Annual Receiving Waters Monitoring Report for the Point Loma Ocean Outfall 2004

City of San Diego
Ocean Monitoring Program
Metropolitan Wastewater Department
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Executive Summary

The ocean monitoring program for the Point Loma Ocean Outfall (PLOO) is conducted in accordance with NPDES permit requirements for the Point Loma Wastewater Treatment Plant (PLWTP) operated by the City of San Diego (NPDES Permit No. CA0107409, Order No. R9-2002-0025). These documents specify the terms and conditions that allow treated effluent originating from the PLWTP to be discharged into the Pacific Ocean via the PLOO. Additionally, Monitoring and Reporting Program (MRP) No. R9-2002-0025 contained within the above permit defines the requirements for monitoring the receiving waters environment, including the sampling plan, compliance criteria, laboratory methods, data analysis, and reporting guidelines. Furthermore, the above MRP was modified effective August 1, 2003 with the adoption of Addendum No. 1 (see City of San Diego 2004).

The main objectives of the Point Loma ocean monitoring program are to provide data that satisfy the requirements of the NPDES permit, demonstrate compliance with the 2001 California Ocean Plan (COP), monitor dispersion of the waste field, and identify environmental changes that may be associated with wastewater discharge. Specifically, the program is designed to assess the environmental impact of wastewater originating from the PLOO, including the effects on ocean water quality, sediment conditions, and the marine biota. The study area is centered around the PLOO discharge site, which is located approximately 7.2 km offshore of the treatment plant at a depth of about 94–98 m. Monitoring at sites along the shore extends from Mission Beach southward to the tip of Point Loma. Offshore monitoring is conducted in an adjacent area overlying the coastal continental shelf at sites ranging up to about 116 m in depth.

The receiving waters monitoring effort for the Point Loma region may be divided into several major components, each comprising a separate chapter in this report: Oceanographic Conditions, Microbiology, Sediment Characteristics, Macrobenthic Communities, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Data regarding various physical and chemical oceanographic parameters are evaluated to characterize water mass transport potential in the region. Water quality monitoring along the shore and in offshore waters includes the measurement of bacteriological indicators to assess both natural and anthropogenic impacts. Benthic monitoring includes sampling and analysis of soft-bottom macrofaunal communities and their associated sediments, while communities of demersal fish and megabenthic invertebrates are the focus of trawling activities. The monitoring of fish populations is supplemented by bioaccumulation studies to determine whether or not contaminants are present in the tissues of "local" species.

In addition to the above activities, the City supports other projects relevant to assessing ocean quality in the region. One such project is a remote sensing study of the San Diego/Tijuana coastal region that is jointly funded by the City, the San Diego Regional Water Quality Control Board (RWQCB), and the International Boundary and Water Commission (IBWC); results from this study are incorporated herein into the interpretations of oceanographic and microbiological data (see Chapters 2 and 3). A long-term study of the Point Loma kelp forest funded by the City is being conducted by scientists at the Scripps Institution of Oceanography, the data of which were recently summarized (see City of San Diego 2003). Finally, the current permit includes plans to perform adaptive or special strategic process studies each year as determined by the City in conjunction with the RWQCB and the USEPA. Such studies included a comprehensive scientific review of the Point Loma ocean monitoring program (SIO 2004) and the design and implementation of a sediment mapping study for the entire San Diego coastal region (see City of San Diego 2005, Appendix A).

The present report focuses on the results of the ocean monitoring activities conducted off Point Loma during calendar year 2004. A general overview and summary of the main findings for each major monitoring component are included below.

Analysis of the receiving waters monitoring data off San Diego indicates that the PLOO discharge has had only a limited effect on the local marine environment after 11 years of wastewater discharge at the present location. During 2004, for example, water samples collected at sites within the Point Loma kelp bed were over 95% compliant with COP bacterial water-contact standards. The few incidences of non-compliance appeared related to stormwater runoff during periods of heavy rainfall, and not to the intrusion of the wastewater plume. In addition, there is no evidence that the waste field from the outfall has affected any shoreline area since the outfall was extended further offshore in 1993. The few bacterial counts that exceeded compliance standards along the shoreline in 2004 were also associated with increased rainfall. In contrast, elevated bacterial concentrations that could be attributable to wastewater discharge were detected primarily at sites adjacent to the discharge site and up to 13 km (8.2 mi) northward at depths of 60 m or below. Finally, no evidence of change in any physical or chemical water quality parameter (e.g., dissolved oxygen, pH) has been found that can be attributed to the discharge of wastewater off Point Loma.

Similar to previous years, the benthic conditions off Point Loma in 2004 continued to show some changes that may be expected near large ocean outfalls, although these were restricted to a relatively small, localized region near the discharge site. For example, sediment quality data indicated slight increases over time in terms of concentrations of sulfides and BOD, as well as the accumulation of coarse sediment particles in the vicinity of the outfall pipe. However, other potential indicators of environmental impact such as concentrations of different sediment contaminants (e.g., trace metals, pesticides) showed no patterns related to wastewater discharge. In addition, several descriptors of macrobenthic community structure (e.g., abundance, diversity, brittle star populations, BRI, ITI) have shown temporal changes between reference areas and sites close to the outfall (i.e., near-ZID), although their values remain characteristic of natural environmental conditions. Analyses of demersal fish and invertebrate communities also reveal no spatial or temporal patterns that can be attributed to effects of the PLOO. The paucity of any pathological evidence from local fishes (e.g., fin rot, tumors, lesions) or the bioaccumulation of contaminants in their tissues also suggests that the fish community remains healthy and is not adversely affected by anthropogenic sources. Consequently, there is presently no evidence of significant long-term impacts on either sediment quality or biotic communities in the coastal waters off San Diego.

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Chapter 1. General Introduction

INTRODUCTION

Treated effluent from the City of San Diego E.W. Blom Point Loma Wastewater Treatment Plant (PLWTP) is discharged to the Pacific Ocean through the Point Loma Ocean Outfall (PLOO) according to requirements set forth in Order No. R9-2002-0025, National Pollutant Discharge Elimination System (NPDES) Permit No. CA0107409. The above Order and associated Monitoring and Reporting Program (MRP No. R9-2002-0025) were adopted by the San Diego Regional Water Quality Control Board (RWQCB) on April 10, 2002. During 2003, the monitoring and reporting requirements for the Point Loma region were further modified with the adoption of Addendum No. 1 to the above Order and NPDES Permit (see City of San Diego 2004). The provisions established in Addendum No. 1 became effective August 1, 2003, thus superceding and entirely replacing all prior receiving waters monitoring requirements for the PLWTP.

The MRP for Point Loma defines the requirements for monitoring the receiving water environment around the PLOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines. The main objectives of the ocean monitoring program are to provide data that satisfy the requirements of the NPDES permit, demonstrate compliance with the 2001 California Ocean Plan (COP), detect movement and dispersion of the wastewater field, and identify any biological or chemical changes that may be associated with wastewater discharge.

BACKGROUND

The City of San Diego began operation of the PLWTP and original ocean outfall off Point Loma in 1963, at which time treated effluent was discharged approximately 3.9 km offshore at a depth of about 60 m (200 ft). From 1963 to 1985, the plant operated as a primary treatment facility, removing approximately 60% of the total suspended solids (TSS) by gravity separation. Since then, considerable improvements have been made to the treatment process. For example, the City began upgrading the process to advanced primary treatment (APT) in mid-1985, with full APT status being achieved by July of 1986. This improvement involved the addition of chemical coagulation to the treatment process, and resulted in an increased TSS removal of about 75%. Since 1986, treatment has been further enhanced with the addition of several more sedimentation basins, expanded aerated grit removal, and refinements in chemical treatment. These enhancements have resulted in consistently lower mass emissions from the plant, with TSS removals of greater than 80%. In addition, the PLOO was extended 3.3 km further offshore in the early 1990s in order to prevent intrusion of the wastewater plume into nearshore waters and thus comply with standards set forth in the COP for water contact sports areas. Construction of the outfall extension was completed in November 1993 at which time discharge was terminated at the original 60-m site. The outfall presently extends approximately 7.2 km offshore to a depth of 94 m (310 ft), where the pipeline splits into a Y-shaped multiport diffuser system. The two diffuser legs extend an additional 762 m to the north and south, each terminating at a depth of about 98 m (320 ft) near the edge of the continental shelf.

The average daily flow of effluent through the PLOO in 2004 was 174 million gallons per day (mgd^{-1}) or 658 million liters per day (mLd^{-1}), ranging from a minimum of 168 mgd^{-1} to a maximum of 187 mgd^{-1} (634–708 mLd^{-1}). This is similar to the average flow of 170 mgd^{-1} during 2003. TSS removal averaged about 85.3%

during 2004, with the total mass emissions of 10,325 mt/yr (see City of San Diego 2005a).

RECEIVING WATERS MONITORING

Prior to 1994, the City conducted an extensive ocean monitoring program off Point Loma centered around the original 60-m discharge site. This program was subsequently modified and expanded with the construction and operation of the deeper outfall. Data from the last year of regular monitoring near the original inshore site are presented in City of San Diego (1995b), while the results of a 3-year recovery study for that area are summarized in City of San Diego (1998). From 1991 through 1993, the City also conducted a voluntary "predischarge" study in the vicinity of the new site in order to collect baseline data prior to the discharge of effluent in these deeper waters (City of San Diego 1995a, 1995b). Results of NPDES-mandated monitoring for the extended PLOO from 1994 through 2003 are available in previous annual receiving waters monitoring reports (e.g., City of San Diego 2004). Additionally, the City has participated in a number of regional and other monitoring efforts throughout the Southern California Bight that have provided useful background information for the entire region (e.g., SCBPP 1998, City of San Diego 1999, 2000, 2001, 2002, 2003, Bight'98 Steering Committee 2003).

The sampling area off Point Loma presently extends from La Jolla southward to Point Loma, and from the shoreline seaward to a depth of about 116 m (380 ft) (**Figure 1.1**). Fixed sites are arranged in a grid surrounding the outfall, and are monitored in accordance with a prescribed sampling schedule. The monitoring program may be divided into the following major components, each comprising a separate chapter in this report: (1) Oceanographic Conditions; (2) Microbiology; (3) Sediment Characteristics; (4) Macrobenthic Communities; (5) Demersal Fishes and Megabenthic Invertebrates; (6) Bioaccumulation of Contaminants in Fish Tissues. Detailed information concerning station locations, sampling equipment, analytical techniques, and quality assurance procedures are included in the Environmental Monitoring and Technical Services Division Laboratory Quality Assurance Project Plan for the City's Ocean Monitoring Program (City of San Diego in prep). Results of the Laboratory's quality assurance procedures are included in the EMTS Division Laboratory Quality Assurance Report (City of San Diego 2005b). In addition, data files, detailed methodologies, completed reports, and other pertinent information submitted to the USEPA and the RWQCB throughout the year are available online at the City's Metropolitan Wastewater Department website (http://www.sandiego.gov/mwwd).

This report summarizes the results from the receiving waters monitoring conducted off Point Loma from January through December 2004. The data are compared to the results from previous years in order to examine long-term patterns of

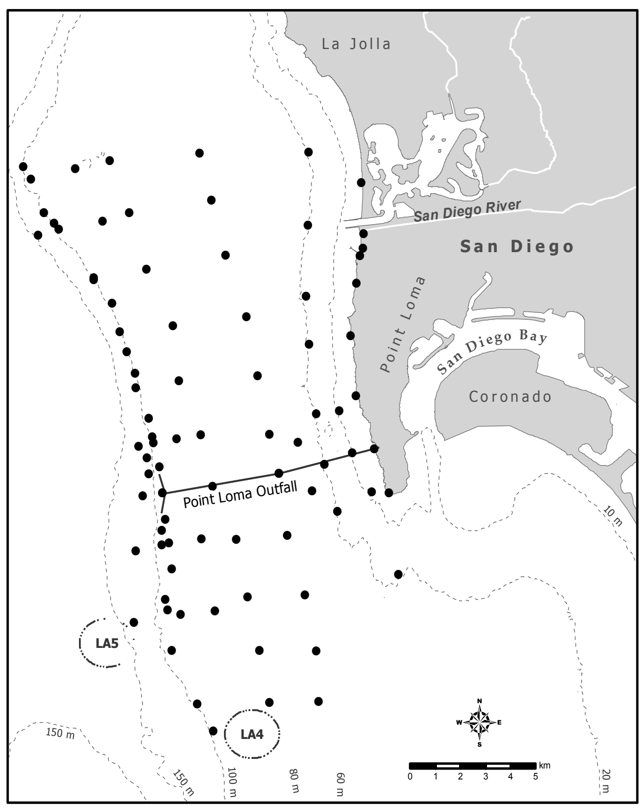

Figure 1.1
Receiving waters monitoring stations for the Point Loma Ocean Outfall Monitoring Program.

change in the region. In addition, results from the continuing coastal remote sensing study of the San Diego/Tijuana Region that is jointly funded by the City, San Diego RWQCB, and the International Boundary and Water Commission have been incorporated into the water quality sections of this report (Chapters 2 and 3). A glossary of technical terms is included.

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Chapter 2. Oceanographic Conditions

INTRODUCTION

The fate of wastewater discharged into deep offshore waters is strongly determined by oceanographic conditions and other events that suppress or facilitate horizontal and vertical mixing. Consequently, measurements of physical and chemical parameters such as water temperature, salinity, and density are important components of ocean monitoring programs because these properties determine water column mixing potential (Bowden 1975). Analysis of the spatial and temporal variability of these parameters as well as transmissivity, dissolved oxygen, pH, and chlorophyll may also elucidate patterns of water mass movement. Taken together, analysis of such measurements for the receiving waters surrounding the discharge areas help: (1) describe deviations from expected patterns, (2) reveal the influence of wastewater plumes relative to other inputs such as from bays and rivers, (3) determine the extent to which water mass movement or mixing affects the dispersion/dilution potential for discharged materials, and (4) demonstrate the influence of natural events such as storms or El Niño/La Niña oscillations. In addition, combining measurements of physical oceanographic parameters with assessments of bacterial concentrations can provide further insight into the transport potential surrounding a discharge site over time.

The City of San Diego regularly monitors oceanographic conditions in the region surrounding the Point Loma Ocean Outfall (PLOO) in order to assess the influence of a variety of sources. For example, although water quality in the region is naturally variable, it is also subject to several natural and anthropogenic sources of contamination. These include inputs from San Diego Bay, Mission Bay, and the San Diego River, as well as discharged wastewater through the PLOO. This chapter describes the oceanographic conditions that occurred off Point Loma during 2004, and is referred to in subsequent chapters to explain patterns of bacteriological occurrence (see Chapter 3) or other effects of the PLOO discharge on the marine environment (see Chapters 4–7). In addition, in the absence of information on deep water currents, bacterial concentrations provide the best indication of horizontal transport of discharged waters (Picard and Emery 1990; see Chapter 3).

MATERIALS AND METHODS

Oceanographic measurements were collected at fixed sampling sites located in a grid pattern surrounding the PLOO (**Figure 2.1**). Thirty-six offshore stations (designated F01-F36 in Figure 2.1) were sampled quarterly in January, April, July, and October, usually over a 3-day period. Three of these stations (F01–F03) are located along the 18-m depth contour, while 11 sites are located along each of the following depth contours: 60-m contour (stations F04–F14); 80-m contour (stations F15–F25); 98-m contour (stations F26–F36). Eight additional stations are located in the Point Loma kelp bed and subject to the 2001 California Ocean Plan (COP) water contact standards. These stations include three sites (stations C4, C5, C6) located along the inshore edge of the kelp bed paralleling the 9-m depth contour, and five sites (stations A1, A6, A7, C7, C8) located along the 18-m depth contour near the offshore edge of the kelp bed. To meet the COP sampling frequency requirements for kelp bed areas, sampling at the eight kelp bed stations was conducted five times per month.

Oceanographic measurements were collected by lowering a SeaBird conductivity, temperature,

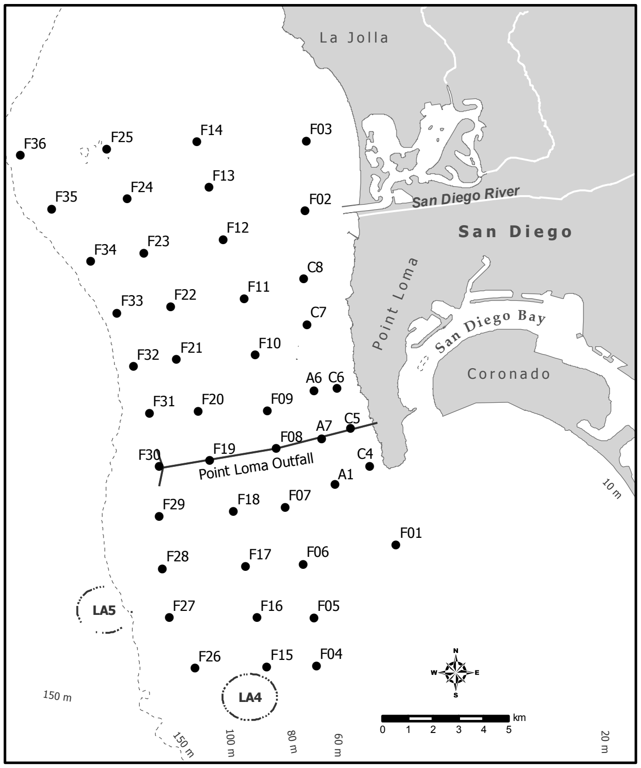

Figure 2.1
Locations of water quality monitoring stations where CTD casts are taken for the Point Loma Ocean Outfall Monitoring Program.

and depth (CTD) instrument through the water column. Profiles of temperature, salinity, density, pH, transmissivity (water clarity), chlorophyll *a*, and dissolved oxygen were constructed for each station by averaging the values recorded over 1-m depth intervals during processing. Further details regarding the CTD data processing are provided in the City's Quality Assurance Plan (City of San Diego in prep). Visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were also recorded prior to each CTD sampling event.

Monitoring of the San Diego and neighboring coastline also included satellite and aerial remote sensing performed by Ocean Imaging Corporation of Solana Beach, California (OI). Satellite imagery included data collected from both Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat Thematic Mapper (TM) instrumentation. The aerial imaging was done using OI's DMSC-MKII digital multispectral sensor (DMSC). Its four channels were configured to a specific wavelength (color) combination, determined by OI's previous research, which maximizes the detection of the PLOO plume's turbidity signature, while also allowing separation between the outfall plume and coastal discharges and turbidity. The depth penetration of the imaging varies between 8 and 15 meters, depending on general water clarity. The spatial resolution of the data is usually 2 meters. Several aerial overflights were performed each month during the rainy season, while fewer flights were conducted during the dry season.

RESULTS AND DISCUSSION

Expected Seasonal Patterns of Physical and Chemical Parameters

The weather in southern California can be classified into two basic "seasons," wet (winter) and dry (spring through fall), and certain patterns in oceanographic conditions off Point Loma follow these "seasons." For instance, temperatures are typically similar at surface and mid-water depths during the winter months, but then diverge beginning in the spring with differences becoming greatest in mid- to late summer. In contrast, waters deeper than 40 m are typically cooler than surface and mid-level waters, and generally exhibit an opposite pattern of being warmest during winter and coldest throughout the spring and early summer.

The typical winter conditions present during January and February each year are characterized by cold water temperatures and a high degree of homogeneity throughout the water column for all physical and chemical parameters. Exceptions to these conditions occur when stormwater runoff due to heavy rainfall periodically influences the density profile and causes a freshwater lens within nearshore surface waters. With minimal stratification of the water column, the chance that the wastewater plume could surface is highest during these winter months.

Usually in March or April a decrease in the frequency of winter storms brings about the transition of seasons. During the spring and early summer months, surface waters begin to warm and cause the return of a seasonal thermocline and pycnocline to coastal and offshore waters. Once the water column becomes stratified, minimal mixing conditions tend to remain throughout the dry summer and fall months. In October or November, cooler weather, reduced solar input, and increased storm activity lead to the return of a well-mixed, homogeneous water column that is characteristic of winter months. Analyses of oceanographic data collected off Point Loma over the past 27 years support this pattern.

Observed Seasonal Patterns of Physical and Chemical Parameters

With the exception of greater than normal rainfall during February, drought conditions persisted from January through the first half of October in 2004 (**Figure 2.2**; NOAA/NWS 2005). Record rainfall occurred during late October followed by below normal rainfall in November and then record rainfall again in December. Despite these circumstances, oceanographic conditions during 2004 followed normal seasonal patterns (**Figure 2.3**). Mean surface water temperatures ranged from 14 to greater than 20°C, with the highest temperatures occurring in July and October (**Table 2.1**). Surface temperatures in winter and spring were approximately 1°C cooler than the previous year and 1–2°C warmer in summer and fall. Bottom waters were generally cooler than the previous year and remained cold throughout the year, with little seasonal variance. Mean bottom water temperatures ranged from 10.0 to 10.9°C in 2004 versus 9.8 to 11.5°C in 2003. The lowest temperatures were recorded in April and July and the warmest in January.

Thermal stratification in 2004 followed the typical annual pattern (Figure 2.3). Stratification was absent in January with surface and mid-level waters differing by less than 0.3°C (**Table 2.2**). However, seasonal stratification of the upper water column started to develop in April as surface water temperatures increased and mid-level and

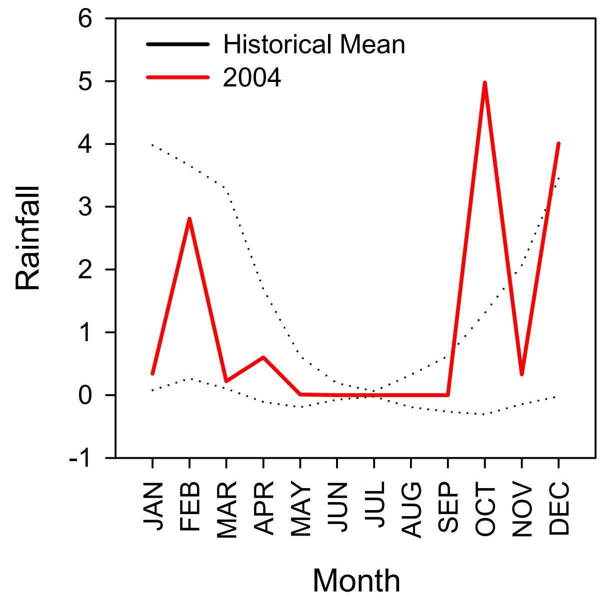

Figure 2.2
Total monthly rainfall (inches) at Lindbergh Field (San Diego, CA) for 2004 compared to monthly average rainfall (+/- 1 standard deviation) for 1914 through 2004.

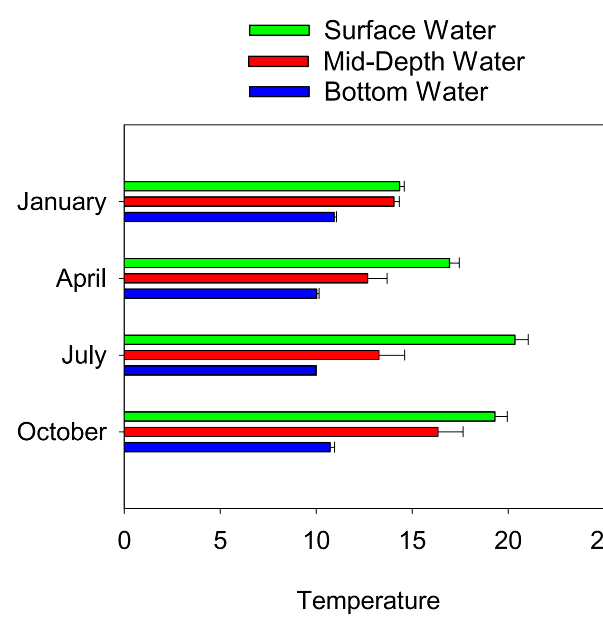

Figure 2.3
Average temperatures (°C) off Point Loma for surface (<2 m), mid-depth (10–20 m), and bottom (>88 m) waters during January, April, July, and October 2004.

Table 2.1

Quarterly mean values for top (≤2 m), mid-depth (10–20 m), and bottom (≥88 m) waters at all quarterly PLOO stations during 2004. Parameters measured are Temp=temperature (°C), salinity (ppt), density (δ/θ), DO=dissolved oxygen (mg/L), pH, XMS=transmissivity (%), and Chl *a*=chlorophyll *a* (µg/L).

		Jan	Apr	Jul	Oct
Temp	*Surface*	14.3	16.9	20.3	19.3
	Mid	14.0	12.7	13.3	16.3
	Bottom	10.9	10.0	10.0	10.7
Salinity	*Surface*	33.20	32.97	33.49	33.33
	Mid	33.20	33.41	33.43	33.25
	Bottom	33.51	33.73	33.79	33.42
Density	*Surface*	24.72	23.97	23.52	23.66
	Mid	24.79	25.22	25.12	24.31
	Bottom	25.63	25.96	26.02	25.60
DO	*Surface*	8.2	5.7	7.8	7.8
	Mid	8.2	7.2	8.1	8.6
	Bottom	4.8	4.3	3.8	5.1
pH	*Surface*	8.2	8.2	8.2	8.2
	Mid	8.1	8.0	8.1	8.2
	Bottom	7.8	7.8	7.7	7.8
XMS	*Surface*	87	79	85	91
	Mid	86	82	89	88
	Bottom	89	87	88	88
Chl *a*	*Surface*	3.2	2.8	2.6	1.2
	Mid	4.7	8.5	3.9	3.5
	Bottom	2.2	1.7	1.3	0.9

bottom water temperatures declined. By July, a highly stratified upper water column was clearly evident. Surface waters were over 20°C at this time and differed from mid-level and bottom waters by 7 and 10°C, respectively. This stratification began to breakdown in October as surface water temperatures fell and mid-level temperatures rose. Stratification at the shallower kelp stations showed a similar pattern (**Figure 2.4; Table 2.3**). In contrast, bottom waters were generally much cooler than surface or mid-level waters throughout the year. For example, bottom waters were at least 3.4°C colder than surface waters and 2.6°C cooler than mid-level waters over the four quarterly surveys. Since temperature is the main contributor to water

Table 2.2

Average temperature differences between surface waters (≤2 m), mid-depth waters (10–20 m) and bottom waters (≥88 m) surrounding the PLOO during 2004.

	Surface vs Mid	Surface vs Bot	Mid vs Bot
Jan	0.29	3.41	3.11
Apr	4.27	6.92	2.65
Jul	7.08	10.39	3.31
Oct	2.95	8.58	5.63

column stratification in southern California (Dailey et. al. 1993), these differences were important to limiting the surfacing potential of the waste field to depths below 40 m (see Chapter 3).

Surface water salinity was lower and more variable than in recent years and was strongly influenced by both unusually heavy rainfall and high summer temperatures. Surface salinity at the offshore stations averaged from 32.97 to 33.49 ppt in 2004 (Table 2.1). Storm runoff resulted in mean surface salinity below 33 ppt in April. In contrast, record air temperatures and the resulting seawater evaporation in July increased surface salinity during the summer months. The effects of the October rains are not reflected in the salinity values of Table 2.1 because quarterly sampling took place prior to the storms; however, a surface lens of freshened seawater (i.e., salinities <33 ppt) was recorded at the kelp stations during October, November, and December (see Table 2.3; City of San Diego 2004a, b, 2005). Seawater density, a function of temperature, salinity, and pressure, reflected the changes brought about by the increased storm activity and warmer than normal summer temperatures. In general, water density was lower throughout the water column when compared to the 2003 survey.

Data for the various other measured parameters (i.e., pH, transmissivity, chlorophyll *a*, dissolved oxygen) also varied in response to sporadic natural events, such as storm activity and increased primary productivity. Turbidity following rainfall events was readily visible in satellite and aerial imagery (see Ocean Imaging 2004a, b, 2005). Data from transmissivity measurements generally supported these aerial observations. For example,

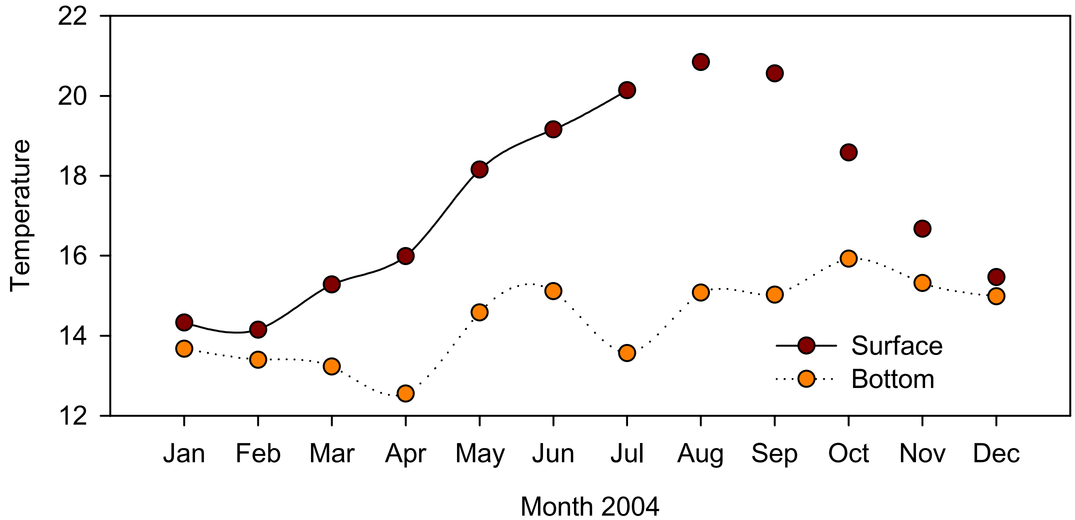

Figure 2.4
Average temperatures (^{o}C) for surface (<2 m) and bottom waters for the Point Loma nearshore Kelp Bed stations sampled during 2004.

Table 2.3
Monthly average values for top (≤2 m) and bottom waters at all PLOO nearshore kelp bed stations sampled during 2004. Parameters measured are: Temp=temperature (^{o}C), salinity (ppt), density (δ/θ), DO=dissolved oxygen (mg/L), pH, XMS=transmissivity (%), and Chl a=chlorophyll a (µg/L).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	Surface	14.3	14.1	15.3	16.0	18.2	19.2	20.1	20.8	20.6	18.6	16.7	15.5
	Bottom	13.7	13.4	13.2	12.5	14.6	15.1	13.6	15.1	15.0	15.9	15.3	15.0
Salinty	Surface	33.22	33.17	33.12	33.29	33.35	33.48	33.51	33.46	33.41	33.14	33.13	33.14
	Bottom	33.21	33.24	33.25	33.48	33.42	33.57	33.42	33.37	33.34	33.20	33.21	33.19
Density	Surface	24.74	24.74	24.46	24.43	23.97	23.82	23.58	23.36	23.39	23.70	24.15	24.44
	Bottom	24.87	24.95	24.98	25.29	24.82	24.81	25.04	24.68	24.65	24.36	24.52	24.58
DO	Surface	7.6	8.3	8.6	9.0	9.1	8.6	8.7	8.2	8.1	8.0	7.6	7.8
	Bottom	7.1	7.3	6.9	6.7	7.2	6.5	6.6	7.9	7.5	7.4	6.9	7.6
pH	Surface	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.1	8.2	8.1	8.1	8.1
	Bottom	8.0	8.0	7.9	7.9	8.1	8.0	8.0	8.1	8.1	8.1	8.1	8.1
XMS	Surface	81.5	78.2	79.0	75.3	77.9	75.8	79.6	84.4	80.9	77.5	76.7	76.2
	Bottom	83.2	82.3	84.0	79.9	79.9	79.9	85.0	85.0	83.9	84.6	81.3	77.4
Chl *a*	Surface	2.14	2.78	2.63	4.08	3.56	4.12	2.71	1.37	2.14	2.93	2.76	1.65
	Bottom	2.26	3.31	2.43	5.42	5.73	5.47	2.74	2.94	3.22	3.07	3.19	2.10

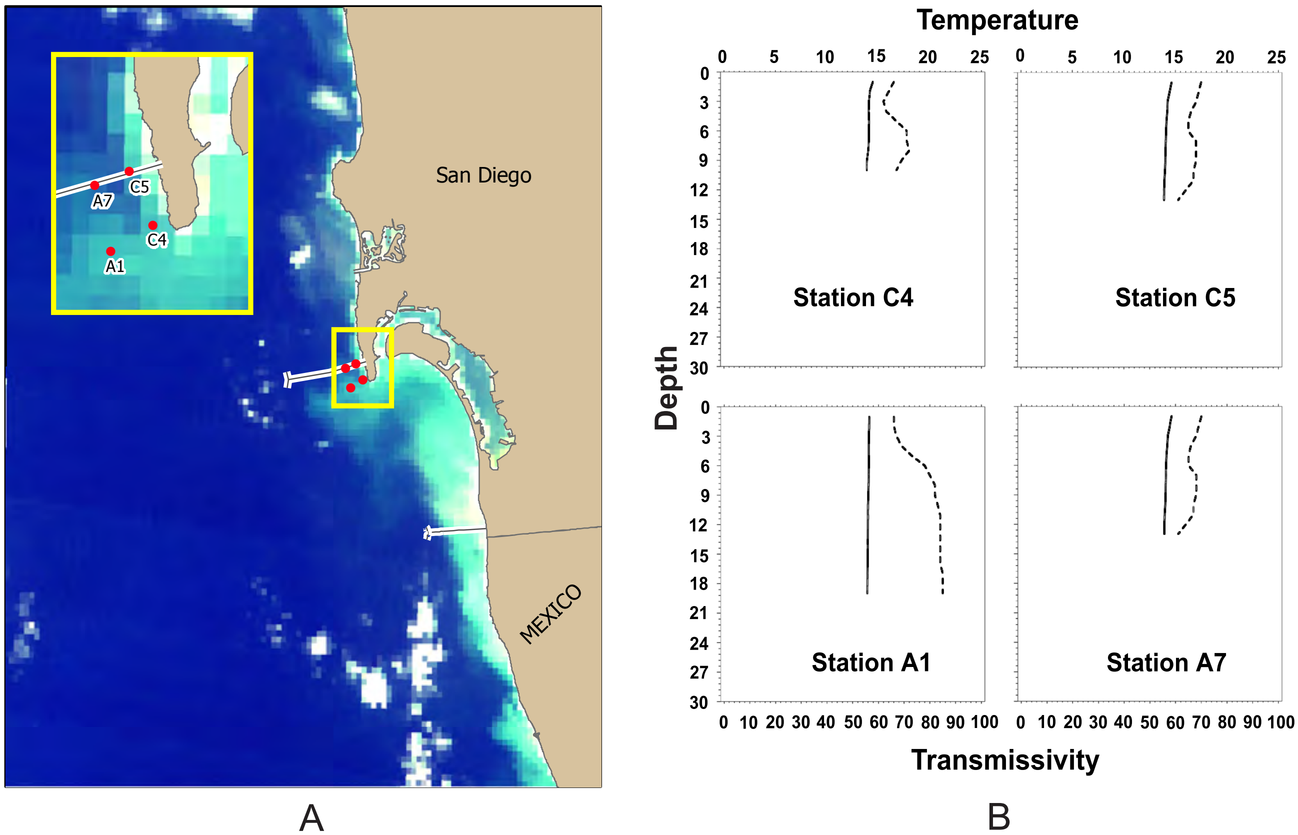

Figure 2.5
(A) MODIS satellite image showing the San Diego water quality monitoring region, captured on February 24, 2004 by Ocean Imaging and (B) CTD profiles of percent transmissivity (dotted lines) at stations A1, C4, A7, and C5 collected on February 25, 2004. White pixels in the MODIS image represent areas obscured by cloud cover offshore or "washout" or band saturation due to the histogram stretches used to enhance turbidity features in surface waters along the shoreline.

from February through April aerial images depict increased discharge of turbid waters from the San Diego Bay, Mission Bay, San Diego River, and more northward sources following the February storms (Ocean Imaging 2004a). The resultant discharge from San Diego Bay was apparent in lowered surface transmissivity at the two southernmost kelp stations (A1 and C4) on February 25, following a 2-day storm that dropped 1.4 inches of rain (**Figure 2.5**). In some cases, these storms gave rise to turbid water masses that extended to and beyond the PLOO outfall area (**Figure 2.6**). These conditions were apparent in lowered surface water transmissivity values (<80% light transmission) in April relative to values (≥ 85%) in January, July, and October (Table 2.1). In contrast, during June, July, August, and September the lack of rain and runoff helped the regional waters remain relatively clear through early October (Ocean Imaging 2004c, 2005). In mid-October and December however, the region was again subject to frequent terrestrial runoff from the winter storms. This caused great volumes of turbid runoff from San Diego Bay and Mission Bay that affected nearshore water conditions that also extended into the PLOO region (**Figure 2.7**). Transmissivity values for offshore stations were obtained prior to the record storms of mid-October and don't reflect these turbid conditions; however, data from the nearshore stations show a corresponding decrease in mean transmissivity values (Table 2.3).

