Effluent discharges to the Southern California Bight from large municipal wastewater treatment facilities in 2001 and 2002

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ABSTRACT - Four municipal wastewater treatment facilities (POTWs) discharge upwards of 100 million gallons of treated wastewater to the Southern California Bight (SCB) every day and are a primary source of contaminants to the SCB. Since 1971, the Southern California Coastal Water Research Project (SCCWRP) has conducted annual assessments of contaminant loading to the SCB from the large POTWs. This report continues these assessments by characterizing effluents from large POTWs in 2001 and 2002. Data from compliance monitoring reports were used to evaluate large POTW effluents in terms of volumes, constituent mass emissions, and average constituent concentrations. Estimates were compared to results from previous years, and long-term trends in large POTW effluents were evaluated. Emphasis for historical comparisons were focused on the years 1992 and 2002 to highlight changes in discharges in the last decade. Effluent discharges in 2002 were generally lower than previous years in terms of volume, concentrations, and mass emissions, despite an anomalous spike in effluent volumes and decline in quality in 2001. Effluent volumes discharged in 2002 were roughly the same as discharge volumes observed in 1992. However, the majority of mass emissions in 2002 were significantly lower than in 1992, indicating that effluent quality has improved in the last decade. Still, large POTWs remain one of the leading point sources of contaminants to the SCB.

INTRODUCTION

The coastal ocean within the Southern California Bight (SCB) is an important recreational and economic resource. With a population of 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 the several point sources of contaminants in the SCB are treated municipal wastewater, industrial effluents, stormwater runoff, and discharges from power generating stations, oil platforms, and dredging projects.

Nineteen municipal wastewater treatment facilities (POTWs) discharge treated wastewater directly to the SCB. The four largest POTWs each discharge upwards of 100 million gallons of treated wastewaters to the SCB every day. 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 Districts; Treatment Plant No. 2, operated by the Orange County Sanitation District (OCSD); and the Point Loma Wastewater Treatment Facility (PLWTP), operated by the City of San Diego (Figure 1). Historically, these facilities have been the most important source of contaminants to the SCB, though effluent quality has improved notably since assessments of large POTW discharges began in 1971 (Steinberger and Schiff 2003a).

Despite comprehensive regulations on large POTW discharges, regional-level assessments of these discharges are not part of the standard regulatory framework. While this may not impede the assessment of short-term trends and the direct regulation of individual facilities, it poses a challenge

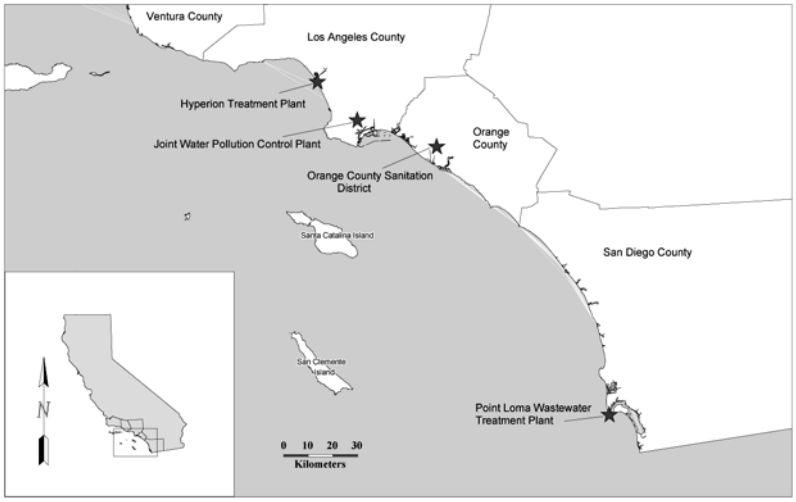

Figure 1. Locations of the four large publicly owned treatment works in the SCB.

when trying to understand the long-term trends in cumulative large POTW discharges. An understanding of these trends is essential to developing environmentally and economically sound policies regarding this point source. SCCWRP has conducted annual regional-scale assessments of large POTWs since 1971 as a means to provide tools that enable managers to monitor the effectiveness of regulations and compare large POTW effluents to other contaminant sources.

This study represents a continuation of these assessments for 2001 and 2002 discharges from large POTWs. As part of this assessment, 2001 and 2002 effluents from the four large POTWs were characterized in terms of total volumes of discharge, annual average constituent concentrations, and annual constituent mass emissions. We compared estimates among facilities and examined changes in discharges between the two years. Further, we looked at historical trends in large POTW discharges. In particular, constituent mass emissions in 1992 and 2002 were examined for statistical differences to evaluate whether effluent quality has improved over the course of a decade.

Methods

Effluent data for the large POTWs were obtained from monthly, quarterly, and annual discharge monitoring reports (DMRs). Analytical methods (Appendix I), reporting levels (Appendix II), and measurement frequencies (Appendix III) were obtained from DMRs, or from laboratory reports or personnel at the individual facilities when information was not available in the DMR. When the frequency of constituent analysis was not noted in the DMR, it was assumed to be the minimum frequency required by the National Pollutant Discharge Elimination System (NPDES) permit.

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. This report includes an analysis of various metals, nutrients, DDTs, PAHs, PCBs, toxicity bioassays, and general constituents such as suspended solids, BOD, and oil and grease.

Annual effluent concentrations and mass emission estimates were calculated for the 2001 and 2002 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 consistent for any given month in the year. 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. The MEs were calculated for each constituent for each month, and then summed over all months in the year to obtain an annual estimate:

$$ME = \sum_{i=1}^{12} uF_i C_i D_i$$

where F_i was the mean daily flow for the month i, C_i was the reported constituent concentration for the month i, D_i was the number of days that discharge occurred during the month i, and u was the appropriate unit conversion factor for calculating the ME in metric tons (mt), kilograms (kg), or liters (L).

Annual average flow-weighted concentrations (FWC) were calculated by dividing the annual ME 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:

$$FWC = u\frac{ME}{AEV}$$

where ME was the annually summed mass emission estimate, AEV was the total annual effluent volume, and u was the unit conversion factor for reporting the FWCs in a specific unit. The AEV for each discharger was calculated from the sum of the monthly effluent volumes:

$$AEV = \sum_{i=1}^{12} uF_iD_i$$

This approach for estimating FWCs sometimes resulted in estimates that were below the RL for constituents that had one or more non-detectable results. In these cases, the FWC were reported as calculated. A constituent that was consistently not detected in a given year resulted in a FWC estimate of zero; these values were expressed as less than the RL provided by the facility during that year for the given constituent.

Metal MEs and FWCs for HTP were estimated as a range of values, since constituent analyses conducted by HTP listed many results as detected but not quantified (DNQ). A DNQ value indicated that the analytical result was above the method detection limit (MDL) but below the practical quantization limit (PQL). Consequently, ME and FWC estimates for HTP were calculated assuming that the analytical result was either the MDL or the PQL, and were represented in our results as the range between these values. The PQL used for metal analyses varied depending on whether the metal was considered carcinogenic or non-carcinogenic. For constituents listed in the HTP permit as carcinogens, the PQL was five times the MDL, while non-carcinogenic constituents had a PQL ten times the MDL. Total large POTW metal MEs were also presented as a range of values to reflect the total estimates if the low range of HTP estimates were used versus the high range of HTP estimates.

