ug/L)	0.6	27	0.3	82	0.1	90	< 2	-	< 2	-	< 2	-	0.8	124	0.2	234	0.09	346	0.2	170	< 1	-	< 1	-
Chromium (ug/L)	7	45	5	40	4.21	23	1.4	182	2	266	< 10	-	13	71	3	234	7.2	128	0.7	206	< 5	-	< 5	-
Copper (ug/L)	36	20	38	14	39.6	9	33.3	16	14.9	63	11.0	84	26	19	25	20	27	17	49	28	64	17	85	54
Lead (ug/L)	0.3	195	1	68	1.90	21	0.28	346	< 3	-	< 5	-	0.8	346	< 8	-	< 8	-	2	243	< 18	-	< 18	-
Mercury (ug/L)	0.04	239	0.01	154	0.03	23	< 0.3	-	< 0.3	-	0.03	346	< 1	-	0.04	346	< 0.5	-	0.04	149	< 0.27	-	< 0.27	-
Nickel (ug/L)	23	25	23	21	26.9	11	9.4	45	10.7	47	5.4	160	46	23	32	66	42	38	1	346	< 14	-	4.0	247
Selenium (ug/L)	0.3	346	3	96	5.9	21	< 1	-	0.34	187	0.8	94	14.9	10	13	25	12.7	21	1.3	20	1.2	10	1.18	10
Silver (ug/L)	1	84	2	70	2.5	17	4.7	33	1.59	51	0.86	120	7	46	5	63	6	36	1.0	275	1	234	< 6.6	-
Zinc (ug/L)	42	9	44	7	56.8	17	43.6	17	36	37	28.9	33	53	37	47	42	51	37	49	39	45	39	43	77
Phenols (ug/L)																								
Chlorinated Phenols	0.42	346	0.27	346	0.16	346	< 8	-	< 8	-	< 8	-	6.3	107	8	98	9	140	< 6.1	-	< 6.1	-	< 6.1	-
Nonchlorinated Phenols	3.6	53	4.0	31	2.6	76	3.6	14	< 31	-	< 31	-	88	70	100	47	120	36	13.0	28	11.7	12	11.7	18
Total DDT (ug/L)	< 0.04	-	< 0.02	-	<0.02	-	< 0.01	-	< 0.01	-	< 0.01	-	0.008	86	0.007	133	0.003	195	< 0.04	-	< 0.04	-	< 0.04	-
Total PAH (ug/L)	< 2.0	-	0.3	346	< 2	-	< 2	-	< 2	-	< 2	-	2	115	1	96	2	97	< 7.8	-	< 7.8	-	< 7.8	-
Total PCB (ug/L)	< 0.20	-	< 0.2	-	< 0.2	-	< 0.065	-	< 0.065	-	< 0.065	-	< 0.9	-	< 0.9	-	< 0.9	-	< 0.6	-	< 0.6	-	< 0.6	-

Dash = Not applicable.

na = Not analyzed.

< = Less than the maximum reporting limit, or MDL, provided (MDLs used for those facilities which did not report RLs).

tration of arsenic (3.06 ug/L) was discharged by HTP in 1998; the highest concentration of zinc (56.8 ug/L) was discharged by OCSD in 2000; and the highest concentrations of lead (2 ug/L) and copper (85 ug/L) were discharged by PLWTP in 1998 and 2000, respectively. The concentrations of most metals at HTP also decreased notably after 1998.

Concentrations of several general constituents in effluent from HTP decreased between 1998 and 2000 (Table 3). In 1998, the concentrations of suspended solids and BOD at HTP were comparable to concentrations being discharged by the other three facilities. In 1999 and 2000, however, these concentrations dropped by 33% and 75%, respectively. In 1998, effluent from PLWTP had the lowest concentrations of oil/grease when compared to effluent from the other three facilities. In 1999 and 2000, the lowest concentrations of oil/grease were found in HTP effluent, where the concentration of this constituent had decreased by 60%.

Large POTWs did not detect most organic constituents between 1998 and 2000 (Table 3). Detectable concentrations of all organic compounds, with the exception of total PCBs, were found in effluent from JWPCP for all three years. PAHs were also detected in the effluent from OCSD in 1999 (0.3 ug/L). Non-chlorinated phenols were the most frequently detected organic compounds and were detected by all facilities during all years, with the exception of HTP, where non-chlorinated phenols were only detected in 1998. No organic constituents were detected in effluents from HTP after 1998. Total PCBs were not detected by any of the facilities between 1998 and 2000.

All four facilities utilized the species *Pimephales promelas* (fathead minnow) for acute toxicity bioassays (Table 3). Acute toxicity levels varied by one order of magnitude between 1998 and 2000, ranging from 0.1 TUa (HTP 1999) to 1.3 TUa (PLWTP 2000). Four species were used for chronic toxicity testing by the individual facilities (Table 3). Chronic toxicity levels varied by one order of magnitude among the facilities, and ranged from 12 TUc (JWPCP 1998) to 214 TUc (PLWTP 1999).

Statistical Changes in Mass Emissions Between 1998 and 2000

Statistical analysis of the individual facility emissions for the years 1998 and 2000 revealed several significant changes in constituent emissions during this time period, 75% of which were decreases (Table 4). Changes in constituent emissions occurred predominantly in effluents from HTP, which had significant decreases in emissions of suspended solids (46%), BOD (75%), oil/grease (68%), organic-nitrogen (45%), phosphorus (31%), copper (71%), silver (84%), zinc (41%), and non-chlorinated phenols (decreased to non-detected values). Since 1998, OCSD showed significant decreases in emissions of BOD (11%) and cadmium (80%), while showing significant increases in emissions of arsenic (741%), lead (455%), selenium (2,023%), and zinc (29%). These changes in mass emissions were not noticeably influenced by variations in RLs due to constituent analysis method changes.