Water clarity was also affected by a regional plankton bloom. Aerial imagery indicated the beginning of a plankton bloom in April (see Ocean Imaging 2004a) that corresponded to increased dissolved oxygen (DO) and chlorophyll *a* values. For example, relatively high mean DO

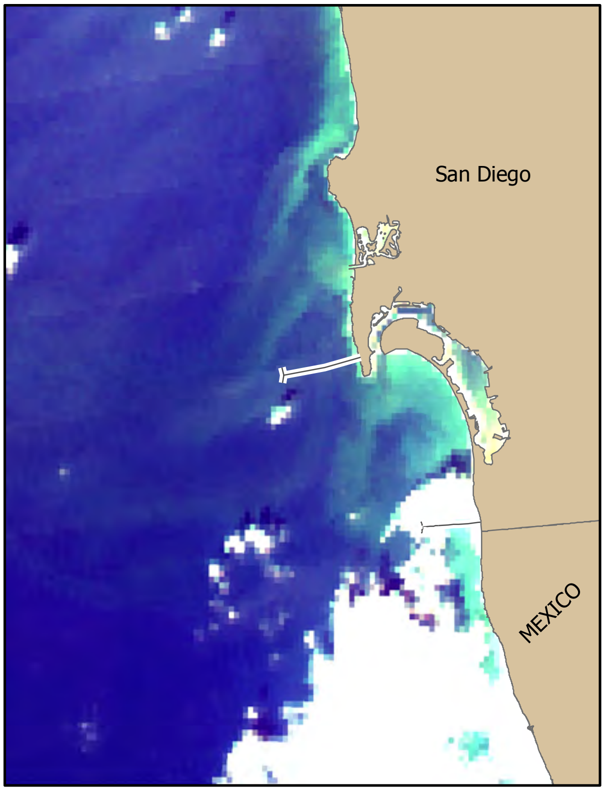

Figure 2.6
MODIS satellite image provided by Ocean Imaging showing the San Diego water quality monitoring region, captured on March 3, 2004. White pixels offshore represent areas obscured by cloud cover. White pixels along the shoreline are the result of "washout" or band saturation due to the histogram stretches used to enhance turbidity features in surface waters.

values (7.2 mg/L) in April mid-level waters corresponded to a very high chlorophyll *a* value (8.5 mg/L) (see Table 2.1). The kelp stations showed low transmissivity values that corresponded to the highest chlorophyll *a* and surface DO values from April through June (Appendix A.1). Relatively low DO values in bottom waters of these nearshore stations over the same period were concurrent with elevated chlorophyll values, suggesting that the low oxygen levels likely resulted from the biological degradation of plankton as it sank below the surface.

These storm and plankton-driven turbidity patterns in surface waters act as markers of water movement within the satellite imagery. From January through September 2004, with few exceptions, aerial imagery of turbidity patterns indicated that water movement was primarily southward (see Figure 2.6, and Ocean Imaging 2004a, b, c). For example, February rains and subsequent runoff from the San Diego River and along the shores of La Jolla and North County gave rise to sediment-laden waters that were advected southwestward over the Point Loma outfall. With the start of record storm activity in October, surface waters in the outfall region were subject to frequent northward currents. For instance, after heavy rainfall in October and December the outer edge of a very large, combined storm water plume from the Tijuana River and from San Diego Bay reached as far northward and seaward as the PLOO outfall wye (see Figure 2.7, and Ocean Imaging 2005). In addition, a storm-related sewage overflow at the Point Loma Facility on October 27 caused 2.2 MG of sewage to flow into the ocean, and this persistent northward flow likely helped flush the sewage effluent out of the kelp bed areas and disperse it offshore (see Chapter 3).

SUMMARY AND CONCLUSIONS

Drought conditions in San Diego continued from January through mid-October in 2004 with the exception of heavy rainfall during February. Then, during the latter half of October and again in December, record rainfall resulted in heavy runoff and turbid waters both inshore and offshore in the Point Loma region. Despite these circumstances, oceanographic conditions during 2004 generally followed normal seasonal patterns. Surface water temperatures were slightly colder during January, but warmer during April, July, and October when compared to 2003. Thermal stratification of the water column followed the typical cycle with maximum seasonal stratification apparent in summer and a mixed water column during late fall and winter.

Surface water salinity was lower and more variable than in recent years and was strongly influenced by both unusually heavy rainfall and high summer temperatures. Surface salinity values fell below

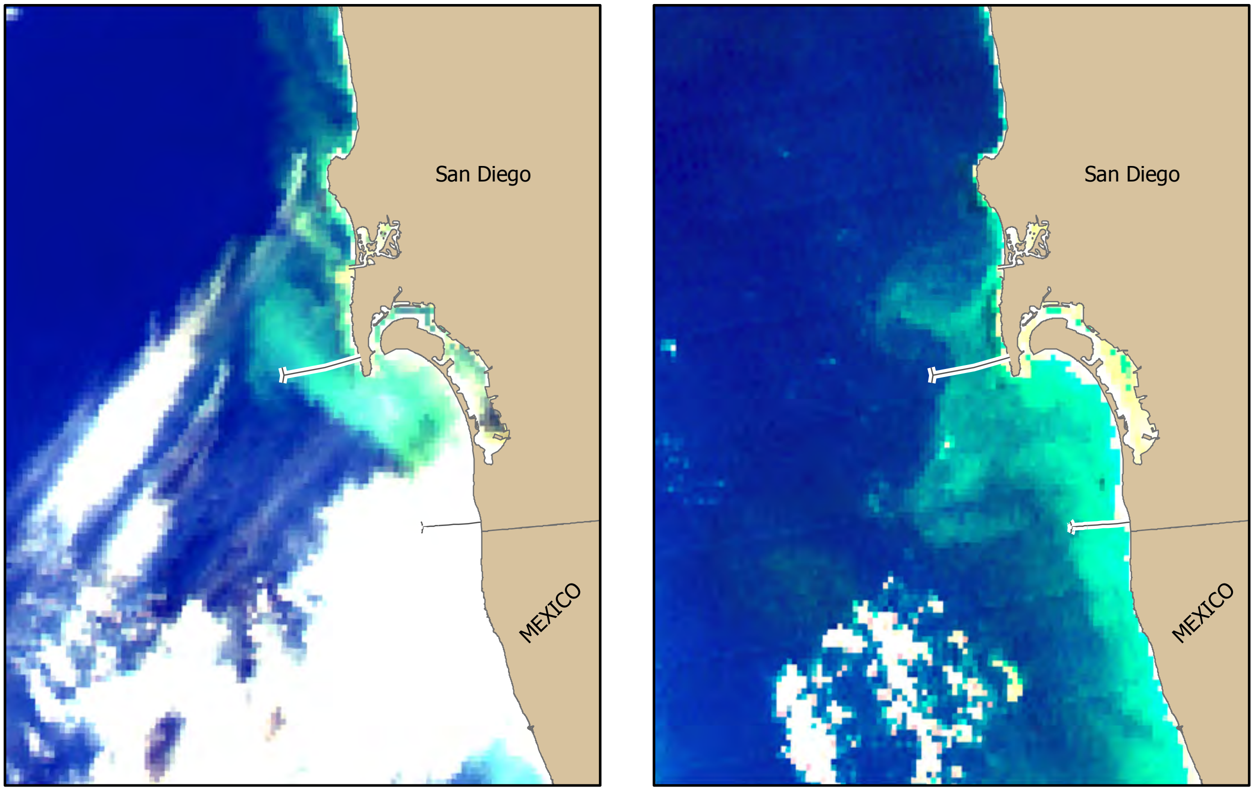

Figure 2.7
MODIS satellite image showing the San Diego water quality monitoring region, captured by Ocean Imaging on (A) October 29, 2004, and (B) December 9, 2004. White pixels offshore represent areas obscured by cloud cover. White pixels along the shoreline are the result of "washout" or band saturation due to the histogram stretches used to enhance turbidity features in surface waters.

33 ppt as a result of river and bay discharge following various storms. Warmer temperatures and lower salinities resulted in lower than normal densities throughout the water column during April and July.

Aerial and satellite imagery indicated that water clarity was frequently compromised by sediment resuspension and embayment flushing events following February, October, and December storms. Transmissivity values at the kelp bed stations reflected this nearshore turbidity, primarily from the Point Loma beaches or near the mouths of San Diego Bay and Mission Bay. In contrast, transmissivity was generally high during January, July and the first part of October.

Analysis of the physical water column properties as well as aerial and satellite imagery off Point Loma in 2004 provided no evidence that wastewater discharged via the PLOO reached either inshore sites or surface waters. Even during the winter months when water column stratification was weakest, there was no indication that the wastewater plume reached depths shallower than 40–60 m. These physical conditions will be important in the analysis of spatial patterns of bacterial concentrations to be discussed in the following chapter.

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Chapter 3. Microbiology

INTRODUCTION

The City of San Diego performs shoreline and water column bacterial monitoring in the region surrounding the Point Loma Ocean Outfall (PLOO). Bacteriological densities, together with oceanographic data (see Chapter 2), provide information about the movement and dispersion of wastewater discharged through the outfall. Analyses of these data may also implicate point or non-point sources other than the outfall as contributing to bacterial contamination events in the region. The PLOO monitoring program is designed to assess general water quality and demonstrate level of compliance with the 2001 California Ocean Plan (COP) as required by the NPDES discharge permit. The results of bacteriological analyses and individual station compliance data are submitted to the San Diego Regional Water Quality Control Board in the form of Monthly Receiving Waters Monitoring Reports. This chapter summarizes and interprets patterns in bacterial concentration data collected off Point Loma during 2004.

MATERIALS AND METHODS

Field Sampling

Water samples for bacteriological analyses were collected at fixed shore and offshore sampling sites throughout the year (**Figure 3.1**). Sampling was performed at eight shore stations (D4, D5, and D7–D12) to monitor bacteria levels along public beaches. Eight stations located in the Point Loma kelp bed were also monitored to assess water quality conditions in areas used for water contact sports (e.g., kelp beds). These stations include three sites (stations C4, C5, C6) located near the inshore edge of the kelp bed along the 9-m depth contour, and five sites (stations A1, A6, A7, C7, C8) located near the offshore edge of the kelp bed along the 18-m depth contour. Samples were taken at three fixed depths for each station (**Table 3.1**). The shore and kelp stations were sampled five times per month according to NPDES permit specifications in order to monitor compliance with COP water contact standards (see **Box 3.1**).

Thirty-six offshore stations (designated F01–F36, Figure 3.1) were sampled quarterly in January, April, July, and October. Sampling at these sites usually takes place over a 3-day period. Three of these stations (F01–F03) are located along the 18-m depth contour, while 33 sites (11 per transect) are located along the 60-m contour (stations F04–F14), the 80-m contour (stations F15–F25), and the 98-m contour (stations F26–F36).

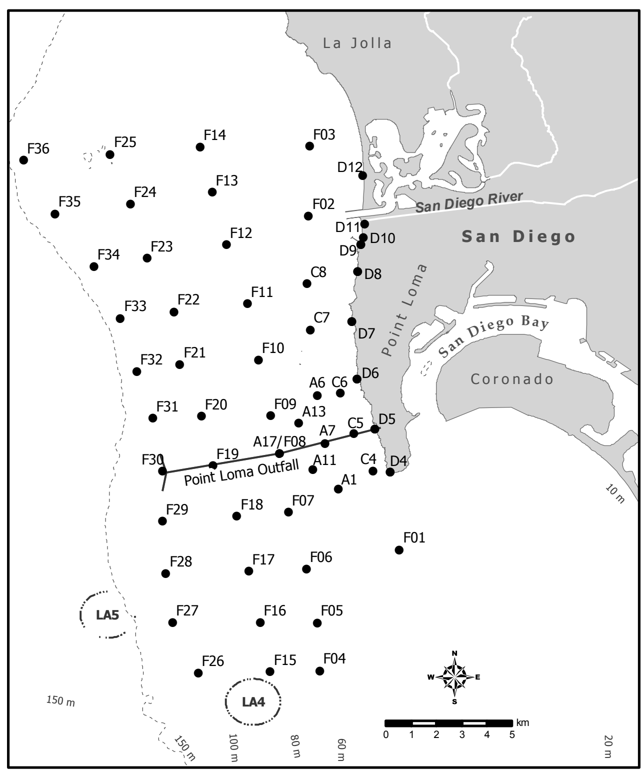

Figure 3.1
Locations of water quality monitoring stations where bacterial samples are taken, Point Loma Ocean Outfall Monitoring Program.

Table 3.1
Depths (m) at which bacteriological samples are collected at the PLOO kelp and quarterly offshore water quality stations.

	Sample depth								
Station transect	1	3	9	12	18	25	60	80	98
9-m kelp bed	x	x	x						
18-m kelp bed	x			x	x				
18-m quarterly	x			x	x				
60-m quarterly	x					x	x		
80-m quarterly	x					x	x	x	
98-m quarterly	x					x	x	x	x

The number of samples taken at each station was depth-dependent and ranged from a minimum of three fixed depths sampled at the 18-m stations to a maximum of five fixed depths sampled at the 98-m stations (Table 3.1).

Seawater samples were collected in sterile 250-mL bottles from the shoreline at each shore station. Visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were recorded at the time of sample collection. The seawater samples were then transported on ice to the City's Marine Microbiology Laboratory and analyzed to determine concentrations of total coliform, fecal coliform, and enterococcus bacteria.

Seawater samples from the kelp bed and quarterly offshore stations were analyzed for the same three bacterial parameters. These samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Aliquots for each analysis were drawn into appropriate sample containers. The samples were refrigerated aboard ship and then transported to the City's Marine Microbiology Laboratory for bacteriological analysis. Visual observations of weather and water conditions were also recorded for each sampling event.

Monitoring of the San Diego and neighboring coastline also included satellite and aerial remote sensing performed by Ocean Imaging Corporation (OI) (see Chapter 2). These surveys assist in the detection of the turbidity signature from the PLOO plume, while also differentiating between the outfall plume and coastal discharges. Such data help distinguish between bacterial contamination events caused by the PLOO discharge from those attributable to other point and non-point sources (e.g., river and bay discharges).

Laboratory Analyses and Data Treatment

All bacterial analyses were performed within eight hours of sample collection and conformed to the membrane filtration techniques outlined in the City's Quality Assurance Plan (City of San Diego in prep). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services (CS-DHS), Water Laboratory Approval Group with respect to sampling and analytical procedures (Bordner, et al. 1978; Greenberg, et al. 1992).

Colony counting, calculation of results, data verification and reporting all follow guidelines established by the EPA (see Bordner et al. 1978). According to these guidelines, plates with bacterial counts above or below permissible counting limits were given greater than (>), less

Box 3.1

Bacteriological compliance standards for water contact areas, 2001 California Ocean Plan (CSWRCB 2001). CFU = colony forming units.

(1) *30-day total coliform standard* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 mL.

(2) *10,000 total coliform standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.

(3) *60-day fecal coliform standard* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.

(4) *geometric mean* — the geometric mean of the fecal coliform concentration at any given station in any 30-day period may not exceed 200 CFU per 100 mL, based on no fewer than five samples.

than (<), or estimated (e) qualifiers. However, these qualifiers were dropped and the counts were treated as discrete values during the calculation of compliance with COP standards and in various statistical analyses.

Spatial and temporal patterns in bacteriological contamination were determined from mean densities of total coliform, fecal coliform, and enterococcus bacteria. These data were analyzed by station, month, and depth, and evaluated relative to (a) monthly rainfall and climatological data collected at Lindbergh Field, San Diego, CA, (b) oceanographic conditions (see Chapter 2), and (c) other events identified through satellite and aerial sensing data (e.g., stormwater flows, nearshore and surface water circulation patterns). Shore and kelp bed station compliance with COP bacteriological standards was summarized according to the number of days per month that each station exceeded the four standards (see Box 3.1). Bacteriological data for offshore stations data are not subject to COP standards; however, these data were used to examine spatio-temporal patterns in the dispersion of waste field. Bacteriological benchmarks for receiving waters discussed in this report are $\geq$ 1000 CFU/100 mL for total coliform values, $\geq$ 400 CFU/100 mL for fecal coliforms, and $\geq$ 104 CFU/100 mL for enterococcus bacteria. These benchmarks were used as reference points to distinguish elevated bacteriological values. Generally, contaminated waters were identified by samples with total coliform concentrations $\geq$ 1000 CFU/mL and a fecal:total (F:T) ratio $\geq$ 0.1 (see CS-DHS 2000). Offshore station water quality samples that met these criteria were used as indicators of the waste field.

Quality assurance tests were performed routinely on water samples to ensure that sampling variability did not exceed acceptable limits. Duplicate and split field samples were collected according to method requirements and processed by laboratory personnel to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in the Quality Assurance Report (City of San Diego 2005).

RESULTS AND DISCUSSION

Compliance with California Ocean Plan Standards – Shore and Kelp Bed Stations

Compliance with COP bacterial standards at the shore and kelp stations were generally high, despite heavy rainfall that periodically affected nearshore water quality (see Chapter 2 and below). Water quality samples from the shoreline

Table 3.2

Summary of compliance with California Ocean Plan water contact standards for PLOO shore stations during 2004. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standards. Shore stations are listed left to right from south to north.

30-Day Total Coliform Standard

Month	# days	D4	D5	D7	D8	D9	D10	D11	D12
January	31	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0
March	31	0	0	0	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0
October	31	0	0	0	15	0	0	3	0
November	30	0	0	0	26	0	0	21	0
December	31	0	0	1	0	0	0	0	0
Compliance (%)		100%	100%	<100%	89%	100%	100%	93%	100%

60-Day Fecal Coliform Standard

Month	# days	D4	D5	D7	D8	D9	D10	D11	D12
January	31	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0
March	31	0	0	0	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0
October	31	0	0	0	15	0	0	0	0
November	30	0	0	0	30	0	0	0	0
December	31	0	0	0	19	0	0	0	0
Compliance (%)		100%	100%	100%	83%	100%	100%	100%	100%

stations were over 80% compliant with the 30-day total and 60-day fecal coliform standards and 100% compliant with the 10,000 total coliform and geometric mean standards. Similarly, samples from the kelp stations were compliant with the 30-day total coliform standard over 95% of the time, and approximately 100% of the time with the other COP standards (**Tables 3.2, 3.3**). The few exceptions occurred in October, November, or December. During this time, water quality samples exceeded the 30-day total coliform standard at stations D8 and D11 (October–November) and Station D7 (December). Samples collected at station D8 also exceeded the 60-day fecal coliform during all three months. In addition, a few samples collected at kelp stations A1, A7, and C4 during November and at most kelp stations in December caused these sites to exceed the 30-day total coliform standard. Stations C4 and C5 exceeded the 10,000 total coliform standard once each in December, and station C4 also exceeded the 60-day fecal coliform standard once in December. Generally, these incidences of non-compliance followed periods of excessive rainfall (see Chapter 2, and below). For example, exceedences of the 10,000 coliform standard at stations C4 and

Table 3.3

Summary of compliance with California Ocean Plan water contact standards for PLOO kelp bed stations during 2004. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standards. Kelp stations are listed left to right from south to north by depth contour.

30-Day Total Coliform Standard

		9-m stations			18-m stations				
Month	**# days**	**C4**	**C5**	**C6**	**A1**	**A7**	**A6**	**C7**	**C8**
January	31	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0
March	31	0	0	0	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0
November	30	1	0	0	1	12	0	0	0
December	31	1	1	1	1	1	0	0	1
Compliance (%)		99%	<100%	<100%	99%	96%	100%	100%	<100%

60-Day Fecal Coliform Standard

		9-m stations			18-m stations				
Month	**# days**	**C4**	**C5**	**C6**	**A1**	**A7**	**A6**	**C7**	**C8**
January	31	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0
March	31	0	0	0	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0
November	30	0	0	0	0	0	0	0	0
December	31	1	0	0	0	0	0	0	0
Compliance (%)		<100%	100%	100%	100%	100%	100%	100%	100%

C5 occurred on December 30 following a 2-day storm that accumulated 2.9 inches of rain (NOAA/NWS 2005). Since these samples had relatively low fecal coliform values and F:T ratios ≤ 0.1, the origin of the contamination probably was not sewage related.

Spatial and Temporal Trends – Shore Stations

Bacteriological concentrations along the shoreline in 2004 were generally low, with mean total coliform densities ranging from 2 to 2030 (**Table 3.4**). The greatest concentrations occurred during periods of heavy rainfall (e.g., February,

Table 3.4

Mean total coliform, fecal coliform and enterococcus bacteria (Entero) densities (CFU per 100 mL) at PLOO shore stations by station, month, and year (2004). Stations are listed left to right in order from south to north. Rainfall (in inches) was measured at Lindbergh Field, San Diego, CA.

Month (rainfall)	Stations n	D4 42	D5 42	D7 42	D8 43	D9 43	D10 23	D11 23	D12 23	All Stations
January	Total	12	24	18	240	16	36	31	5	48.7
(0.34)	Fecal	4	4	13	48	3	10	15	3	12.6
	Entero	11	3	2	44	3	18	92	4	22.4
February	Total	2	38	18	100	252	355	414	637	232.7
(2.8)	Fecal	2	5	12	41	23	58	26	40	26.5
	Entero	2	2	7	39	58	65	56	60	37.0
March	Total	9	11	37	57	9	90	11	13	29.8
(0.22)	Fecal	2	3	13	11	2	31	5	8	9.4
	Entero	4	2	2	4	2	63	6	4	10.8
April	Total	2	44	4	63	49	26	28	9	29.0
(0.6)	Fecal	2	5	3	8	2	10	10	5	5.6
	Entero	4	3	3	4	3	3	22	3	5.6
May	Total	2	8	nd	74	109	45	48	24	46.2
(0.0)	Fecal	2	2	nd	6	18	13	19	6	9.6
	Entero	4	2	nd	3	4	5	6	10	4.8
June	Total	86	101	nd	33	143	24	72	43	71.4
(0.0)	Fecal	8	41	nd	7	11	8	59	2	19.4
	Entero	12	116	nd	5	4	2	12	4	22.1
July	Total	11	11	nd	61	8	66	55	77	40.8
(0.0)	Fecal	2	2	nd	5	3	34	25	6	11.0
	Entero	4	2	nd	2	2	12	10	5	5.2
August	Total	78	18	nd	47	64	71	30	16	46.3
(0.0)	Fecal	3	4	nd	26	3	18	11	5	10.0
	Entero	9	2	nd	5	7	24	9	2	8.4
September	Total	77	47	nd	1129	42	25	27	44	220.4
(0.0)	Fecal	2	9	nd	639	2	5	10	5	108.6
	Entero	5	2	nd	6	2	7	4	9	5.2
October	Total	135	648	153	2030	506	498	934	98	685.6
(4.79)	Fecal	36	65	87	684	24	37	84	84	154.2
	Entero	13	20	41	1024	15	22	50	16	177.9
November	Total	17	168	40	235	37	40	78	158	93.1
(0.33)	Fecal	7	21	5	151	12	8	18	23	30.6
	Entero	4	16	4	72	4	5	193	12	38.6
December	Total	62	279	489	63	146	120	63	55	162.4
(3.96)	Fecal	8	70	31	130	36	41	49	29	49.6
	Entero	27	306	140	383	132	132	94	40	157.5
Annual	**Total**	44	108	107	387	109	111	139	92	
mean	**Fecal**	6	18	20	159	11	22	26	17	
	Entero	8	36	28	134	17	29	43	13	

Table 3.5

Mean total coliform, fecal coliform and enterococcus bacteria (Entero) densities (CFU per 100 mL) at PLOO shore stations by station, month, and year (2004). Stations are listed left to right in order from south to north. Rainfall (in inches) was measured at Lindbergh Field, San Diego, CA.

Date	72-hr rain	Station	Total	Fecal	Entero	F:T
February 23	1.39	D9	1200	100	280	0.08
		D10	1600	140	280	0.09
		D11	2000	80	260	0.04
		D12	2200	80	200	0.04
September 29	0.00	**D8**	5200	4400	2	**0.85**
October 17	0.09	**D8**	10000	3600	6000	**0.36**
October 23	0.10	D11	1400	20	12	0.01
October 29	3.00	D5	2800	260	82	0.09
		D8	1200	120	50	**0.10**
		D9	1800	84	54	0.05
		D10	1600	140	96	0.09
		D11	3200	380	220	**0.12**
December 28	1.16	D7	2400	140	680	0.06

October, December). For example, mean concentrations of the three indicator bacteria peaked in October as a result of samples collected during the October 23 and 29 surveys; these surveys were completed over a 12 day period when 4.8 inches of rain accumulated (NOAA/NWS 2005). In addition, of the 13 samples with total coliforms ≥ 1000 CFU/100 mL, 10 were collected within 72-hour periods of rain events that exceeded 1.0 inch, including four samples in February, five samples in October, and one sample in December (**Table 3.5**). However, it appears that none of these samples were related to sewage contamination. For example, the two samples collected at stations D8 and D11 on October 29 had a F:T ratio ≥ 0.1, but had fecal coliform densities below the benchmark of 400 CFU/100 mL. These low fecal coliform values suggest that the source of contamination was likely related to storm discharge. In contrast, two samples collected at station D8 on September 29 and October 17 had total and fecal coliform densities well above their respective benchmark values, but occurred when there was little to no rain. Visual observations recorded during both sampling events indicated large amounts of kelp, trash, and the presence of dogs, all of which are likely contributors to the source of the elevated coliform densities (see City of San Diego 2004a, b).

Spatial and Temporal Trends – Offshore Stations

Of the 564 bacteriological samples collected at the offshore quarterly stations in 2004, four samples had total coliform densities that were uncountable due to overgrowth of non-coliform bacteria, and 67 (12%) had total coliform densities ≥ 1000 CFU/mL and an F:T ratio ≥ 0.1 (**Appendix A.1**). Total coliform concentrations in surface and subsurface waters (1–25 m) ranged from non-detectable levels to 400 CFU/100 mL throughout the year. Moreover, all surface and subsurface fecal coliform densities were <160 CFU/100 mL. In contrast, total coliform concentrations in relatively deep waters (60–98 m) ranged between 2 and 22,000 CFU/100 mL. Each of the 67 samples with total coliform densities ≥ 1000 CFU/mL and F:T ratios ≥ 0.1 came from this depth range (**Figure 3.2A**), suggesting that the stratified water column restricted the plume to

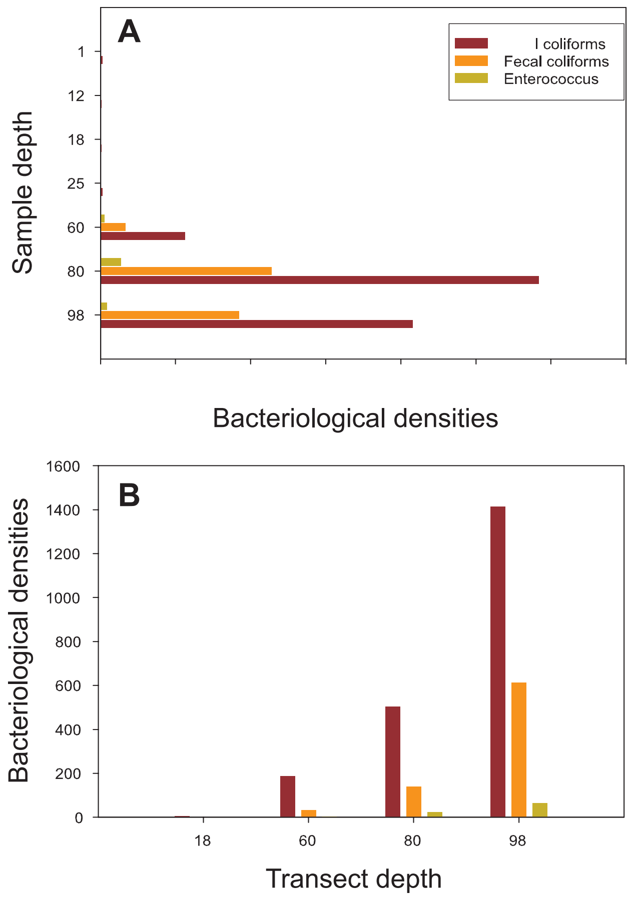

Figure 3.2
Mean total coliform, fecal coliform, and enterococcus bacteria densities (CFU/100 mL) at PLOO quarterly sampling stations by sample depth (A) and transect depth (B). Depths are in meters.

mid- and deep-water depths throughout the year (see Chapter 2).

Similarly, there was little evidence that discharged wastewater impacted nearshore waters in 2004. Mean bacterial levels along the 80 and 98-m depth transects stations were much higher than those closer to shore (i.e., 18 and 60-m transects) (**Figure 3.2B**). Sixty-five of the sixty-seven samples with total coliform densities ≥ 1000 CFU/mL and F:T coliform ratios ≥ 0.1 came from the 80 and 98-m depth transects. The other two samples occurred along the 60-m transect, both at station F08. In addition, mean bacterial concentrations at the kelp bed stations were similar to the 18-m quarterly stations for every month except October (**Table 3.6**). The October kelp station values were relatively high because of elevated bacterial densities found in samples collected during the October 21 and 29 surveys (see above). Bacteriological densities at the quarterly stations were lower because these surveys occurred before the rains began. It is also possible that persistent northward surface currents helped drive storm-related contamination from more southern sources in to the waters off Point Loma (see Chapter 2). For example, even after a storm-related sewage overflow at the Point Loma Wastewater Treatment Plant on October 27 caused 2.2 MG of sewage to flow into the ocean, kelp station samples collected offshore of the treatment plant on October 29 were relatively low. The only samples with elevated bacterial densities were collected at southern kelp stations A1 (1-m sample) and A7 (1 and 12-m samples), but all had low fecal coliform values and were likely a result of stormwater contamination from San Diego Bay and the Tijuana River (see Chapter 2; Ocean Imaging 2005). In addition, maximum total and fecal coliform densities in samples from the kelp and the 18-m quarterly stations were all below their respective benchmarks during every month except October and December when stormwater runoff and possibly northward flowing currents affected nearshore water quality.