Reporting levels varied among facilities for individual constituents. When more than one RL was used during the year for a given constituent and facility, the range of values was reported, and the greatest RL was used for reporting non-detectable values in FWC estimates. Method detection limits (MDL) were used in place of RLs whenever RLs were not available. 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 the years of this study were appended to existing historical information in order to establish ongoing trends in large POTW emissions. Additionally, historical annual mass emissions for all large POTWs combined were normalized for the volume of discharge to determine the average constituent concentration discharged by large POTWs for a given year. The concentrations of selected constituents between 1971 and 2002 were examined for trends in effluent quality.

Additional trends analysis included the statistical comparison of mass emission estimates for the individual years 1992 and 2002. These years were chosen because the volumes of discharge during these years were within 1% of each other, and this comparison would highlight any changes in effluent quality over the course of a decade that were not associated with changes in the effluent volume. The datasets were tested for normality using the Kosmogorov-Smirnov Normality Test, and statistical differences between years were investigated using the Mann-Whitney Rank Sum Test. Since the 2002 metal loads at HTP were reported as an estimated range, the mid-points were used in the summation of total metal loads from large POTWs combined. All historical data were taken from Steinberger and Schiff (2003a) and Raco-Rands and Steinberger (2001).

Results

Effluent Discharges in 2001 and 2002

The combined mean effluent flow from large POTWs was 1,063 mgd and 1,032 mgd in 2001 and 2002, resulting in the discharge of 1,469 and 1,426

Table 1. Annual average primary, secondary, and total flow rates of effluent discharge to the SCB from the four large POTWs in 2001 and 2002.

	2001			2002		
Facility	Advanced Primary Flow (mgd)	Advanced Secondary Flow (mgd)	Total Flow (mgd)	Advanced Primary Flow (mgd)	Advanced Secondary Flow (mgd)	Total Flow (mgd)
HTP	0	326	326	0	307	307
JWPCP	177	147	324	98	227	325
OCSD	119	119	238	116	116	231
PLWTP	175	0	175	169	0	169
Combined	471	593	1,063	382	650	1,032

Table 2. Estimated constituent mass emissions in effluent discharges to the SCB from large POTWs in 2001 and 2002.

		HTP		JWPCP		OCSD		PLWTP		TOTAL[a]	
Constituent	**Units**	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Volume	L x 10^9	451	425	447	449	329	320	241	233	1,469	1,426
Settleable Solids	L x 10^6	3.7	nd	52	45	174	177	24	43	254	264
TSS	mt x 10^3	7.3	7.4	32	22	17	14	10	10	67	54
BOD	mt x 10^3	6.8	6.9	50	31	24	21	23	22	103	81
COD	mt x 10^3	--	--	113	80	--	--	55	56	168	136
TOC	mt x 10^3	11	9.3	32	23	--	--	--	--	43	32
Oil/grease	mt x 10^3	0.8	nd	6.4	3.6	4.7	4.7	2.1	2.2	14	10
Ammonia-N	mt x 10^3	14	14	14	15	8.7	8.8	6.8	6.5	44	44
Nitrate-N	mt	125	44	70	22	--	--	125	176	320	242
Nitrite-N	mt	--	--	52	31	--	--	--	--	52	31
Organic-N	mt	1,230	1,362	3,424	2,650	--	--	--	--	4,654	4,011
Total Phosphorus[b]	mt	1,268	1,100	1,561	1,178	--	--	188	279	3,017	2,557
Phosphate-P	mt	--	--	1,561	1,178	--	--	--	--	1,561	1,178
Phosphorus	mt	1,268	1,100	--	--	--	--	--	--	1,268	1,100
ortho-Phosphate	mt	--	--	--	--	--	--	188	279	188	279
Cyanide	mt	0.68-3.4	0.49-2.4	5.8	3.4	nd	0.56	0.63	0.81	8.5	6.3
Arsenic	mt	0.42-2.1	0.96-1.5	1.1	1.1	0.85	0.66	0.19	0.30	3.3	3.3
Cadmium	mt	nd	nd	0.12	0.04	0.25	0.06	0.02	0.09	0.39	0.19
Chromium	mt	0.38-3.8	0.11-1.1	2.0	nd	2.3	1.6	0.37	nd	6.8	2.2
Copper	mt	3.8-38	2.5-25	13	8.7	14	12	28	17	75	51
Lead	mt	0.19-1.9	0.38-3.8	nd	nd	0.71	0.45	nd	nd	1.8	2.5
Mercury	mt	0.01-0.06	0.004-0.02	nd	nd	0.01	0.01	nd	nd	0.04	0.02
Nickel	mt	0.72-7.2	1.3-13	19	14	13	13	nd	nd	36	34
Selenium	mt	0.30-3.0	0.38-0.73	5.5	4.7	1.6	1.3	0.27	0.27	9.0	6.9
Silver	mt	0.12-1.2	0.05-0.54	2.9	2.2	0.87	0.79	0.13	0.18	4.6	3.4
Zinc	mt	4.1-41	2.6-26	20	16	18	18	7.7	6.5	69	56
Total Phenols[c]	mt	--	--	139	88	--	--	--	--	139	88
Chlorinated Phenols	mt	nd	nd	3.7	2.3	0.03	nd	nd	nd	3.8	2.3
Nonchlorinated Phenols	mt	nd	nd	71	7.9	1.2	2.5	2.7	2.7	75	13
Total DDT	kg	nd	nd	1.1	2.7	nd	nd	nd	nd	1.1	2.7
Total PAH	kg	nd	nd	538	nd	47	nd	nd	nd	585	nd
Total PCB	kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

[a] The total is the sum of constituent mass emissions from all facilities; where HTP emissions are given as a range of values, the midpoint of the range was used for the
[b] Total phosphorus is the sum of the P component all phosphorus/phosphate measurements, where more than one was applicable.
[c] Total phenols values are results from analysis of total phenols; not the sum of individually resolved phenols.
Dash = not applicable/ not analyzed.
nd = Not detected.
mt = Metric tons (1 mt = 1000 kg).

billion liters of effluent to the SCB, respectively (Table 1; Table 2). The HTP and JWPCP, together, accounted for 61% of the total volume in both 2001 and 2002. In 2001, 56% of the total effluent flow from large POTWs was treated at the secondary level, while in 2002, 63% of the total effluent flow was treated at the secondary level. The HTP treated all effluents at the secondary treatment level during both years, while the PLWTP treated all effluents at the advanced primary level. In 2001, the JWPCP treated 45% of effluents at the secondary level, but increased its secondary treatment capacity to 70% in 2002.

The majority of constituent MEs were higher in 2001 than in 2002 (Table 2). Of the 29 constituents analyzed, only MEs for settleable solids, lead, total DDT, and ortho-phosphate (only analyzed by PLWTP) were higher in 2002. Ninety-three percent of constituent MEs from JWPCP decreased between 2001 and 2002, with the only exceptions being increases in ammonia-N and total DDT. At the HTP, OCSD, and PLWTP facilities, 66-86% of constituent MEs decreased between 2001 and 2002, except for metal MEs at HTP, where an increase or decrease could not be determined due to HTP's new reporting procedures. Increases in constituent MEs at the individual facilities ranged from 1-293% with a median increase of 6%, and decreases in constituent MEs at the individual facilities ranged from 1-89% with a median decrease of 23%. In general, declines in constituent MEs from 2001 to 2002 were mostly a result of more advanced effluent treatment at the JWPCP facility between the two years.