Historical Trends

Since 1971, the cumulative flow from large POTWs has gradually increased an overall 16%, although notable perturbations in this trend occurred in the late 1970s and in the early 1990s (Figure 2, Table 5). Although the cumulative flow from large POTWs has increased since 1971, cumulative mass emissions for trace metals have declined drastically (Figure 3). Since 1990, though, discharges of trace metals have remained relatively stable. Changes in emissions of trace metals since 1971 range from decreases of 33% for selenium to almost 100% for cadmium, chromium, lead, and mercury.

Cumulative emissions of general constituents have also declined considerably since 1971 (Figure 4), with decreases ranging from 10% (nitrate-N) to almost 100% (total phosphorus). After large decreases in general constituents between 1971 and 1988, emissions of general constituents remained stable until 1998. However, these constituents seem to have declined again in 1999-2000, with decreases in cumulative facility emissions between 1998 and 2000 ranging from approximately 14% for suspended solids to 28% for BOD.

Cumulative emissions of organic compounds have also dramatically declined since 1971 (Figure 5). Total DDT emissions decreased nearly 100% during this time period, and emissions of total PCBs have not changed since decreasing to non-detectable levels in 1988.

There do not appear to be any discernible historical trends in acute toxicity results (Figure 6).

DISCUSSION

Concomitant with increases in population, the cumulative flow of the large POTWs has increased since 1971 (Figure 4, Table 5). Between 1971 and

Table 4. Results of statistical analysis of 1998 and 2000 constituent mass emissions for each of the large POTWs.

Constituent	Statistics Test Used	Higher Year	P Value	Significant Change*	Constituent	Statistics Test Used	Higher Year	P Value	Significant Change*
OCSD					**PLWTP**				
Suspended Solids	t-test	2000	0.5845		Suspended Solids	t-test	1998	0.3035	
BOD	Signed rank test	1998	0.0005	D	BOD	Signed rank test	1998	0.0005	
Oil/Grease	t-test	1998	0.0304		Oil/Grease	t-test	1998	0.6333	
Ammonia-N	t-test	2000	0.1692		Ammonia-N	t-test	2000	0.4174	
Cyanide	-	-	-		Nitrate-N	t-test	2000	0.7532	
Arsenic	Signed rank test	2000	0.0005	I	Cyanide	t-test	1998	0.0205	
Cadmium	Signed rank test	1998	0.0005	D	Arsenic	Signed rank test	1998	0.0005	D
Chromium	t-test	1998	0.0073		Cadmium	t-test	1998	0.0663	
Copper	Signed rank test	2000	0.1763		Chromium	t-test	1998	0.1243	
Lead	Signed rank test	2000	0.0005	I	Copper	t-test	2000	0.0768	
Mercury	t-test	1998	0.6297		Lead	t-test	1998	0.1762	
Nickel	t-test	2000	0.2162		Mercury	t-test	1998	0.0393	
Selenium	Signed rank test	2000	0.0005	I	Nickel	t-test	2000	0.3182	
Silver	t-test	2000	0.0047		Selenium	t-test	1998	0.0380	
Zinc	t-test	2000	0.0003	I	Silver	t-test	1998	0.2348	
Nonchlorinated Phenols	t-test	1998	0.1064		Zinc	t-test	1998	0.4016	
Chlorinated Phenols	t-test	1998	0.5462		Chlorinated Phenols	-	-	-	
Total DDT	-	-	-		Nonchlorinated Phenols	t-test	1998	0.0829	
Total PCB	-	-	-		Total DDT	-	-	-	
					Total PCB	-	-	-	
HTP					**JWPCP**				
Suspended Solids	Signed rank test	1998	0.0005	D	Suspended Solids	t-test	1998	0.0765	
BOD	Signed rank test	1998	0.0005	D	BOD	t-test	1998	0.0243	
Oil/Grease	Signed rank test	1998	0.0005	D	Oil/Grease	t-test	1998	0.0396	
Ammonia-N	t-test	1998	0.3201		Ammonia-N	t-test	2000	0.2620	
Nitrate-N	t-test	2000	0.4498		Nitrate-N	t-test	1998	0.4238	
Nitrite-N	t-test	2000	0.1004		Nitrite-N	t-test	1998	0.1056	
Organic-N	t-test	1998	0.0009	D	Organic-N	t-test	1998	0.5237	
Phosphorus	Signed rank test	1998	0.0005	D	Cyanide	t-test	2000	0.0718	
Cyanide	t-test	2000	0.6841		Arsenic	t-test	1998	0.0250	
Arsenic	t-test	1998	0.1864		Cadmium	t-test	1998	0.0451	
Cadmium	-	-	-		Chromium	t-test	1998	0.1421	
Chromium	t-test	1998	0.0831		Copper	Signed rank test	2000	0.4697	
Copper	Signed rank test	1998	0.0010	D	Lead	t-test	1998	0.3388	
Lead	t-test	1998	0.3388		Mercury	-	-	-	
Mercury	t-test	2000	0.3388		Nickel	t-test	1998	0.4961	
Nickel	t-test	1998	0.0708		Selenium	t-test	1998	0.0016	D
Selenium	t-test	2000	0.0038		Silver	t-test	1998	0.6922	
Silver	Signed rank test	1998	0.0005	D	Zinc	Signed rank test	1998	0.6221	
Zinc	Signed rank test	1998	0.0010	D	Chlorinated Phenols	t-test	2000	0.4531	
Chlorinated Phenols	-	-	-		Nonchlorinated Phenols	t-test	2000	0.0235	
Nonchlorinated Phenols	t-test	1998	0.0004	D	Total DDT	t-test	1998	0.0100	
Total DDT	-	-	-		Total PCB	-	-	-	
Total PCB	-	-	-						

* Significance assumed for P value less than 0.002; null records indicate the change was not significant.

Dash = Not included in statistical analyses since constituent not detected in effluent for given year.

I = Increase in mass emissions from 1998 to 2000.

D = Decrease in mass emissions from 1998 to 2000.