Bacteriological data from offshore stations suggested that the waste field was detected at stations around the PLOO discharge site to approximately 13 km (8.2 mi) to the north. Samples indicative of the possible waste field intrusion were only occasionally collected up to 5.9 km (3.7 mi) to the south of the PLOO. For example, approximately 88% of the samples with total coliform densities ≥ 1000 CFU/mL and F:T ratios ≥ 0.1 were collected at sites within approximately 2 km of the PLOO (i.e., stations F19, F29, F30, and F31) or to the north at stations F20–25 and F32–36 (see Appendix A.1). In contrast, about 9% were found to the south at stations F15–F18 and F26–F28. Collectively, these data suggest that the wastewater plume was limited primarily to depths greater than 60 m within the vicinity of the

Table 3.6
Mean bacteria densities (CFU/100 mL) for January, April, July, and October sampling at PLOO quarterly offshore stations and kelp bed stations, by transect.

Month	Station	Total	Fecal	Entero
January	9-m kelp bed	3	2	2
	18-m kelp bed	15	3	2
	18-m quarterly	4	2	2
	60-m quarterly	94	18	5
	80-m quarterly	483	230	37
	98-m quarterly	982	437	79
April	9-m kelp bed	3	2	2
	18-m kelp bed	34	8	3
	18-m quarterly	12	3	2
	60-m quarterly	575	102	6
	80-m quarterly	483	230	37
	98-m quarterly	2114	752	75
July	9-m kelp bed	3	2	2
	18-m kelp bed	12	2	3
	18-m quarterly	4	2	2
	60-m quarterly	38	7	3
	80-m quarterly	79	21	5
	98-m quarterly	2180	963	80
October	9-m kelp bed	227	32	11
	18-m kelp bed	159	20	12
	18-m quarterly	3	2	2
	60-m quarterly	41	6	2
	80-m quarterly	374	68	10

discharge site, but carried up to 13.3 km (8.2 mi) northward of the PLOO.

SUMMARY AND CONCLUSIONS

Bacteriological data from water quality surveys of offshore stations suggest that discharge from the Point Loma Ocean Outfall (PLOO) rarely, if ever, impacted surface or nearshore recreational waters during 2004. Evidence of contamination along the shoreline and within the kelp bed was minimal, and limited primarily to periods associated with heavy rainfall and shore-based discharges. The single exception occurred at shore station D8 during September when this station experienced elevated bacterial counts during a prolonged dry period. However, visual observations recorded at the time of sampling suggest that recreational usage was the most likely cause of elevated counts at this site.

Overall rates of compliance with the four California Ocean Plan (COP) standards were high in 2004 despite the influences of heavy rainfall in February, October, and December. Water quality samples from the shoreline stations were over 80% compliant with the 30-day total and 60-day fecal coliform standards and 100% compliant with the 10,000 total coliform and geometric mean standards. Similarly, samples from the kelp bed stations were compliant with the 30-day total coliform standard over 95% of the time, and 100% of the time with all other COP standards. Incidences of non-compliance were primarily associated with rainfall events. For example, incidences of non-compliance at shore stations D8 and D11, located south of the San Diego River, were limited to October, November, and December following periods of the heaviest rainfall. Similarly, stations within the Point Loma kelp bed had incidents of non-compliance with the 30-day total coliform standard in November and December following particularly heavy rains and during periods of northward current flow. Patterns of bacterial concentration and visible satellite imagery data indicate that land-based sources were likely the cause of shoreline and near shore contamination during the year (see Ocean Imaging 2004, 2005). Sources of nearshore contamination in 2004 likely include discharge from north county lagoons, Mission Bay, the San Diego River, San Diego Bay, and as far south as the Tijuana River and Los Buenos Creek, Mexico. In certain cases (e.g., shore station D8), localized terrestrial runoff, or patterns of coastal recreation usage may also be responsible for sporadic high bacterial counts.

Throughout 2004, moderate and high levels of bacteria (>1000 CFU/100 mL) introduced to offshore waters by the PLOO discharge were restricted to deep waters far from shore. Bacteriological data from offshore samples indicate that discharged materials were prevalent in the deeper waters immediately surrounding the outfall diffusers, with lateral transport northward. This lateral transport would have been parallel to shore and constrained to deeper waters. Contaminated waters that may be indicative of the waste field were also evident to the south, but were very infrequent. Northward transport of the waste field appeared to be the predominant pattern throughout the year.

In addition to minimal transport shoreward, the bacterial data from 2004 also indicate that the wastewater plume did not reach surface waters, even at stations directly above the outfall diffusers. Although physical characteristics of the water column suggest strong seasonal stratification, the lack of an increase in bacterial concentrations in surface waters during winter months indicates that seasonal stratification was not the primary factor limiting plume influences on local surface waters (see Chapter 2). The depth of discharge (94–98 m) into cold waters may in fact be the strongest factor restricting the wastewater plume to mid- and deep-water depths. Although research shows that vertical displacement of isothermal surfaces within the water column off Point Loma can be as dramatic as 40 m within a 6-hour time period (Hendricks 1994), data from the region do not indicate that such transport ever caused the plume to reach the surface in 2004.

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Chapter 4. Sediment Characteristics

INTRODUCTION

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

Natural factors that affect the distribution and stability of sediments on the continental shelf include bottom currents, wave exposure, the presence and abundance of calcareous organisms, and proximity to river mouths, sandy beaches, submarine basins, canyons and hills (Emery 1960). The analysis of various sediment parameters (e.g., particle size, sorting coefficient, percentages of sand, silt, and clay) can provide useful information relevant to the amount of wave action, current velocity, and sediment stability in an area.

The chemical composition of sediments can be affected by the geological history of an area. For example, sediment erosion from cliffs and shores, and sediment laden discharge from bays, rivers, and streams contribute metals and sedimentary detritus to a given area (Emery 1960). In addition, the organic content of sediments is greatly affected by primary productivity in nearshore waters, as well as terrestrial plant debris released from bays, estuaries, and rivers (Mann 1982, Parsons et al. 1990). Finally, concentrations of various constituents within sediments are often influenced by sediment particle size. For example, the levels of organic materials and trace metals within ocean sediments generally rise with increasing amounts of fine particles (Emery 1960, Eganhouse and Vanketesan 1993).

Ocean wastewater outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of sediments through the discharge and deposition of a wide variety of organic and inorganic compounds. Some of the most commonly detected compounds in municipal wastewater discharges include various organic compounds (e.g., organic carbon, nitrogen, and sulfide compounds), trace metals, and pesticides (Anderson et al. 1993). Additionally, the physical structure of the outfall pipe can alter the hydrodynamic regime and subsequently substrate composition in the immediate area (see Shepard 1973).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2004 in the vicinity of the City of San Diego's Point Loma Ocean Outfall (PLOO). The major goals are to assess any impact of wastewater discharged through the outfall on sediment quality in the region. Included are analyses of the spatial and temporal patterns of the various sediment grain size and chemistry parameters in an effort to determine the presence of sedimentary and chemical footprints near the discharge site.

MATERIALS AND METHODS

Field Sampling

Sediment samples were collected during January 2004 at 22 stations surrounding the PLOO (**Figure 4.1**). These stations span the terminus of the outfall and are located along the 88, 98, and 116-m depth contours. The 17 "E" stations are located within 8 km of the outfall, while the five "B" stations are located greater than 11 km from the discharge site. In July, the sampling was limited to the 12 primary core stations along the 98-m contour due to participation in special strategic process studies as determined by the City in coordination with the

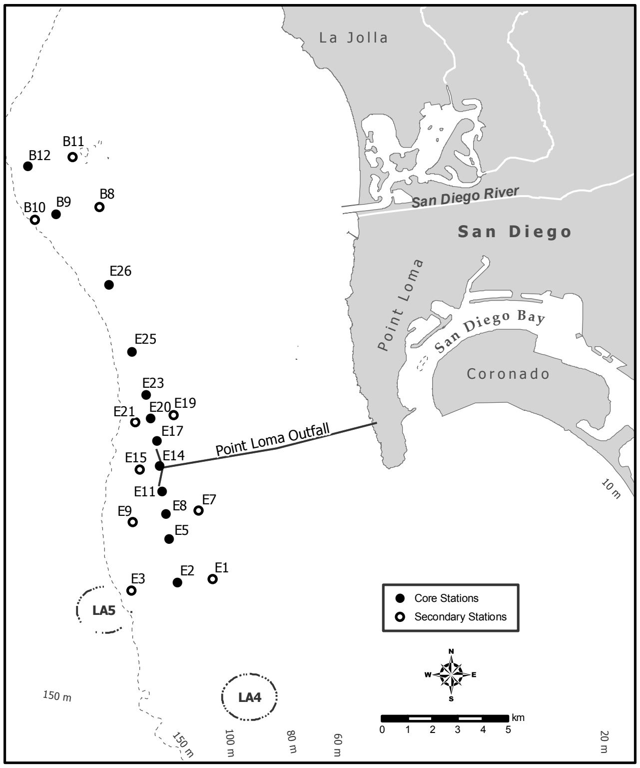

Figure 4.1
Benthic stations surrounding the City of San Diego's Point Loma Ocean Outfall. Core stations (filled circles) were sampled in January and July 2004. Secondary stations (open circles) were sampled July 2004.

Executive Officer of the RWQCB and the USEPA (City of San Diego 2005a).

Benthic sediment samples were collected using a modified 0.1-m^2 chain-rigged van Veen grab (see City of San Diego in prep). Sub-samples were taken from the top two cm of the sediment surface and handled according to United States Environmental Protection Agency guidelines (USEPA 1987).

Laboratory Analyses

All sediment chemistry and grain size analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory (see City of San Diego 2005b). Particle size analysis was performed using a Horiba LA-920 laser scattering particle analyzer, which measures particles ranging in size from -1 to 11 phi (i.e., 0.00049–2.0 mm; sand, silt, and clay fractions). Coarser sediments (e.g., very coarse sand, gravel, shell hash) were removed prior to analysis by screening the samples through a 2.0 mm mesh sieve. These data were expressed as the percent "Coarse" of the total sample sieved.

A more sensitive ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry) technique for analysis of metals was introduced mid-year of 2003. An IRIS axial ICP-AES system replaced the Atomscan radial ICP-AES. The superior abilities of the IRIS axial ICP-AES lowered the method detection limits by approximately an order of magnitude. Consequently, low concentrations of metals that would not have been detected in previous surveys were detected during July 2003 and all subsequent surveys.

Data Analyses

The data output from the Horiba particle size analyzer was categorized as follows: sand was defined as particles ranging in size from <2 to 62.5 mm, silt as particles from < 62.5 to 0.0039 mm, and clay as particles < 0.0039 mm (see **Table 4.1**). These data were standardized and incorporated with a sieved coarse fraction containing particles >2.0 mm in diameter to obtain a distribution of coarse, sand, silt, and clay fractions totaling 100%. The coarse fraction was included with the phi -1 fraction in the calculation of various particle size parameters, using a normal probability scale (see Folk 1968). These parameters included mean and median phi size, standard deviation of phi size (sorting coefficient), skewness, kurtosis, and percent sediment type (coarse materials, sand, silt, clay).

Chemical parameters analyzed were total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl compounds (PCBs) (**see Appendix B.1**). Prior to analysis, these data were generally limited to values above the method detection level (MDL). In addition, some parameters were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry) but at levels below the MDL. These

Table 4.1

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

Wentworth Scale				Sorting Coefficient	
Phi Size	Microns	Millimeters	Description	Standard Deviation	Sorting
-2	4000	4.000	Pebble	Under 0.35 phi	very well sorted
-1	2000	2.000	Granule	0.35–0.50 phi	well sorted
0	1000	1.000	Very coarse sand	0.51–0.70 phi	moderately well sorted
1	500	0.500	Coarse sand	0.71–1.00 phi	moderately sorted
2	250	0.250	Medium sand	1.01–2.00 phi	poorly sorted
3	125	0.125	Fine sand	2.01–4.00 phi	very poorly sorted
4	62.5	0.063	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31	0.031	Coarse silt		

Conversions for Diameter in Phi to Millimeters: $D(mm) = 2^{-phi}$

Conversions for Diameter in Millimeters to Phi: D(phi) = -3.3219log10D(mm)

were included in the data as estimated values. Any null or "not detected" value was treated as a zero when performing statistical analysis or estimating overall means for the survey area.

Values for metals, TOC, TN, and pesticides (i.e., DDE) were compared to median values for the Southern California Bight. These bight-wide values were based on the cumulative distribution function (CDF) for each parameter (see Schiff and Gossett 1998) and are presented as the 50% CDF in the tables included herein. Levels of sediment contamination were further evaluated by comparing the results of this study to the available Effects Range Low (ERL) sediment quality guidelines of Long et al. (1995). The ERL represents chemical concentrations below which adverse biological effects were rarely observed.

RESULTS AND DISCUSSION

Particle Size Distribution

During 2004, ocean sediments off Point Loma were composed predominantly of very fine sand and coarse silt with a mean particle size of 0.068 mm or 3.9 phi (**Table 4.2**). Fine sediments (silt and clay fractions combined) averaged about 37% of the sediments overall, while sands accounted for 60%. Coarser materials such as shell hash and gravel comprised the remaining 3%. The sorting coefficients (standard deviation) were greater than 1.0 phi at every station, indicating that sediments within the survey area were poorly sorted (i.e., consisted of particles of varied sizes; see Table 4.1). This result reflects the multiple origins of sediments in the region (see Emery 1960), and suggests that these sites are subject to slow moving currents or reduced water motion (Gray 1981).

Sediments at most stations had particle sizes averaging between 0.05 and 0.09 mm in diameter (**Figure 4.2**). Sediments were coarsest (mean >0.09 mm) at northern reference station B12, station E3 near the LA-5 dredge disposal site, and station E9 southwest of the PLOO. The finest sediments (mean <0.05 mm) were found at just two stations (B8 and E7) located along the shallower 88-m depth contour. The coarser sediments at station B12 may be partially related to its location along the outer shelf edge where strong currents and internal waves export fine sediments down the slope and leave shell hash and larger particles behind (see Shepard and Marshall 1978, Heathershaw et al. 1987, Boczar-Karakiewicz et al. 1991). The sediments at stations E3 and E9 were generally composed of varying amounts of sandy materials likely related to their location between the LA-5 disposal site and the PLOO. Evidence that the main disposal mound has dispersed into areas outside the boundaries of LA-

Table 4.2

Summary of particle size parameters and organic loading indicators at PLOO stations during 2004. Data are expressed as annual means; n=2 for the core stations indicated in bold type; n=1 for all others. CDF=cumulative distribution functions (see text); NA=not analyzed. MDL=method detection limit. Area Mean=area mean for 2004. Values that exceed the median CDF are indicated in bold type.

		Particle Size						Organic Indicators				
Station	**Depth**	**Mean phi**	**Mean mm**	**SD phi**	**Coarse %**	**Sand %**	**Fines %**	**BOD mg/L**	**Sulfides ppm**	**TN WT%**	**TOC WT%**	**TVS WT%**
North reference stations												
B-11	88	4.2	0.056	1.9	3.7	49.5	46.8	390	1.1	**0.087**	**0.891**	4.47
B-8	88	4.6	0.041	1.5	0.1	42.1	57.8	326	1.1	**0.086**	**0.800**	3.27
B-12	98	3.1	0.125	2.5	10.8	59.5	28.2	653	11.0	**0.055**	**1.176**	3.08
B-9	98	4.1	0.055	1.6	1.1	57.5	41.3	300	0.6	**0.060**	0.556	2.81
B-10	116	4.0	0.062	1.8	0.5	68.2	28.1	337	1.0	**0.066**	0.542	3.02
Stations north of the outfall												
E-19	88	4.3	0.051	1.5	0.2	52.7	47.1	277	21.6	**0.063**	0.587	2.72
E-20	98	3.9	0.063	1.4	0.2	64.0	35.7	243	1.3	**0.052**	0.461	2.17
E-23	98	4.1	0.055	1.5	0.2	59.0	40.7	353	1.0	**0.056**	0.572	2.23
E-25	98	4.0	0.059	1.4	0.8	60.1	39.1	280	1.1	**0.053**	0.497	2.66
E-26	98	4.3	0.052	1.6	0.2	56.5	43.1	327	2.2	**0.062**	0.566	2.64
E-21	116	3.8	0.072	1.3	0.1	70.4	29.5	188	2.0	0.039	0.350	2.07
Outfall stations												
E-11	98	3.7	0.074	1.3	0.3	69.7	29.9	328	7.2	0.047	0.410	2.04
E-14	98	3.8	0.070	1.4	1.5	68.2	30.2	413	39.5	0.050	0.451	2.04
E-17	98	3.8	0.071	1.4	0.7	68.2	31.0	316	6.6	0.048	0.431	1.90
E-15	116	4.0	0.064	1.6	0.8	67.2	32.0	304	2.7	**0.052**	0.478	2.46
Stations south of the outfall												
E-1	88	4.0	0.062	1.6	0.4	61.7	37.3	267	2.1	0.050	0.467	2.20
E-7	88	4.6	0.042	2.4	0.0	49.3	45.7	279	1.0	0.043	0.413	2.43
E-2	98	4.2	0.056	1.8	2.5	52.5	44.9	293	5.4	**0.076**	**0.719**	2.52
E-5	98	3.9	0.065	1.5	0.3	65.3	34.2	231	2.0	0.046	0.417	2.09
E-8	98	3.8	0.070	1.3	0.3	68.1	31.5	226	0.9	0.043	0.380	2.00
E-3	116	3.4	0.097	2.9	16.0	52.1	27.4	222	0.8	0.033	0.308	1.87
E-9	116	3.1	0.120	4.0	26.9	36.2	31.9	231	0.4	0.049	0.456	2.12
Area Mean		3.9	0.068	1.7	2.5	60.2	36.6	316	5.6	0.055	0.546	2.44
MDL								2	0.14	0.005	0.010	0.11
50% CDF								NA	NA	0.050	0.597	NA

5 have been previously detected by the United States Geological Survey (Gardner et al. 1998**; Figure 4.3**). Additionally, visual examination and observations of the field samples collected at several outfall stations have occasionally revealed the presence of coarse, black sand that was used as stabilizing material for the outfall pipe (see **Appendix B.2**). During 2004, this type of black sand was regularly present at s tations south and east of the outfall (i.e., E14, E8, E9, E11, E15) indicating the potential spread of this ballast material.

Organic Indicators

Generally, the distribution of organic indicators in PLOO sediments during 2004 was similar to patterns seen prior to discharge (see City of San Diego 1995). The highest concentrations of biochemical oxygen demand (BOD), total nitrogen, total organic carbon (TOC), and total volatile solids were generally found north of the PLOO at stations that contained higher percentages

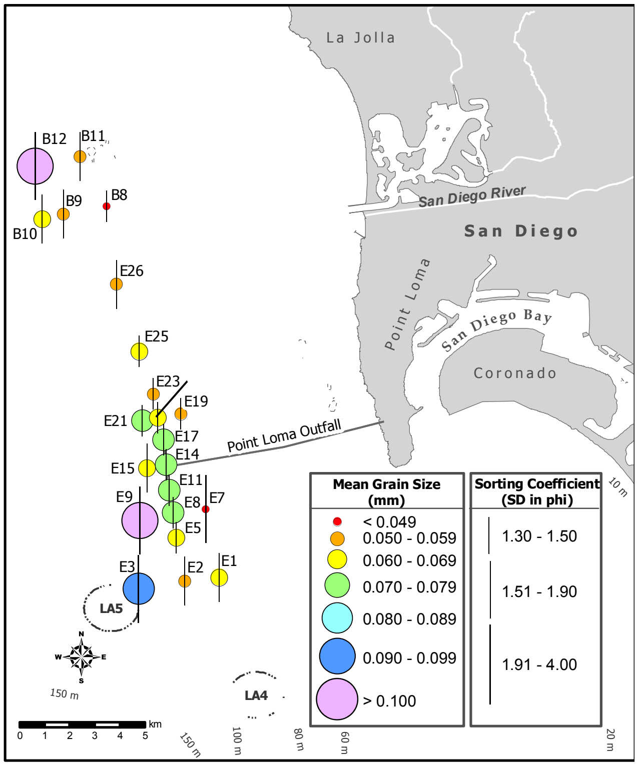

Figure 4.2

Particle size distribution for sediment chemistry stations during 2004. n=2 for the core stations (see text); n=1 for all others. Mean particle size is based on diameter in millimeters, and sorting coefficient (standard deviation) is in phi units.

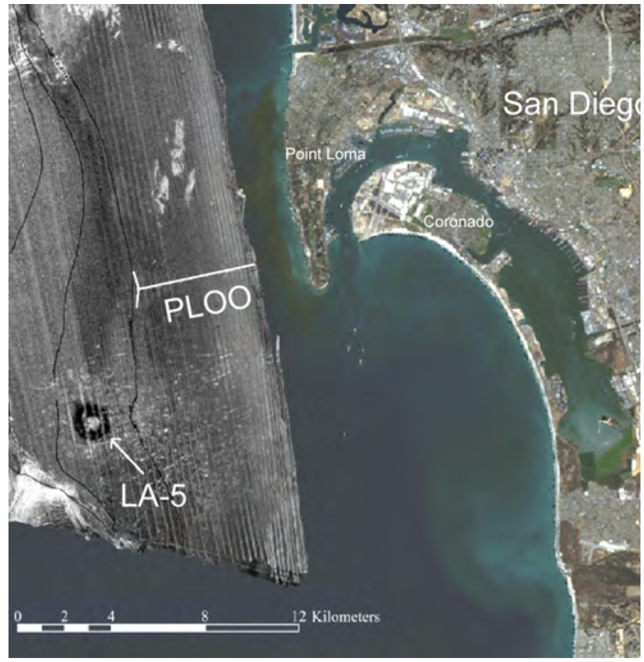

Figure 4.3

The LA-5 dredge disposal site shown as an acoustic backscatter image superimposed on a Landsat-7 satellite land image of San Diego (USGS 1998). Lighter areas represent harder (more dense) substrates.

of fine particles (Table 4.2). Station B12 was an exception to this general pattern. It had the highest BOD (653 mg/L) and TOC (1.175 %), but as in several past surveys, had the coarsest sediments. The highest sulfide concentrations were found at station E14 (39.5 ppm) along with the second highest concentration of BOD (413 mg/L).

Trace Metals

Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, tin, and zinc were frequently detected at concentrations above their MDL in the sediments off Point Loma (**Table 4.3**). Silver occurred in concentrations that were often below their MDL, while selenium occured at one sute and thallium was not detected at any station.

Overall concentrations of the 17 frequently detected trace metals were less than the median values for the Southern California Bight (50% CDF) and well below ERL levels. Despite these generally low values sediments at six stations included three or more metals whose concentrations were higher than the median CDF. These included several northern stations (i.e., B8, B9, B11, B12), station E26 located between the outfall and the north reference stations, and station E2 located east of the LA-5 disposal site. Station B12 has historically contained some of the highest concentrations of metals as well the coarsest sediments in the PLOO survey area. This is possibly related to differences in geological origin of the sediments at this site. In contrast to the 28% fines at station B12, stations B8, B9, B11, E26, and E2 contained sediments consisting of >40% fine particles. In addition to the high percentage of fine particles, the deposition of metals-laden sediments dredged from San Diego Bay likely contributes to the elevated metal concentrations at station E2 (see City of San Diego 2003c). Metal concentrations were generally low at the stations near the outfall (E11, E14, E15, and E17). Overall, trace metal concentrations increased with increasing proportions of fine particles, and there

Table 4.3

Concentrations of trace metals (parts per million) detected at each PLOO station during 2004; n=2 for the primary core stations indicated in bold type; n=1 for all others. CDF=cumulative distribution function (see text). MDL=method detection limit. ERL=Effects Range Low Threshold Value. NA=not available. Values that exceed the median CDF are indicated in bold type. The names of each trace metal represented by the periodic table symbol are presented in Appendix B.1.

Station	Depth	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
North reference stations																		
B-11	88	**10000**	**1.1**	4.2	51.9	0.25	**0.38**	23.9	8.5	**18000**	7.62	115.0	**0.050**	9.6	nd	0.12	1.64	42.1
B-8	88	**10000**	**0.9**	3.7	54.4	0.21	0.12	21.3	9.9	15200	8.20	116.0	**0.047**	9.4	0.25	0.05	1.98	38.4
B-12	98	8865	**0.5**	4.5	29.5	**0.33**	0.19	29.1	6.0	**23400**	6.55	123.7	0.021	6.8	nd	0.03	0.85	41.2
B-9	98	**12645**	**0.9**	3.7	99.0	**0.29**	0.10	25.4	7.1	**18950**	5.51	183.4	0.032	8.0	nd	0.02	2.08	40.5
B-10	116	7450	**0.7**	2.4	28.5	0.19	**0.33**	19.1	5.5	12700	5.33	75.4	0.022	6.3	nd	0.08	1.59	31.1
Stations north of the outfall																		
E-19	88	**10400**	**1.1**	2.7	50.5	0.18	0.15	19.1	8.2	12600	6.20	110.0	0.038	8.6	nd	nd	2.34	34.6
E-20	98	**10605**	**0.6**	3.2	36.6	0.19	0.12	17.6	6.3	13000	5.27	160.6	0.026	7.0	nd	0.02	1.73	30.2
E-23	98	**13475**	**0.7**	3.0	44.4	0.23	0.13	20.7	7.1	14750	4.92	194.1	0.029	7.9	nd	0.02	2.12	34.6
E-25	98	**13140**	**0.6**	2.9	42.2	0.23	0.13	20.7	7.2	14600	5.15	191.6	0.025	8.1	nd	nd	1.89	34.2
E-26	98	**12480**	**0.5**	2.8	42.6	0.23	0.14	20.5	8.1	15000	5.62	175.6	0.**041**	8.5	nd	0.11	2.11	35.1
E-21	116	5710	**0.5**	2.6	26.3	0.14	0.12	13.0	5.2	8270	4.85	68.7	0.024	5.8	nd	0.07	1.34	23.1
Outfall stations																		
E-11	98	8945	**0.3**	2.8	29.6	0.18	0.12	15.6	5.4	11655	4.34	151.3	0.022	6.1	nd	0.05	1.59	26.8
E-14	98	7650	**0.3**	3.3	33.0	0.16	0.13	15.3	6.8	10640	4.53	114.7	0.028	6.6	nd	0.06	1.34	26.1
E-17	98	**11540**	**0.4**	2.6	34.3	0.21	0.14	18.2	6.1	13950	4.16	197.3	0.026	6.7	nd	0.12	2.03	30.4
E-15	116	6800	**0.7**	2.5	27.3	0.16	0.12	15.0	6.4	9600	5.27	74.7	0.030	6.5	nd	0.03	1.71	24.6
Stations south of the outfall																		
E-1	88	8100	**0.8**	2.6	40.9	0.16	0.11	17.0	8.4	10300	6.80	84.9	**0.049**	7.6	nd	0.05	1.72	28.6
E-7	88	8010	**0.7**	3.7	40.4	0.16	0.12	18.5	7.3	11500	6.09	91.5	0.034	8.6	nd	0.06	1.67	28.9
E-2	98	**17000**	**1.1**	2.6	74.6	**0.27**	0.13	22.8	13.2	**19500**	7.46	217.5	**0.056**	8.6	nd	nd	2.35	44.6
E-5	98	**9960**	**0.3**	2.6	36.1	0.19	0.11	16.0	7.2	12450	4.69	131.4	0.032	6.4	nd	0.05	1.66	27.6
E-8	98	**9730**	**0.5**	2.6	32.1	0.19	0.11	16.6	6.5	11755	4.60	139.2	0.037	6.4	nd	0.01	1.81	28.2
E-3	116	8520	**0.7**	2.2	48.5	0.14	0.08	14.6	10.2	12200	6.94	99.9	**0.056**	5.2	nd	nd	1.52	30.7
E-9	116	6150	**0.7**	3.5	27.5	0.17	0.09	17.8	9.0	10800	6.22	66.6	0.030	6.2	nd	0.05	1.58	32.9
MDL		1.15	0.13	0.33	0.002	0.001	0.01	0.016	0.028	0.75	0.142	0.004	0.003	0.036	0.24	0.013	0.059	0.052
50% CDF		9400	0.2	4.80	NA	0.26	0.29	34.0	12.0	16800	NA	NA	0.040	NA	0.29	0.17	NA	56.0
ERL		NA	NA	8.2	NA	NA	1.2	81	34	NA	46.7	NA	0.2	20.9	NA	1.0	NA	150

was no discernable pattern of metal distribution related to proximity to the PLOO.

Pesticides, PCBs, and PAHs

DDT was detected as its final metabolic degradation product (p,p-DDE) at two stations, and heptachlor epoxide occurred at one station (**Table 4.4**). Heptachlor epoxide occurred in concentrations well below the MDL (5700 ppt) at station E25. DDT was detected at stations E2 and E26. Concentrations of DDT were also below the MDL (3800 ppt for DDE) and well below the median CDF value for total DDT (10,000 ppt). However, the concentration of total-DDT at station E26 was 2750 ppt, which was slightly above the ERL (1580 ppt). Generally, pesticide concentrations appear to result from sources unrelated to the PLOO discharge. For example, total DDT concentrations throughout the study area peaked in 1993, just two years into a seven year period when ten large dredging projects disposed contaminated sediment from San Diego Bay at LA-5 (Steinberger et al. 2003) (see **Figure 4.4**). The decline in DDT values in 2004 relative to prior surveys continues a trend that began in 1996.

Polychlorinated biphenyl compounds (PCBs) were mostly undetected during 2004. The sediments at station E2 contained two congeners, PCB 101 and PCB 110, whose concentrations were equal to their MDLs of 2600 and 2900 ppt, respectively. Total PCB at this station (2750 ppt) was slightly higher than the median CDF of 2600 ppt and well below the ERL of 22,700 ppt (see Table 4.4).

Twenty-one polycyclic aromatic hydrocarbons (PAH) compounds were detected in low concentrations during 2004 (**Appendix B.3**). All total-PAH concentrations from the sampling area were well below the ERL of 4022 ppb, and near or below their respective MDL levels. The detection of low levels of PAHs at all stations appears to reflect a change in methodology where values below method detection limits can be reliably estimated with qualitative identification via a mass spectrophotometer (see Methods and Materials). The highest concentrations of total PAHs were found north of the outfall at station E23 (1583 ppb) and north of the LA-5 dredge materials disposal site at station E9 (1545 ppb). These two stations also had the greatest mix of PAH compounds, 20 and 12 different compounds, respectively. Station E9 is one of four stations (E1, E2, E3, E9) within the survey area where PAHs have been frequently detected (see City of San Diego 2000, 2001, 2002, 2003a–c). PAHs

Table 4.4

Mean concentrations for pesticides (parts per trillion), total PCBs (parts per trillion), and total PAHs (parts per billion) in PLOO sediments during 2004. MDL=method detection limit. CDF=cumulative distribution function (see text). Undetected values are indicated by "nd." ERL=Effects Range Low Threshold Value. n=2 for the primary core stations indicated in bold type; n=1 for all others.

Station	Depth	Heptachlor epoxide	Total DDT	Total PCB	Total PAHs
North reference stations					
B11	88	nd	nd	nd	191
B8	88	nd	nd	nd	79
B12	98	nd	nd	nd	121
B9	98	nd	nd	nd	383
B10	116	nd	nd	nd	65
Stations north of the outfall					
E19	88	nd	nd	nd	171
E20	98	nd	nd	nd	162
E23	98	nd	nd	nd	1583
E25	98	2850		nd	157
E26	98	nd	1900	nd	171
E21	116	nd	nd	nd	187
Outfall stations					
E11	98	nd	nd	nd	114
E14	98	nd	nd	nd	109
E17	98	nd	nd	nd	240
E15	116	nd	nd	nd	153
Stations south of the outfall					
E1	88	nd	nd	nd	97
E7	88	nd	nd	nd	47
E2	98	nd	290	2750	201
E5	98	nd	nd	nd	116
E8	98	nd	nd	nd	115
E3	116	nd	nd	nd	73
E9	116	nd	nd	nd	1545
MDL		5700	—	—	—
50% CDF			10,000	2600	NA
ERL			1580	22700	4022

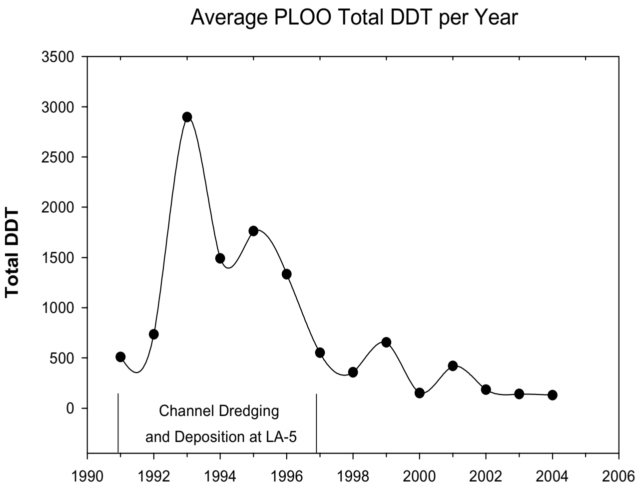

Figure 4.4
Changes in average total DDT within the PLOO sampling area are shown for the period 1991–2004. Several channel dredging projects occurred between 1991 and 1997.

at these stations have largely been attributed to misplaced dredge material deposits intended for LA-5 (see Anderson et al. 1993). In addition, low concentrations (≤ 240 ppb) of some PAHs were present at sites near the outfall (i.e., stations E11, E14, E15, E17), but there did not appear to be a pattern of distribution with respect to the outfall.