Large POTWs discharged 54 and 67 thousand mt of suspended solids (TSS) to the SCB in 2001 and 2002, respectively (Table 2). Ammonia-N discharges were constant between 2001 and 2002 at 44 thousand mt. Among organic compounds, phenols were discharged in the largest quantities during both years; total DDTs had a minor increase in discharge in 2001, but decreased again in 2002. Total PCBs were not detected in effluents from any of the facilities in either 2001 or 2002.

Metal MEs could not be determined exactly due to the range of estimates calculated for the HTP facility. The HTP would have discharged the largest loads for most metal constituents if the high range of the ME estimate were used for comparison to the other facilities (Table 2). In contrast, if the low range of the ME estimate were used, HTP would have discharged the smallest metal loads to the SCB for most metal constituents. For example, discharges of copper and zinc from HTP in both 2001 and 2002 were 47-86% lower than discharges from other facilities when the low estimate was used for comparison, but 26-187% higher than discharges from other facilities when the high estimate was used for comparison (Figure 2). Furthermore, when compared to MEs in 2000, discharges of copper and zinc would have increased over time for HTP if the high estimate were considered, but would have decreased if the low estimate were considered.

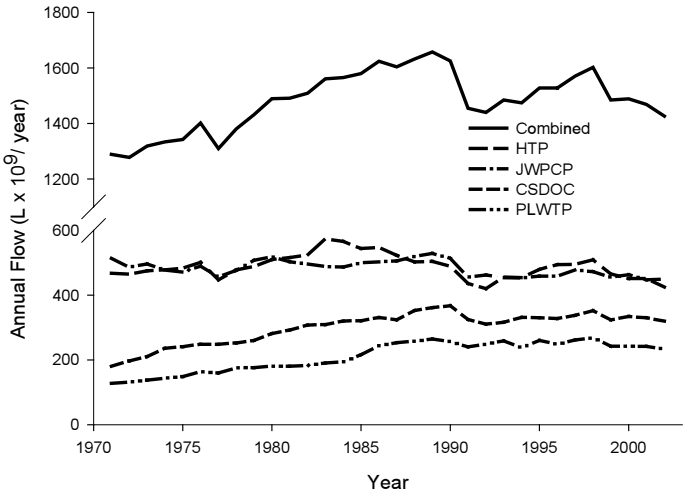

Figure 2. Individual and combined effluent volumes for large POTWs between 1971 and 2002.

Total metal MEs discharged by large POTWs combined also showed notable difference depending on whether the low or high estimate for HTP was used (Figure 3). If the high HTP estimate were used, overall metal emissions from large POTWs generally would have increased since 2000. If the low estimate were used for summation of the total metal MEs, then large POTWs would show a general decline in these discharges.

In both 2001 and 2002, JWPCP generally had the highest FWCs for most constituents, primarily for general and organic constituents (Table 3). Metal FWCs were more difficult to compare among facilities because of the uncertainty in the HTP estimates. Assuming that most of the results were at the upper limit of the range, HTP generally had the highest FWCs for metal constituents. However, if the low range of the estimate were used, then no single facil-

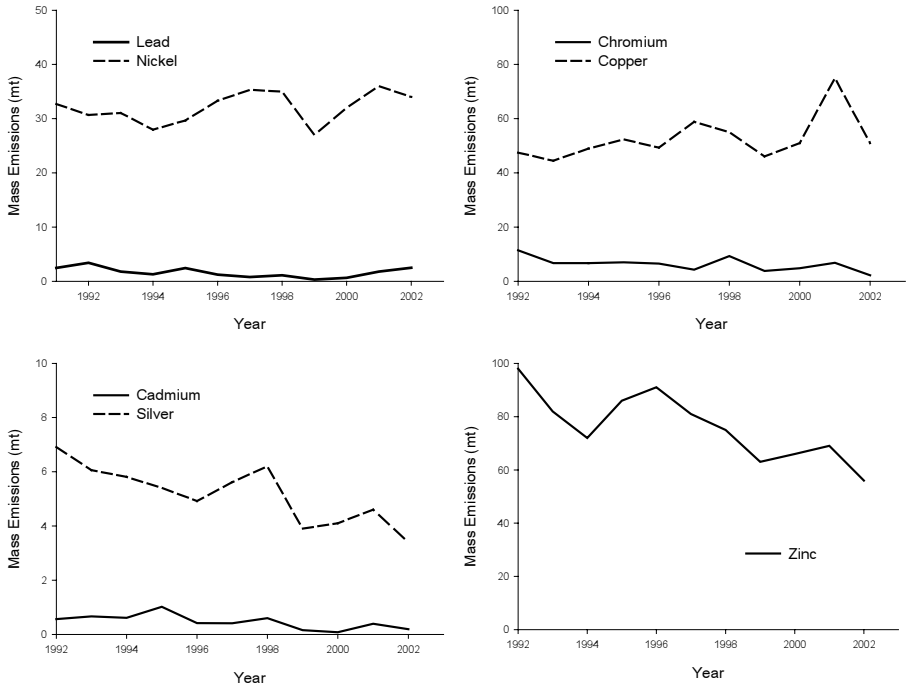

Figure 3. Combined estimated mass emissions from large POTWs of trace metals (a) lead and nickel, (b) chromium and copper, (c) cadmium and silver, and (d) zinc between 1992 and 2002.

ity would be identified as having the highest concentrations of metals in its effluents.

The FWC estimates for general constituents were typically more dependable since variances associated with these results were generally lower than for metals and organics (Table 3). Coefficients of variance (CVs) for general constituents ranged from 0-346%, metals ranged from 7-346%, and organics ranged from 17-346%. General constituents showed the lowest variances with a median CV of 19% for both years and all facilities. The median CV for metal constituents was 33%, and for organic compounds, the median CV was 79%.

Six different species were used by large POTWs to conduct acute toxicity bioassays (Table 3). In 2001, acute toxicity to the test species *Pimephales promelas* was observed to be highest at JWPCP (1.45 TUa). In 2002, different species were used by the facilities and a direct comparison of acute toxicity could not be made.

Nine different species were used for chronic toxicity studies by the large POTWs in 2001 and 2002 (Table 3). The highest chronic toxicities for both years were observed in PLWTP effluents for the species *Macrocystis pyrifera*, though, again, direct comparisons could not be made among facilities since no other facility tested this species. Development in the species *Haliotis rufescens* was tested by all facilities except JWPCP, and the highest chronic toxicities were again observed in PLWTP effluents (64 TUc).

Historical Discharges from Large POTWS

Effluent discharge volumes from large POTWs increased 11% from 1971 to 2002 (Figure 2). During this time, the greatest volume of effluents were discharged in 1989, with a secondary peak observed in 1998. Since 1998, however, discharge volumes have decreased approximately 11% (Table 4).

Effluent quality showed the most significant improvements between 1971 and 1989, and only moderate improvement, and in some cases deterioration, between 1989 and 2002 (Figures 3-5). Between 1971 and 1989, all constituent concentrations in large POTW effluents decreased by 15-100%. Concentrations of metals and organics had the largest declines, while decreases in general constituent concentrations (i.e., ammonia-N and oil/grease) were relatively minor. Between 1989 and 2002, most constituent concentrations decreased by 12-94%, though increases were observed in the aver-

Table 3. Annual average flow-weighted consituent concentrations in effluents discharged to the SCB from large POTWs in 2001 and 2002. Non-detectable constituents are reported as less than the range of analytical reporting limits used during the given year; where the reporting limit was not provided the method detection limit was used.