2000, the population in the four coastal counties that comprise the SCB increased by 5.8 million (57%). In response, large POTW flow has increased by 200 x 10^9 L/yr (16 %). Despite these increases in population and flow, mass emissions for most constituents have decreased over the same time period (Figures 4-6, Table 5). For example, suspended solids decreased by 230,000 mt (78%), combined trace metals decreased by over 3500 mt (95%), and total DDT and total PCB decreased by more than 21 mt and 8 mt, respectively (>99.9% each). These reductions have largely been the result of increased and improved treatment processes, land disposal of biosolids, source control, and reclamation or reuse of wastewater. Historically notable decreases in mass emissions can be attributed to specific pollution control measures

(Schafer 1989), such as the ban on DDT and PCB in the early 1970s, the phase-out of lead in the 1980s, and the cessation of biosolids disposal in Santa Monica Bay in 1987. In fact, the dramatic declines over the last three decades have been cited as one of the best examples of environmental stewardship around the country (Boesch *et al.* 2001).

Probably the most significant advance in pollution control during this study period was the conversion of HTP from blended advanced primary/secondary treatment (ca. 50/50) to full secondary treatment in December 1998. This management action cost the City of Los Angeles over $1 billion and took more than 10 years to complete. The result of this infrastructure improvement led to a significant decrease in concentrations and mass emissions of most constituents within one year. For example, suspended solids decreased nearly 7,000 mt (46%), BOD decreased over 26,800 mt (75%), and oil and grease decreased approximately 3,400 mt (68%). Similar reductions in toxic constituents could also be observed. For example, copper decreased 12 mt (71%), zinc decreased 9 mt (42%), and lead decreased 0.14 mt (non-detectable concentrations). These clearly represent substantial reductions over a very short time span.

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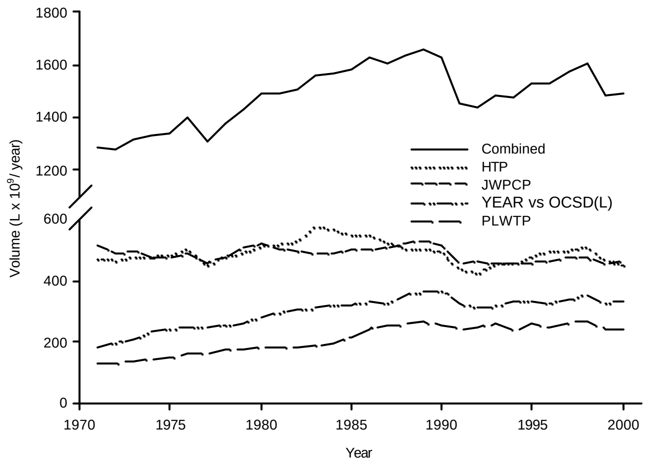

Figure 2. Individual and combined effluent volumes for the large POTWs from 1971 through 2000.

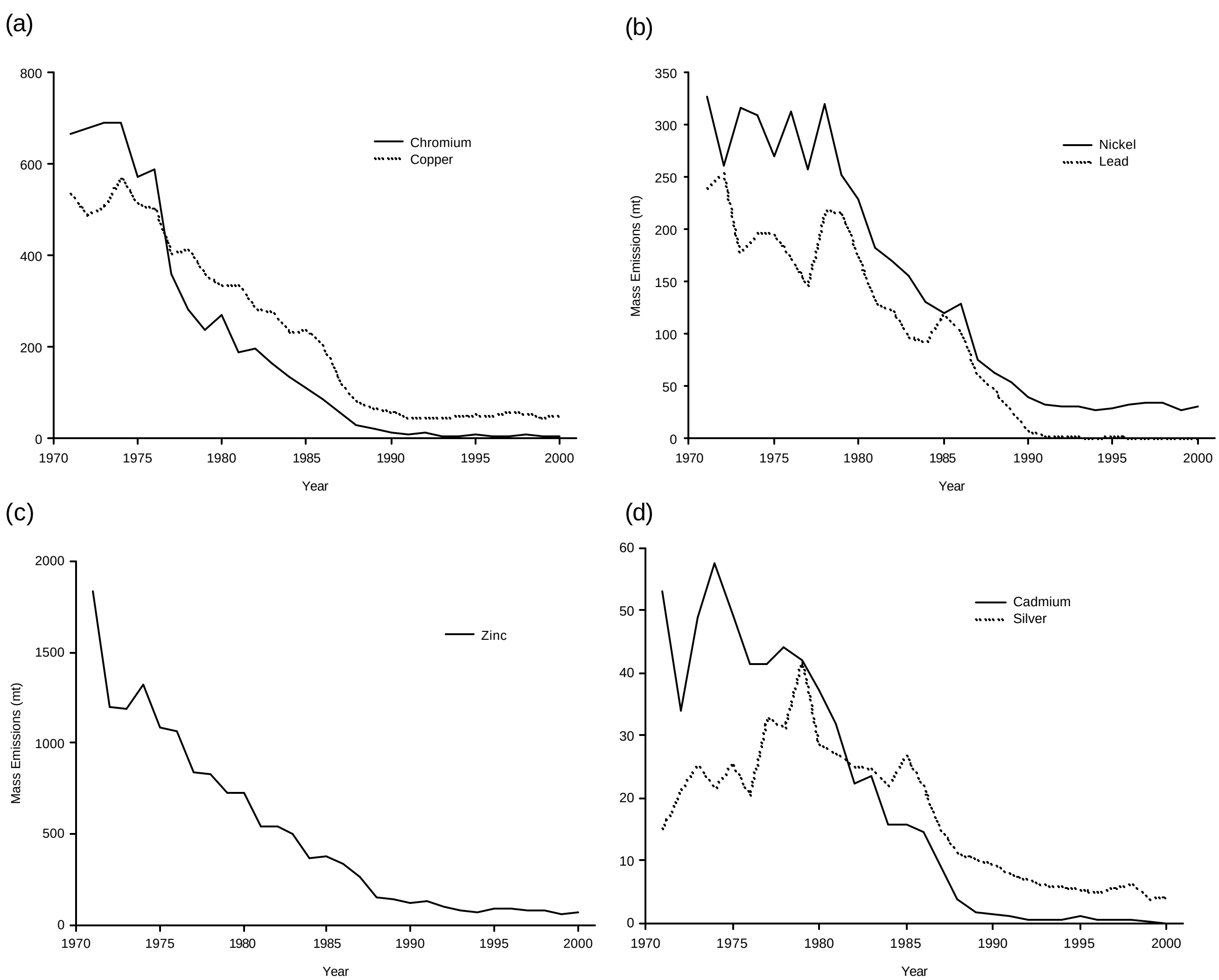

Figure 3. Combined estimated mass emissions of trace metals (b) nickel and lead, (a) chromium and copper, (c) zinc, and (d) cadmium and silver, from large POTWs between 1971 and 2000.