SUMMARY AND CONCLUSIONS

Ocean sediments at stations surrounding the PLOO in 2004 consisted primarily of very fine sand and coarse silt with a mean particle size of 0.068 mm (3.9 phi). Area sediments were poorly sorted (i.e., consisting of particles of varied sizes), which suggests that the region was subject to low wave and current activity. Stations containing the finest particles were found along the 88-m contour, while those with the coarsest particles were found along the 98-m and 116-m contours at the northernmost reference site, near the LA-5 dredge disposal site, and a site southwest of the PLOO. Stations near the PLOO contained sand that was more coarse than surrounding sites, and several stations located between the outfall and LA-5 contained variable amounts of ballast sand, coarse particles, and shell hash. Generally, these results reflect multiple anthropogenic (e.g., outfall construction, dredge disposal) and natural influences (e.g., Pleistocene and recent detrital deposits) on the region's sediment composition (Emery 1960).

The distribution of organic indicators in 2004 was very similar to previous surveys. The highest concentrations of BOD, total nitrogen, total carbon, and total volatile solids occurred at sites north of the PLOO, while the highest values for sulfides occurred near the site of discharge at station E14. Stations located south of the outfall and near to the LA-5 disposal site generally had relatively low values of organic indicators.

Seventeen trace metals were frequently detected at concentrations above the MDL, and most of these occurred in concentrations well below median values for the Southern California Bight (50% CDF) and ERL levels. Only aluminum and antimony occurred in concentrations that were frequently above the 50% CDF values. Four northern reference sites, one site north of the PLOO, and one station near the LA-5 disposal site had concentrations of three or more trace metals that exceeded the 50% CDF. Metals associated with industry and antifouling materials were found at stations near LA-5 and may be associated with the disposal of dredged sediments from San Diego Bay (see City of San Diego 2003c). In general, the highest trace metal concentrations occurred at stations with relatively high amounts of fine particles (>40%). This is expected since the accumulation of fine particles generally influences the content of organic materials and metals in sediments (Eganhouse and Venkatesan 1993).

Two pesticides were detected at just three stations during the 2004 sediment surveys. Heptachlor epoxide was found at station E25 north of the PLOO in concentrations below the MDL. DDE, the final metabolic degradation product of DDT, was found west of LA-5 at station E3 and north of the PLOO at station E26. DDE concentrations at both sites were below the MDL; however, the concentration at station E26 was above the ERL sediment quality guideline. In past surveys DDE has shown a more widespread distribution within the PLOO area particularly from 1991 to 1996. Higher DDT levels during this period may have been caused by the dispersion of contaminated sediments into the survey area from the disposal of San Diego Bay dredge materials at LA-5. Even with a change in methodology where values below the MDL can be reliably estimated with qualitative identification, detection of DDE within the survey area was lower than previous years. An analysis of historical data indicates an ongoing reduction in detectable DDT concentrations since 1996.

Values for PAHs and PCBs were generally near or below method detection limits at all sampling sites. A change in methodology for determining values below MDL levels resulted in the detection of PAHs at all stations. The highest concentration was found north of the outfall, while relatively low concentrations were detected at stations surrounding the outfall. The low concentrations near the discharge site are not unexpected since a recent study found that PAHs were not detected in effluents from large municipal wastewater treatment facilities in southern California (Steinberger and Schiff 2003). PAHs and PCBs were found together at only two stations located near the LA-5 dredge materials disposal site (stations E2 and E9). In previous surveys, concentrations of PAHs and PCBs have been higher at these southern stations than elsewhere off San Diego, and are most likely the result of misplaced deposits of dredged material that were originally destined for LA-5. Previous studies have attributed elevated levels of various contaminants such as PAHs, PCBs, trace metals, and DDT in this area to the deposits from LA-5 (see Anderson et al. 1993; City of San Diego 2003c; Steinberger et al. 2003).

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Chapter 5. Macrobenthic Communities

INTRODUCTION

Sediments on the southern California coastal shelf typically contain a diverse community of macrofaunal invertebrates (Fauchald and Jones 1979, Thompson et al. 1992, Bergen et al. 2001). These animals are essential members of the marine ecosystem, serving vital functions in wide ranging capacities. For example, many species of benthic invertebrates provide the prey base for fish and other organisms, while others decompose organic material as a crucial step in nutrient cycling. The structure of macrofaunal communities is influenced by many factors including sediment conditions (e.g., particle size and sediment chemistry), water conditions (e.g., temperature, salinity, dissolved oxygen, and current velocity) and biological factors (e.g., food availability, competition, and predation). While human activities can affect these factors, natural processes largely control the structure of invertebrate communities in marine sediments. Therefore, in order to determine whether changes in community structure are related to human impacts or natural processes, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the region surrounding the Point Loma Ocean Outfall (PLOO) and the San Diego region in general (e.g., City of San Diego 1995, 1999, 2003).

Benthic macrofauna living in marine soft sediments can be sensitive indicators of environmental disturbance (Pearson and Rosenberg 1978). Because benthic macrofauna have limited mobility, many are unable to avoid adverse conditions such as those brought about by natural stressors (e.g., El Niño/La Niña events) or human impacts (e.g., toxic contamination and organic enrichment from anthropogenic sources). Consequently, the assessment of benthic communities has been used to monitor the effects of municipal wastewater discharge on the ocean environment (see Zmarzly et al. 1994, Diener et al. 1995, Bergen et al. 2000). This chapter presents analyses and interpretation of the macrofaunal data collected during 2004 at fixed stations surrounding the PLOO discharge site off San Diego, California. Included are descriptions and comparisons of the different assemblages that inhabit soft bottom sediments in the area and analysis of benthic community structure.

MATERIALS AND METHODS

Collection and Processing of Samples

Benthic samples were collected at 22 stations that span 8 km south and 11 km north of the outfall terminus along the 88, 98, and 116-m depth contours (**Figure 5.1**). A total of 68 benthic grabs were taken during two surveys in 2004. All 22 stations were sampled during the January survey while the July sampling was limited to the 12 primary core stations located along the 98-m contour due to a regulatory agreement to conduct a special sediment mapping study of the region (see City of San Diego 2005, Appendix A). Detailed methods for locating the stations and conducting benthic grabs are described in the City of San Diego Quality Assurance Plan (City of San Diego in prep).

Samples for benthic community analysis were collected from two replicate 0.1 m^2 van Veen grabs per station during each survey. The criteria established by the United States Environmental Protection Agency to ensure the consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0 mm mesh screen. Organisms retained on the

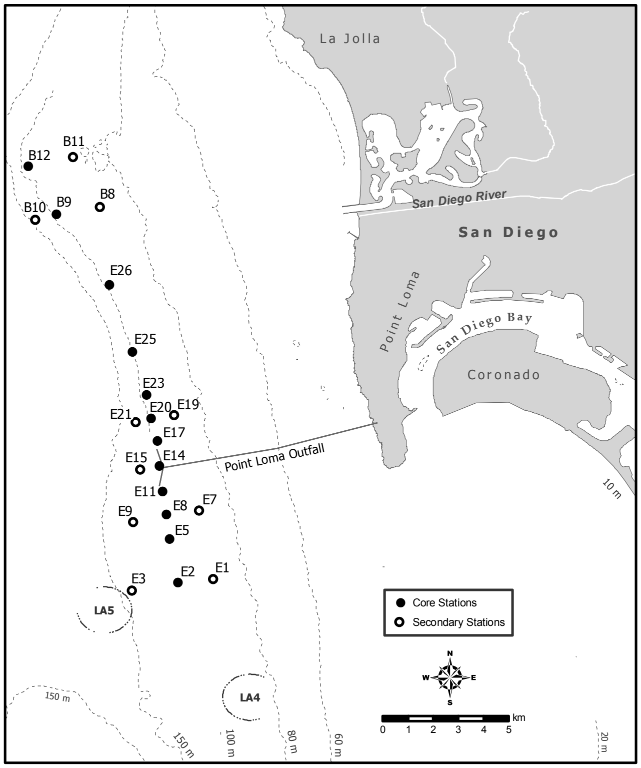


Figure 5.1
Benthic stations surrounding the Point Loma Ocean Outfall. Core stations (filled circles) were sampled in January and July 2004. Secondary core stations (open circles) were sampled only in July 2004.

screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego in prep). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into major taxonomic groups then identified to species or the lowest taxon possible and enumerated.

Statistical Analyses

Multivariate analyses were performed using PRIMER v5 software to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling (MDS). Prior to analysis, macrofaunal abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for comparison in both classification and ordination. Analyses were run on mean abundances of replicate grabs per station/survey to identify distinct cluster groups from 68 samples among 22 stations.

Annual means for the following community parameters were calculated for each station and each cluster group: species richness (number of species per grab); total number of species (i.e., cumulative of two replicate samples); abundance (number of individuals per grab); biomass (grams per grab, wet weight); Shannon diversity index (H′ per grab); Pielou's evenness index (J′ per grab); Swartz dominance index (minimum number of species accounting for 75% of the abundance in each grab; see Swartz 1978); Infaunal Trophic Index (ITI per grab; see Word 1980) and Benthic Response Index (BRI per grab; see Smith et al. 2001).

A BACIP (Before-After-Control-Impact-Paired) statistical model was used to test the null hypothesis that there were no changes in various community parameters due to discharge through the Point Loma outfall (see Bernstein and Zalinski 1983, Stewart-Oaten et al. 1986, 1992, Osenberg et al. 1994). Briefly, the BACIP model tests differences between control (reference) and impact sites at times before (i.e., July 1991–October 1993) and after (i.e., January 1994–July 2004) an "impact" event (i.e., the onset of discharge). The analyses presented in this report are based on 2.5 years (10 quarterly surveys) of before impact data and 11 years (41 quarterly or semi-annual surveys) of after impact data. The E stations, located within 8 km of the outfall, are the most likely to be affected by the discharge. Station E14 was selected as the impact site for all analyses; this station is located nearest the Zone of Initial Dilution (ZID) and is probably the site most susceptible to impact. In contrast, the B stations are located farther from the outfall (>11 km) and are the obvious candidates for reference or control sites. However, benthic communities differed between the B and E stations prior to discharge (Smith and Riege 1994, City of San Diego 1995). Thus, two stations (E26 and B9) were selected to represent separate control sites in the BACIP tests. Station E26 is located ~8 km from the outfall and is considered the E station least likely to be impacted. Previous analyses suggested that station B9 was one of the most appropriate B stations for comparison with the E stations (Smith and Riege 1994, City of San Diego 1995). Six dependent variables were analyzed, including three community parameters (number of species, infaunal abundance, ITI) and abundances of three taxa that are considered sensitive to organic enrichment. These indicator taxa included ophiuroids in the genus *Amphiodia* (mostly *A. urtica*) and amphipods in the genera *Ampelisca* and *Rhepoxynius*. All BACIP analyses were interpreted using a Type I error rate of α=0.05.

RESULTS AND DISCUSSION

Community Parameters: Site Comparisons and Region-wide Summaries

Number of Species

In total, 491 macrofaunal taxa were identified during the 2004 PLOO surveys. Mean values of species richness ranged from 72 to 106 species per 0.1 m^2 (**Table 5.1**). As in previous years, the number of species was highest at the northern reference station B11, as well as stations characterized by coarser sediments (e.g., B12 and E3) (City of San Diego 2003). The lowest species richness was found at stations B8 and E7, which are characterized by the finest sediments in the region (see chapter 4).

Polychaetes were the most diverse taxa in the region, accounting for approximately 53% of all species collected during 2004. Crustaceans accounted for 23% of the species, molluscs 13%, echinoderms 7%, and all remaining taxa combined accounted for approximately 4% of the species.

Macrofaunal Abundance

Mean macrofaunal abundance among sites averaged 167 to 639 animals per 0.1 m^2 in 2004 (Table 5.1). The greatest number of animals occurred at stations B11 (n=639) and E26 (n=637), while the fewest were collected at stations E21 (n=167) and E7 (n=170). The remaining sites ranged from 215 to 458 animals per 0.1 m^2.

Polychaetes were the most numerous organisms collected, accounting for 59% of the mean abundance. Crustaceans accounted for 16% of mean abundance, echinoderms 14%, molluscs 9%, and all other phyla combined about 2%. Station E14, located nearest to the outfall, had the third highest relative abundance of polychaetes among all stations (70%) and the lowest relative abundance of echinoderms (4%). These values generally were similar to those reported for 2003 (see City of San Diego 2004). The two most abundant species collected in 2004 were the polychaete worm, *Myriochele striolata* (4137 individuals), and the ophiuroid, *Amphiodia urtica* (1846 individuals).

Species Diversity and Dominance

Species diversity (H′) among sites during 2004 was similar to that observed prior to wastewater discharge (see City of San Diego 1995). Mean diversity values ranged from 2.5 to 4.2 during the year (Table 5.1). The highest diversity occurred at stations B10, E3, and E9 located along the 116-m contour, B12 along the 98-m contour, and station E2, nearest the LA5 disposal dumpsite. Diversity was lowest at station E26.

Species dominance was expressed as the Swartz 75% dominance index, the minimum number of species comprising 75% of a community by abundance. Therefore, lower index values (i.e., fewer species) indicate higher dominance. Benthic assemblages in 2004 were characterized by relatively high numbers of evenly distributed species. Dominance averaged 30 species per station, similar to the 28 species per station present in 2003 (see City of San Diego 2004). Dominance index values were lowest at stations E26 and B8, averaging 11 and 14 species, respectively. Evenness (J′) values have also remained stable over time, with mean values ranging from 0.6 to 0.9 among all stations (Table 5.1).

Environmental Disturbance Indices

Benthic response index (BRI) mean values ranged

Table 5.1

Benthic community parameters at PLOO stations sampled during 2004. Data are expressed as annual means for: species richness, no. species/0.1 m^2 (SR); total cumulative no. species for the year (Tot Spp); abundance/0.1 m^2 (Abun); diversity (H′); evenness (J′); Swartz dominance (Dom); benthic response index (BRI); infaunal trophic index (ITI). n values indicate number of grabs as statistical replicates. n values for total species data are given in parentheses.

	n	SR	Tot Spp	Abun	H′	J′	Dom	BRI	ITI
88-m									
B11	2 (1)	105	148	639	2.8	0.6	20	5	76
B8	2 (1)	73	103	367	2.9	0.7	14	4	82
E19	2 (1)	78	113	232	3.7	0.8	29	5	87
E7	2 (1)	72	103	170	3.7	0.9	31	5	86
E1	2 (1)	88	129	279	3.6	0.8	29	2	84
98-m core									
B12	4 (2)	106	148	327	4.2	0.9	39	8	78
B9	4 (2)	88	127	348	3.2	0.7	20	0	77
E26	4 (2)	86	125	637	2.5	0.6	11	4	73
E25	4 (2)	93	124	428	3.6	0.8	25	5	79
E23	4 (2)	75	105	227	3.7	0.9	29	7	84
E20	4 (2)	74	102	234	3.8	0.9	28	6	81
E17	4 (2)	88	119	288	3.9	0.9	32	9	82
E14	4 (2)	97	137	458	3.4	0.7	25	13	72
E11	4 (2)	78	110	215	3.9	0.9	32	11	82
E8	4 (2)	86	121	287	3.8	0.9	30	5	83
E5	4 (2)	86	119	257	3.9	0.9	33	4	82
E2	4 (2)	99	144	276	4.1	0.9	39	4	82
116-m									
B10	2 (1)	98	132	297	4.2	0.9	38	9	78
E21	2 (1)	74	109	167	3.9	0.9	34	8	83
E15	2 (1)	90	123	254	4.0	0.9	39	5	82
E9	2 (1)	98	148	248	4.2	0.9	43	3	82
E3	2 (1)	103	155	221	4.2	0.9	49	6	83
All Stations									
Mean		88	125	312	3.7	0.8	30	6	81
Min		72	102	167	2.5	0.6	11	0	72
Max		106	155	639	4.2	0.9	49	13	87

from 0 to 13 at the various stations in 2004. These values suggest that benthic communities in the region are relatively undisturbed, as BRI values below 25 (on a scale of 100) are indicative of reference conditions (see Smith et al. 2001). Mean annual ITI values ranged from 72 to 87 per station in 2004 (Table 5.1). These values were similar to those reported in previous years (see City of San Diego 2004), with the lowest value again occurring at station E14 located nearest the discharge site. Nevertheless, mean ITI values remained >60 at all stations

Table 5.2

Dominant macroinvertebrates at PLOO benthic stations sampled during 2004. Included are the 10 most abundant taxa overall and per occurrence, and the 10 most widely occurring taxa. Data are expressed as: MAS=mean abundance per sample; MAO=mean abundance per occurrence; and PO=percent occurrence.

Species	Higher Taxa	MAS	MAO	PO
Most Abundant				
Myriochele striolata[1]	Polychaeta: Oweniidae	60.8	89.9	68
Amphiodia urtica	Echinodermata: Ophiuroidea	27.1	27.1	100
Proclea sp A	Polychaeta: Terebellidae	9.9	10.2	97
Amphiuridae	Echinodermata: Ophiuroidea	8.3	8.8	94
Chaetozone hartmanae	Polychaeta: Cirratulidae	7.5	7.7	97
Euphilomedes carcharodonta	Crustacea: Ostracoda	7.5	8.2	91
Myriochele gracilis	Polychaeta: Oweniidae	7.3	7.3	100
Chloeia pinnata	Polychaeta: Amphinomidae	6.7	8.1	82
Euphilomedes producta	Crustacea: Ostracoda	5.9	5.9	100
Rhepoxynius bicuspidatus	Crustacea: Amphipoda	5.1	5.2	97
Most Abundant per Occurence				
Myriochele striolata	Polychaeta: Oweniidae	60.8	89.9	68
Amphiodia urtica	Echinodermata: Ophiuroidea	27.1	27.1	100
Caecum crebricinctum	Mollusca: Gastropoda	1.0	11.8	9
Proclea sp A	Polychaeta: Terebellidae	9.9	10.2	97
Amphiuridae	Echinodermata: Ophiuroidea	8.3	8.8	94
Euphilomedes carcharodonta	Crustacea: Ostracoda	7.5	8.2	91
Chloeia pinnata	Polychaeta: Amphinomidae	6.7	8.1	82
Chaetozone hartmanae	Polychaeta: Cirratulidae	7.5	7.7	97
Myriochele gracilis	Polychaeta: Oweniidae	7.3	7.3	100
Adontorhina cyclia	Mollusca: Bivalvia	4.4	6.0	74
Most Frequently Collected				
Amphiodia urtica	Echinodermata: Ophiuroidea	27.1	27.1	100
Myriochele gracilis	Polychaeta: Oweniidae	7.3	7.3	100
Euphilomedes producta	Crustacea: Ostracoda	5.9	5.9	100
Prionospio (*Prionospio*) *jubata*	Polychaeta: Spionidae	4.9	4.9	100
Amphiodia sp	Echinodermata: Ophiuroidea	4.5	4.5	100
Sternaspis fossor	Polychaeta: Sternaspidae	4.4	4.4	100
Clymenura gracilis	Polychaeta: Maldanidae	2.5	2.5	100
Proclea sp A	Polychaeta: Terebellidae	9.9	10.2	97
Chaetozone hartmanae	Polychaeta: Cirratulidae	7.5	7.7	97
Rhepoxynius bicuspidatus	Crustacea: Amphipoda	5.1	5.2	97

[1]*Myrochele striolata* was identified as *Myrochele* sp M in previous reports.

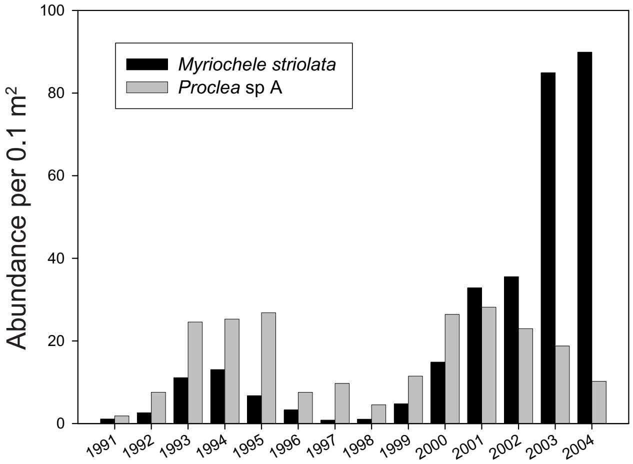


Figure 5.2
Mean annual abundance of *Myriochele striolata* and *Proclea* sp A at the PLOO benthic stations, 1991–2004.

in 2004, indicating undisturbed sediments or "normal" environmental conditions (see Bascom et al. 1979).

Dominant Species

The dominant animals that occurred off Point Loma during 2004 are listed in **Table 5.2**. Various polychaetes species were dominant throughout the region. The two most abundant polychaetes were the oweniid *Myriochele striolata* (previously reported as *Myriochele* sp M) and the terebellid *Proclea* sp A averaging 61 and 10 individuals per 0.1 m^2, respectively. The ophiuroid *Amphiodia urtica* was the second most abundant species, averaging 27 individuals per 0.1 m^2. However, since juvenile ophiuroids usually cannot be identified to species and are recorded at the generic or familial level (i.e., *Amphiodia* sp or Amphiuridae), this number underestimates actual populations of *A. urtica*. The only other species of *Amphiodia* that occurred in 2004 was *A. digitata*, which accounted for about 6% of ophiuroids in the genus that could be identified to species (i.e., *A. urtica* = about 94%). If the values for these taxa are adjusted accordingly, then the estimated population size for *A. urtica* off Point Loma is about 39 animals per 0.1 m^2.

Many of these abundant species were dominant prior to discharge in 1993 and have remained so since the initiation of outfall operation (e.g., City of San Diego 1995, 1999, 2004). For example, *A. urtica* has been among the most abundant and most commonly occurring species along the outer shelf since sampling began. In contrast, densities of some numerically dominant polychaetes have been far more cyclical. For instance, while *M. striolata* and *Proclea* sp A were the most abundant polychaetes in 2004, their populations have varied considerably over time (**Figure 5.2**). Such variation can have significant effects on other descriptive statistics (e.g., dominance, diversity, abundance) and environmental indices such as ITI and BRI, which use the abundance of indicator species in their equations.

Table 5.3
Results of BACIP t-tests for number of species (SR), infaunal abundance, ITI, and the abundance of several representative taxa around the Point Loma Ocean Outfall (1991–2004). Impact site=near-ZID station E14; Control sites=far-field station E26 or reference station B9. Before Impact period=July 1991 to October 1993 (n=10); After Impact period=January 1994 to July 2004 (n=41). Critical t value=1.680 for α=0.05 (one-tailed t-tests, df=49). ns=not significant.

Variable	Control vs Impact	t	p
SR	E26 v E14	-3.262	0.001
	B9 v E14	-3.855	<0.001
Abundance	E26 v E14	-1.415	ns
	B9 v E14	-2.797	0.004
ITI	E26 v E14	-3.679	<0.001
	B9 v E14	-2.252	0.014
Amphiodia spp	E26 v E14	-7.530	<0.001
	B9 v E14	-5.136	<0.001
Ampelisca spp	E26 v E14	-1.466	ns
	B9 v E14	-0.870	ns
Rhepoxynius spp	E26 v E14	-0.493	ns
	B9 v E14	-0.568	ns

Environmental Disturbance Indices

Significant differences were found between the impact site (station E14) and the control sites (stations E26 and B9) in seven out of twelve BACIP t-tests (**Table 5.3**). For example, there has been a net change in the mean difference between impact and control sites in species richness, ITI values, and ophiuroid abundance (*Amphiodia* spp).

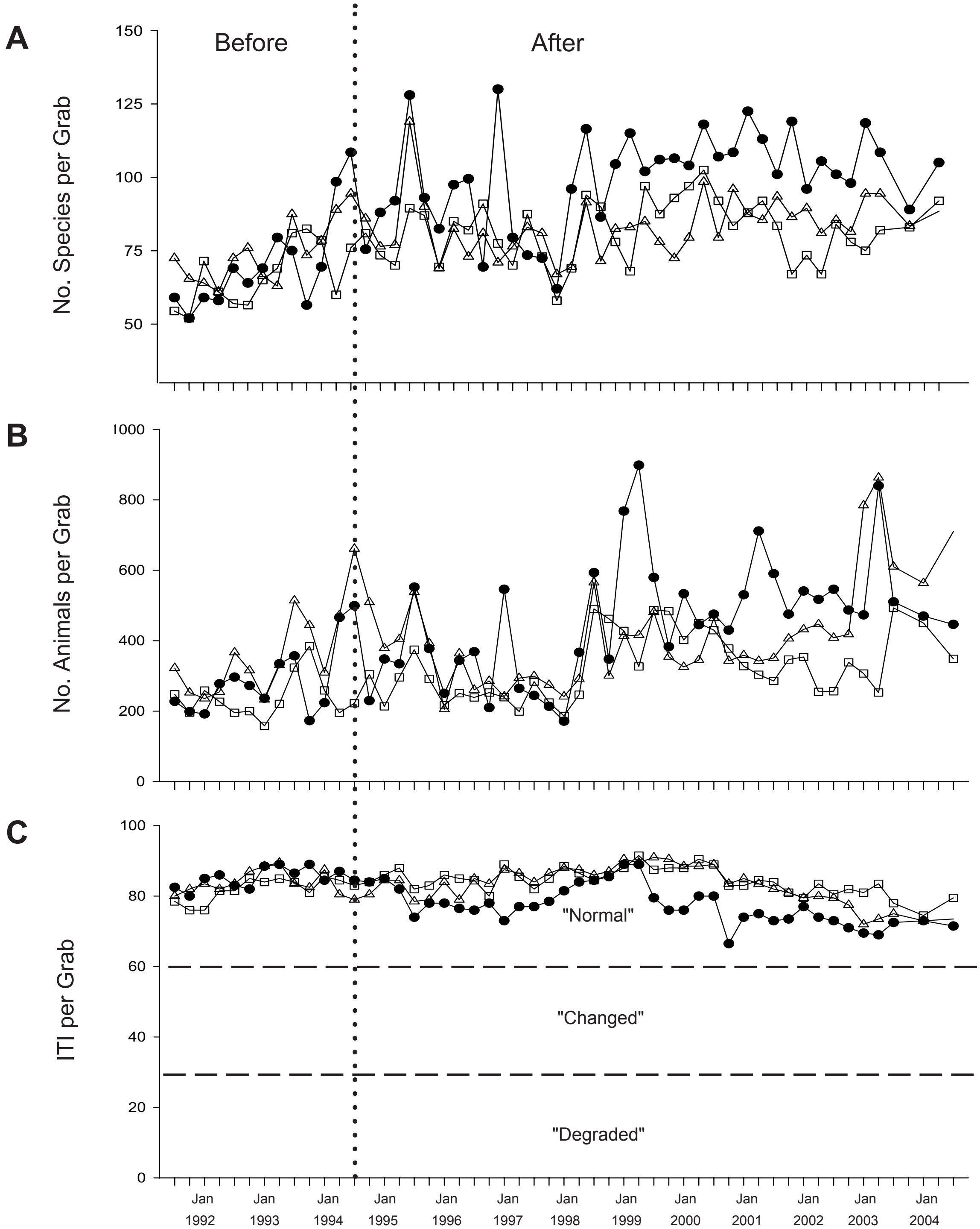


Figure 5.3

Comparison of several parameters at "impact" site (station E14) and "control" sites (stations E26, B9) used in BACIP analyses (see Table 5.3). Data for each station are expressed as quarterly means per 0.1 m^2 (n=2). (A) Number of infaunal species; (B) infaunal abundance; (C) infaunal trophic index (ITI); (D) abundance of *Ampelisca* spp (Amphipoda); (E) abundance of *Amphiodia* spp (Ophiuroidea).

The difference in species richness may be due to the increased variability and higher numbers of species at the impact site (**Figure 5.3a**). Results for *Amphiodia* populations mostly reflect a decrease in the number of these ophiuroids collected at the impact site since discharge began (Figure 5.3e). Similarly, the difference in ITI is due to generally lower index values at station E14 since the outfall began operation (Figure 5.3c). These decreased ITI values may in part be explained by the lower

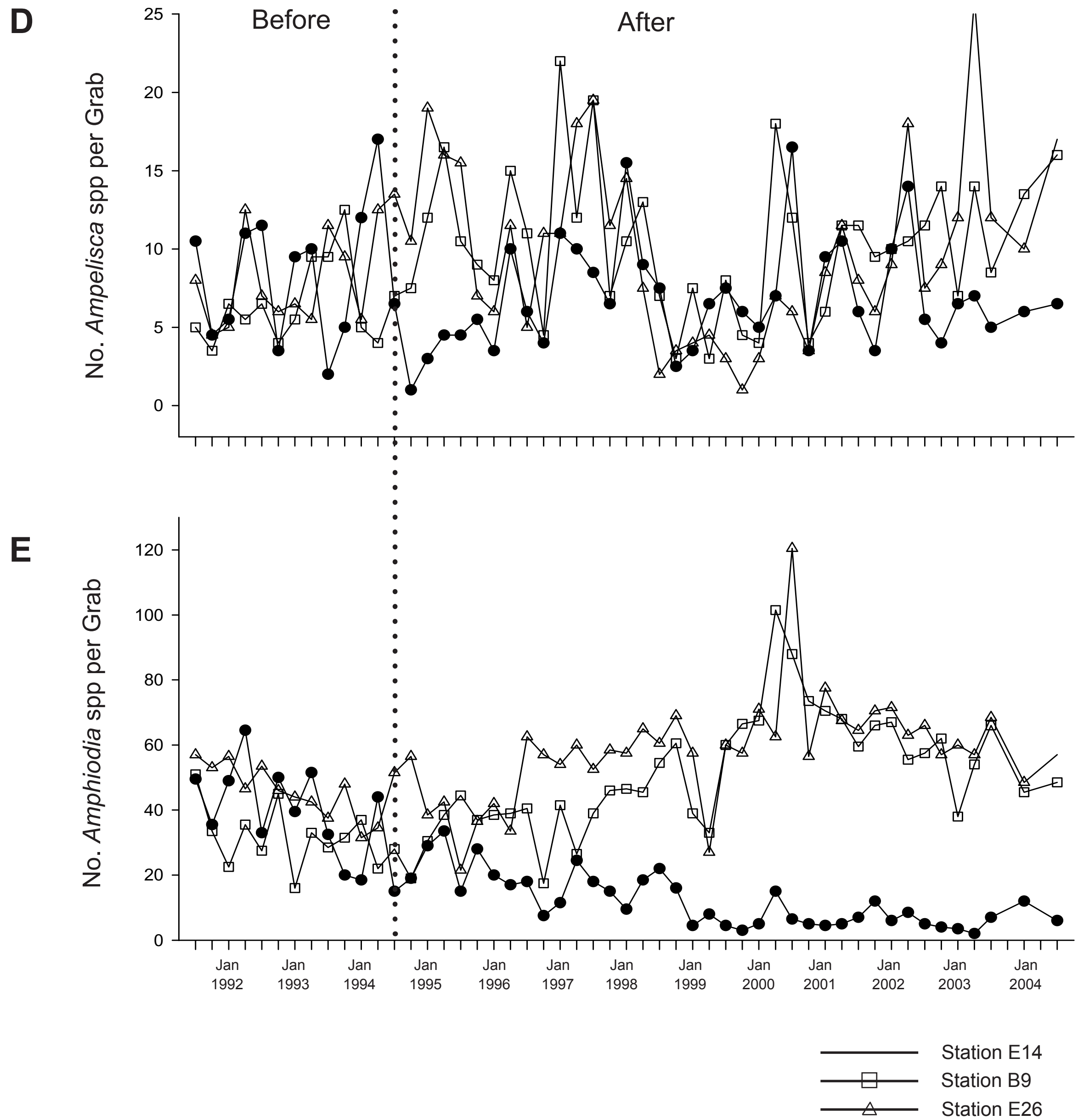


Figure 5.3 *Continued*

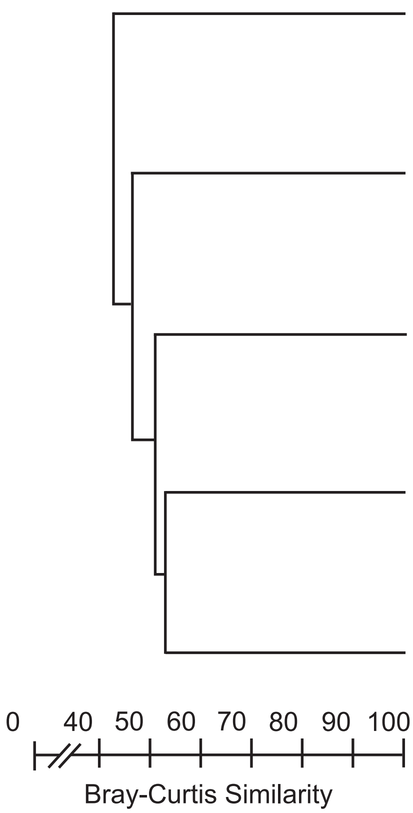
numbers of *Amphiodia*. The results for infaunal abundances were more ambiguous (Figure 5.3b). Although a significant change was indicated between the impact site and station B9, no such pattern was found regarding the second control site (E26). Finally, there was no net change in the average difference between impact and control sites in numbers of ampeliscid or phoxocephalid amphipods.

Classification of Benthic Assemblages

Classification analyses discriminated differences between five main benthic assemblages (cluster groups A–E) during 2004 (**Figures 5.4, 5.5**). These assemblages differed in terms of their species composition, including the specific taxa present and their relative abundances. The dominant species for each assemblage are listed in **Table 5.4**. MDS ordination of the survey entities confirmed the validity of cluster groups A–E (Figure 5.4).