		HTP[a]				JWPCP				OCSD				PLWTP			
Constituent	Units	2001 mean	CV	2002 mean	CV	2001 mean	CV	2002 mean	CV	2001 mean	CV	2002 mean	CV	2001 mean	CV	2002 mean	CV
TSS	mg/L	16	9	17	16	72	19	49	40	52.0	5.6	44.4	13	43	12	44	9
Settleable Solids	ml/L	0.008	346	nd	--	0.1	33	0.1	0	0.5	19	0.6	32	0.1	60	0.2	46
Turbidity	NTU	7	12	8	14	55	24	34	49	38	13	38	14	40	10	45	4
BOD	mg/L	15	12	16	18	112	33	69	50	72	6	67	9	94	8	94	8
COD	mg/L	--	--	--	--	253	24	178	36	--	--	--	--	227	6	238	7
TOC	mg/L	23	19	22	15	71.5	24	50.7	35	--	--	--	--	--	--	--	--
Oil/Grease	mg/L	2	60	nd	--	14	25	8.0	67	14.3	8.2	14.6	14	8.7	11	9.4	13
Ammonia-N	mg/L	31.2	7	32.5	6	32.0	6	33.7	6	26	3	28	3	28.0	3	27.9	5
Nitrate-N	mg/L	0.28	43	0.10	76	0.16	73	0.05	91	--	--	--	--	0.52	73	0.75	86
Nitrite-N	mg/L	--	--	--	--	0.12	54	0.07	56	--	--	--	--	--	--	--	--
Organic-N	mg/L	2.7	16	3.2	17	7.7	21	5.9	24	--	--	--	--	--	--	--	--
Total Phosphorus																	
Phosphate-P	mg/L	--	--	--	--	3.49	26	2.62	35	--	--	--	--	--	--	--	--
Phosphorus	mg/L	2.81	10	2.59	18	--	--	--	--	--	--	--	--	--	--	--	--
ortho-Phosphate	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	0.78	102	1.2	48
Cyanide	ug/L	1.5-15	60	1.2-12	88	13	45	8	14	< 2	--	1.8	78	2.6	67	3.5	50
Arsenic	ug/L	0.92-4.6	31	2.3-3.6	87-86	2.4	15	2.4	27	2.57	13	2.07	18	0.80	23	1.3	26
Cadmium	ug/L	< 1	--	< 1	--	0.3	249	0.08	346	0.77	117	0.20	140	0.10	346	0.40	208
Chromium	ug/L	0.84-8.4	346	0.26-2.6	181	4.4	190	< 12	--	7.1	28	4.9	30	1.5	346	0	--
Copper	ug/L	8.4-84	47	6.0-60	49	29	24	19	37	42.3	16	36.5	7	114	20	72	33
Lead	ug/L	0.43-4.3	346	0.89-8.9	171-199	< 8	--	< 8	--	2.2	25	1.4	11	< 18	--	< 18	--
Mercury	ug/L	0.0026-0.26	346	0.0010-0.10	104	< 0.5	--	< 0.5	--	0.040	32	0.043	24	< 0.27	--	< 0.27	--
Nickel	ug/L	1.6-16	346	3.0-30	88	42	13	32	55	40	29	40	69	< 14	--	< 14	--
Selenium	ug/L	0.67-6.7	74	0.90-1.7	93	12.2	32	10.5	21	4.85	12	4.21	33	1.1	11	1.2	11
Silver	ug/L	0.26-2.6	124	0.13-1.3	181	7	20	5	68	2.65	17	2.47	16	0.54	346	0.78	346
Zinc	ug/L	9.1-91	31	6.2-62	112	45	50	36	83	55	16	56	43	32	22	28	19
Total Phenols	ug/L	--	--	--	--	311	25	195	58	--	--	--	--	--	--	--	--
Chlorinated Phenols	ug/L	< 2-8	--	< 1-8	--	8.3	79	5.2	124	0.10	346	< 0.11-2.6	--	< 3.4-6.1	--	< 1.34-5.87	--
Nonchlorinated Phenols	ug/L	< 1-31	--	< 1-31	--	159	53	18	122	3.7	45	8.0	17	11	25	11	30
Total DDT	ug/L	< 0.002-0.010	--	< 0.001-0.010	--	0.003	181	0.006	171	< 0.007-0.02	--	< 0.007-0.02	--	< 0.020-0.040	--	< 0.020	--
Total PAH	ug/L	< 1-1.5	--	< 1-2	--	1.2	116	< 0.008-50	--	0.14	346	< 0.41-1.6	--	< 1.6-7.68	--	< 1.52-7.68	--
Total PCB	ug/L	< 0.025-0.065	--	< 0.010-0.065	--	< 0.08-0.9	--	< 0.05-0.9	--	< 0.2	--	< 0.2	--	< 0.070-0.6	--	< 2-4	--
Acute Toxicity																	
Atherinops affinis	TUa	--	--	--	--	--	--	--	--	--	--	--	--	2.41	40	1.60	206
Ceriodaphnia dubia	TUa	--	--	--	--	--	--	--	--	0.51	94	1.22	13	1.51	15	1.36	13
Holmeimysis costata	TUa	--	--	--	--	--	--	--	--	--	--	4.54	59	--		--	
Menidia beryllina	TUa	--	--	--	--	--	--	--	--	--	--	2.53	25	--		--	
Mysidopsis bahia	TUa	--	--	--	--	--	--	--	--	--	--	--	--	2.48	61	1.70	58
Pimephales promelas	TUa	0.74	20	0.33	125	1.45	37	0.86	63	0.59	--(1)	--	--	1.23	13	1.18	19
Chronic Toxicity																	
Atherinops affinis (growth)	TUc	--	--	--	--	--	--	--	--	--	--	--	--	--	--	64	--(1)
Haliotis rufescens (development,	TUc	38.0	42	47.6	0	--	--	--	--	55.60	93	60.50	24	64	0	64	0
Macrocystis pyrifera (germ-tube length)	TUc	--	--	--	--	--	--	--	--	--	--	--	--	128.07	56	111.38	88
Macrocystis pyrifera (germination)	TUc	--	--	--	--	--	--	--	--	--	--	--	--	94.16	44	67.39	12
Menidia beryllina (biomass)	TUc	--	--	--	--	--	--	48.7	34	--	--	--	--	--	--	--	--
Menidia beryllina (survival)	TUc	--	--	--	--	--	--	42	0	--	--	--	--	--	--	--	--
Mysidopsis bahia (biomass,	TUc	--	--	--	--	48.76	33	65.8	72	--	--	--	--	--	--	--	--
Mysidopsis bahia (survival)	TUc	--	--	--	--	42.00	0	42	0	--	--	--	--	--	--	--	--
Strongylocentrotus purpuratus (fertilization)	TUc	--	--	--	--	--	--	--	--	63.08	84	55.56	0	--	--	--	--
Bacteria																	
Enterococcus	cfu/100mL[b]	19,000	36	36,000	48	--	--	--	--	--	--	--	--	--	--	--	--
Fecal Coliform	cfu/100mL[b]	108,000	25	288,000	47	--	--	--	--	--	--	--	--	--	--	--	--
Total Coliform	cfu/100mL[b]	792,000	38	1,868,000	67	--	--	--	--	--	--	--	--	16,000,000	88	16,000,000	82

[a] A range of FWCs provided for constituents reported by the discharger as DNQ (detected but not quatified); range represents FWC calculated using the MDL (low value) and using the PQL (high value). Actual FWC is between these values as defined by the DNQ classification, which indicates that the analytical result for the constituent was above the MDL but below the PQL.
[b] Units for PLWTP bacteria data are mpn/100mL.
nd = not detected, no reporting limit provided.
Dash = not applicable, not analyzed.
(1) = Only one sample taken during year, CV calculation not applicable.