Table 5. Estimated combined mass emissions the large POTWs for selected years from 1971 through 2000.

Constituent	1971[a]	1976[a]	1981[a]	1986[a]	1991[a]	1996[a]	1997[a]	1998	1999	2000
Volume (L x 10^9)	1,289	1,402	1,491	1,624	1,455	1,528	1,571	1,602	1,485	1,489
Flow (mgd)	932	1,013	1,079	1,176	1,054	1,103	1,137	1,159	1,074	1,074
Suspended Solids (mt x 10^3)	295	285	224	185	79	70	75	75	61	65
BOD[b] (mt x 10^3)	282	255	261	182	139	127	137	137	101	98
Oil/Grease (mt x 10^3)	63	57	36	29	19	18	20	19	15	15
Nitrate-N (mt x 10^3)	0.31	0.14	0.21	0.41	0.24	0.30	0.15	0.23	0.57	0.28
Nitrite-N (mt x 10^3)	0.16	0.01	0.03	0.07	0.11	0.10	0.07	0.30	0.51	0.44
Ammonia-N (mt x 10^3)	54	37	41	45	44	41	42	42	41	43
Organic-N (mt x 10^3)	17	13	12	11	6.0	5.2	5.5	5.8	4.1	4.5
Total P[c] (mt x 10^3)	11.7	9.7	9.5	9.2	6.0	3.4	3.6	2.6	1.9	1.9
MBAS (mt x 10^3)	6.7	6.1	5.6	4.8	3.5	-[d]	-[d]	-[d]	-[d]	-[d]
Cyanide (mt)	194	244	91	27	16	10	9.8	8.1	8.2	9.2
Arsenic (mt)	7.9	11	11	12	5.4	4.2	3.2	3.3	2.5	3.4
Cadmium (mt)	53	42	32	14	1.2	0.42	0.41	0.63	0.16	0.08
Chromium (mt)	666	591	187	86	10	6.5	4.3	9.3	3.8	4.8
Copper (mt)	535	504	336	203	47	49	59	55	46	51
Lead (mt)	240	173	130	104	2.4	1.2	0.76	1.1	0.32	0.64
Mercury (mt)	2.9	2.5	1.3	0.71	0.23	0.03	0.03	0.03	0.02	0.02
Nickel (mt)	327	313	183	130	33	33	35	35	27	32
Selenium (mt)	13	20	5.8	8.1	7.1	7.4	8.3	7.5	7.4	8.5
Silver (mt)	15	20	27	22	8.0	4.9	5.6	6.2	3.9	4.1
Zinc (mt)	1,834	1,055	538	341	125	90	81	75	63	66
DDT[e] (kg)	21,580	1,640	498	50	6.4	1.4	2.1	4.0	3.0	1.5
PCB[e] (kg)	8,946	4,672	1,247	35	-[f]	-[f]	-[f]	-[f]	-[f]	-[f]

[a]Reproduced from Raco-Rands and Steinberger (2001).
[b]Hyperion's 7-mile outfall is not included (applicable to years prior to 1987).
[c]Sum of total phosphorus (Htp), phosphate-P (JWPCP), and soluble phosphate-P (PLWTP).
[d]Analyses discontinued.
[e]Estimates for OCSD for 1971 were based on Bodega Bay Marine Laboratories and University Washington analyses, except DDT estimates for JWPCP were based on JWPCP's own analyses. Estimates for PLWTP for 1976 were based on SCCWRP analyses. Estimates for remaining years are based on discharger data. No analyses were used for PLWTP for 1971.
[f]Concentrations were below method detection limits.
MBAS = Methylene blue active substances.