<u>Cluster group A</u> included deeper sites along the 98 and 116-m contours. Sediments associated with cluster group A had the highest percentage of

A



CG	SR	ABUN	% FINES	Top Three Taxa
A (n=4)	103.3 (78–124)	281 (179–428)	28.9 (25.1–31.9)	*Chloeia pinnata*, *Myriochele striolata*, *Euphilomedes producta*
B (n=4)	92 (79–107)	264 (185–369)	40.5 (34.9–47.2)	*Myriochele striolata*, *Amphiodia urtica*, *Myriochele gracilis*
C (n=2)	97 (82–121)	458 (301–639)	30.2 (29.2–31.3)	*Myriochele striolata*, *Chloeia pinnata*, *Euphilomedes carcharodonta*
D (n=9)	88 (69–108)	463 (201–969)	44.3 (38.4–57.8)	*Myriochele striolata*, *Amphiodia urtica*, *Proclea* sp A
E (n=15)	81 (62–101)	245 (149–364)	33.8 (28.1–45.7)	*Amphiodia urtica*, *Proclea* sp A, Amphiuridae

B

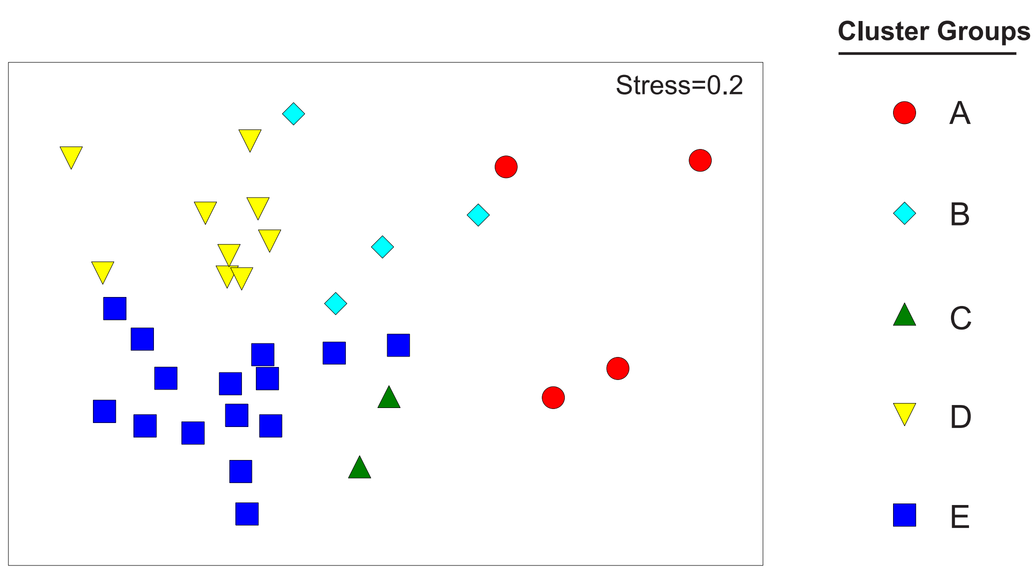


Figure 5.4

(A) Cluster results of the macrofaunal abundance data for the PLOO benthic stations sampled during 2004. Data are expressed as mean values per 0.1 m^2 grab over all stations in each group. CG=cluster group; SR=number of species; ABUN=number of individuals; % Fines=percent of silt + clay fractions in the sediment. Ranges in parentheses are for individual grab samples. (B) MDS ordination of PLOO benthic stations sampled during 2004. Plot based on square-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.

coarse particles (16%) and the lowest percentage of fine particles (29%) compared to the other groups. As is typical of these sites, species richness was relatively high, approximately 103 species per 0.1 m^2. The amphinomid polychaete *Chloeia pinnata* was among the dominant animals in this assemblage. Other dominant species included the oweniid polychaete *Myriochele striolata* and the ostracod crustacean *Euphilomedes producta.* This cluster group had the highest average abundance of the ophiuroid *Amphiodia digitata* and the gastropod *Caecum crebricinctum* which are usually associated with coarser grain sediments.

Cluster group B represented three southern stations along the 88 and 98-m contours. The sediments at these station were mainly composed of fine sands and silt. This assemblage averaged 264 individuals and 92 species per 0.1 m^2. The dominant species in this group were the polychaetes *M. striolata* and *M. gracilis* as well as the ophiuroid, *Amphiodia urtica*.

Cluster group C comprised station E14 located nearest to the PLOO discharge. Sediments here were characterized as sandy silt with some coarse particles. This assemblage was heavily dominated by *M. striolata* which averaged 146 individuals per 0.1 m^2. The polychaete *Chloeia pinnata* and the ostracod *Euphilomedes carcharodonta* also were prominent. The opportunistic polychaete *Capitella* "*capitata*" (spp complex) was much less abundant in this assemblage compared to previous years. When present in high numbers, this species is considered an indicator of organic enrichment (Reish 1971, Grassle and Grassle 1974, Pearson and Rosenberg 1978, Zmarzly et al. 1994). Only two individuals were collected at E14 during 2004 compared to an average of 14 individuals per 0.1 m^2 in 2003. Although *A. urtica* was present, it occurred in low densities (6.3 per 0.1 m^2) relative to most other assemblages.

Cluster group D comprised six northern stations along the 88 and 98-m contours. The sediments in this group had the highest percentage of fine particles (44%) among all cluster groups and highest macrofaunal abundance (463 individuals per 0.1 m^2 on average), but the second lowest species richness (88 species per 0.1 m^2) compared to the other cluster groups. The most abundant organisms were *M. striolata*, *A. urtica,* and the terebellid polychaete, *Proclea* sp A.

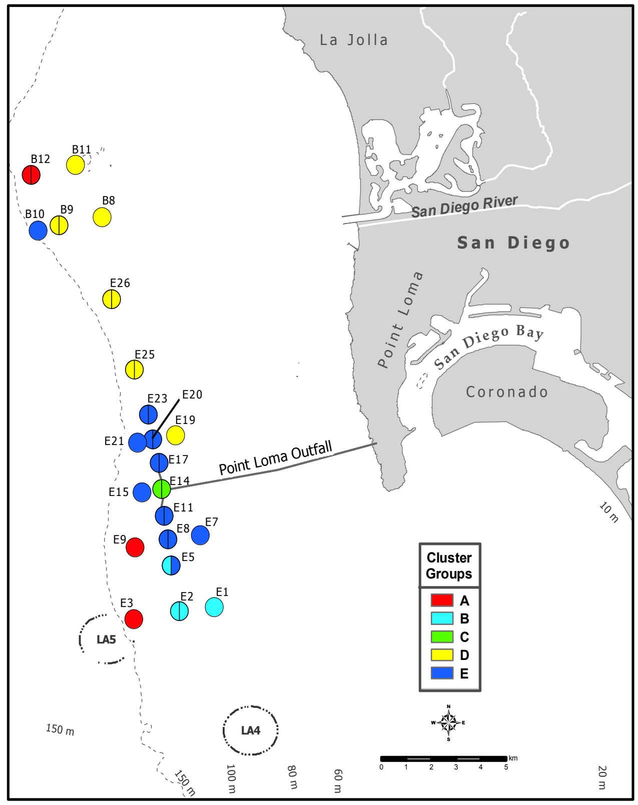


Figure 5.5
Results of ordination and classification analyses of macrofaunal abundance data during 2004. Cluster groups are color-coded on the map to reveal spatial patterns in the distribution of benthic assemblages.

Cluster group E was the largest assemblage, comprising 10 stations and 44% of the samples collected during 2004. Silty sand characterized the sediments at the sites comprising this cluster group. This group averaged 245 individuals and 81 species per 0.1 m^2, the lowest among all cluster groups. Dominant species included *A. urtica*, immature ophiuroids (i.e., Amphiuridae), and *Proclea* sp A. *Myriochele striolata*, a dominant species in all other cluster groups, was much less abundant here than elsewhere in the region.

Table 5.4

Summary of the most abundant taxa composing cluster groups A–E from the PLOO benthic stations surveyed in 2004. Data are expressed as mean abundance per sample (no./0.1m^2) and represent the ten most abundant taxa in each group. Animals absent from a cluster group are indicated by a dash. The three most abundant taxa in each cluster group are bolded.

		Cluster Group				
Species/Taxa	**Higher Taxa**	**A** (n=4)	**B** (n=4)	**C** (n=2)	**D** (n=9)	**E** (n=15)
Adontorhina cyclia	Mollusca: Bivalvia	0.3	0.1	1.3	11.4	2.9
Amphiodia digitata	Echinodermata: Ophiuroidea	7.6	1.3	0.3	1.0	0.8
Amphiodia sp	Echinodermata: Ophiuroidea	2.6	6.6	2.5	5.2	4.4
Amphiodia urtica	Echinodermata: Ophiuroidea	3.4	26.1	6.3	45.3	25.7
Amphiuridae	Echinodermata: Ophiuroidea	2.9	7.5	3.3	7.5	11.1
Axinopsida serricata	Mollusca: Bivalvia	0.1	0.5	8.0	8.4	3.4
Caecum crebricinctum	Mollusca: Gastropoda	8.9	—	—	—	—
Chaetozone hartmanae	Polychaeta: Cirratulidae	4.4	8.3	13.5	7.6	7.3
Chloeia pinnata	Polychaeta: Amphinomidae	12.9	1.9	25.8	3.8	5.5
Euphilomedes carcharodonta	Crustacea: Ostracoda	4.3	4.1	18.8	2.6	10.7
Euphilomedes producta	Crustacea: Ostracoda	9.1	3.5	7.5	4.8	6.1
Mediomastus sp	Polychaeta: Capitellidae	3.6	1.4	8.8	2.3	1.6
Myriochele gracilis	Polychaeta: Oweniidae	7.5	9.4	5.3	7.4	7.0
Myriochele striolata	Polychaeta: Oweniidae	11.4	27.9	146.0	178.9	0.6
Paradiopatra parva	Polychaeta: Onuphidae	5.0	3.5	5.3	4.4	2.7
Photis californica	Crustacea: Amphipoda	3.5	1.6	7.5	0.4	—
Prionospio (Prionospio) jubata	Polychaeta: Spionidae	5.6	1.4	17.3	3.2	5.0
***Proclea* sp A**	Polychaeta: Terebellidae	0.8	7.5	4.3	14.2	11.2
Rhepoxynius bicuspidatus	Crustacea: Amphipoda	0.5	1.9	4.0	6.6	6.4
Spiophanes duplex	Polychaeta: Spionidae	2.5	5.5	1.0	6.0	5.0
Sternaspis fossor	Polychaeta: Sternaspidae	2.4	5.4	4.0	5.6	4.1
Urothoe varvarini	Crustacea: Amphipoda	7.8	—	—	1.3	0.2

SUMMARY AND CONCLUSIONS

Benthic communities around the PLOO continue to be dominated by ophiuroid-polychaete based assemblages, with few major changes having occurred since monitoring began (see City of San Diego 1995, 2004). Polychaete worms continue to dominate the fauna in numbers of species and abundance. Although many of the 2004 assemblages were dominated by similar species, the relative abundance of these species varied between sites. The oweniid polychaete, *Myriochele striolata,* was dominant in all assemblages except the ten sites forming cluster group E. *Amphiodia urtica* was the second most abundant species and the most widespread benthic invertebrate in the region, being dominant or co-dominant in assemblages that comprised 86% of the samples. Assemblages similar to those off Point Loma have been described for other areas in the Southern California Bight (SCB) by Barnard and Ziesenhenne (1961), Jones (1969), Fauchald and Jones (1979), Thompson et al. (1987, 1992, 1993), Zmarzly et al. (1994), Diener and Fuller (1995), and Bergen et al. (1998, 2000).

Although variable, benthic communities off Point Loma generally have remained similar between years in terms of the number of species, number of individuals, and dominance (City of San Diego 1995, 2004). In addition, values for these parameters in 2004 were similar to those described for other sites throughout the SCB (e.g., Thompson et al. 1992, Bergen et al. 1998, 2001). In spite of this overall stability, there has been an increase in the number of species and macrofaunal abundances since discharge began (see City of San Diego 1995, 2004). However, the increase in species has been most pronounced nearest the outfall, suggesting that significant environmental degradation is not occurring at the PLOO. In addition, the observed increases in abundance at most stations have been accompanied by decreases in dominance, patterns inconsistent with predicted pollution effects. Whatever the cause of such changes, benthic communities around the PLOO are not numerically dominated by a few pollution tolerant species.

Changes near the outfall suggest some effects coincident with anthropogenic activities. Indicative of organic enrichment or disturbance was a decrease in the infaunal trophic index (ITI) at station E14 after discharge began (see City of San Diego 1995, 2004). In addition, benthic response index (BRI) values are higher at E14 than at other sites in the region. However, both ITI and BRI values at this and all other sites remain characteristic of undisturbed areas. In addition, the increased variability in number of species and infaunal abundance at near-ZID station E14 since discharge began may be indicative of community destabilization (see Warwick and Clarke 1993, Zmarzly et al. 1994). The instability or patchiness of sediments near the PLOO and the corresponding shifts in assemblages suggest that changes in this area may be related to localized physical disturbance (e.g., shifting sediment types) associated with the structure of the outfall pipe as well as to organic enrichment associated with the discharge of effluent.

Populations of some indicator taxa revealed changes that correspond to organic enrichment near the outfall, while populations of others revealed no evidence of impact. For example, there has been a significant change in the difference between ophiuroid (*Amphiodia* spp) populations that occur near the outfall (i.e., station E14) and those present at reference sites. This difference is due mostly to decreased numbers of ophiuroids near the outfall as compared to those at the control sites during the post-discharge period. Although changes in *Amphiodia* populations at E14 are likely to be related to organic enrichment, they may also be due in part to increased predation pressure from fish living near the outfall pipe. Whether or not these changes are related to enrichment, predation, altered sediment composition or some other factor, abundances of *Amphiodia* off Point Loma are still within the range of those occurring naturally in the SCB (Barnard and Ziesenhenne 1961, Jones 1969). In addition, natural population fluctuations of these and other resident organisms (e.g. *M. striolata* and *Proclea* sp A) are common off San Diego (Zmarzly et al. 1994, Deiner et al. 1995). Further complicating the picture, patterns of change in populations of pollution sensitive amphipods (i.e., *Rhepoxynius, Ampelisca*) have shown no outfall-related effects.

While it is difficult to detect specific effects of the PLOO on the offshore benthos, it is possible to see some changes occurring near the discharge site (i.e., E14). Because of the minimal extent of these changes, it has not been possible to determine whether any effect is due to the physical structure of the outfall pipe or to organic enrichment in the area. Such impacts have spatial and temporal dimensions that vary depending on a range of biological and physical factors. In addition, abundances of soft bottom invertebrates exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, 1992b, Otway 1995). The effects associated with the discharge of advanced primary treated (APT) and secondary treated sewage may also be negligible or difficult to detect in areas subjected to strong currents that facilitate the dispersion of the wastewater plume (see Diener and Fuller 1995). Although some changes in benthic assemblages have appeared near the outfall, assemblages in the region are still similar to those observed prior to discharge and to natural indigenous communities characteristic of the southern California continental shelf.

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Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fishes and megabenthic invertebrates are conspicuous components of soft-bottom habitats of the mainland shelves and slopes off southern California. More than 100 species of fish inhabit the Southern California Bight (SCB) (Allen 1982, Allen et al. 1998), while the megabenthic invertebrate fauna consists of more than 200 species (Allen et al. 1998). For the Point Loma region off San Diego, the most common trawl-caught fishes include Pacific sanddab, longfin sanddab, Dover sole, hornyhead turbot, California tonguefish, plainfin midshipman, and yellowchin sculpin. The common trawl-caught invertebrates include relatively large animals such as sea urchins and sea stars.

Communities of bottom dwelling fish and megabenthic invertebrates have become an important focus of monitoring programs throughout the world. For example, these organisms have been sampled extensively on the SCB mainland shelf for more than 30 years, primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). Although much is known about the condition of these types of assemblages (e.g., Allen et al. 1998), additional studies are useful in documenting community structure and stability, and may provide insight into the effects associated with anthropogenic and natural influences.

The City of San Diego Ocean Monitoring Program was designed to monitor the effects of the Point Loma Ocean Outfall (PLOO) on the local marine environment. This chapter presents analyses and interpretation of demersal fish and megabenthic invertebrate data collected under this program during 2004. A long-term analysis of changes in these communities from 1991 through 2004 is also presented.

MATERIALS AND METHODS

Field Sampling

A total of 12 trawls were performed during two surveys off Point Loma in 2004. The trawling area extends from about 8 km north to 9 km south of the outfall. Stations SD7–SD14 are located along the 100-m contour and were sampled during January and July (**Figure 6.1**). A single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.5 knots along a predetermined heading. Detailed methods for locating the stations and conducting trawls are described in the City of San Diego Quality Assurance Plan (City of San Diego in prep).

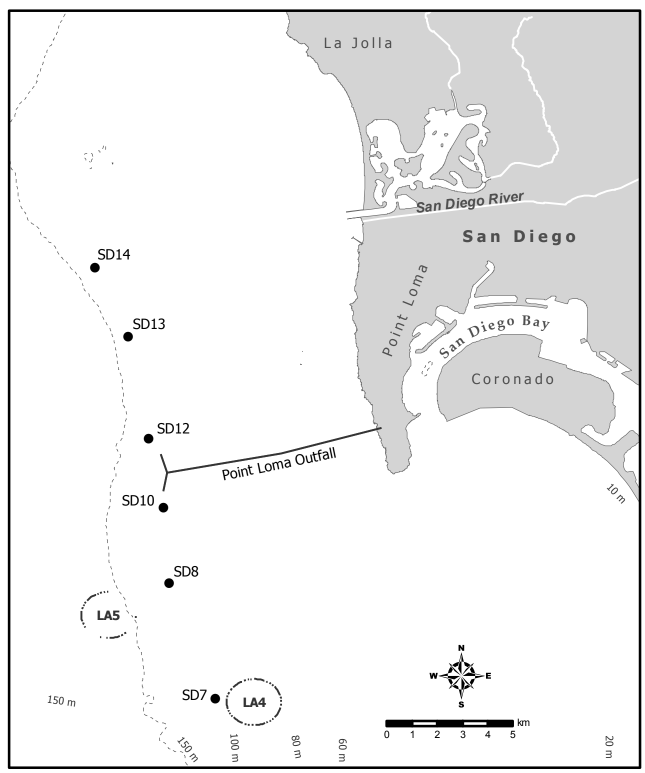

Figure 6.1
Otter trawl station locations, Point Loma Ocean Outfall Monitoring Program.

Table 6.1
Demersal fishes collected in 12 trawls off Point Loma, San Diego during 2004. Data for each species are expressed as percent abundance (PA), frequency of occurrence (FO), and mean abundance per occurence (MAO).

Species	PA	FO	MAO	Species	PA	FO	MAO
Pacific sanddab	57	100	229	Bay goby	<1	42	1
Dover sole	9	100	38	California lizardfish	<1	25	2
Longspine combfish	8	100	32	Bluespotted poacher	<1	33	2
Yellowchin sculpin	6	83	29	Greenspotted rockfish	<1	25	2
Stripetail rockfish	6	83	29	Spotted cuskeel	<1	25	2
Halfbanded rockfish	3	92	14	Bigmouth sole	<1	42	1
Shortspine combfish	1	92	6	California skate	<1	33	1
Plainfin midshipman	1	83	6	Chilipepper rockfish	<1	17	2
California scorpionfish	1	42	11	Greenblotched rockfish	<1	8	2
Slender sole	1	50	9	Hornyhead turbot	<1	17	1
English sole	1	92	5	Pygmy poacher	<1	8	2
California tonguefish	1	67	6	Calico rockfish	<1	8	1
Pacific argentine	1	33	8	Sanddab unidentified	<1	8	1
Greenstriped rockfish	1	67	4	Cowcod	<1	8	1
Longfin sanddab	<1	58	3	Flag rockfish	<1	8	1
Blackbelly eelpout	<1	33	5	Flatfish unidentified	<1	8	1
Spotfin sculpin	<1	17	8	Gobiidae unidentified	<1	8	1
Rockfish unidentified	<1	58	2	Jack mackerel	<1	8	1
Pink seaperch	<1	67	2	Roughback sculpin	<1	8	1
Blacktip poacher	<1	17	6	Stripedfin ronquil	<1	8	1

Trawl catches were brought on board ship for sorting and inspection. All organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. For fish, the total number of individuals and total biomass (wet weight, kg) were recorded for each species. Additionally, each individual fish was inspected for the presence of external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter according to standard protocols (see City of San Diego in prep). For invertebrates, the total number of individuals was recorded per species. When the white sea urchin, *Lytechinus pictus,* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals per 1.0 kg subsample by the total urchin biomass.

Data Analyses

Populations of each fish and invertebrate species were summarized in terms of percent abundance (number of individuals/total of all individuals caught x 100), frequency of occurrence (number of occurrences/ total number of trawls x 100) and mean abundance per occurrence (number of individuals/number of occurrences). In addition, species richness (number of species), total abundance, and Shannon diversity index (H') were calculated for both the fish and invertebrate assemblages at each station. Total biomass was also calculated for each fish species by station.

Multivariate analyses were performed on the six stations using PRIMER (Plymouth Routines in Multivariate Ecological Research) software

Table 6.2

Summary of demersal fish community parameters for 2004. Data are expressed as total number of species, mean number of species, mean abundance, mean diversity (H'), and mean biomass (BM) (kg, wet weight).

	No. of Species				
Station	Total	Mean	Abund	H'	BM
SD7	20	14	276	1.22	3.8
SD8	26	19	206	1.49	3.7
SD10	21	15	331	1.22	6.6
SD12	23	16	480	1.93	7.8
SD13	24	18	594	1.64	11.8
SD14	25	20	541	1.19	8.8

to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking, and ordination by non-metric multidimensional scaling (MDS). The fish abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination.

RESULTS

Fish Community

At least 36 species of fish were collected in the area surrounding the PLOO during 2004 (**Table 6.1**). The total catch for the year was 4852 individuals, representing an average of about 404 fish per trawl. The Pacific sanddab comprised 57% of the total catch and occurred in every haul. Other frequently occurring fishes were Dover sole, longspine combfish, yellowchin sculpin, stripetail rockfish, halfbanded rockfish, shortspine combfish, plainfin midshipman, and English sole. These common species tended to be relatively small with an average length <20 cm (**Appendix C.1**).

Fish abundance and biomass were highly variable during 2004. For example, abundance averaged from 206 to 594 fish per haul (**Table 6.2**). Relatively large hauls were collected at both of the northern farfield stations (SD13 and SD14), which were nearly twice that of the southern stations (SD7 and SD8). This difference was primarily due to substantial numbers of Pacific sanddab present at stations SD13 and SD14 in January and July (**Appendix C.2**). The wide range in total fish biomass per haul (mean = 3.7 to 11.8 kg) was generally attributable to variation in the size of the catch or the occurrence of large individuals (e.g., California scorpionfish). For example, the greatest biomass occurred at station SD16 in April due to three relatively large California halibut that weighed approximately 7 kg combined (**Appendix C.3**).

In contrast to abundance and biomass, values for species richness and diversity (H') varied little and were relatively low in 2004 (Table 6.2). The average number of species was 20 or less at all stations over the year. Diversity values were less than 2 at all stations. These relatively low diversity values are due to the predominance of Pacific sanddabs.

Fluctuating populations of dominant species have been the primary factor contributing to variation in the structure of the fish community off Point Loma since 1992 (**Figure 6.2**). For example, species richness has remained fairly consistent over the years averaging from 10–20 species per station, while mean abundances have fluctuated substantially with mean values ranging from 93–690 individuals. These fluctuations in abundance have been greatest at stations SD10–SD14 and generally reflect differences in populations of several dominant species, especially the Pacific sanddab (**Figure 6.3**). Overall, none of the observed changes appear to be associated with the discharge of wastewater from the Point Loma outfall.

Ordination and classification of sites sampled during July between 1991 and 2004 resulted in seven major clusters (see **Figure 6.4**). These seven assemblages (station groups 1–7) differed mainly in terms of numbers of the more common species (**Table 6.3**). Station groups 1 through 4 consist of 1–2 trawls each characterized by low abundances of Pacific sanddabs and a variety of other species.

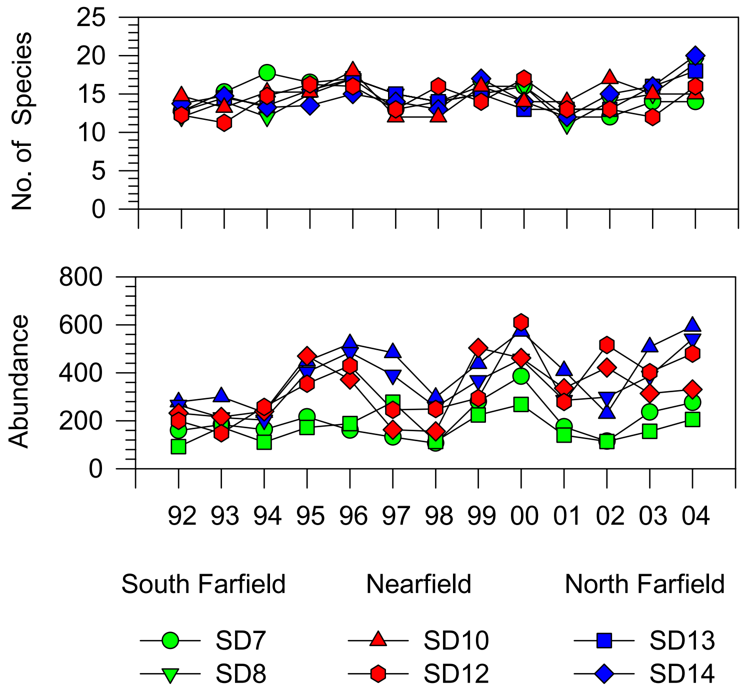

Figure 6.2
Number of species and total abundance of demersal fishes collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

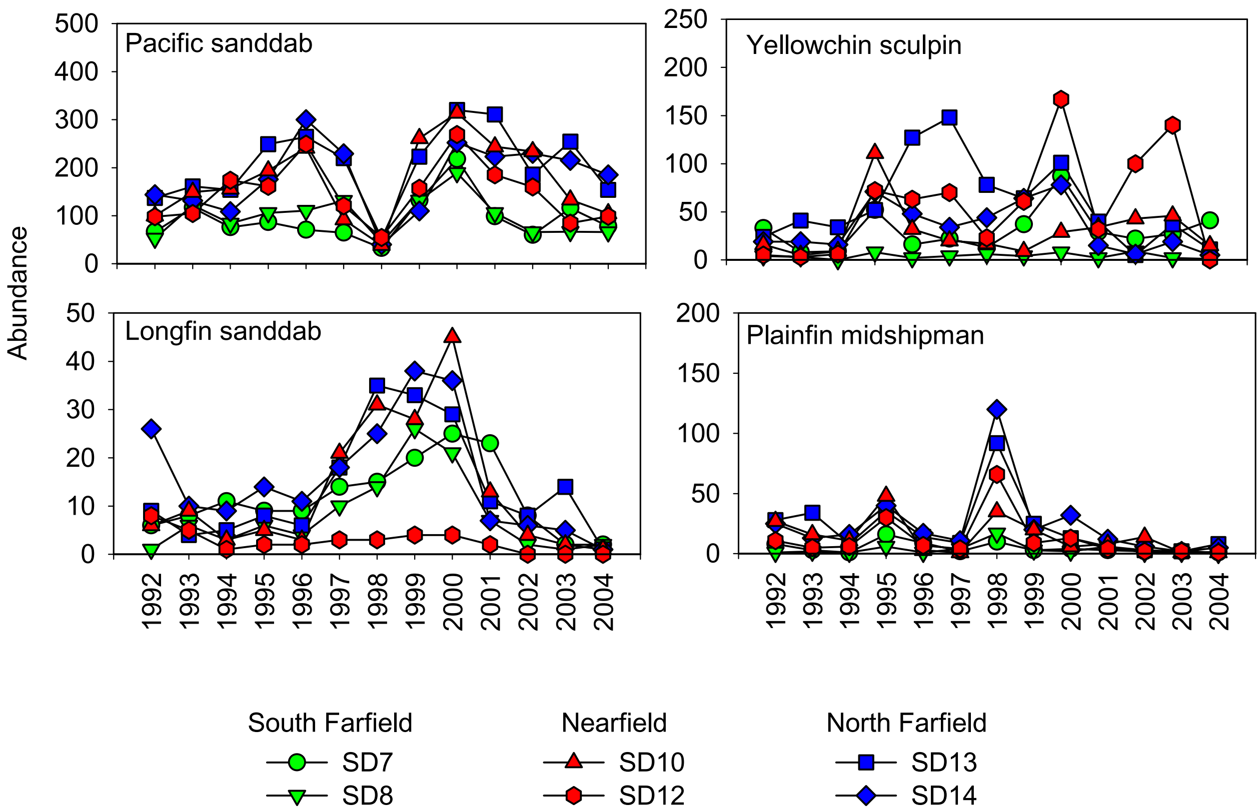

Figure 6.3
Number of individuals of each of the four most abundant species collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

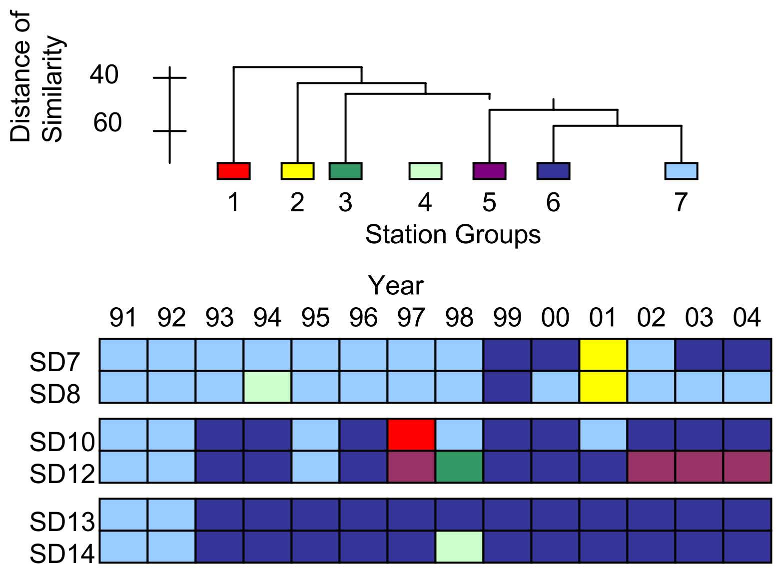

Figure 6.4
Classification analyses of demersal fish collected at PLOO stations from July 1991 through 2004. Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

Station group 5 also represents an infrequently occurring assemblage. This assemblage occurred at SD12 in just four of 14 years and consisted of moderate numbers of Pacific sandabs, and relatively high numbers of halfbanded rockfish and longspine combfish. By contrast, station groups 6 and 7 reflect hauls that were more typical for the region. Station group 6 occurred in 12 of the past 14 years and represented 50% of the sampled stations. This relatively consistent assemblage contained high numbers of Pacific sanddabs, Dover sole, yellowchin sculpin, and stripetail rockfish, and is typical of the cold water conditions that predominate in deep waters off Point Loma. The fish assemblage comprising station group 7 is representative of the southern stations SD7 and SD8 and becomes more widespread during warmer water years (i.e., 1991–1992, 1995, 1998). This assemblage was characterized by lower abundances of the colder water species listed for station group 6, especially Pacific sanddabs. These changes in fish assemblages appear to be unrelated to the discharge of wastewater from the PLOO.

Physical Abnormalities and Parasitism

The occurrences of fin rot and other physical abnormalities were generally low in fish populations off Point Loma during 2004. For example, only ten Dover soles (approximately 2% of the Dover population) collected at stations near and far away from the outfall were found to have tumors. According to Dr. J. Allen of the Southern California Coastal Water Research Project (personal communication), these tumors are likely from a Dover specific infection and have not been associated with degraded environments. The copepod eye parasite *Phrixocephalus cincinnatus* occurred on 2% of the Pacific sanddabs collected and was present at all stations during all surveys. The ectoparasitic isopod, *Elthusa vulgaris*, also occurred in two trawls (**Appendix C.4**). However, the host fishes are unknown since this isopod becomes detached from the host during sorting. Although *E. vulgaris* occurs on a wide variety of fish species off southern California, it is especially common on sanddabs and California lizardfish, where it may reach infestation rates of 3% and 80%, respectively (Brusca 1978, 1981).

Invertebrate Community

A total of 17,977 megabenthic invertebrates, representing 38 species, were collected during 2004 (**Table 6.4**, Appendix C.4). The white sea urchin *Lytechinus pictus* was the most abundant and most frequently captured species. It was present in all of the

Table 6.3

Summary of the demersal fish assemblages for the seven main station cluster groups defined in Figure 6.4. Data include number of hauls, mean number of species, mean number of individuals, as well as the distribution of abundant and frequently occurring fish species in each group. Most abundant species in bold.

	SG1	SG2	SG3	SG4	SG5	SG6	SG7
Number of hauls	1	2	1	2	4	42	32
Mean no. of species per haul	7	11	16	11	15	15	13
Mean no. of individuals per haul	44	25	261	74	292	364	163
Species	**Mean Abundance**						
Pacific sanddab	**23**	**46**	**75**	**48**	**126**	**243**	**100**
Plainfin midshipman			**116**	2		9	**14**
Dover sole		1	36	6	24	**27**	12
Halfbanded rockfish	**16**				**44**		2
Longspine combfish		3	7	2	35	11	
Stripetail rockfish				**8**	6	16	7
Yellowchin sculpin		**5**				18	3
Slender sole					18	4	
Longfin sanddab	1	3				8	5
Shortspine combfish					9		3
Pink seaperch	1		4	2		5	
Gulf sanddab	1		5	1			
Squarespot rockfish					6		
Greenstriped rockfish				1	5		
California tonguefish		3					3
Spotfin sculpin	1			2			3
Blackfin eelpout			4				
Bay goby		1				3	
Blackbelly eelpout					4		
Roughback sculpin		2	2				
English sole			3				
Bigmouth sole		3					
California scorponfish			2				
Greenblotched rockfish				2			
California lizardfish		1					
Greenspotted rockfish	1						

trawls and accounted for 94% of the total invertebrate catch. Other species that occurred in at least half of the hauls included the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* and the sea cucumber *Parastichopus californicus*.