Table 4. Estimated combined mass emissions from the large POTWs from 1971 through 2000; results displayed for selected years between 1971 and 1996, and every year since 1996. Data for excluded years can be found in Raco-Rands and Steinberger (2001).

Constituent	1971[a]	1976[a]	1981[a]	1986[a]	1989[a]	1991[a]	1992	1996[a]	1997[a]	1998[a]	1999[a]	2000[a]	2001	2002
Volume (L x 10^9)	1,289	1,402	1,491	1,624	1,658	1,455	1,440	1,528	1,571	1,602	1,485	1,489	1,469	1,426
Flow (mgd)	932	1,013	1,079	1,176	1,200	1,054	1,039	1,103	1,137	1,159	1,074	1,074	1,063	1,032
Suspended Solids (mt x 10^3)	295	285	224	185	83	79	79	70	75	75	61	65	67	54
BOD[b] (mt x 10^3)	282	255	261	182	162	139	135	127	137	137	101	98	103	81
Oil/Grease (mt x 10^3)	63	57	36	29	22	19	19	18	20	19	15	15	14	10
Nitrate-N (mt x 10^3)	0.31	0.14	0.21	0.41	0.34	0.24	0.21	0.30	0.15	0.23	0.57	0.28	0.32	0.24
Nitrite-N (mt x 10^3)	0.16	0.01	0.03	0.07	0.08	0.11	0.06	0.10	0.07	0.30	0.51	0.44	0.05	0.03
Ammonia-N (mt x 10^3)	54	37	41	45	45	44	42	41	42	42	41	43	44	44
Organic-N (mt x 10^3)	17	13	12	11	7.2	6.0	5.7	5.2	5.5	5.8	4.1	4.5	4.7	4.0
Total P[c] (mt x 10^3)	11.7	9.7	9.5	9.2	6.3	6.0	5.2	3.4	3.6	2.6	1.9	1.9	3.0	2.6
Cyanide (mt)	194	244	91	27	12	16	18	10	9.8	8.1	8.2	9.2	8.5	6.3
Arsenic (mt)	7.9	11	11	12	7.4	5.4	5.5	4.2	3.2	3.3	2.5	3.4	3.3	3.3
Cadmium (mt)	53	42	32	14	1.7	1.2	0.56	0.42	0.41	0.63	0.16	0.08	0.39	0.19
Chromium (mt)	666	591	187	86	22	10	11	6.5	4.3	9.3	3.8	4.8	6.8	2.2
Copper (mt)	535	504	336	203	67	47	47	49	59	55	46	51	75	51
Lead (mt)	240	173	130	104	27	2.4	3.4	1.2	0.76	1.1	0.32	0.64	1.8	2.5
Mercury (mt)	2.9	2.5	1.3	0.71	0.39	0.23	0.04	0.03	0.03	0.03	0.02	0.02	0.04	0.02
Nickel (mt)	327	313	183	130	54	33	31	33	35	35	27	32	36	34
Selenium (mt)	13	20	5.8	8.1	7.4	7.1	7.3	7.4	8.3	7.5	7.4	8.5	9.0	6.9
Silver (mt)	15	20	27	22	10	8.0	6.9	4.9	5.6	6.2	3.9	4.1	4.6	3.4
Zinc (mt)	1,834	1,055	538	341	145	125	99	90	81	75	63	66	69	56
DDT[d] (kg)	21,580	1,640	498	50	22	6.4	13	1.4	2.1	4.0	3.0	1.5	1.1	2.7
PCB[e] (kg)	8,946	4,672	1,247	35	-[e]	-[e]	-[e]	-[e]	-[e]	-[e]	-[e]	-[e]	-[e]	-[e]

[a]Reproduced from Steinberger and Schiff (2003).
[b]Hyperion's 7-mile outfall is not included in results (applicable to years prior to 1987).
[c]Sum of total phosphorus (HTP), phosphate-P (JWPCP), and soluble phosphate-P (PLWTP).
[d]Estimates for OCSD for 1971 were based on Bodega Bay Marine Laboratories and University of 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.
[e]Results reported by dischargers were below method detection limits.

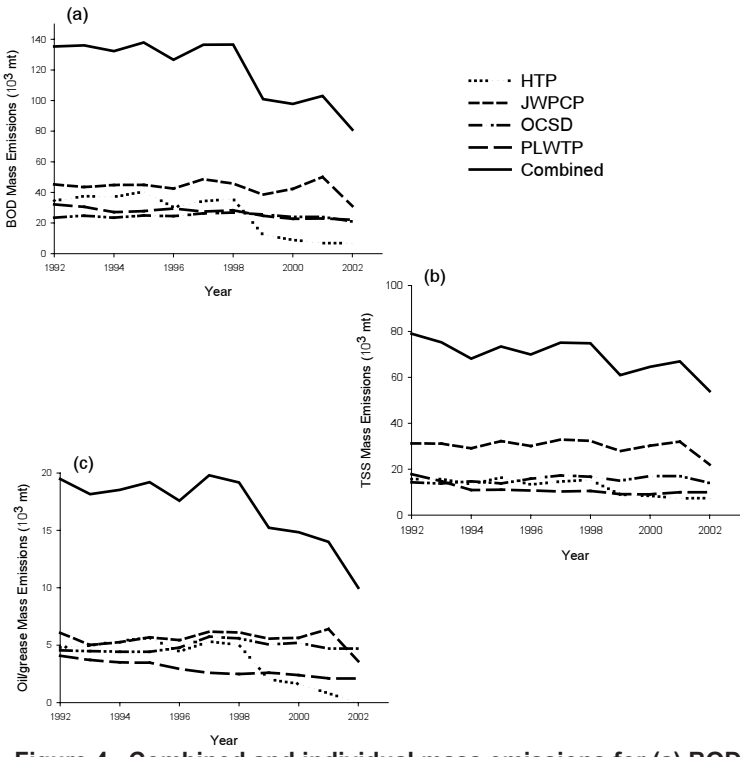

Figure 4. Combined and individual mass emissions for (a) BOD, (b) TSS, and (c) oil/grease between 1992 and 2002.

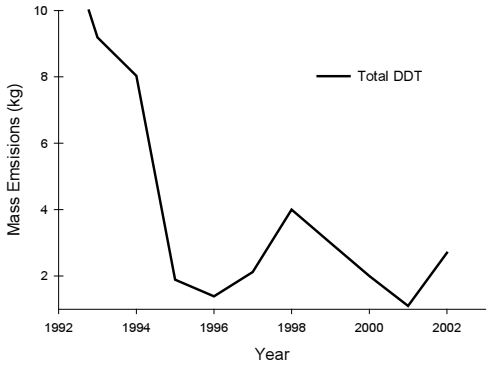

Figure 5. Combined estimated mass emissions for total DDTs for large POTWs between 1992 and 2002.

age concentrations of ammonia-N (13%) and selenium (8%).