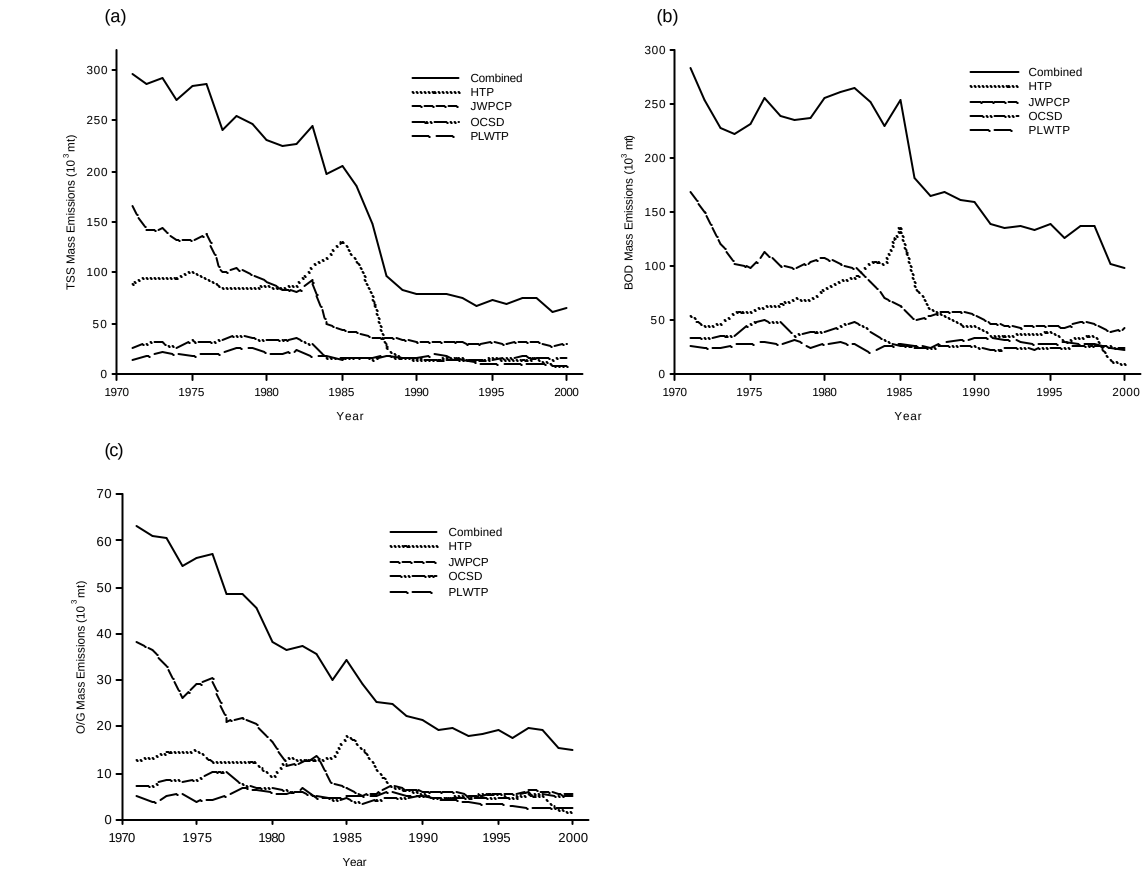

Figure 4. Individual and combined estimated mass emissions of (a) suspended solids (TSS), (b) BOD, and (c) oil/grease (O/G) from large POTWs between 1971 and 2000 from large POTWs.

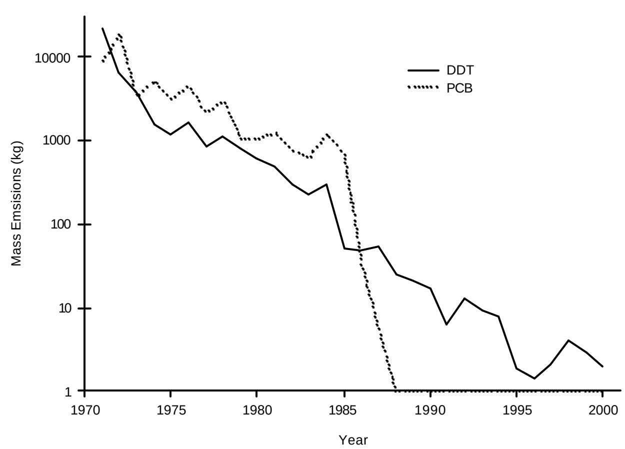

Figure 5. Combined estimated mass emissions of total DDT and total PCB from large POTWs between 1971 and 2000.

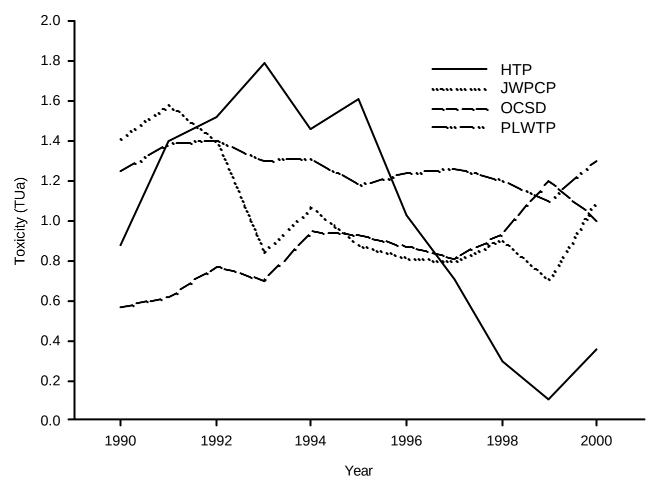

Figure 6. Acute toxicity to the test species, Pimephales promelas, of effluents from the large POTWs between 1971 and 2000.

Appendix I. Analytical methods used for constituent analyses conducted by the individual large POTWs and/or contract laboratories for 1998-2000.