As with the fishes, numbers of invertebrates varied among stations and between surveys during the year, while species richness and diversity were relatively uniform (**Table 6.5, Appendix C.5**). For example, the mean number of species per station ranged from 8 to 15, while abundance per station averaged from 555 to 2578 individuals. The largest hauls (in terms of abundance) occurred at stations SD8 and SD13, primarily due to large numbers of the urchin *L. pictus*. Diversity values were also extremely low (<1) for the entire area due to the numeric dominance of this urchin. The numeric dominance of *L. pictus* is typical of similar habitats throughout the SCB.

Invertebrate species richness and abundance has varied over time (**Figure 6.5**). The annual species richness has averaged from 5 to 20 species between 1992 and 2004, although the patterns of change have been similar among stations. In contrast, changes

Table 6.4

Megabenthic invertebrate species collected in 12 trawls off Point Loma, San Diego during 2004. Data for each species are expressed as percent abundance (PA), frequency of occurrence (FO), and mean abundance per occurence (MAO).

Species	PA	FO	MAO
Lytechinus pictus	94	100	1406
Acanthoptilum sp	3	67	76
Astropecten verrilli	1	83	12
Platymera gaudichaudii	1	42	20
Luidia foliolata	1	75	10
Parastichopus californicus	<1	83	5
Ophiura luetkenii	<1	75	3
Crangon alaskensis	<1	33	5
Luidia asthenosoma	<1	33	4
Allocentrotus fragilis	<1	33	3
Philine auriformis	<1	17	5
Megasurcula carpenteriana	<1	25	2
Octopus rubescens	<1	42	1
Pleurobranchaea californica	<1	25	2
Thesea sp B	<1	33	2
Nymphon pixellae	<1	25	2
Rossia pacifica	<1	25	1
Tritonia diomedea	<1	17	2
Astropecten ornatissimus	<1	17	1
Elthusa vulgaris	<1	17	1
Loligo opalescens	<1	17	1
Metridium farcimen	<1	17	1
Ophiopholis bakeri	<1	17	1
Amphiodia urtica	<1	8	1
Armina californica	<1	8	1
Cancellaria crawfordiana	<1	8	1
Florometra serratissima	<1	8	1
Fusinus barbarensis	<1	8	1
Loxorhynchus grandis	<1	8	1
Luidia armata	<1	8	1
Mediaster aequalis	<1	8	1
Nassarius insculptus	<1	8	1
Neosimnia barbarensis	<1	8	1
Paguristes turgidus	<1	8	1
Podochela hemphillii	<1	8	1
Spatangus californicus	<1	8	1
Telesto californica	<1	8	1
Virgularia agassizi	<1	8	1

in abundance have differed among stations. For example, the average annual invertebrate catches were consistently low at stations SD13 and SD14, while the remaining stations demonstrated large peaks in abundance at various times. These fluctuations typically reflect changes in several dominant echinoderm populations, especially that of *L. pictus* and another urchin, *Allocentrotus fragilis* (see **Figure 6.6**). None of the observed variability in the invertebrate community could be attributed to the discharge of wastewater from the Point Loma outfall.

Table 6.5

Summary of megabenthic invertebrate community parameters off Point Loma for 2004. Data are expressed as total number of species, mean number of species, mean abundance, and mean diversity (H').

	No. of Species			
Station	Total	Mean	Abund	H'
SD7	15	12	555	0.83
SD8	15	9	2560	0.12
SD10	22	15	1084	0.85
SD12	18	12	1453	0.45
SD13	11	8	2578	0.11
SD14	12	8	750	0.44

SUMMARY AND CONCLUSIONS

Pacific sanddabs once again dominated the demersal fish assemblages surrounding the Point Loma Ocean Outfall during 2004. Other fish, such as the Dover sole, longspine combfish, yellowchin sculpin, stripetail rockfish, halfbanded rockfish, shortspine combfish, plainfin midshipman, and English sole were also collected frequently. The megabenthic invertebrate assemblages were also dominated by a few, prominent species. The white sea urchin *Lytechinus pictus* was the most abundant species, while the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* and the sea cucumber *Parastichopus californicus* were also common.

As in previous years, variation among stations and between surveys in both fish and invertebrate communities in the region was generally due to population fluctuations of the dominant species mentioned above. Fluctuations in fish abundance have been greatest at stations SD10–SD14, and generally reflect differences in the populations of the Pacific sanddab and several other dominant species. Invertebrate abundances were largely

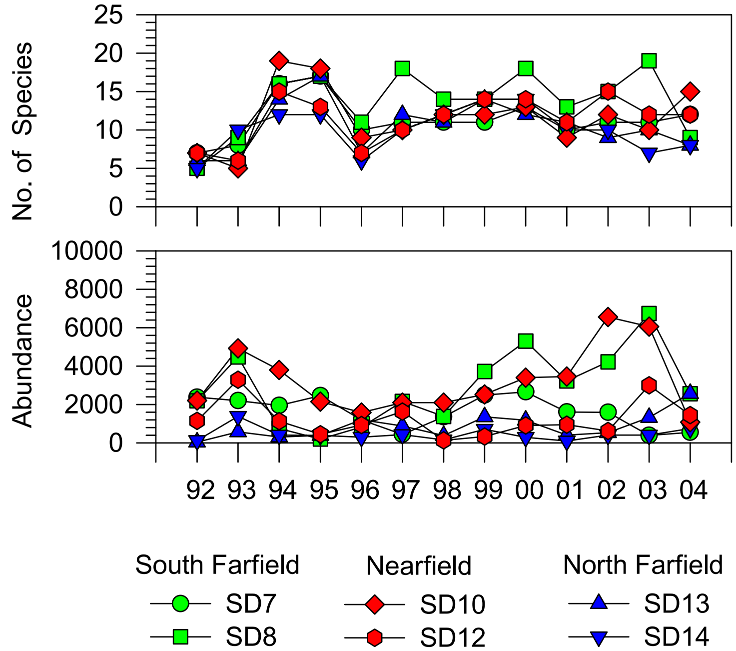

Figure 6.5
Number of species and total abundance of megabenthic invertebrates collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

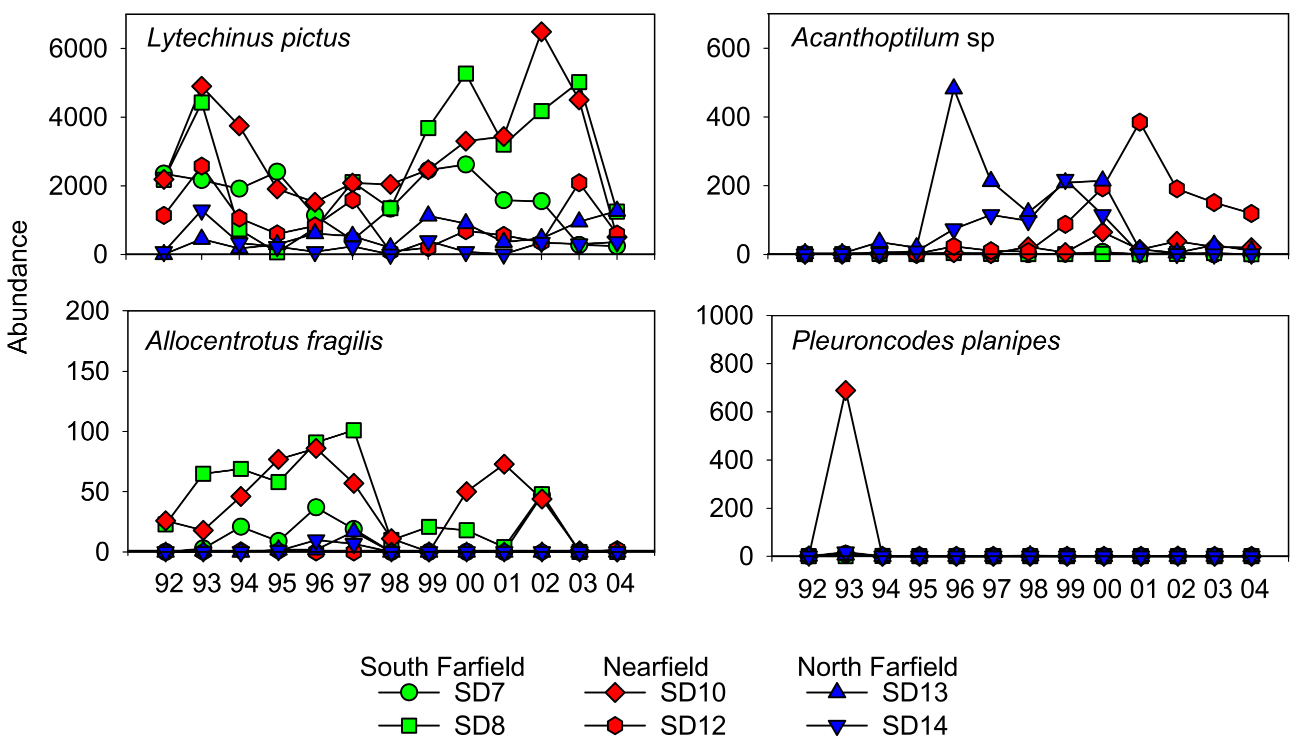

Figure 6.6
Number of individuals of each of the four most abundant species of megabenthic invertebrates collected at each PLOO station from 1992 through 2004. Data are presented as annual means (n=4 for 1991–2002; n=3 in 2003; n=4 in 2004).

affected by changes in three echinoderms, *Lytechinus pictus, Astropectin verrilli*, and *Luidia foliolata,* especially at stations SD7–SD10.

Demersal fish and megabenthic invertebrate communities are inherently variable, and the observed changes in community structure may be influenced by both anthropogenic and natural factors. Anthropogenic influences include inputs from such things as ocean outfalls and storm drain runoff. None of the observed variability in the trawl-caught fish or invertebrate communities off Point Loma can be attributed to such influences. Natural factors may include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niño (Karinen et al. 1985). In general, the observed variability in the PLOO assemblages was more likely due to such natural factors that can impact the migration of adult fish or the recruitment of juveniles into an area (see Murawski 1993). Population fluctuations that affect diversity and abundance may also be due to the mobile nature of many species (e.g., aggregations of urchins).

Overall, there was no evidence that wastewater discharge from the Point Loma Ocean Outfall in 2004 affected either demersal fish or megabenthic invertebrate communities in the region. Despite the variable structure of these assemblages, patterns of species diversity, abundance, and biomass at stations near the outfall were similar to sites located further away. In addition, no changes have been found in these assemblages that can be attributed to over 11 years of waste water discharge. Furthermore, the low incidences of physical abnormalities on local fishes suggest that populations in the area are healthy.

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Chapter 7: Bioaccumulation of Contaminants in Fish Tissues

INTRODUCTION

Bottom dwelling (i.e., demersal) fishes are collected as part of the Point Loma Ocean Outfall (PLOO) monitoring program to assess the accumulation of contaminants in their tissues. The bioaccumulation of contaminants in fish occurs through biological uptake and retention of chemical contaminants derived from various exposure pathways (see Tetra Tech 1985). Exposure routes for these fishes include the adsorption or absorption of dissolved chemical constituents from the water and the ingestion and assimilation of pollutants from food sources. They also accumulate pollutants by ingesting pollutant-containing suspended particulate matter or sediment particles. Demersal fish are useful in biomonitoring programs because of their proximity to bottom sediments. For this reason, levels of contaminants in tissues of these fish are often related to those found in the environment (Schiff and Allen 1997).

The bioaccumulation portion of the PLOO monitoring program consists of two components: (1) analysis of liver tissues from trawl-caught fishes; (2) analysis of muscle tissues from fishes collected by rig fishing. Fishes collected from trawls are considered representative of the demersal fish community, and certain species are targeted based on their ecological significance (i.e., prevalence). Chemical analyses are performed using livers from these fish because this is where contaminants typically concentrate due to the physiological role of this organ and the high lipid levels found there. In contrast, fishes targeted for collection by rig fishing are typical of a sport fisher's catch. Muscle tissue is analyzed from these fishes because it is the part of a fish most often consumed by humans, and the results are therefore directly pertinent to human health.

All muscle and liver tissue samples were analyzed for contaminants as specified in the NPDES discharge permit governing the PLOO monitoring program. Most of these contaminants are also included in the NOAA National Status and Trends Program. NOAA initiated this program to detect changes in the environmental quality of our nation's estuarine and coastal waters by tracking contaminants thought to be of concern (Lauenstein and Cantillo 1993). This chapter presents the results of all tissue analyses that were performed during 2004.

MATERIALS AND METHODS

Collection

Fishes were collected by trawl during October 2004 in four zones (Z1–Z4) and two rig fishing stations (RF1 and RF2) (**Figure 7.1**). Trawl-caught fishes were collected, measured and weighed following

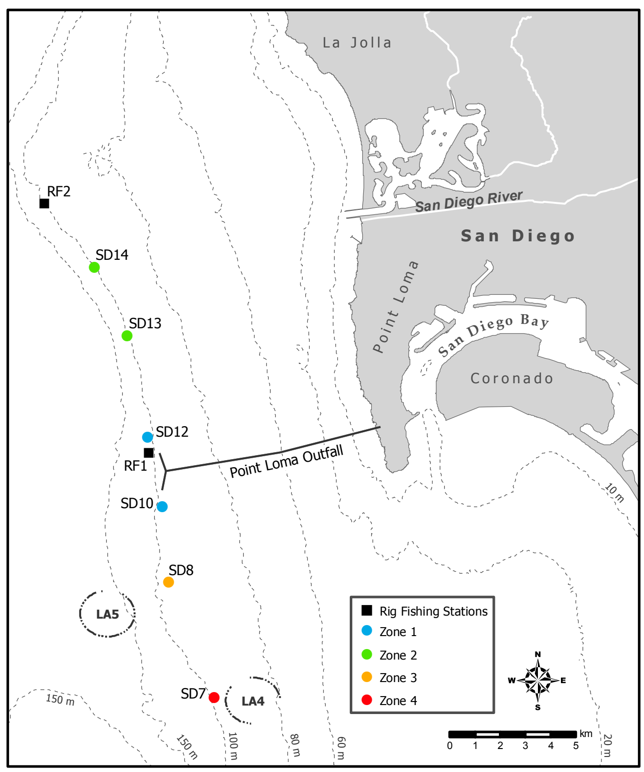

Figure 7.1
Otter trawl and rig fishing stations/zones surrounding the City of San Diego's Point Loma Ocean Outfall.

Table 7.1

Species of fish collected for tissue analysis from each trawl zone (Z1–Z4) or rig fishing station (RF1–RF2) during October 2004. PS=Pacific sanddab; ES=English sole; LS=longfin sanddab; CR=copper rockfish; MR=mixed rockfish; GR=greenspotted rockfish.

Station/Zone	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9
Zone1	ES	ES	ES	PS	PS	PS	LS	LS	LS
Zone2	ES	ES	ES	PS	PS	PS	LS	LS	LS
Zone3	PS	PS	PS	ES	ES	LS			
Zone4	PS	PS	PS						
RF1	CR	CR	MR						
RF2	GR	MR	MR						

established guidelines as described in Chapter 6 of this report. Fishes were collected at rig fishing sites primarily using rod and reel fishing tackle following standard procedures (City of San Diego in prep). Fish traps were used at the rig fishing sites to facilitate the collection of fish. Only fish >12 cm standard length were retained for tissue analyses. These fish were sorted into composite samples, each containing a minimum of three individuals. The fish were then wrapped in aluminum foil, labeled, put in ziplock bags, and placed on dry ice for transport to the Marine Biology Laboratory freezer. The species that were analyzed from each station/zone are summarized in **Table 7.1**

Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis (see City of San Diego in prep). Each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus prior to dissection. The standard length (cm) and weight (g) of each fish were recorded (**Appendix D.1**). Dissections were carried out on Teflon pads that were cleaned between samples. Tissue samples were then placed in glass jars, sealed, labeled and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City of San Diego Wastewater Chemistry Laboratory within seven days of dissection.

All tissue samples were analyzed for the chemical constituents specified by the NPDES permit under which this sampling was performed, including various trace metals, chlorinated pesticides, PCBs, and PAHs (**Appendix D.2**). A summary of all parameters detected at each station during each survey is listed in **Appendix D.3**. Detected parameters include some that were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry), but at levels actually below the MDL. These were included in the data as estimated values. A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Laboratory (City of San Diego 2005).

RESULTS

Contaminants in Trawl-Caught Species

Metals

Aluminum, arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, selenium, silver, tin, and zinc occurred frequently in the liver tissues of all trawl-caught species of fish (**Table 7.2**). Each of these metals was detected in over 60% of the samples, with variable concentrations. For example, iron occurred in all species at concentrations ranging from about 45 to 190 ppm.

Table 7.2

Concentrations (ppm) of metals detected in liver tissues from fish collected as part of the PLOO monitoring program during 2004. n=number of detected values.

	Al	Sb	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
Pacific sanddab																
n (out of 12)	8	2	12	12	12	12	12	12	nd	12	12	nd	12	11	12	12
Min	2.3	0.56	1.3	0.036	4.1	0.21	2.3	45	—	0.76	0.048	—	0.74	0.06	0.32	20.4
Max	8.0	1.02	2.9	0.059	10.1	0.81	4.9	133	—	1.16	0.102	—	1.55	0.13	0.97	30.3
Mean	5.1	0.79	2.2	0.047	6.4	0.35	4.0	91	—	0.94	0.074	—	1.08	0.09	0.66	25.3
English sole																
n (out of 8)	6	nd	8	8	8	8	8	8	7	8	8	nd	8	8	7	8
Min	2.8	—	4.1	0.030	0.5	0.17	0.9	106	0.4	0.99	0.039	—	2.05	0.08	0.26	32.9
Max	7.0	—	8.0	0.047	0.8	0.33	5.2	119	1.1	1.31	0.130	—	3.21	0.32	0.49	86.9
Mean	5.0	—	6.2	0.034	0.7	0.28	2.1	114	0.704	1.15	0.064	—	2.65	0.15	0.40	52.7
Longfin sanddab																
n (out of 7)	3	1	7	7	7	7	7	7	nd	7	7	1	7	7	7	7
Min	4.6	0.54	8.2	0.027	1.9	0.23	4.3	159	—	0.84	0.053	0.102	3.06	0.16	0.46	21.4
Max	8.6	0.54	16.7	0.052	4.3	0.37	9.4	190	—	1.05	0.111	0.102	4.37	0.34	0.78	28.0
Mean	6.4	0.54	11.5	0.040	3.0	0.28	6.7	174	—	0.92	0.088	0.102	3.65	0.25	0.60	23.3
ALL SPECIES																
% Detected	63	11	100	100	100	100	100	100	26	100	100	4	100	96	96	100

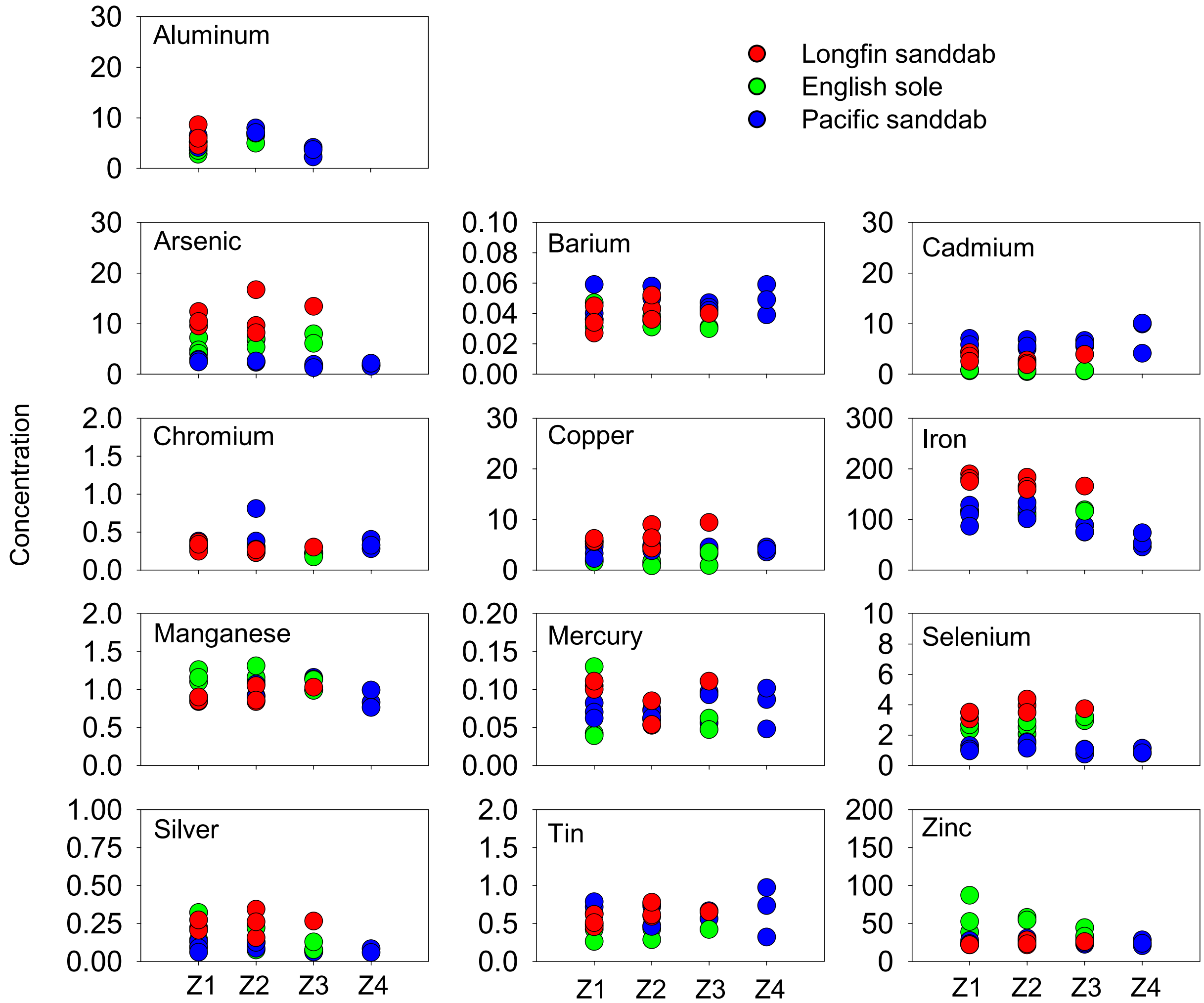

Figure 7.2

Concentrations of metals (ppm) detected frequently in liver tissues of fish collected as part of the PLOO monitoring program during 2004. Z1 represents the zone located closest to the discharge site.

In addition, the range of values from fish collected at stations closest to the discharge site (Zone 1) were similar to those from farther away (Zones 2–4) (**Figure 7.2**). Overall there was no clear relationship between contaminant levels and proximity to the outfall.

Chlorinated Pesticides

Four pesticides were detected in liver tissues from fishes collected in the Point Loma coastal region (**Table 7.3**). DDT was the most prevalent pesticide; it occurred in all samples with concentrations of total DDT ranging between 47 ppb and 2191 ppb. Chlordane (i.e., alpha(*cis*)chlordane, gamma(*trans*)chlordane, *cis*-nonachlor, and *trans*-nonachlor), hexachlorobenzene (HCB), and Mirex were also detected, although at concentrations less than 100 ppb. Of these constituents, alpha(*cis*)chlordane, HCB and *trans*-nonachlor were the most common, with detection rates of 70% or greater.

The four most frequently detected pesticides (or pesticide components) were plotted by zone to assess spatial patterns (**Figure 7.3**). DDT, alpha(*cis*)chlordane, HCB, and *trans*-nonachlor were detected in fishes collected from all four zones. As with metals, there was no clear relationship between concentrations of these parameters and proximity to the outfall.

PCBs

Polychlorinated biphenyls (PCBs) occurred in all fish samples (Table 7.3 and Appendix D.3). Total

Table 7.3

Concentrations of chlorinated pesticides, PCBs, and lipids detected in liver tissues from fish collected as part of the PLOO monitoring program during 2004. HCB=hexachlorobenzene, A(c)C=alpha(*cis*) chlordane, G(t)C= gamma(*trans*)chlordane, CN=*cis*-nonachlor, TN=*trans*-nonachlor. Values are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt). n=number of detected values.

	Chlorinated Pesticides:								
	Total			Chlordane				Total	
	DDT	HCB	Mirex	A(c)C	G(t)C	CN	TN	PCB	Lipids
Pacific sanddab									
n (out of 12)	12	12	1	12	1	3	12	12	12
Min	167	2.4	3.7	2.9	1.8	4.3	5.2	66	32.3
Max	1815	4.4	3.7	10.5	1.8	7.0	21.0	695	49.7
Mean	590	3.6	3.7	6.6	1.8	5.6	10.2	331	40.9
English sole									
n (out of 8)	8	5	nd	nd	nd	nd	nd	8	8
Min	47	0.9	—	—	—	—	—	68	5.2
Max	732	1.6	—	—	—	—	—	327	14.4
Mean	194	1.3	—	—	—	—	—	143	10.9
Longfin sanddab									
n (out of 7)	7	7	1	7	1	3	7	7	7
Min	541	1.6	48.0	4.1	4.9	5.7	8.2	413	18.4
Max	2191	3.8	48.0	18.0	4.9	19.0	65.0	1800	42.8
Mean	922	2.4	48.0	8.9	4.9	11.6	20.1	802	25.6
ALL SPECIES									
% Detect.	100	89	7	70	7	22	70	100	100

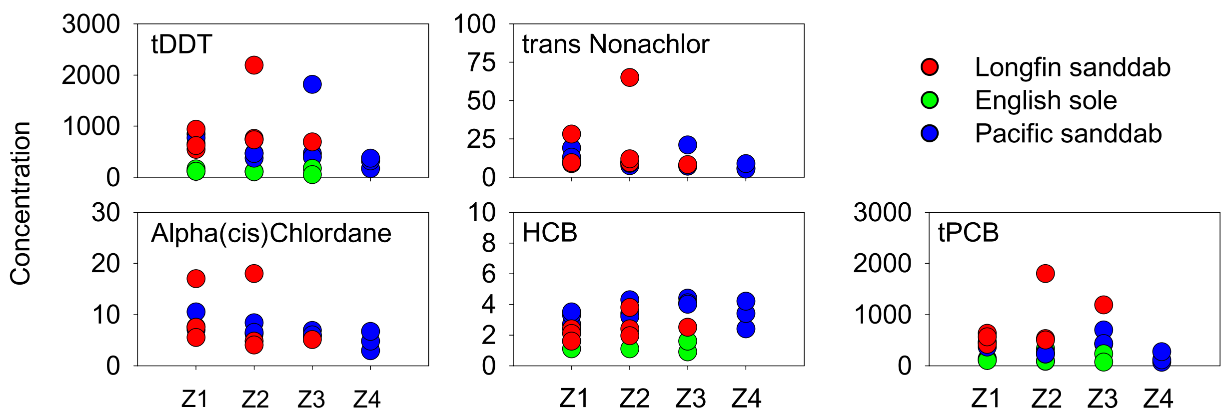

Figure 7.3

Concentrations of frequently detected chlorinated pesticides (or components) and total PCB (ppb) detected in liver tissues of fish as part of the PLOO monitoring program during 2004. Z1 represents the zone loacted closest to the discharge site

Table 7.4

Concentrations (ppm) of various metals and total DDT detected in muscle tissues from fish collected at PLOO rig fishing stations during 2004. Also included are US FDA action limits and median international standards. Bolded values exceed international standards.

	As	Cd	Cr	Cu	Pb	Hg	Se	Sn	Zn	tDDT
Mixed rockfish										
n (out of 3)	3	nd	3	3	nd	3	3	2	3	3
Min	1.2	—	0.14	0.12	—	0.113	0.26	0.36	3.1	0.010
Max	**2.0**	—	0.17	0.23	—	0.243	**0.42**	0.44	3.3	0.017
Mean	**1.5**	—	0.15	0.18	—	0.170	**0.329**	0.40	3.2	0.013
Copper rockfish										
n (out of 2)	2	nd	2	2	nd	2	2	nd	2	2
Min	0.7	—	0.18	0.14	—	0.162	**0.46**	—	4.0	0.019
Max	**2.2**	—	0.20	0.19	—	**0.777**	**0.69**	—	4.8	0.063
Mean	**1.4**	—	0.19	0.17	—	0.470	**0.57**	—	4.4	0.041
Greenspotted rockfish										
n (out of 1)	1	nd	1	1	nd	1	1	1	1	1
Min	**1.9**	—	0.19	0.14	—	0.291	0.20	0.24	3.3	0.013
Max	**1.9**	—	0.19	0.14	—	0.291	0.20	0.24	3.3	0.013
Mean	**1.9**	—	0.19	0.14	—	0.291	0.20	0.24	3.3	0.013
ALL SPECIES										
% Dect.	100	0	100	100	0	100	100	50	100	100
US FDA Action Limit*						1				5
Median International Standard*	1.4	1.0	1.0	20.0	2.0	0.5	0.3	175.0	70.0	5.0

*From Table 2.3 in Mearns et al. 1991. USFDA action limit for total DDT is for fish muscle tissue, US FDA mercury action limits and all international standards are for shellfish, but are often applied to fish. All limits apply to the sale of seafood for human consumption.

PCB concentrations were variable and ranged from about 66 to 1800 ppb. No clear relationship was evident between concentrations of PCBs in fish livers and proximity to the outfall (Figure 7.3).

Contaminants in Rig-Caught Fish

Concentrations of contaminants in muscle tissue samples from rig-caught fishes were compared to national and international limits and standards to address human health concerns, both of which apply to the sale of seafood for human consumption (Mearns et al. 1991). In 2004, arsenic, chromium, copper, mercury, selenium, zinc, and DDT were detected in all of the muscle samples that were collected (**Table 7.4**). Of these, arsenic, mercury, and selenium occurred in some samples at concentrations that exceeded their median international standards. In addition, the maximum detected value of mercury in copper rockfish exceeded the United States Food and Drug Administration (FDA) action limit for this metal. All values of total DDT were below the FDA action limit.

Spatial patterns were assessed for total DDT and total PCB, as well as all metals that occurred

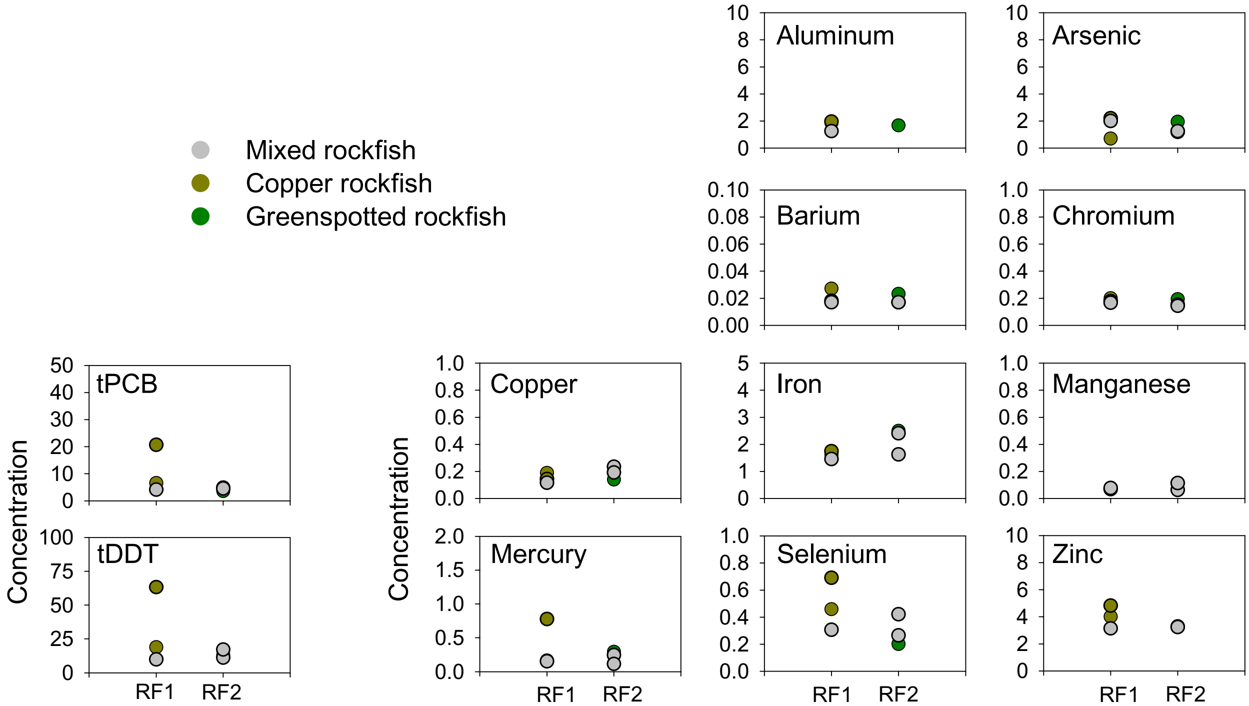

Figure 7.4
Concentrations of frequently detected metals (ppm), total DDT (ppb) and total PCB (ppb) in muscle tissues of fish collected at PLOO rig fishing stations during 2004. RF1 represents the station located closest to the discharge site.

frequently in fish muscle tissues (**Figure 7.4**). A single sample from RF1 had the highest concentration of several parameters (e.g., mercury, selenium, zinc, DDT, PCB) (see Table 7.4). In addition, fish from both sites had concentrations of arsenic and selenium that exceeded the international standards. Although concentrations of all parameters varied, samples from the nearfield station (RF1) had values generally similar to those of the farfield station (RF2).