The total discharge volume from all large POTWs combined in 2002 was roughly the same as the volume discharged in 1992; however, in 2002 constituent MEs were 5-79% less than in 1992, indicating that large POTW effluents have improved in quality over the last decade. A comparison of 1992 and 2002 effluents showed that only nitrate-N, ammonia-N, and copper MEs were higher in 2002 by 15%, 5%, and 9%, respectively. Of these three increases in constituent MEs, only the ammonia-N data was considered statistically significant based on the Mann-Whitney Rank Sum Test (Table 5). In addition, for the 17 constituent MEs that exhibited a decrease between 1992 and 2002 (total PCBs were the same), 13 of these changes were statistically significant. Decreases in MEs between 1992 and 2002 for cyanide, mercury, nickel, and selenium were not significant.

Discussion

Decreases in constituent mass emissions to the SCB from large POTWs can result from one of three factors: (1) pretreatment source control, (2) decreases in discharge volumes, or (3) improvements in treatment capacity and capability that result in improved effluent quality. When considering the long-term trends in constituent mass emissions, the majority of reductions in mass emissions have resulted from pretreatment source control. For example, data from JWPCP show that the vast majority of reductions in metals and organics in POTW effluent have resulted from reductions in influent concentration due to pretreatment. Furthermore, it is apparent that changes in wastewater treatment practices have played an important role in improving effluent quality, especially prior to 1989 when discharge volumes were steadily increasing while mass emissions were steadily declining. Over the more recent short-term, both changes in effluent volume and quality have influenced contaminant loading from large POTWs to the SCB.

In general, based on the comparison of 1992 and 2002 data for large POTWs, effluent quality appears to still be improving. However, recent trend estimates were complicated by the fact that, starting in 2001, HTP implemented a new reporting procedure for constituent analyses in which constituents that were above the MDL but below the PQL were reported as “Detectable, but not Quantified” (DNQ). This procedure is consistent with new state NPDES reporting requirements and will become the standard reporting procedure in all four facilities as their permits are renewed. However, this reporting method complicated efforts to accurately assess total emissions from large POTWs to the SCB in 2001 and

Table 5. Results from statistical comparison of 1992 and 2002 constituent mass emissions. Data were tested for normality using the Kolmogorov-Smirnov Normailty Test, and differences in the data sets were tested using the Mann-Whitney Rank Sum Test.

Constituent	Normal Dataset?[a]	P value	Significant Difference?	Higher Year
Total Suspended Solids	yes	<0.001	yes	1992
Oil/grease	yes	<0.001	yes	1992
BOD	yes	<0.001	yes	1992
Ammonia-N	yes	0.044	yes	2002
Nitrate-N	yes	0.493	no	2002
Nitrite-N	yes	0.007	yes	1992
Organic-N	yes	<0.001	yes	1992
Total P	yes	<0.001	yes	1992
Cyanide	no	0.017	no	1992
Arsenic	yes	<0.001	yes	1992
Cadmium	yes	0.053	yes	1992
Chromium	no	<0.001	yes	1992
Copper	yes	0.348	no	2002
Lead	no	0.04	yes	1992
Mercury	no	0.157	no	1992
Nickel	yes	0.314	no	2002
Selenium	yes	0.376	no	1992
Silver	yes	<0.001	yes	1992
Zinc	yes	<0.001	yes	1992
Total DDT	no	0.004	yes	1992
Total PCB	no	0.976	no	1992

[a] Indicates whether dataset passed the Kolmogorov-Smirnov Normality Test.

2002, compare contributions among facilities, and make specific conclusions regarding trends in large POTW discharges. Furthermore, this change in reporting procedures coincided with a transition period in treatment practices at HTP, confounding our ability to evaluate the effectiveness of these new practices. In 1999, HTP began treating all effluents at the secondary level. As a result, effluent quality at HTP improved notably in 1999 and 2000. However, use of the DNQ reporting procedure makes it impossible to know whether HTP continued to improve effluent quality in 2001 and 2002. Between 2000 and 2001-2002, slight declines were observed in MEs for all constituents at HTP that were not affected by the DNQ reporting procedure, except ammonia-N, and overall emissions from large POTWs appear to continue to be declining. However, changes in metal MEs at HTP were irresolute. As a major contributor of emissions to the SCB, changes at HTP directly influence overall trends in large POTW effluent emissions. The DNQ reporting procedure at HTP required that estimates for metal MEs be calculated as a range. This range implied a margin of uncertainty in the overall estimates of constituent MEs from large POTWs. Inland POTWs report "estimated concentrations" along with DNQ values. Assuming this procedure is adopted by the POTWs that discharge to the ocean, future mass emissions may be estimated. However, the DNQ reporting procedure may complicate efforts to make conclusions regarding effect of improved source control and treatment on overall emissions from these point sources.

Improved source control and treatment have resulted in tremendous improvements in effluent quality from large POTWs over the last 30 years, and these improvements continue to be observed. However, large POTWs continue to be the leading point source of contaminant inputs to the SCB, mainly due to the large volumes they discharge daily. Discharge volumes and mass loadings from other known point sources such as small POTWs, industrial facilities, dredge materials, oil platforms, and power generating stations are consistently minor compared to large POTWs (Steinberger and Schiff 2003a, 2003c, 2003b, Steinberger *et al.* 2003). While the discharge water quality from large POTWs has continued to improve, similar improvements in non-point source pollutant inputs have not been observed. Consequently, stormwater runoff has become the largest source of contaminants to the coastal ocean in southern California (Schiff *et al.* 2000).

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Appendix I. Analytical methods used for constituent analyses conducted by the large POTWs and/or contract laboratories in 2001 and 2002.