	OCSD			HTP			JWPCP		
Constituent	1998	1999	2000[a]	1998	1999	2000	1998	1999	2000
Suspended Solids	nf	nf	nf	SM 2540 D	SM 2540 D	SM 2540 D	SM 2540 D	SM 2540 D	SM 2540 D
Settleable Solids	EPA 160.5	EPA 160.5	EPA 160.5	nf	nf	nf	SM 2540 F	SM 2540 F	SM 2540 F
BOD	EPA 405.1	EPA 405.1	EPA 405.1	SM 5210	SM 5210	SM 5210 B	SM 5210 B	SM 5210 B	SM 5210 B
Oil/Grease	EPA 413.1	EPA 413.1	EPA 413.1	na	EPA 1664	EPA 1664	SM 5520 B	SM 5520 B	SM 5520 B
Ammonia-N	EPA 350.1	EPA 350.1	EPA 350.1	SM 4500-NH3 E	SM 4500-NH3 E	SM 4500-NH3 B E	SM 4500 NH3 B/E	SM 4500 NH3 B/E	SM 4500 NH3 B/E
Nitrate-N	na	na	na	SM 4500-NO3 E	SM 4500-NO3 E	SM 4500-NO3 E	SM 4500 NO3 E	SM 4500 NO3 E	SM 4500 NO3 E
Nitrite-N	na	na	na	calc	calc	calc	SM 4500 NO2	SM 4500 NO2	SM 4500 NO2
Organic-N	na	na	na	SM 4500Norg B	SM 4500Norg B	SM 4500Norg B	SM 4500 Norg/ SM 4500 NH3 B/E	SM 4500 Norg/ SM 4500 NH3 B/E	SM 4500 Norg/ SM 4500 NH3 B/E
Phosphate,T	na	na	na	na	na	na	SM 4500 P B,5/E	SM 4500 P B,5/E	SM 4500 P B,5/E
Phosphorus	na	na	na	SM 4500-P	SM 4500-P	SM 4500-P B5 E	na	na	na
Ortho-Phosphate	na	na	na	na	na	na	na	na	na
Cyanide	EPA 335.2	EPA 335.2	EPA 335.2	SM 4500-CN C&E	SM 4500-CN C&E	SM 4500-CN E	SM 4500 CN B/C/E	SM 4500 CN B/C/E	SM 4500 CN B/C/E
Turbidity	EPA 180.1	EPA 180.1	EPA 180.1	nf	nf	nf	SM 2130 B	SM 2130 B	SM 2130 B
Acute Toxicity									
Pimephales promelas (survival)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Chronic Toxicity									
P. promelas/C. dubia (growth/reproduction)	na	na	na	na	(d)	(d)	na	na	na
Pimephales promelas (survival/growth)	na	na	na	(d)	na	na	na	na	na
Haliotis rufescens (development)	(c)	(c)	(c)	na	na	na	na	na	na
Macrocystis pyrifera (germ tube length)	na	na	na	na	na	na	(e)	(e)	(e)
Macrocystis pyrifera (germination)	na	na	na	na	na	na	(e)	(e)	(e)
Arsenic	EPA 204.2	EPA 204.2	EPA 204.2,200.8	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B 4,d	SM 3114 B 4,d	SM 3114 B 4,d
Cadmium	EPA 213.2	EPA 213.2	EPA 213.2,200.8	SM 3120 B	SM 3120 B	SM 3120 B	SM 3111 B	SM 3111 B	SM 3111 B
Chromium	EPA 218.2	EPA 218.2	EPA 218.2,200.8	SM 3120 B	SM 3120 B	SM 3120 B	EPA 218.1	EPA 218.1	EPA 218.1
Copper	EPA 200.7	EPA 200.7	EPA 200.7,200.8	SM 3120 B	SM 3120 B	SM 3120 B	SM3111 B	SM3111 B	SM3111 B
Lead	EPA 239.2	EPA 239.2	EPA 239.2,200.8	SM 3113 B	SM 3113 B	SM 3113 B	SM3111 B	SM3111 B	SM3111 B
Mercury	EPA 245.1	EPA 245.1	EPA 245.1	SM 3112 B	SM 3112 B	SM 3112 B	SM 3112 B	SM 3112 B	SM 3112 B
Nickel	EPA 249.2	EPA 249.2	EPA 249.2,200.8	SM 3120 B	SM 3120 B	SM 3120 B	SM3111 B	SM3111 B	SM3111 B
Selenium	EPA 270.2	EPA 270.2	EPA 270.2,200.8	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B
Silver	EPA 272.2	EPA 272.2	EPA 272.2,200.8	SM 3113 B	SM 3113 B	SM 3113 B	SM3111 B	SM3111 B	SM3111 B
Zinc	EPA 200.7	EPA 200.7	EPA 200.7,200.8	SM 3120 B	SM 3120 B	SM 3120 B	SM3111 B	SM3111 B	SM3111 B
Phenols	na	na	na	na	na	na	na	EPA 625	EPA 625
Chlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625
Nonchlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625
Total DDT	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608
Total PAH	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625	EPA 625
Total PCB	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608

[a] OCSD switched metals analysis methods in February 2000; where there are two numbers, the second number represents the method used during the latter portion of the year.

(b) - (U.S. EPA 1985).

(c) - (U.S. EPA 1995).

(d) - (SWRCB-Cal EPA 1997).

(e) - (SWRCB 1990).

na = Not analyzed.

nf = Not found.

"SM" refers to protocols found in the Standard Methods for the Examination of Water and Wastewater (Clesceri 1992).

"EPA" refers to protocols established in the California Ocean Plan: Water Quality Control Plan, Ocean Water of California (SWRCB-Cal EPA).

Appendix II. Reporting limits used for constituent analyses by the large POTWs and/or their respective contract laboratories for 1998-2000.