SUMMARY AND CONCLUSIONS

Demersal fish collected around the Point Loma Ocean Outfall in 2004 were characterized by contaminant loads within the range of those reported previously for other Southern California Bight (SCB) fish assemblages (see Mearns et al. 1991, Allen et al. 1998, 2002). In addition, concentrations of these contaminants were generally similar to those reported previously by the City of San Diego (City of San Diego 1996–2004).

The frequent occurrence of metals and chlorinated hydrocarbons in PLOO fish tissues may be due to many factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals (e.g., aluminum and iron) occur naturally in the environment, although little information is available on their background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998).

Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species. For example, exposure to contaminants can vary greatly between different species and also among individuals of the same species depending on migration habits (Otway 1991). Fish may be exposed to contaminants in one highly contaminated area and then move into an area that is less contaminated. This may explain why many of the pesticides and PCBs detected in fish tissues during 2004 were rarely detected or not detected at all in the sediments immediately surrounding the PLOO (see Chapter 4). In addition, differences in feeding habits, age, reproductive status, and gender can affect the amount of contaminants a fish will retain (e.g., Connell 1987, Evans et al. 1993). These factors make comparisons of contaminants among species and between stations difficult.

Overall, there was no evidence that fishes collected in 2004 were contaminated by the discharge of waste water from the Point Loma Ocean Outfall. With one exception, concentrations of all mercury and DDT in muscle tissues from sport fish collected in the area were below FDA human consumption limits. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot or other physical anomalies (see Chapter 6).

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GLOSSARY

Absorption The movement of a dissolved substance (e.g. pollution) into cells by osmosis or diffusion.

Adsorption The accumulation of a dissolved substance on the sediment or on the surface of an organism (e.g. a flatfish).

Ambicoloration A term specific to flatfish that describes the presence of pigmentation on both the eyed and the blind sides. Normally in flatfish, only the eyed side is pigmented.

Anthropogenic Made and introduced into the environment by humans, especially pertaining to pollutants.

Assemblage An association of interacting populations in a given habitat. For example, an assemblage of benthic invertebrates on the ocean floor.

BACIP(Before-After-Control-Impact-Paired) An analytical tool used to assess environmental changes caused by the effects of pollution. A statistical test is applied to data from matching pairs of control and impacted sites before and after an event (i.e., initiation of wastewater discharge) to test for significant change. Significant differences are generally interpreted as being the result of the environmental change attributed to the event (i.e., initiation of wastewater discharge). Variation that is not significant reflects natural variation.

Benthic Pertaining to the environment inhabited by organisms living on or in the ocean bottom.

Benthos Living organisms (e.g. algae and animals) associated with the sea bottom.

Bioaccumulation The process by which a chemical in animal tissue becomes accumulated over time through direct intake of contaminated water, the consumption of contaminated prey, or absorption through the skin.

BOD (Biochemical Oxygen Demand) The amount of oxygen consumed (through biological or chemical processes) during the decomposition of organic material contained in a water or sediment sample. It is a measure for certain types of organic pollution, such that high BOD levels suggest elevated levels of organic pollution.

Biota The living organisms within a habitat or region.

BRI (Benthic Response Index) An index that measures levels of environmental disturbance by assessing the condition of a benthic assemblage. The index was based on organisms found in the soft sediments of the Southern California Bight.

California Ocean Plan (COP) California's ocean water quality control plan. It limits wastewater discharge and implements ocean monitoring. Federal law requires the plan to be reviewed every three years.

CFU (colony-forming unit) A unit (measurement) of density used to estimate bacteria concentrations in ocean water. The number of bacterial cells that grow to form entire colonies, which can then be quantified visually.

Congeners The EPA defines a congener as, "one of the 209 different PCB compounds. A congener may have between 1 and 10 chlorine atoms, which may be located at various positions on the PCB molecule."

Control site A geographic location that is far enough from a known pollution source (e.g., ocean outfall) to be considered representative of an undisturbed environment. Information collected within control sites is used as a reference and compared to impacted sites.

Crustacea A group (subphylum) of marine invertebrates characterized by jointed legs and an exoskeleton. Crabs, shrimps, and lobsters are examples.

CTD (conductivity, temperature, and depth) A device consisting of a group of sensors that continually measure various physical and chemical properties such as conductivity (a proxy for salinity), temperature, and pressure (a proxy for depth) as it is lowered through the water. These parameters are used to assess the physical ocean environment.

Demersal Organisms living on or near the bottom of the ocean and capable of active swimming. For example, flatfish.

Dendrogram A treelike diagram used to represent hierarchal relationships from a multivariate analysis where results from several monitoring parameters are compared among sites.

Detritus Particles of organic material from decomposing organisms. Used as an important source of nutrients in a food web.

Diversity (Shannon diversity index, H′) A measurement of community structure that describes the abundances of different species within a community, taking into account their relative rarity or commonness.

Dominance (Swartz) A measurement of community structure that describes the minimum number of species accounting for 75% of the abundance in each grab.

Echinodermata A group (phylum) of marine invertebrates characterized by the presence of spines, a radially symmetrical body, and tube feet. For example, sea stars, sea urchins, and sea cucumbers.

Ectoparasite A parasite that lives on the outside of its host, and not within the host's body. Isopods and leeches attached to flatfish are examples.

Effluent Wastewater that flows out of a sewer, treatment plant outfall, or other point source and is discharged into a water body (e.g. ocean, river).

Epibenthic Referring to organisms that live on or near, not within, the sediments. See demersal.

Epifauna Animals living on the surface of sea bottom sediments.

Halocline A vertical zone of water in which the salinity changes rapidly with depth.

Impact site A geographic location that has been altered by the effects of a pollution source, such as a wastewater outfall.

Indicator Species Marine invertebrates whose presence in the community reflects the health of the environment. The loss of pollution-sensitive species or the introduction of pollution-tolerant species can indicate anthropogenic impact.

Infauna Animals living in the soft bottom sediments usually burrowing or building tubes within.

Invertebrate An animal without a backbone. For example, a seastar, crab, or worm.

ITI (Infaunal Trophic Index) An environmental disturbance index based on the feeding structure of marine soft-bottom benthic communities and the rationale that a change in sediment quality will restructure the invertebrate community to one best suited to feed in the altered sediment type. Generally, ITI values less than 60 indicate a pollution impacted benthic community.

Kurtosis A measure that describes the shape (i.e., peakedness or flatness) of distribution relative to a normal distribution (bell shape) curve. Kurtosis can indicate the range of a data set, and is used herein to describe the distribution of particle sizes within sediment samples.

Macrobenthic invertebrate (Macrofauna) Epifaunal or infaunal benthic invertebrates that are visible with the naked eye. Larger than meiofauna and smaller than megafauna, this group typically includes those animals collected in grab samples from soft-bottom marine habitats and retained on a 1 mm mesh screen.

MDL (method detection limit) The EPA defines MDL as "the minimum concentration that can be determined with 99% confidence that the true concentration is greater than zero."

Megabenthic invertebrate (Megafauna) A larger, usually epibenthic and motile, bottom-dwelling animal such as a sea urchin, crab, or snail. Typically collected by otter trawls with a minimum mesh size of 1 cm.

Mollusca A taxonomic group (phylum) of invertebrates characterized as having a muscular foot, visceral mass, and a shell. Examples include snails, clams, and octupuses.

Motile Self-propelled or actively moving.

NPDES (National Pollutant Discharge Elimination System) A federal permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

Niskin Bottle A long plastic tube with caps open at both ends allowing water to pass through until the caps are triggered to close from the surface. They often are arrayed with several others in a rosette sampler to collect water at various depths.

Non-point source Pollution sources from numerous points, not a specific outlet, generally carried into the ocean by storm water runoff.

Ophiuroidea A taxonomic group (class) of echinoderms that comprises the brittle stars. Brittle stars usually have five long, flexible arms and a central disk-shaped body.

PAHs (Polynuclear aromatic hydrocarbons) The USGS defines PAHs as, "hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases. They are also called Polycyclic Aromatic Hydrocarbons."

PCBs (Polychlorinated biphenyls) The EPA defines PCBs as, "a category, or family, of chemical compounds formed by the addition of Chlorine (C_{l2}) to Biphenyl ($C_{12}H_{10}$), which is a dual-ring structure comprising two 6-carbon Benzene rings linked by a single carbon-carbon bond."

Phi (size) The conventional unit of sediment size based on the log of sediment grain diameter. The larger the Phi number, the smaller the grain size.

Plankton Animal and plant-like organisms, usually microscopic, that are passively carried by the ocean currents.

PLOO (Point Loma Ocean Outfall) The PLOO is the underwater pipe originating at the Point Loma Wastewater Treatment Plant and used to discharge treated wastewater. It extends 7.2 km (4.5 miles) offshore and discharges into about 96 m (320 ft) of water.

Point source Pollution discharged from a single source (e.g. municipal wastewater treatment plant, storm drain) to a specific location through a pipe or outfall.

Polychaeta A taxonomic group (class) of invertebrates characterized as having worm-like features, segments, and bristles or tiny hairs. Examples include bristle worms.

Pycnocline A depth zone in the ocean where density increases (associated with a decline in temperature and increase in salinity) rapidly with depth.

Recruitment In an ocean environment, the retention of young individuals into the adult population.

Red relict sand Coarse reddish-brown sand that is a remnant of a pre-existing formation after other parts have disappeared. Typically originating from land and transported to the ocean bottom through erosional processes.

Rosette sampler A device consisting of a round metal frame housing a CTD in the center and multiple bottles (see Niskin bottle) arrayed about the perimeter. As the instrument is lowered through the water column, continuous measurements of various physical and chemical parameters are recorded by the CTD, and discrete water samples can be captured at desired depths by the bottles.

Shell hash Sediment composed of shell fragments with the size and consistency of very coarse sand.

Skewness A measure of the lack of symmetry in a distribution or data set. Skewness can indicate where within a distribution most of the data lies. It is used herein to describe the distribution of particle sizes within sediment grain size samples.

Sorting The range of grain sizes comprising marine sediments, and may also refer to the process by which sediments of similar size are naturally segregated during transport and deposition according to the velocity and transporting medium. Well-sorted sediments are of similar size (such as desert sand), while poorly-sorted sediments have a wide range of grain sizes (as in a glacial till).

SBOO (South Bay Ocean Outfall) The SBOO is the underwater pipe originating at the International Wastewater Treatment Plant and used to discharge treated wastewater. It extends 5.6 km (4.5 miles) offshore and discharges into about 27 m (90 ft) of water.

South Bay Water Reclamation Plant Provides local wastewater treatment services and reclaimed water to the South Bay. The plant began operation in 2002 and has a wastewater treatment capacity of 15 million gallons a day.

SCB (Southern California Bight) The geographic region that stretches from Point Conception, U.S.A. to the Cabo Colnett, Mexico, and encompasses nearly 80,000 km^2 of coastal land and sea.

Species Richness The number of species per unit area. A metric used to evaluate the health of macrobenthic communities.

Standard length The measurement of a fish from the most forward tip of the body to the base of the tail but excluding the tail fin rays. Fin rays can sometimes be eroded by pollution or preservation so a measurement that includes them (i.e., total length) is considered less reliable.

Terrigenous Referring to suspended oceanic sediments derived from land-based material.

Thermocline The zone in a thermally stratified body of water that separates warmer surface water from colder deep water. At a thermocline, temperature decreases rapidly over a short depth.

Tissue burden Refers to the total amount of measured chemicals that are present in the tissue (e.g. fish muscle) at a given point in time.

Transmissivity A measure of water clarity based upon the ability of water to transmit light along a straight path. Light that is scattered or absorbed by particulates (e.g., plankton, suspended solid materials) decreases the transmissivity (or clarity) of the water.

Upwelling The movement of nutrient-rich, and typically cold, water from the depths of the ocean to the surface waters.

USGS (United States Geological Survey) The USGS provides geologic, topographic, and hydrologic information on water, biological, energy, and mineral resources.

Van Dorn bottle A water-sampling device made of a plastic tube open at both ends that allows water to flow through. Rubber caps at the tube ends can be triggered to close underwater to collect water at a specified depth.

Van Veen Grab A mechanical device designed to collect bottom sediment samples. The device consists of a pair of hinged jaws and a release mechanism that allows the opened jaws to close and entrap a 0.1 m^2 sediment sample once they touch bottom.

Wastewater A mixture of water and waste materials originating from homes, businesses, and industries.

ZID (zone of initial dilution) The region of initial mixing of the surrounding receiving waters with wastewater from the diffuser ports of the outfall. This area includes the underlying seabed. In the ZID, the environment is chronically exposed to pollutants and often is the most impacted.

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Appendix A

Supporting Data

2004 PLOO Stations

Microbiology

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Appendix A.1

Bacteriological samples where total coliform densities were ≥ 1000 CFU/100 mL and fecal to total coliform ratio (F:T) ≥ 0.1 (see text) for the PLOO quarterly stations sampled in 2004. Depth in meters. N=north of the 2 km radius surrounding the PLOO wye (see O); O=stations within 2 km of the PLOO wye or along the PLOO (i.e., F08); S=south of the 2 km radius surrounding the PLOO wye. Values for stations within 2 km radius of PLOO wye are bolded.

Month	Station	Transect Position	Sample Depth (m)	Total	Fecal	Entero	F:T ratio
January	F08	**60-m – O**	**60**	**1400**	**320**	**32**	**0.23**
	F21	80-m – N	80	1200	400	74	0.33
	F22	80-m – N	80	2400	480	180	0.20
	F23	80-m – N	80	1500	380	54	0.25
	F24	80-m – N	80	2200	460	86	0.21
	F19	**80-m – O**	**80**	**9000**	**2000**	**280**	**0.22**
	F19	**80-m – O**	**60**	**1800**	**220**	**6**	**0.12**
	F18	80-m – S	60	1800	660	130	0.37
	F32	98-m – N	80	7800	1100	260	0.14
	F33	98-m – N	80	8000	2200	360	0.28
	F33	98-m – N	98	1200	340	72	0.28
	F30	**98-m – O**	**80**	**16000**	**12000**	**2400**	**0.75**
	F30	**98-m – O**	**98**	**1400**	**400**	**140**	**0.29**
	F31	**98-m – O**	**80**	**16000**	**4600**	**580**	**0.29**
April	F08	**60-m – O**	**60**	**16000**	**3000**	**54**	**0.19**
	F21	80-m – N	60	3200	960	180	0.30
	F21	80-m – N	80	1600	280	110	0.18
	F23	80-m – N	60	5800	130	380	0.02
	F23	80-m – N	80	1100	300	140	0.27
	F19	**80-m – O**	**80**	**1200**	**160**	**50**	**0.13**
	F19	**80-m – O**	**60**	**1100**	**340**	**120**	**0.31**
	F17	80-m – S	80	13000	2400	400	0.18
	F18	80-m – S	80	16000	5400	260	0.34
	F32	98-m – N	80	6400	2000	300	0.31
	F32	98-m – N	60	3600	720	300	0.20
	F32	98-m – N	98	1300	400	90	0.31
	F34	98-m – N	60	3600	1100	380	0.31
	F34	98-m – N	80	1600	540	80	0.34
	F35	98-m – N	60	1000	420	110	0.42
	F29	**98-m – O**	**98**	**22000**	**9000**	**340**	**0.41**
	F29	**98-m – O**	**60**	**4400**	**620**	**120**	**0.14**
	F29	**98-m – O**	**80**	**3200**	**480**	**100**	**0.15**
	F30	**98-m – O**	**80**	**16000**	**12000**	**520**	**0.75**
	F30	**98-m – O**	**98**	**16000**	**7000**	**480**	**0.44**
	F30	**98-m – O**	**60**	**1100**	**240**	**98**	**0.22**
	F31	**98-m – O**	**60**	**1800**	**580**	**130**	**0.32**
	F31	**98-m – O**	**98**	**1400**	**380**	**90**	**0.27**
	F31	**98-m – O**	**80**	**1300**	**400**	**160**	**0.31**
	F27	98-m – S	80	22000	3400	180	0.15
	F28	98-m – S	80	4600	840	130	0.18
July	F24	80-m – N	80	1100	380	40	0.35
	F32	98-m – N	80	16000	12000	1600	0.75
	F32	98-m – N	60	12000	1800	64	0.15
	F32	98-m – N	98	1600	500	4	0.31
	F33	98-m – N	80	16000	6000	460	0.38
	F33	98-m – N	60	2800	460	12	0.16
	F33	98-m – N	98	2600	520	26	0.20
	F34	98-m – N	80	2400	800	160	0.33
	F35	98-m – N	80	2400	840	110	0.35
	F35	98-m – N	98	1200	560	40	0.47
	F36	98-m – N	98	1300	280	56	0.22
	F36	98-m – N	80	1100	300	46	0.27

Appendix A.1 *continued*.

Bacteriological samples where total coliform densities were ≥ 1000 CFU/100 mL and fecal to total coliform ratio (F:T) ≥ 0.1 (see text) for the PLOO quarterly stations sampled in 2004. Depth in meters. N=north of the 2 km radius surrounding the PLOO wye (see O); O=stations within 2 km of the PLOO wye or along the PLOO (i.e., F08); S=south of the 2 km radius surrounding the PLOO wye. Values for stations within 2 km radius of PLOO wye are bolded.

Month	Station	Transect Position	Sample Depth (m)	Total	Fecal	Entero	F:T ratio
October	F20	80-m – N	80	2600	500	38	0.19
	F24	80-m – N	80	1500	440	74	0.29
	F19	**80-m – O**	**80**	**9400**	**1400**	**140**	**0.15**
	F18	80-m – S	80	1100	300	14	0.27
	F32	98-m – N	98	1100	110	62	0.10
	F33	98-m – N	80	1300	380	94	0.29
	F35	98-m – N	98	1600	240	56	0.15
	F29	**98-m – O**	**98**	**3800**	**820**	**36**	**0.22**
	F31	**98-m – O**	**80**	**6400**	**1400**	**120**	**0.22**
	F31	**98-m – O**	**98**	**1700**	**500**	**72**	**0.29**

Appendix B

Supporting Data

2004 PLOO Stations

Sediment Characteristics

Appendix B.1

Sediment chemistry constituents analyzed for Point Loma Ocean Outfall sampling during 2004.

Cholorinated Pesticides

Aldrin	BHC, Delta isomer	Endrin Aldehyde	Mirex	p,p-DDE
Alpha (cis) Chlordane	BHC, Gamma isomer	Gamma (trans) Chlordane	o,p-DDD	p,p-DDT
Alpha Endosulfan	Cis_Nonachlor	Heptachlor	o,p-DDE	Trans Nonachlor
Beta Enddosulfan	Dieldrin	Heptachlor epoxide	o,p-DDT	
BHC, Alpha isomer	Endosulfan sulfate	Hexachlorobenzene	Oxychlordane	
BHC, Beta isomer	Endrin	Methoxychlor	p,p-DDD	

Polycylic Aromatic Hydrocarbons

1-methylnaphthalene	Acenaphthene	Benzo[G,H,I]perylene	Fluorene
1-methylphenanthrene	Acenaphthylene	Benzo[K]fluoranthene	Indeno(1,2,3-CD)pyrene
2,3,5-trimethylnaphthalene	Anthracene	Biphenyl	Naphthalene
2,6-dimethylnaphthalene	Benzo[A]anthracene	Chrysene	Perylene
2-methylnaphthalene	Benzo[A]pyrene	Dibenzo(A,H)anthracene	Phenanthrene
3,4-benzo(B)fluoranthene	Benzo[e]pyrene	Fluoranthene	Pyrene

Metals

Aluminum (Al)	Cadmium (Cd)	Manganese (Mn)	Silver (Ag)
Antimony (Sb)	Chromium (Cr)	Mercury (Hg)	Thallium (Tl)
Arsenic (As)	Copper (Cu)	Nickel (Ni)	Tin (Sn)
Barium (Ba)	Iron (Fe)	Selenium (Se)	Zinc (Zn)
Beryllium (Be)	Lead (Pb)		

PCB Congeners

PCB 18	PCB 81	PCB 126	PCB 169
PCB 28	PCB 87	PCB 128	PCB 170
PCB 37	PCB 99	PCB 138	PCB 177
PCB 44	PCB 101	PCB 149	PCB 180
PCB 49	PCB 105	PCB 151	PCB 183
PCB 52	PCB 110	PCB 153/168	PCB 187
PCB 66	PCB 114	PCB 156	PCB 189
PCB 70	PCB 118	PCB 157	PCB 194
PCB 74	PCB 119	PCB 158	PCB 201
PCB 77	PCB 123	PCB 167	PCB 206

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Appendix B.2

Particle size statistics for PLOO sediments, January 2004 survey. Primary core stations indicated in bold.

Stations	Depth (m)	Mean Phi	Mean mm	SD Phi	Median Phi	Skewness Phi	Kurtosis Phi	Coarse %	Sand %	Silt %	Clay %	Sediment Observations
North reference stations												
B-11	88	4.2	0.056	1.9	3.9	0.2	0.8	3.7	49.5	44.6	2.2	silt, sand, coarse sand, shell hash
B-8	88	4.6	0.041	1.5	4.3	0.3	1.0	0.1	42.1	54.4	3.4	clay, silt
B-12	98	3.6	0.082	1.9	3.0	0.4	1.0	4.5	64.2	29.7	1.6	silt, sand, coarse sand, shell hash,
B-9	98	4.2	0.053	1.6	3.8	0.4	1.0	0.3	57.3	39.6	2.8	silt, mud balls
B-10	116	4.0	0.062	1.8	3.4	0.5	1.3	0.5	68.2	25.7	2.4	silt, shell hash
Stations north of the outfall												
E-19	88	4.3	0.051	1.5	3.9	0.4	1.2	0.2	52.7	44.2	2.9	silt
E-20	98	4.0	0.061	1.4	3.7	0.4	1.2	0.2	62.3	35.1	2.4	silt
E-23	98	4.2	0.053	1.6	3.8	0.4	1.0	0.2	57.2	39.9	2.8	silt
E-25	98	4.0	0.061	1.5	3.7	0.4	1.2	1.5	60.1	35.9	2.5	silt, shell hash
E-26	98	4.3	0.052	1.6	3.8	0.4	1.1	0.2	56.8	40.0	3.0	silt
E-21	116	3.8	0.072	1.3	3.5	0.4	1.4	0.1	70.4	27.3	2.2	silt
Outfall stations												
E-11	98	3.7	0.076	1.3	3.5	0.4	1.3	0.5	70.3	27.4	1.8	clay, silt, coarse black sand, shell hash
E-14	98	3.8	0.074	1.4	3.5	0.4	1.4	2.7	68.1	27.2	2.0	clay, silt, sand, coarse black sand, shell hash
E-17	98	3.8	0.070	1.4	3.6	0.4	1.3	0.3	67.6	29.9	2.2	silt,
E-15	116	4.0	0.064	1.6	3.5	0.5	1.2	0.8	67.2	29.1	2.9	silt, coarse black sand, shell hash
Stations south of the outfall												
E-1	88	4.0	0.062	1.6	3.6	0.4	1.0	0.4	61.7	34.7	2.6	silt, coarse sand, shell hash
E-7	88	4.6	0.042	2.4	4.0	0.5	1.5	0.0	49.3	39.6	6.1	clay, silt
E-2	98	4.2	0.056	1.9	3.9	0.2	0.8	4.5	48.3	47.1	0.1	silt, sand, coarse sand, shell hash
E-5	98	3.9	0.065	1.5	3.6	0.4	1.1	0.4	64.6	32.5	2.4	silt,
E-8	98	3.9	0.068	1.4	3.5	0.4	1.2	0.3	67.4	30.1	2.3	clay,silt, coarse black sand, shell hash,
E-3	116	3.4	0.097	2.9	2.8	0.3	1.2	16.0	52.1	24.9	2.5	silt, coarse sand, gravel, shell hash
E-9	116	3.1	0.120	4.0	3.4	0.1	0.8	26.9	36.2	24.3	7.6	silt, sand, coarse black sand, shell hash

Appendix B.2 *continued.*

Particle size statistics for PLOO sediments, July 2004 survey.

Stations	Depth	Mean	Mean	SD	Median	Skewness	Kurtosis	Coarse	Sand	Silt	Clay	Sediment Observations
	(m)	Phi	mm	Phi	Phi	Phi	Phi	%	%	%	%	
North reference stations												
B-12	98	2.6	0.169	3.1	2.8	0.0	1.4	17.2	54.9	23.4	1.8	silt, sand, shell hash
B-9	98	4.1	0.057	1.7	3.7	0.4	1.1	1.9	57.8	37.5	2.8	clay, silt, mud balls, pea gravel
Stations north of the outfall												
E-20	98	3.9	0.066	1.4	3.6	0.4	1.2	0.2	65.8	31.8	2.2	silty and sandy mud, shell hash
E-23	98	4.1	0.058	1.4	3.7	0.4	1.1	0.2	60.9	36.6	2.3	muddy clay, shell hash
E-25	98	4.1	0.057	1.4	3.7	0.5	1.1	0.0	60.1	37.6	2.3	mud, shell hash
E-26	98	4.3	0.052	1.6	3.8	0.4	1.1	0.2	56.2	40.3	3.1	muddy clay, shell hash
Outfall stations												
E-11	98	3.8	0.072	1.3	3.5	0.4	1.3	0.0	69.1	28.9	1.8	silt, fine sand, mud, shell hash
E-14	98	3.9	0.067	1.4	3.5	0.4	1.2	0.3	68.4	29.4	1.9	sand, coarse black sand, mud,shell hash
E-17	98	3.8	0.073	1.4	3.5	0.4	1.3	1.1	68.9	28.4	1.6	muddy silt,shell hash
Stations south of the outfall												
E-2	98	4.2	0.056	1.8	3.7	0.4	0.9	0.5	56.7	39.6	3.2	silt,sand, coarse sand shell hash
E-5	98	3.9	0.066	1.5	3.5	0.4	1.2	0.3	66.1	31.4	2.3	silt, coarse sand, shell hash
E-8	98	3.8	0.073	1.3	3.5	0.4	1.3	0.3	68.8	28.9	1.8	silt, coarse sand, shell hash

Appendix B.3

Summary of annual mean concentrations of PAHs (ppb) for PLOO monitoring stations during 2004. MDL=method detection limit. ERL=Effects Range Long. Undetected values are indicated by "nd." Primary core stations are indicated in bold type.

Station	1-Methylnaphthalene	2,6-Dimethylnaphthalene	2-methylnaphthalene
B-8	nd	nd	27.5
B-9	35.2	41.4	63.9
B-10	nd	nd	21.9
B-11	16.8	nd	36.5
B-12	10.1	18.2	33.8
E-1	nd	nd	17.9
E-2	6.6	21.0	31.5
E-3	nd	nd	17.4
E-5	9.5	23.7	36.5
E-7	nd	nd	23.0
E-8	8.3	19.8	33.0
E-9	nd	nd	14.1
E-11	7.4	20.2	31.3
E-14	7.6	26.7	32.2
E-15	12.0	nd	22.5
E-17	25.1	38.0	53.1
E-19	12.5	19.9	21.6
E-20	11.9	30.6	40.3
E-21	16.9	20.8	26.5
E-23	11.9	28.3	50.8
E-25	11.8	29.4	47.9
E-26	10.6	29.5	45.7
MDL	12	32	12

Appendix B.3 *continued.*

Summary of annual mean concentrations of PAHs (ppb) for PLOO monitoring stations during 2004. MDL=method detection limit. ER =Effects Range Long. Undetected values are indicated by “nd.” Primary core stations are indicated in bold type.

Station	3,4-Benzo(B)Fluoranthene	Acenaphthene	Acenaphthylene	Anthracene
B-8	nd	nd	nd	nd
B-9	nd	nd	9.5	13.9
B-10	nd	nd	nd	nd
B-11	nd	nd	nd	nd
B-12	nd	nd	nd	nd
E-1	nd	nd	nd	nd
E-2	11.9	nd	nd	nd
E-3	nd	nd	nd	nd
E-5	nd	nd	nd	nd
E-7	nd	nd	nd	nd
E-8	nd	nd	nd	nd
E-9	305.0	nd	nd	40.0
E-11	nd	nd	nd	nd
E-14	nd	nd	nd	nd
E-15	nd	nd	nd	nd
E-17	nd	nd	3.9	nd
E-19	nd	nd	nd	nd
E-20	nd	nd	nd	nd
E-21	nd	nd	nd	nd
E-23	123.5	12.8	6.4	30.4
E-25	nd	nd	nd	nd
E-26	nd	nd	nd	nd
MDL	63	28	15	18

Appendix B.3 *continued.*

Summary of annual mean concentrations of PAHs (ppb) for PLOO monitoring stations during 2004. MDL=method detection limit. ERL=Effects Range Long. Undetected values are indicated by "nd." Primary core stations are indicated in bold type.

Station	Benzo[A]Anthracene	Benzo[A]Pyrene	Benzo[G,H,I]Perylene	Benzo[K]Fluoranthene
B-8	nd	nd	nd	nd
B-9	20.7	nd	nd	nd
B-10	nd	nd	nd	nd
B-11	nd	nd	nd	nd
B-12	nd	nd	nd	nd
E-1	32.0	nd	nd	nd
E-2	17.4	27.5	nd	5.3
E-3	33.6	nd	nd	nd
E-5	nd	nd	nd	nd
E-7	nd	nd	nd	nd
E-8	nd	nd	nd	nd
E-9	138.0	226.0	87.8	134.0
E-11	nd	nd	nd	nd
E-14	nd	nd	nd	nd
E-15	30.4	nd	nd	nd
E-17	15.8	nd	nd	nd
E-19	28.1	nd	nd	nd
E-20	12.4	nd	nd	nd
E-21	32.2	nd	nd	nd
E-23	116.0	88.0	58.5	49.0
E-25	nd	nd	nd	nd
E-26	nd	nd	nd	nd
MDL	32	55	56	82

Appendix B.3 *continued.*

Summary of annual mean concentrations of PAHs (ppb) for PLOO monitoring stations during 2004. MDL=method detection limit. ERL=Effects Range Long. Undetected values are indicated by "nd." Primary core stations are indicated in bold type.

Station	Benzo[e]Pyrene	Biphenyl	Chrysene	Fluoranthene	Fluorene
B-8	nd	24.1	nd	nd	nd
B-9	nd	36.5	nd	20.4	13.0
B-10	nd	20.9	nd	nd	nd
B-11	nd	29.7	nd	nd	nd
B-12	nd	20.3	nd	4.1	nd
E-1	nd	25.6	nd	nd	nd
E-2	28.5	21.2	nd	6.2	nd
E-3	nd	22.0	nd	nd	nd
E-5	nd	21.3	nd	5.7	nd
E-7	nd	24.3	nd	nd	nd
E-8	nd	21.4	nd	5.1	nd
E-9	158.0	20.2	262.0	nd	nd
E-11	nd	19.2	nd	3.5	nd
E-14	nd	11.5	nd	6.3	nd
E-15	nd	20.2	11.0	14.4	nd
E-17	nd	23.6	8.4	8.8	3.3
E-19	nd	22.3	9.9	10.7	nd
E-20	nd	18.1	3.1	4.8	1.5
E-21	nd	20.1	nd	13.0	8.1
E-23	66.0	23.1	127.5	268.0	nd
E-25	nd	24.5	nd	nd	nd
E-26	nd	24.3	nd	6.4	nd
MDL	57	10	36	24	13

Appendix B.3 *continued.*

Summary of annual mean concentrations of PAHs (ppb) for PLOO monitoring stations during 2004. MDL=method detection limit. ERL=Effects Range Long. Undetected values are indicated by "nd." Primary core stations are indicated in bold type.