	HYP5		JWPCP		OCSD		PLWTP	
GroupingLevel	2001	2002	2001	2002	2001	2002	2001	2002
Suspended Solids	SM2540 D	SM2540 D	SM 2540 D	SM 2540 D	SM 2540D/EPA 160.2	SM 2540D/EPA 160.2	SM 2540 D	SM 2540 D
Settleable Solids	nf	nf	SM 2540 F	SM 2540 F	EPA 160.5	EPA 160.5	SM 2540 F	SM 2540 F
Turbidity	nf	nf	SM 2130 B	SM 2130 B	nf	nf	SM 2130 B	SM 2130 B
TOC	SM 5310 B,C,D	SM 5310 B,C,D	nf	nf	na	na	na	na
BOD	SM 5210 B	SM 5210 B	SM 5210 B	SM 5210 B	EPA 405.1	EPA 405.1	SM 5210 B	SM 5210 B
COD			nf	nf	na	na	SM 5220 D	SM 5220 D
Oil/grease	EPA 1664	EPA 1664	SM 5520 B	SM 5520 B	SM 1664	SM 1664	SM 5520 B	SM 5520 B
Cyanide	SM 4500 CN E	SM 4500 CN E	SM 4500 CN B,C,E	SM 4500 CN B,C,E	EPA 335.2	EPA 335.2	SM 4500 CN E	SM 4500 CN E
Ammonia-N	SM 4500 NH3 B,E	SM 4500 NH3 B,E	SM 4500 NH3 B,E	SM 4500 NH3 B,E	EPA 350.1	EPA 350.1	SM 4500 NH3 B&E	SM 4500 NH3 B&E
Nitrate-N	SM 4500 NO3 E/EPA 300.0	SM 4500 NO3 E/EPA 300.0	SM 4500 NO3 E	SM 4500 NO3 E	na	na	EPA 300.0	EPA 300.0
Nitrite-N	na	na	SM 4500 NO2	SM 4500 NO2	na	na	na	na
Organic-N	SM 4500 Norg B	SM 4500 Norg B	SM 4500 Norg B	SM 4500 Norg B	na	na	na	na
Phosphate-P (Phosphorus)	SM 4500 P B5,E	SM 4500 P B5,E	SM 4500 P B5,E	SM 4500 P B5,E	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	EPA 300.0	EPA 300.0
Arsenic	SM 3114 B	SM 3114 B	SM 3114 B 4,D	SM 3114 B 4,D	EPA 200.8	EPA 200.8	EPA 200.7	SM 3114 B
Cadmium	SM 3120 B	SM 3120 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Chromium	SM 3120 B	SM 3120 B	EPA 218.1	EPA 218.1	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Copper	SM 3120 B	SM 3120 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Lead	SM 3113 B	SM 3113 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Mercury	SM 3112 B	SM 3112 B	SM 3112 B	SM 3112 B	EPA 245.1	EPA 245.1	EPA 200.7	SM 3112 B
Nickel	SM 3120 B	SM 3120 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Selenium	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Silver	SM 3113 B	SM 3113 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Zinc	SM 3120 B	SM 3120 B	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Phenols	na	na	EPA 625	EPA 625	na	na	na	na
Nonchlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Chlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Total DDT	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	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Total PCB	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608
Toxicity								
Atherinops affinis	na	na	na	na	na	na	EPA/600/4-90/027F	EPA/600/4-90/027F
Ceriodaphnia dubia	na	na	na	na	EPA/600/4-90/027F	EPA/600/4-90/027F	EPA/600/4-90/027F	EPA/600/4-90/027F
Haliotis rufescens	EPA/600/R-95/136	EPA/600/R-95/136	na	na	EPA/600/R-95/136	EPA/600/R-95/136	EPA/600/R-95/136	EPA/600/R-95/136
Holmesimysis costata	na	na	na	na	na	EPA/600/4-90/027F	na	na
Macrocystis pyrifera	na	na	na	na	na	na	EPA/600/R-95/136	EPA/600/R-95/136
Menidia beryllina	na	na	na	EPA/600/4-91/003	na	EPA/600/4-85/013	na	na
Mysidopsis bahia	na	na	EPA/600/4-91/003	EPA/600/4-91/003	na	na	EPA/600/4-90/027F	EPA/600/4-90/027F
Pimephales promelas	EPA/600/4/91/027	EPA/600/4-91/027	EPA/600/4-85/013	EPA/600/4-85/013	EPA/600/4-85/013	na	EPA/600/4-85/013	EPA/600/4-85/013
Strongylocentrotus purpuratus	na	na	na	na	EPA/600/R-95/136	EPA/600/R-95/136	na	na
Bacteria								
Enterococcus	SM 9230 C & 9020 B4	SM 9230 C & 9020 B4	nf	nf	nf	nf	nf	nf
Fecal Coliforms	SM 9222 B & 9020 B4	SM 9222 B & 9020 B4	nf	nf	nf	nf	nf	nf
Total Coliforms	SM 9222 B & 9020 B4	SM 9222 B & 9020 B4	nf	nf	nf	nf	MTF	MTF

na = not analyzed.
nf = method not found.
"SM" refers to protocols found in the Standard Methods for the Examination of Water and Wastewater (Clesceri 1992).
"EPA" refers to protocols found in the California Ocean Plan: Water Quality Control Plan, Ocean Water of California (SWRCB_Cal EPA).

Appendix II. Reporting levels (italics) and/or method detection limits used for constituent analyses by the large POTWs and/or their respective contract laboratories in 2001 and 2002.

Constituent	2001				2002			
	HYP	OCSD	JWPCP	PLWTP	HYP	OCSD	JWPCP	PLWTP
Suspended Solids (mg/L)	np	np	np	np	np	np	np	0.6
Settleable Solids (mL/L)	0.1	*0.1*	np	np	0.1	*0.1*	np	0.1
BOD (mg/L)	np	np	np	np	np	np	np	2
Oil/Grease (mg/L)	np	np	np	np	np	np	*5-5.4*	1.4
Nitrate-N (mg/L)	10	na	*0.09*	0.03	10-20	na	*0.05*	0.03
Nitrite-N (mg/L)	np	na	0.005	np	np	na	0.01	np
Ammonia-N (mg/L)	0.1	np	0.1	0.2	0.1	np	0.1	0.2
Organic-N (mg/L)	100	na	np	na	100	na	0.1	na
Phosphate-P (Phosphorus) (mg/L)	10	np	0.16	np	10	np	0.04	np
ortho-Phosphate (mg/L)	na	na	na	0.05	na	na	na	0.05
Cyanide (ug/L)	2	4.1	10	*2*	2	*2*	4	*2*
Arsenic (ug/L)	1	0.47	0.4	0.18	0.05-1	*0.47*	1	0.18
Cadmium (ug/L)	1	0.16	*1*	*1*	1	*0.16*	*1*	*1*
Chromium (ug/L)	10	0.17	*12-16*	*5*	1-10	*0.17*	*12*	*5*
Copper (ug/L)	10	0.47	4	4	4-10	*0.47*	6	4
Lead (ug/L)	5	0.31	*8*	18	2-5	*0.31*	8	*18*
Mercury (ug/L)	0.3	0.004	*0.5*	*0.27*	0.02-0.3	*0.02*	*0.5*	*0.09-0.27*
Nickel (ug/l)	20	0.69	0.01	*14*	5-20	*0.69*	*25*	*14*
Selenium (ug/L)	1	0.14	0.1-1	0.4	0.1-1	*0.14*	1	0.4
Silver (ug/L)	0.62	0.41	4.3	*6.6*	0.5-0.62	*0.41*	*5*	*6.6*
Zinc (ug/L)	10	5	*25*	4	10-17.2	*5*	*25-53*	4
Total Phenols (mg/L)	na	na	0.01	na	na	na	*0.01*	na
Chlorinated Phenols (ug/L)								
2,4,6-trichlorophenol	3	0.57	*1-10*	3.4	1-3	0.32-0.57	*10-100*	1.75
2,4-dichlorophenol	3	0.86	*1-10*	6.1	1-3	0.35-0.86	*5-50*	1.95
2-chlorophenol	2	1.3	*1-10*	3.6	1-2	0.11-1.3	*5-50*	1.76
4-chloro-3-methylphenol	2	2.6	*1-10*	3.6	1-2	0.23-2.6	*5-50*	1.34
Pentachlorophenol	8	2	*1-10*	5.87	1-8	1.5-2	*5-50*	5.87
Nonchlorinated Phenols (ug/L)								
Phenol	1	2	1	2.53	1	0.54-2	*5-50*	2.53
2,4-dimethylphenol	3	3.3	*1-30*	4.6	1-3	0.28-3.3	*5-50*	1.32
2,4-dinitrophenol	31	1.8	*6-100*	6.07	1-31	1-1.8	*20-200*	6.07
2-methyl-4,6-dinitrophenol	6	1.3-1.8	*1-50*	4.29	1-6	0.24-1.3	*10-100*	4.29
2-nitrophenol	3	1.1	*1-50*	4.5	1-3	0.25-1.1	*10-100*	1.88
4-nitrophenol	5	5	*1-50*	6.1	1-5	0.8-5	*10-100*	3.17
Total DDT (ug/L)								
o,p'-DDD	0.01	0.011	*0.02*	0.02	0.001-0.01	0.011	*0.01-0.02*	0.02
o,p'-DDE	0.002	0.01	*0.03*	0.03	0.001-0.002	0.01	*0.01-0.03*	0.03
o,p'-DDT	0.002	0.02	*0.02*	0.02	0.001-0.002	0.02	*0.01-0.02*	0.02
p,p'-DDD	0.002	0.009	*0.02*	0.03	0.001-0.002	0.009	*0.01-0.02*	*0.02*
p,p'-DDE	0.002	0.007	*0.01*	0.020	0.001-0.002	0.007	*0.01*	0.020
p,p'-DDT	0.002	0.019	*0.02*	0.020	0.001-0.002	0.019	*0.01-0.02*	0.050
Total PCB (ug/L)								
arochlor-1016	0.046	0.2	*0.5*	0.6	0.020-0.046	0.2	*0.1-0.5*	4
arochlor-1221	0.034	0.2	*0.8*	0.6	0.030-0.034	0.2	*0.1-0.8*	4
arochlor-1232	0.033	0.2	*0.5*	0.6	0.020-0.033	0.2	*0.1-0.5*	4
arochlor-1242	0.04	0.2	*0.9*	0.07	0.04	0.2	*0.1-0.9*	4
arochlor-1248	0.057	0.2	*0.08*	0.07	0.020-0.057	0.2	*0.08-0.1*	2
arochlor-1254	0.025	0.2	*0.4*	0.07	0.010-0.025	0.2	*0.05-0.4*	2
arochlor-1260	0.065	0.2	*0.1*	0.03	0.030-0.065	0.2	*0.1*	2
Total PAH (ug/L)								
Acenaphthene	1	0.85	*1-25*	2.2	1	0.85	*5-50*	2.2
Acenaphthylene	1	0.86	*1-25*	2.02	1	0.86	*5-50*	2.02
Anthracene	1	0.56	*0.24-10*	4.04	1	0.56	*0.24-25*	4.04
Benzo(a)anthracene	1	0.41	*0.016-10*	7.68	0.4-2	0.41	*0.016-25*	7.68
Benzo(a)pyrene	1	0.47	*0.013-20*	7.4	0.4-1	0.47	*0.013-25*	6.53
Benzo(b)fluoranthene	1	0.63	*0.017-10*	6.63	0.5-1	0.63	*0.017-25*	6.63
Benzo(g,h,i)perylene	1.5	0.5	*0.025-20*	7	0.5-1.5	0.5	*0.025-25*	7
Benzo(k)fluoranthene	1	0.71	*0.008-10*	7.36	1-2	0.71	*0.008-25*	7.36
Chrysene	1	0.44	*0.021-10*	7.49	1	0.44	*0.021-25*	7.49
Dibenzo(a,h)anthracene	1.5	0.55	*0.023-20*	7.8	0.3-1.5	0.55	*0.023-25*	6.19
Fluoranthene	1	0.7	*1-25*	6.9	1	0.7	*5-50*	6.9
Fluorene	1	0.69	*0.25-10*	2.43	1	0.69	*0.25-25*	2.43
Indeno[1,2,3-cd]pyrene	1.5	1.5	*0.017-20*	7.4	1-1.5	1.5	*0.017-25*	6.27
Naphthalene	2	1.6	*3-25*	1.6	1-2	1.6	*5-50*	1.52
Phenanthrene	1	0.46	*0.25-10*	4.15	1	0.46	*0.25-25*	4.15
Pyrene	1	0.76	*0.038-10*	5.19	1	0.76	*0.038-25*	5.19
Acute Toxicity (TUa)								
Atherinops affinis (survival)	na	na	na	*1.5*	na	na	na	np
Chronic Toxicity (TUc)								
Mysidopsis bahia (survival)	na	na	*1.5*	na	na	na	np	na