	1998				1999				2000			
Constituent	HYP[c]	OCSD	JWPCP	PLWTP[c]	HYP[c]	OCSD[c]	JWPCP	PLWTP	HYP[c]	OCSD[c]	JWPCP	PLWTP
Suspended Solids (mg/L)	np	np	np	np	np	9.6	np	np	np	np	np	1.6
Settleable Solids (mL/L)	0.1	np	np	np	0.1	np	np	0.1[b]	0.1	np	np	0.1
BOD (mg/L)	np	np	np	np	np	np	np	np	np	np	np	2
Oil/Grease (mg/L)	np	np	np	np	np	np	np	np	np	np	np	1.4
Nitrate-N (mg/L)	np	np	0.05	0.03	np	np	0.05[a]	0.03	np	np	0.05[a]	0.03
Nitrite-N (mg/L)	0.01	na	np	np	np	na	0.005[a]	np	np	na	0.005[a]	np
Ammonia-N (mg/L)	np	np	np	np	np	np	0.1[a]	1.6	np	np	0.1[a]	0.2
Phosphate (mg/L)	np	np	na	0.05	np	np	0.16[a]	0.05	np	np	na	na
ortho-Phosphate (mg/L)	na	na	na	na	na	na	na	na	na	na	na	0.05
Cyanide (ug/L)	2,4	5	np	2	2	1.3	10[a]	2	2	4.1	10[a]	2
Acute Toxicity (TUa)												
Pimephales promelas (survival)	np	np	np	np	np	np	np	np	np	np	np	np
Chronic Toxicity (TUc)												
Macrocystis pyrifera (germ tube length)	na	na	16.7	np	na	na	np	np	na	na	np	np
Macrocystis pyrifera (germination)	na	na	16.7	np	na	na	np	np	na	na	np	np
P. promelas/C. dubia (growth/reproduction)	na	na	na	na	15	na	na	na	np	na	na	na
Pimephales promelas (survival/growth)	16	na	na	na	na	na	na	na	na	na	na	na
Haliotis rufescens (development)	na	np	na	na	na	np	na	na	na	np	na	na
Strongylocentrotus purpuratus (fertilization)	na	na	na	na	na	na	na	na	na	np	na	na
Mysidopsis bahia (biomass)	na	na	na	na	na	na	na	na	na	na	np	na
Mysidopsis bahia (survival)	na	na	na	na	na	na	na	na	na	na	np	na
Arsenic (ug/L)	np	2	np	0.18		0.19,0.46	1[a]	0.18	1	0.47	1[a]	0.18
Cadmium (ug/L)	2	np	1	1	2	0.02,0.16	1	1	1,2	0.16	1	1[b]
Chromium (ug/L)	4	np	12	5	4	0.02,0.16	12	5	4,10	0.17	12	5[b]
Copper (ug/L)	np	np	np	4	10	0.16,0.82	10[a]	4	10	0.47	10[a]	4
Lead (ug/L)	3	2	8	18	3	0.17,0.33	8	18	3,5	0.31	8	18[b]
Mercury (ug/L)	0.3	0.2,10	0.5,1	0.27	0.3	0.004,0.42	0.5,1	0.27	0.3	0.0038	0.5	0.27[b]
Nickel (ug/l)	5	np	np	14	5	0.33,0.82	25	14	5,20	0.69	10, 20[a]	14[b]
Selenium (ug/L)	1	2	np	0.4	1	0.14,0.23	1[a]	0.4	1	0.14	1[a]	0.4
Silver (ug/L)	np	2	5	6.6	0.4	0.16	5	6.6	0.6	0.41	5	6.6[b]
Zinc (ug/L)	np	np	np	4	np	0.17,0.41	32	4	np	5	15[a]	4
Phenols (mg/L)												
Chlorinated Phenols (ug/L)												
2,4,6-trichlorophenol	3	1.7	1,2,4,10	3.4	3	1.7,1.9	1,2	3.4	3	0.57,1.7	1,5	3.45
2,4-dichlorophenol	3	1.9	1,10	6.1	3	1.7,1.9	1,2	6.1	3	0.86,1.9	1,5	6.1
2-chlorophenol	2	2	1,10	3.6	2	1.9,2	1	3.6	2	1.3,2	1,5	3.6
4-chloro-3-methylphenol	2	1.9	1,10	3.6	2	1.9	1,2	3.6	2	1.9,2.6	1,5	3.6
Pentachlorophenol	8	1.7	1,20	1.6	8	1.7	1,2	1.6[b]	8	1.7,2	1,5	1.6[b]
Nonchlorinated Phenols (ug/L)												
Phenol	np	1.9	1	1.8	1	1.6,1.9	1	3.6	1	1.9,2	1[a]	3.6
2,4-dimethylphenol	3	1.7	np	4.6	3	1.7,1.9	1,2	4.6	3	1.7,3.3	1	4.6
2,4-dinitrophenol	31	2	6,100	3.3	31	1.7,2	6	3.3	31	1.8,2	6,30	3.375
2-methyl-4,6-dinitrophenol	6	1.7	1,100	3	6	1.7,5	1	3	6	1.3,1.7	1,5	3.15
2-nitrophenol	3	1.9	1,10	4.5	3	1.9,2	1	4.5	3	1.1,1.9	1,5	4.5
4-nitrophenol	5	5	1,20	6.1	5	2,5	1	6.1	5	5	1,5	6.1
Total DDT (ug/L)												
o,p'-DDD	0.01	0.02	0.02	0.02	0.01	0.007,0.011	0.02	0.02	0.01	0.011	0.02	0.02
o,p'-DDE	0.002	0.02	0.03	0.04	0.002	0.008,0.01	0.03	0.04	0.002	0.01	0.03	0.04
o,p'-DDT	0.002	0.01	0.02	0.02	0.002	0.009,0.02	0.02	0.02	0.002	0.02	0.02	0.02
p,p'-DDD	0.002	0.04	0.02	0.03	0.002	0.006,0.009	0.02	0.03	0.002	0.009	0.02	0.03
p,p'-DDE	0.002	0.01	0.01	0.02	0.002	0.005,0.007	0.01	0.02	0.002	0.007	0.01	0.02
p,p'-DDT	0.002	0.04	0.02	0.02	0.002	0.013,0.019	0.02	0.02	0.002	0.019	0.02	0.02
Total PCB (ug/L)												
arochlor-1016	0.046	0.2	0.5	0.6	0.046	0.2,0.23	0.5	0.6	0.046	0.2	0.5	0.6
arochlor-1221	0.034	0.2	0.8	np	0.034	0.2	0.8	np	0.034	0.2	0.8	np
arochlor-1232	0.033	0.2	0.5	np	0.033	0.2	0.5	np	0.033	0.2	0.5	np
arochlor-1242	0.04	0.2	0.9	0.07	0.04	0.2	0.9	0.07	0.04	0.2	0.9	0.07
arochlor-1248	0.057	0.2	0.8	np	0.057	0.2	0.08	np	0.057	0.2	0.08	np
arochlor-1254	0.025	0.2	0.4	np	0.025	0.2	0.4	np	0.025	0.2	0.4	np
arochlor-1260	0.065	0.2	0.1	0.3	0.065	0.2	0.1	0.3	0.065	0.2	0.1	0.3
Total PAH (ug/L)												
Acenaphthene	1	0.76	1,10	1.2	1	0.61,0.76	1	1.2	1	0.76,0.85	1,5	1.2
Acenaphthylene	1	0.61	1,10	0.9	1	0.61,1	1	0.9	1	0.61,0.85,0.86	1,5	0.9
Anthracene	1	1	0.24,1,10	1.2	1	0.98,1	0.24,1	1.2	1	1	0.24,1,5	1.2
Benzo(a)anthracene	1	1.8	0.016,1,10	1.2	1	1.8,1.9	0.016,1	1.2	1	0.41,1.8	0.016,1,5	1.2
Benzo(a)pyrene	1	1.9	0.013,1,10	7.4	1	1.8,1.9	0.013,0.2	7.4	1	0.47,1.9	0.013,1,0.2	0.2,7.4
Benzo(b)fluoranthene	1	1.6	0.017,1,10	0.8	1	1.6,2	0.017,1	0.8	1	0.63,1.6	0.017,1,5	0.8
Benzo(g,h,i)perylene	1.5	1.6	0.025,1,20	7	1.5	1.6,1.9	0.025,1	7	1.5	0.5,1.6	0.025,1,5	7
Benzo(k)fluoranthene	1	1.8	0.008,1,10	1	1	1.6,1.8	0.008,1	1	1	0.71,1.8	0.008,1,5	1
Chrysene	1	2	0.021,1	1.4	1	1.8,2	0.021,1	1.4	1	0.44,2	0.021,1	1.4
Dibenzo(a,h)anthracene	1.5	1.9	0.023,1,20	7.8	1.5	1.5,1.9	0.023,1	7.8	1.5	0.55,1.9	0.023,1,5	7.8
Fluoranthene	1	1.9	1,10	1.3	1	1,1.9	1	1.3	1	0.7,1.9	1,5	1.3
Fluorene	1	0.84	0.25,1,10	1.1	1	0.76,0.84	0.25,1	1.1	1	0.69,0.84	0.25,1,5	1.1
Indeno[1,2,3-cd]pyrene	1.5	1.5	0.017,1,20	7.4	1.5	1.5,1.9	0.017,1	7.4	1.5	1.5	0.017,1,5	7.4
Naphthalene	2	1	1,10	1.6	2	1,1.9	1	1.6	2	1,1.6	1,5	1.6
Phenanthrene	1	0.98	0.25,1,10	0.9	1	0.84,0.98	0.25,1	0.9	1	0.46,0.98	0.25,0.5,1	0.9
Pyrene	1	1.9	0.038,1,10	1.5	1	1.9	0.038,1	1.5	1	0.76,1.9	0.038,1,5	1.5