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

Appendix III. Frequency of constituent analyses used by the large POTWs and/or their contract laboratories in 2001 and 2002.

	HTP		JWPCP		OCSD		PLWTP	
Constituent	2001	2002	2001	2002	2001	2002	2001	2001
Suspended Solids	daily	daily	daily	daily	daily	daily	daily	daily
Settleable Solids	daily	daily	daily	daily	daily	daily	daily	daily
Turbidity	daily	daily	daily	daily	daily	daily	daily	daily
Oil/grease	weekly	weekly	daily	daily	daily	daily	daily	daily
TOC	weekly	weekly	4/month	monthly	na	na	na	na
BOD	daily	daily	daily	daily	daily	daily	daily	daily
COD	na	na	daily	daily	na	na	monthly	monthly
Ammonia-N	monthly	monthly	monthly	monthly	daily	daily	monthly	monthly
Nitrate-N	monthly	monthly	monthly	monthly	na	na	monthly	monthly
Nitrite-N	na	na	monthly	monthly	na	na	na	na
Organic-N	monthly	monthly	monthly	monthly	na	na	na	na
Phosphate-P (Phosphorus)	monthly	monthly	monthly	monthly	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	monthly	monthly
Arsenic	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Cadmium	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Chromium	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Copper	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Cyanide	monthly	monthly	monthly	monthly	monthly	monthly	monthly	monthly
Lead	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Mercury	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Nickel	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Selenium	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Silver	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Zinc	monthly	monthly	monthly	monthly	monthly	monthly	monthly	weekly
Phenols	na	na	monthly	monthly	na	na	na	na
Nonchlorinated Phenols	quarterly	quarterly	6/yr	quarterly	monthly	3/month	monthly	monthly
Chlorinated Phenols	quarterly	quarterly	monthly	monthly	monthly	3/month	monthly	monthly
Total DDT	quarterly	quarterly	monthly	monthly	2/month	3/month	monthly	monthly
Total PAH	quarterly	quarterly	6/yr	quarterly	2/month	3/month	monthly	monthly
Total PCB	quarterly	quarterly	monthly	monthly	2/month	3/month	monthly	monthly
Toxicity								
Atherinops affinis (growth)	na	na	na	na	na	na	na	monthly
Atherinops affinis (survival)	na	na	na	na	na	na	monthly	quarterly
Ceriodaphnia dubia (survival)	na	na	na	na	monthly	monthly	monthly	monthly
Haliotis rufescens (development)	monthly	monthly	na	na	monthly	monthly	monthly	monthly
Holmesimysis costata (survival)	na	na	na	na	na	monthly	na	na
Macrocystis pyrifera (germination)	na	na	na	na	na	na	monthly	monthly
Macrocystis pyrifera (germ tube length)	na	na	na	na	na	na	monthly	monthly
Menidia beryllina (biomass)	na	na	na	monthly	na	na	na	na
Menidia beryllina (survival)	na	na	na	monthly	na	monthly	na	na
Mysidopsis bahia (biomass)	na	na	monthly	monthly	na	na	na	na
Mysidopsis bahia (survival)	na	na	monthly	monthly	na	na	monthly	quarterly
Pimephales promelas (survival)	monthly	monthly	monthly	monthly	monthly	na	monthly	quarterly
Strongylocentrotus purpuratus (fertilization)	na	na	na	na	monthly	monthly	na	na
Bacteria								
Enterococcus	5/month	5/month	na	na	na	na	na	na
Fecal Coliforms	5/month	5/month	na	na	na	na	na	na
Total Coliforms	5/month	5/month	na	na	na	na	monthly	monthly

na = Not analyzed.
monthly = one sampling per month.
weekly = one sampling per week.
quarterly = one sampling per quarter.
annually = one sampling per year.