[a] Values given are method detection limits, no reporting level provided.

[b] Value for given facility reported as a reporting level, rest of values are method detection limits.

[c] Values are method detection levels except where otherwise noted.

na = Not analyzed.

np = Not provided in monitoring report, all samples detected.

Appendix III. Frequency of constituent analysis conducted by the large POTWs and/or their contract laboratories for 1998-2000.

	1998				1999				2000			
Constituent	OCSD	HTP	JWPCP	PLWTP	OCSD	HTP	JWPCP	PLWTP	OCSD	HTP	JWPCP	PLWTP
Suspended Solids	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	29/month, Daily[a]
Settleable Solids	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	29/month, Daily[a]
BOD	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	24/month, Daily[a]
Oil/Grease	7/month	Weekly	Daily, 7/month[a]	Daily	Daily	4/month	Daily	Daily	Daily	Weekly	Daily	17/month, Daily[a]
Ammonia-N	7-8/month	Monthly	Monthly	Weekly	7-10/month	Monthly	Monthly	Weekly	9-23/month	Monthly	Monthly	3-4/month
Nitrate-N	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	1-4/month
Nitrite-N	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	na
Organic-N	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	Monthly	na	Monthly	Monthly	na
Nitrogen	1-2/month	na	na	na	na	na	na	na	na	na	na	na
Phosphate	na	na	Monthly	Monthly	na	na	Monthly	Monthly	na	na	Monthly	na
Phosphorus	na	Monthly	na	Monthly	na	Monthly	na	Monthly	na	Monthly	na	na
ortho-Phosphate	na	na	na	na	na	na	na	na	na	na	na	1-4/month
Cyanide	Monthly	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	3-4/month
Turbidity	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Acute Toxicity (TUa)												
Pimephales promelas (survival)	Monthly	Monthly	Monthly	Monthly	1-6/month	Monthly	Monthly	Monthly	1-2/month	Monthly	Monthly	Monthly
Chronic Toxicity (TUc)												
P. promelas/C. dubia (growth/reproduction)	na	na	na	na	na	Monthly	na	na	na	Monthly	na	na
Pimephales promelas (survival/growth)	na	Monthly	na	na	na	na	na	na	na	na	na	na
Haliotis rufescens (development)	Monthly	na	na	Monthly	1-4/month	na	na	Monthly	5/year	na	na	Monthly
Macrocystis pyrifera (germ tube length)	na	na	Monthly	Monthly	na	na	Monthly	Monthly	na	na	Monthly	Monthly
Macrocystis pyrifera (germination)	na	na	Monthly	Monthly	na	na	Monthly	Monthly	na	na	Monthly	Monthly
Arsenic	Monthly	Monthly	Monthly	Weekly	1-4/month	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	3-4/month
Cadmium	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Chromium	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Copper	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Lead	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Mercury	Monthly	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	3-4/month
Nickel	3/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Selenium	Monthly	Monthly	Monthly	Weekly	1-4/month	Monthly	Monthly	Weekly	Monthly	Monthly	Monthly	3-4/month
Silver	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Zinc	1-8/month	Monthly	Monthly	Weekly	1-7/month	Monthly	Monthly	Weekly	4/month	Monthly	Monthly	3-4/month
Phenols	na	na	na	na	na	na	Quarterly	na	na	na	Monthly	na
Chlorinated Phenols	Monthly	Quarterly	Monthly	Weekly	1-4/month	Quarterly	Monthly	Weekly	Monthly	Quarterly	Monthly	3-4/month
Nonchlorinated Phenols	Monthly	Quarterly	Quarterly	Weekly	1-4/month	Quarterly	5/year	Weekly	Monthly	Quarterly	5/year	3-4/month
Total DDT	Monthly	Quarterly	Monthly	Weekly	1-3/month	Quarterly	Monthly	Weekly	1-2/month	Quarterly	Monthly	1-4/month
Total PAH	Monthly	Quarterly	Monthly	Monthly	1-5/month	Quarterly	5/year	Monthly	1-4/month	Quarterly	5/year	1-3/month
Total PCB	1-7/month	Quarterly	Monthly	Weekly	1-2/month	Quarterly	Monthly	Weekly	1-2/month	Quarterly	Monthly	1-4/month

[a] Frequency varied within the year between given rates.

na = Not analyzed.