Station	Indeno(1,2,3-CD)Pyrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total PAH
B-8	nd	27.3	nd	nd	nd	78.9
B-9	nd	79.4	nd	20.7	29.1	383.5
B-10	nd	21.7	nd	nd	nd	64.5
B-11	nd	108.0	nd	nd	nd	191.0
B-12	nd	35.1	nd	nd	nd	121.5
E-1	nd	21.0	nd	nd	nd	96.5
E-2	nd	13.1	nd	nd	11.4	201.4
E-3	nd	nd	nd	nd	nd	73.0
E-5	nd	14.2	nd	nd	5.8	116.5
E-7	nd	nd	nd	nd	nd	47.3
E-8	nd	20.8	nd	nd	6.8	115.0
E-9	91.8	nd	68.4	nd	nd	1545.3
E-11	nd	26.0	nd	nd	6.3	113.8
E-14	nd	15.3	nd	nd	9.4	108.9
E-15	nd	26.1	nd	nd	16.1	152.7
E-17	nd	45.1	nd	6.4	8.8	239.9
E-19	nd	26.6	nd	8.4	10.7	170.7
E-20	nd	28.2	nd	nd	11.3	161.9
E-21	nd	40.1	nd	8.9	nd	186.6
E-23	54.5	31.8	29.6	165.0	242.0	1582.9
E-25	nd	33.4	nd	nd	9.7	156.6
E-26	nd	37.5	nd	nd	17.5	171.4
MDL	76	21	23	21	35	

Appendix C

Supporting Data

2004 PLOO Stations

Demersal Fishes and Megabenthic Invertebrates

Appendix C.1

Summary of demersal fish species captured during 2004 at PLOO stations. Data are number of fish collected (n) and minimum, maximum and mean length (cm SL). Taxonomic arrangement and scientific names are of Eschmeyer (1998), in accordance with a recent update posted to the California Academy of Sciences website.*

			Length		
Taxon/Species	**Common Name**	**n**	**Min**	**Max**	**Mean**
RAJIFORMES					
Rajidae					
Raja inornata	California skate	4	17	23	19
OSMERIFORMES					
Argentinidae					
Argentina sialis	Pacific argentine	31	8	9	9
AULOPIFORMES					
Synodontidae					
Synodus lucioceps	California lizardfish	7	12	24	16
OPHIDIIFORMES					
Ophidiidae					
Chilara taylori	spotted cuskeel	6	14	23	17
BATRACHOIDIFORMES					
Batrachoididae					
Porichthys notatus	plainfin midshipman	63	6	16	10
SCORPAENIFORMES					
Scorpaenidae	(juv. rockfish unid.)	14	3	11	6
Scorpaena guttata	California scorpionfish	57	13	26	19
Sebastes chlorostictus	greenspotted rockfish	6	5	19	10
Sebastes dallii	calico rockfish	1	7	7	7
Sebastes elongatus	greenstriped rockfish	28	3	10	6
Sebastes goodei	chilipepper rockfish	4	10	15	12
Sebastes levis	cowcod	1	9	9	9
Sebastes rosenblatti	greenblotched rockfish	2	10	10	10
Sebastes rubrivinctus	flag rockfish	1	12	12	12
Sebastes saxicola	stripetail rockfish	285	5	13	8
Sebastes semicinctus	halfbanded rockfish	153	6	12	9
Hexagrammidae					
Zaniolepis frenata	shortspine combfish	70	7	17	12
Zaniolepis latipinnis	longspine combfish	379	6	16	9
Cottidae	(juv. sculpin unid.)				
Chitonotus pugetensis	roughback sculpin	1	8	8	8
Icelinus quadriseriatus	yellowchin sculpin	286	4	8	6
Icelinus tenuis	spotfin sculpin	15	6	10	8
Agonidae					
Odontopyxis trispinosa	pygmy poacher	2	7	7	7
Xeneretmus latifrons	blacktip poacher	11	12	14	13
Xeneretmus triacanthus	bluespotted poacher	6	9	16	12
PERCIFORMES					
Carangidae					
Trachurus symmetricus	Pacific jack mackerel	1	17	17	17
Embiotocidae					
Zalembius rosaceus	pink seaperch	13	6	12	9
Bathymasteridae					
Rathbunella hypoplecta	stripedfin ronquil	1	13	13	13
Zoarcidae					
Lycodopsis pacifica	blackbelly eelpout	18	15	22	18
Gobiidae		1	3	3	3
Lepidogobius lepidus	bay goby	7	6	8	7
PLEURONECTIFORMES	(juv. flatfish unid.)	1	3	3	3
Paralichthyidae					
Chitharichthy sp		1	4	4	4
Citharichthys sordidus	Pacific sanddab	2743	3	21	9
Citharichthys xanthostigma	longfin sanddab	22	13	17	14
Hippoglossina stomata	bigmouth sole	5	16	22	19
Pleuronectidae					
Eopsetta exilis	slender sole	56	8	17	13
Microstomus pacificus	Dover sole	450	5	22	12
Pleuronectes vetulus	English sole	51	12	21	15
Pleuronichthys verticalis	hornyhead turbot	2	10	16	13
Cynoglossidae					
Symphurus atricauda	California tonguefish	47	7	16	13

*Eschmeyer, William N. and Earl S. Herald. 1998. A field guide to Pacific coast fishes of North America. Houghton and Mifflin Company, New York 336p. California Academy of Sciences website: http://www.calacademy.org/research/ichthyology/species/. May 2003.

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Appendix C.2

Demersal fish abundance for each PLOO station during January and July 2004.

January 2004 **NAME**	**SD7**	**SD8**	**SD10**	**SD12**	**SD13**	**SD14**	**Species Abundance by Survey**
Pacific sanddab	164	110	216	293	330	393	1506
Longspine combfish	5	2	73	83	56	64	283
Dover sole	2	2	9	48	111	59	231
Yellowchin sculpin	120	2	53	1	35	18	229
Stripetail rockfish	3	5	15	84	59	60	226
Halfbanded rockfish		15	1	56	1	2	75
California scorpionfish	2		16	4	30	5	57
Plainfin midshipman	1	1	3	4	21	15	45
Shortspine combfish	9	6	2	14	1	3	35
California tonguefish	8	1		13	2	9	33
English sole	1	5	8	9	5	3	31
Pacific argentine		3		8	19	1	31
Longfin sanddab	8	2	1		2	4	17
Pink seaperch	1		4		3	1	9
California lizardfish			3		2	2	7
Greenspotted rockfish		2		2		2	6
Rockfish unid.			1		4	1	6
Greenstriped rockfish		1		1	2	1	5
Bigmouth sole		1	1	1			3
Chilipepper rockfish					3		3
Spotfin sculpin		3					3
Bay goby	1					1	2
California skate	1				1		2
Blackbelly eelpout						1	1
Bluespotted poacher						1	1
Cowcod						1	1
Flag rockfish		1					1
Jack mackerel					1		1
Roughback sculpin	1						1
Slender sole						1	1
TOTAL	327	162	406	621	688	648	2852

Appendix C.2 *continued.*

Demersal fish abundance for each PLOO station during January and July 2004.

July 2004 **NAME**	**SD7**	**SD8**	**SD10**	**SD12**	**SD13**	**SD14**	**Species Abundance by Survey**
Pacific sanddab	147	152	203	101	286	348	1237
Dover sole	15	28	23	33	87	33	219
Longspine combfish	1	1	3	51	37	3	96
Halfbanded rockfish	3	7	1	45	19	3	78
Stripetail rockfish			4	19	14	22	59
Yellowchin sculpin	42		5		8	2	57
Slender sole		6	2	34	12	1	55
Shortspine combfish	4	12		15	2	2	35
Greenstriped rockfish	1	4		16	2		23
English sole		6	2	1	9	2	20
Plainfin midshipman	4			1	10	3	18
Blackbelly eelpout				4	9	4	17
California tonguefish	3	7	4				14
Spotfin sculpin		12					12
Blacktip poacher				8		3	11
Rockfish unid.	1			5	1	1	8
Spotted cuskeel	1		3	2			6
Bay goby	1				1	3	5
Bluespotted poacher		1		2		2	5
Longfin sanddab		4	1				5
Pink seaperch		1		1	1	1	4
Bigmouth sole		1			1		2
California skate			1			1	2
Greenblotched rockfish			2				2
Horneyhead turbot	1	1					2
Pygmy poacher		2					2
Calico rockfish		1					1
Chilipepper rockfish				1			1
Citharichthys sp			1				1
Flatfish unid.		1					1
Gobiidae unid.		1					1
Stripedfin ronquil		1					1
TOTAL	224	249	255	339	499	434	2000

Appendix C.3

Demersal fish biomass for each PLOO station during January and July 2004.

January 2004							Biomass
NAME	**SD7**	**SD8**	**SD10**	**SD12**	**SD13**	**SD14**	**by Survey**
Pacific sanddab	1.6	1.5	1.9	5.1	4	6	20.1
California scorpionfish	0.3		5.4	1.6	7.2	1.7	16.2
Dover sole	0.1	0.1	0.3	0.7	1.5	0.8	3.5
Stripetail rockfish	0.1	0.1	0.1	0.6	0.5	0.7	2.1
Longspine combfish	0.1	0.1	0.5	0.6	0.4	0.4	2.1
English sole	0.1	0.4	0.7	0.4	0.1	0.2	1.9
Halfbanded rockfish		0.1	0.1	1.0	0.1	0.1	1.4
Yellowchin sculpin	0.5	0.1	0.3	0.1	0.1	0.1	1.2
Plainfin midshipman	0.1	0.1	0.1	0.1	0.2	0.3	0.9
Shortspine combfish	0.2	0.2	0.1	0.2	0.1	0.1	0.9
Longfin sanddab	0.4	0.1	0.1		0.1	0.1	0.8
California tonguefish	0.1	0.1		0.3	0.1	0.1	0.7
Greenspotted rockfish		0.3				0.1	0.4
California lizardfish			0.2		0.1	0.1	0.4
Greenstriped rockfish		0.1		0.1	0.1	0.1	0.4
Pacific argentine		0.1		0.1	0.1	0.1	0.4
Pink seaperch	0.1		0.1		0.1	0.1	0.4
Rockfish unid.			0.1	0.1	0.1	0.1	0.4
Bigmouth sole		0.1	0.1	0.1			0.3
Bay goby	0.1					0.1	0.2
California skate	0.1				0.1		0.2
Blackbelly eelpout						0.1	0.1
Bluespotted poacher						0.1	0.1
Chilipepper rockfish					0.1		0.1
Cowcod						0.1	0.1
Flag rockfish		0.1					0.1
Jack mackerel					0.1		0.1
Roughback sculpin	0.1						0.1
Slender sole						0.1	0.1
Spotfin sculpin		0.1					0.1
TOTAL	4	3.7	10.1	11.1	15.2	11.7	55.8

Appendix C.3 *continued.*

Demersal fish biomass for each PLOO station during January and July 2004.

July 2004 NAME	SD7	SD8	SD10	SD12	SD13	SD14	Biomass by Survey
Pacific sanddab	2.1	0.8	1.9	0.9	4.4	3.6	13.7
Dover sole	0.5	0.5	0.1	0.6	1.6	0.6	3.9
Slender sole		0.1	0.1	0.8	0.3	0.1	1.4
Halfbanded rockfish	0.1	0.1	0.1	0.6	0.3	0.1	1.3
English sole		0.5	0.1	0.1	0.4	0.1	1.2
Longspine combfish	0.1	0.1	0.1	0.3	0.3	0.1	1.0
Stripetail rockfish			0.1	0.3	0.2	0.4	1.0
Shortspine combfish	0.1	0.2		0.1	0.1	0.1	0.6
California tonguefish	0.1	0.2	0.1				0.4
Greenstriped rockfish	0.1	0.1		0.1	0.1		0.4
Pink seaperch		0.1		0.1	0.1	0.1	0.4
Plainfin midshipman	0.1			0.1	0.1	0.1	0.4
Rockfish unid.	0.1			0.1	0.1	0.1	0.4
Yellowchin sculpin	0.1		0.1		0.1	0.1	0.4
Bay goby	0.1				0.1	0.1	0.3
Blackberry eelpout				0.1	0.1	0.1	0.3
Bluespotted poacher		0.1		0.1		0.1	0.3
Spotted cuskeel	0.1		0.1	0.1			0.3
Bigmouth sole		0.1			0.1		0.2
Blacktip poacher				0.1		0.1	0.2
California skate			0.1			0.1	0.2
Horneyhead turbot	0.1	0.1					0.2
Longfin sanddab		0.1	0.1				0.2
Calico rockfish		0.1					0.1
Chilipepper rockfish				0.1			0.1
Citharichthys sp			0.1				0.1
Flatfish unid.		0.1					0.1
Gobiidae unid.		0.1					0.1
Greenblotched rockfish			0.1				0.1
Pygmy poacher		0.1					0.1
Spotfin sculpin		0.1					0.1
Stripedfin ronquil		0.1					0.1
TOTAL	3.7	3.7	3.2	4.6	8.4	6.0	29.6

Appendix C.4

Summary of megabenthic invertebrate taxa captured during 2004 at PLOO stations. Data are number of individuals collected (n).

Taxon/ Species	n
CNIDARIA	
ANTHOZOA	
Stolonifera	
Telestidae	
Telesto californica	1
Alcyonacea	
Muriceidae	
Thesea sp B	7
Pennatulacea	
Virgulariidae	
Acanthoptilum sp	604
Virgularia agassizi	1
Actiniaria	
Metridiidae	
Metridium farcimen	2
MOLLUSCA	
GASTROPODA	
Neotaeniglossa	
Ovulidae	
Neosimnia barbarensis	1
Neogastropoda	
Nassariidae	
Nassarius insculptus	1
Fasciolariidae	
Fusinus barbarensis	1
Cancellariidae	
Cancellaria crawfordiana	1
Turridae	
Megasurcula carpenteriana	7
Cephalaspidea	
Philinidae	
Philine auriformis	9
Notaspidea	
Pleurobranchidae	
Pleurobranchaea californica	7
Nudibranchia	
Tritoniidae	
Tritonia diomedea	3
Arminidae	
Armina californica	1

Appendix C.4 *continued*

Taxon/ Species	n
CEPHALOPODA	
Sepiolida	
Sepiolidae	
Rossia pacifica	4
Teuthida	
Loliginidae	
Loligo opalescens	2
Octopoda	
Octopodidae	
Octopus rubescens	7
ARTHROPODA	
PYCNOGONIDA	
Pegmata	
Nymphonidae	
Nymphon pixellae	5
Malacostraca	
ISOPODA	
Cymothoidae	
Elthusa vulgaris	2
DECAPODA	
Crangonidae	
Crangon alaskensis	18
Diogenidae	
Paguristes turgidus	1
Calappidae	
Platymera gaudichaudii	99
Majidae	
Loxorhynchus grandis	1
Podochela hemphillii	1
ECHINODERMATA	
CRINOIDEA	
Comatulida	
Antedonidae	
Florometra serratissima	1
ASTEROIDEA	
Paxillosida	
Luidiidae	
Luidia armata	1
Luidia asthenosoma	15
Luidia foliolata	94
Astropectinidae	
Astropecten ornatissimus	2
Astropecten verrilli	117
Valvatida	
Goniasteridae	
Mediaster aequalis	1

Appendix C.4 *continued*

Taxon/ Species	n
OPHIUROIDEA	
Ophiurida	
Ophiactidae	
Ophiopholis bakeri	2
Amphiuridae	
Amphiodia urtica	1
Ophiuridae	
Ophiura luetkenii	24
ECHINOIDEA	
Temnopleuroida	
Toxopneustidae	
Lytechinus pictus	16,876
Echinoida	
Strongylocentrotidae	
Allocentrotus fragilis	12
Spatangoida	
Spatangidae	
Spatangus californicus	1
HOLOTHURIODEA	
Aspidochirotida	
Stichopodidae	
Parastichopus californicus	46

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Appendix C5.

Megabenthic invertebrates for each PLOO station during January and July 2004.

January 2004 NAME	SD7	SD8	SD10	SD12	SD13	SD14	Species Abundance by Survey
Lytechinus pictus	105	775	57	1180	1800	1254	5171
Acanthoptilum sp			74	54	32		160
Astropecten verrilli	35	2	25	1		1	64
Luidia foliolata				4	17	41	62
Crangon alaskensis	4		10	1	3		18
Ophiura leutkenii	5		1	2	3	3	14
Parastichopus californicus	7	3	2		1	1	14
Luidia asthenosoma	6		5				11
Octopus rubescens	3					1	4
Platymera gaudichaudii	1	1	2				4
Astropecten ornatissimus	1		1				2
Megasurcula carpenteriana			2				2
Ophiopholis bakeri		1		1			2
Thesea sp B			2				2
Allocentrotus fragilis				1			1
Amphiodia urtica			1				1
Cancellaria crawfordiana			1				1
Elthusa vul garis				1			1
Fusinus barbarensis		1					1
Loligo opalescens			1				1
Metridium farcimen		1					1
Nassarius insculptus				1			1
Nymphon pixellae	1						1
Podochela hemphillii		1					1
Rossia pacifica	1						1
TOTAL	169	785	184	1246	1856	1301	5541

Appendix C5. *continued.*

Megabenthic invertebrates for each PLOO station during January and July 2004.

July 2004 NAME	SD7	SD8	SD10	SD12	SD13	SD14	Species Abundance by Survey
Lytechinus pictus	869	4217	1957	1200	3276	186	11,705
Acanthoptilum sp		1	6	420	12	5	444
Platymera gaudichaudii		93		2			95
Astropecten verrilli	32		2	12	2	5	53
Luidia foliolata	5	1	2	8	4	12	32
Parastichopus californicus	12	15	2	2	1		32
Allocentrotus fragilis	6			4	1		11
Ophiura luetkenii	1		1	3		5	10
Philine auriformis	7		2				9
Pleurobranchaea californica		1	4	2			7
Megasurcula carpenteriana			2	3			5
Thesea sp *B*		3	1			1	5
Luidia asthenosoma	2					2	4
Nymphon pixellae	3		1				4
Octopus rubescens	1		1	1			3
Rossia pacifica	2	1					3
Tritonia diomedea					2	1	3
Armina californica			1				1
Elthusa vulgaris						1	1
Florometra serratissima			1				1
Loligo opalescens		1					1
Loxorhynchus grandis					1		1
Luidia armata	1						1
Mediaster aequalis				1			1
Metridium farcimen						1	1
Neosimnia barbarensis				1			1
Paguristes turgidus				1			1
Spatangus californicus		1					1
Telesto californica			1				1
Virgularia agassizii					1		1
TOTAL	941	4334	1984	1660	3300	219	12,438

Appendix D

Supporting Data

2004 PLOO Stations

Bioaccumulation of Contaminants in Fish Tissues

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Appendix D.1

Lengths and weights of fishes used in PLOO fish tissue samples for October 2004.

				Length			Weight		
Station	Rep	Species	n	min	max	mean	min	max	mean
RF1	1	Copper rockfish	3	26	36	30	700	1300	967
RF1	2	Copper rockfish	3	30	42	35	900	2300	1500
RF1	3	Scorpaena guttata	3	17	32	23	120	400	240
RF2	1	Greenspotted rockfish	3	20	26	23	250	500	367
RF2	2	mixed rockfish	3	22	23	23	300	400	367
RF2	3	mixed rockfish	3	28	32	30	550	1000	750
ZONE1	1	English sole	5	18	22	20	94	175	122
ZONE1	2	English sole	10	15	19	16	56	119	79
ZONE1	3	English sole	8	16	19	17	63	97	78
ZONE1	4	Pacific sanddab	7	14	19	17	40	93	72
ZONE1	5	Pacific sanddab	9	15	18	16	45	78	58
ZONE1	6	Pacific sanddab	9	14	18	16	42	86	54
ZONE1	7	Longfin sanddab	11	13	16	14	35	69	49
ZONE1	8	Longfin sanddab	11	12	16	14	33	75	54
ZONE1	9	Longfin sanddab	8	13	15	14	41	60	46
ZONE2	1	English sole	7	16	21	91	57	137	91
ZONE2	2	English sole	6	16	21	18	68	124	89
ZONE2	3	English sole	6	15	21	18	57	143	89
ZONE2	4	Pacific sanddab	10	14	17	15	35	75	51
ZONE2	5	Pacific sanddab	10	14	17	15	34	61	43
ZONE2	6	Pacific sanddab	7	16	18	17	58	97	71
ZONE2	7	Longfin sanddab	9	14	16	15	50	82	59
ZONE2	8	Longfin sanddab	10	14	17	15	44	84	54
ZONE2	9	Longfin sanddab	12	13	16	14	44	71	51
ZONE3	1	Pacific sanddab	4	18	20	19	75	134	99
ZONE3	2	Pacific sanddab	4	16	22	19	64	180	116
ZONE3	3	Pacific sanddab	5	16	20	18	66	148	95
ZONE3	4	English sole	5	18	22	20	76	176	118
ZONE3	5	English sole	9	14	18	16	43	90	54
ZONE3	6	Longfin sanddab	9	12	15	14	29	66	49
ZONE4	1	Pacific sanddab	3	18	22	20	80	198	139
ZONE4	2	Pacific sanddab	3	20	21	20	127	158	145
ZONE4	3	Pacific sanddab	4	19	19	19	107	130	114

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Appendix D.2

Analyzed constituents for PLOO fish tissue samples for October 2004.

Chlorinated Pesticides			
Aldrin	BHC, Gamma isomer	Hexachlorobenzene	p,p-DDE
Alpha (cis) Chlordane	Cis Nonachlor	Mirex	p,p-DDMU
Gamma (trans) Chlordane	Dieldrin	o,p-DDD	p,p-DDT
Alpha Endosulfan	Endrin	o,p-DDE	Oxychlordane
BHC, Alpha isomer	Heptachlor	o,p-DDT	Trans Nonachlor
BHC, Beta isomer	Heptachlor epoxide	p,p-DDD	Toxaphene
BHC, Delta isomer			

Polycyclic Aromatic Hydrocarbons (RF stations only)			
1-methylnaphthalene	Acenaphthene	Benzo(e)pyrene	Fluorene
1-methylphenanthrene	Acenaphthylene	Benzo(G,H,I)perylene	Indeno(1,2,3-CD)pyrene
2,3,5-trimethylnaphthalene	Anthracene	Benzo(K)fluoranthene	Naphthalene
2,6-dimethylnaphthalene	Benzo(A)anthracene	Biphenyl	Perylene
2-methylnaphthalene	Dibenzo(A,H)anthracene	Chrysene	Phenanthrene
3,4-benzo(B)fluoranthene	Benzo(A)pyrene	Fluoranthene	Pyrene

Metals			
Aluminum	Cadmium	Manganese	Silver
Antimony	Chromium	Mercury	Thallium
Arsenic	Copper	Nickel	Tin
Barium	Iron	Selenium	Zinc
Beryllium	Lead		

PCB Congeners			
PCB 18	PCB 81	PCB 126	PCB 169
PCB 28	PCB 87	PCB 128	PCB 170
PCB 37	PCB 99	PCB 138	PCB 177
PCB 44	PCB 101	PCB 149	PCB 180
PCB 49	PCB 105	PCB 151	PCB 183
PCB 52	PCB 110	PCB 153/168	PCB 187
PCB 66	PCB 114	PCB 156	PCB 189
PCB 70	PCB 118	PCB 157	PCB 194
PCB 74	PCB 119	PCB 158	PCB 201
PCB 77	PCB 123	PCB 167	PCB 206

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Appendix D.3

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
RF1	1	Copper rockfish	Muscle	Aluminum	1.86	mg/kg	0.583
RF1	1	Copper rockfish	Muscle	Arsenic	0.683	mg/kg	0.375
RF1	1	Copper rockfish	Muscle	Barium	0.027	mg/kg	0.007
RF1	1	Copper rockfish	Muscle	Chromium	0.199	mg/kg	0.08
RF1	1	Copper rockfish	Muscle	Copper	0.188	mg/kg	0.068
RF1	1	Copper rockfish	Muscle	Hexachlorobenzene	0.2E	ug/kg	
RF1	1	Copper rockfish	Muscle	Iron	1.62	mg/kg	0.096
RF1	1	Copper rockfish	Muscle	Lipids	1.19	wt%	0.005
RF1	1	Copper rockfish	Muscle	Manganese	0.083	mg/kg	0.007
RF1	1	Copper rockfish	Muscle	Mercury	0.162	mg/kg	0.03
RF1	1	Copper rockfish	Muscle	o,p-DDE	0.5E	ug/kg	
RF1	1	Copper rockfish	Muscle	p,p-DDD	0.3E	ug/kg	
RF1	1	Copper rockfish	Muscle	p,p-DDE	18	ug/kg	1.33
RF1	1	Copper rockfish	Muscle	p,-p-DDMU	0.6E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 101	0.5E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 105	0.3E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 110	0.4E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 118	0.8E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 128	0.3E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 138	1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 153/168	1.1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 180	0.4E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 183	0.2E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 187	0.4E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 206	0.1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 66	0.1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 70	0.1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 74	0.1E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 87	0.3E	ug/kg	
RF1	1	Copper rockfish	Muscle	PCB 99	0.4E	ug/kg	
RF1	1	Copper rockfish	Muscle	Selenium	0.457	mg/kg	0.06
RF1	1	Copper rockfish	Muscle	Total DDT	18.8	ug/kg	
RF1	1	Copper rockfish	Muscle	Total PCB	6.5	ug/kg	
RF1	1	Copper rockfish	Muscle	Total Solids	22.6	wt%	0.4
RF1	1	Copper rockfish	Muscle	Zinc	3.99	mg/kg	0.049
RF1	2	Copper rockfish	Muscle	Alpha (cis) Chlordane	0.5E	ug/kg	
RF1	2	Copper rockfish	Muscle	Aluminum	1.95	mg/kg	0.583
RF1	2	Copper rockfish	Muscle	Arsenic	2.19	mg/kg	0.375
RF1	2	Copper rockfish	Muscle	Barium	0.018	mg/kg	0.007
RF1	2	Copper rockfish	Muscle	Chromium	0.178	mg/kg	0.08
RF1	2	Copper rockfish	Muscle	Copper	0.142	mg/kg	0.068
RF1	2	Copper rockfish	Muscle	Hexachlorobenzene	0.2E	ug/kg	
RF1	2	Copper rockfish	Muscle	Iron	1.74	mg/kg	0.096
RF1	2	Copper rockfish	Muscle	Lipids	1.21	wt%	0.005
RF1	2	Copper rockfish	Muscle	Manganese	0.068	mg/kg	0.007
RF1	2	Copper rockfish	Muscle	Mercury	0.777	mg/kg	0.03
RF1	2	Copper rockfish	Muscle	o,p-DDE	0.8E	ug/kg	
RF1	2	Copper rockfish	Muscle	p,p-DDD	0.8E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
RF1	2	Copper rockfish	Muscle	p,p-DDE	61	ug/kg	1.33
RF1	2	Copper rockfish	Muscle	p,-p-DDMU	0.8E	ug/kg	
RF1	2	Copper rockfish	Muscle	p,p-DDT	0.6E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 101	1.2E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 105	0.7E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 110	0.9E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 118	1.9	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 128	0.5E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 138	2.6	ug/kg	1.33
RF1	2	Copper rockfish	Muscle	PCB 149	0.9E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 151	0.3E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 153/168	3.8	ug/kg	1.33
RF1	2	Copper rockfish	Muscle	PCB 156	0.3E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 180	2	ug/kg	1.33
RF1	2	Copper rockfish	Muscle	PCB 183	0.5E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 187	1.6	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 194	0.3E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 201	0.5E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 206	0.2E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 49	0.3E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 66	0.3E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 70	0.2E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 74	0.2E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 87	0.4E	ug/kg	
RF1	2	Copper rockfish	Muscle	PCB 99	1E	ug/kg	
RF1	2	Copper rockfish	Muscle	Selenium	0.69	mg/kg	0.06
RF1	2	Copper rockfish	Muscle	Total DDT	63.2	ug/kg	
RF1	2	Copper rockfish	Muscle	Total PCB	20.6	ug/kg	
RF1	2	Copper rockfish	Muscle	Total Solids	23.8	wt%	0.4
RF1	2	Copper rockfish	Muscle	Trans Nonachlor	0.8E	ug/kg	
RF1	2	Copper rockfish	Muscle	Zinc	4.82	mg/kg	0.049
RF1	3	Mixed rockfish	Muscle	Aluminum	1.24	mg/kg	0.583
RF1	3	Mixed rockfish	Muscle	Arsenic	1.99	mg/kg	0.375
RF1	3	Mixed rockfish	Muscle	Barium	0.017	mg/kg	0.007
RF1	3	Mixed rockfish	Muscle	BHC, Beta isomer	0.6E	ug/kg	
RF1	3	Mixed rockfish	Muscle	BHC, Delta isomer	0.5E	ug/kg	
RF1	3	Mixed rockfish	Muscle	Chromium	0.165	mg/kg	0.08
RF1	3	Mixed rockfish	Muscle	Cis Nonachlor	0.4E	ug/kg	
RF1	3	Mixed rockfish	Muscle	Copper	0.115	mg/kg	0.068
RF1	3	Mixed rockfish	Muscle	Gamma (trans) Chlordane	0.6E	ug/kg	
RF1	3	Mixed rockfish	Muscle	Iron	1.45	mg/kg	0.096
RF1	3	Mixed rockfish	Muscle	Lipids	0.3	wt%	0.005
RF1	3	Mixed rockfish	Muscle	Manganese	0.076	mg/kg	0.007
RF1	3	Mixed rockfish	Muscle	Mercury	0.153	mg/kg	0.03
RF1	3	Mixed rockfish	Muscle	o,p-DDE	0.9E	ug/kg	
RF1	3	Mixed rockfish	Muscle	p,p-DDD	0.4E	ug/kg	
RF1	3	Mixed rockfish	Muscle	p,p-DDE	8.5	ug/kg	1.33
RF1	3	Mixed rockfish	Muscle	PCB 101	0.3E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 105	0.2E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
RF1	3	Mixed rockfish	Muscle	PCB 118	0.6E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 138	0.8E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 153/168	1.1E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 180	0.4E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 187	0.4E	ug/kg	
RF1	3	Mixed rockfish	Muscle	PCB 99	0.3E	ug/kg	
RF1	3	Mixed rockfish	Muscle	Selenium	0.305	mg/kg	0.06
RF1	3	Mixed rockfish	Muscle	Total DDT	9.8	ug/kg	
RF1	3	Mixed rockfish	Muscle	Total PCB	4.1	ug/kg	
RF1	3	Mixed rockfish	Muscle	Total Solids	21.7	wt%	0.4
RF1	3	Mixed rockfish	Muscle	Zinc	3.13	mg/kg	0.049
RF2	1	Greenspotted rockfish	Muscle	Aluminum	1.66	mg/kg	0.583
RF2	1	Greenspotted rockfish	Muscle	Arsenic	1.94	mg/kg	0.375
RF2	1	Greenspotted rockfish	Muscle	Barium	0.023	mg/kg	0.007
RF2	1	Greenspotted rockfish	Muscle	Chromium	0.192	mg/kg	0.08
RF2	1	Greenspotted rockfish	Muscle	Copper	0.139	mg/kg	0.068
RF2	1	Greenspotted rockfish	Muscle	Hexachlorobenzene	0.1E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	Iron	2.49	mg/kg	0.096
RF2	1	Greenspotted rockfish	Muscle	Lipids	0.55	wt%	0.005
RF2	1	Greenspotted rockfish	Muscle	Manganese	0.126	mg/kg	0.007
RF2	1	Greenspotted rockfish	Muscle	Mercury	0.291	mg/kg	0.03
RF2	1	Greenspotted rockfish	Muscle	p,p-DDE	13	ug/kg	1.33
RF2	1	Greenspotted rockfish	Muscle	p,-p-DDMU	0.3E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 101	0.3E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 105	0.2E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 118	0.5E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 138	0.9E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 153/168	1E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 180	0.4E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	PCB 99	0.2E	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	Selenium	0.201	mg/kg	0.06
RF2	1	Greenspotted rockfish	Muscle	Tin	0.241	mg/kg	0.24
RF2	1	Greenspotted rockfish	Muscle	Total DDT	13	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	Total PCB	3.5	ug/kg	
RF2	1	Greenspotted rockfish	Muscle	Total Solids	21.1	wt%	0.4
RF2	1	Greenspotted rockfish	Muscle	Zinc	3.29	mg/kg	0.049
RF2	2	Mixed rockfish	Muscle	Arsenic	1.19	mg/kg	0.375
RF2	2	Mixed rockfish	Muscle	Barium	0.017	mg/kg	0.007
RF2	2	Mixed rockfish	Muscle	Chromium	0.151	mg/kg	0.08
RF2	2	Mixed rockfish	Muscle	Copper	0.234	mg/kg	0.068
RF2	2	Mixed rockfish	Muscle	Hexachlorobenzene	0.1E	ug/kg	
RF2	2	Mixed rockfish	Muscle	Iron	2.4	mg/kg	0.096
RF2	2	Mixed rockfish	Muscle	Lipids	0.32	wt%	0.005
RF2	2	Mixed rockfish	Muscle	Manganese	0.062	mg/kg	0.007
RF2	2	Mixed rockfish	Muscle	Mercury	0.243	mg/kg	0.03
RF2	2	Mixed rockfish	Muscle	p,p-DDD	0.2E	ug/kg	
RF2	2	Mixed rockfish	Muscle	p,p-DDE	11	ug/kg	1.33
RF2	2	Mixed rockfish	Muscle	p,-p-DDMU	0.3E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 101	0.3E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
RF2	2	Mixed rockfish	Muscle	PCB 105	0.2E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 118	0.6E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 138	1E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 153/168	1.2E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 180	0.6E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 187	0.6E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 194	0.1E	ug/kg	
RF2	2	Mixed rockfish	Muscle	PCB 99	0.2E	ug/kg	
RF2	2	Mixed rockfish	Muscle	Selenium	0.42	mg/kg	0.06
RF2	2	Mixed rockfish	Muscle	Tin	0.437	mg/kg	0.24
RF2	2	Mixed rockfish	Muscle	Total DDT	11.2	ug/kg	
RF2	2	Mixed rockfish	Muscle	Total PCB	4.8	ug/kg	
RF2	2	Mixed rockfish	Muscle	Total Solids	21	wt%	0.4
RF2	2	Mixed rockfish	Muscle	Zinc	3.26	mg/kg	0.049
RF2	3	Mixed rockfish	Muscle	Arsenic	1.24	mg/kg	0.375
RF2	3	Mixed rockfish	Muscle	Barium	0.017	mg/kg	0.007
RF2	3	Mixed rockfish	Muscle	Chromium	0.142	mg/kg	0.08
RF2	3	Mixed rockfish	Muscle	Copper	0.191	mg/kg	0.068
RF2	3	Mixed rockfish	Muscle	Hexachlorobenzene	0.1E	ug/kg	
RF2	3	Mixed rockfish	Muscle	Iron	1.62	mg/kg	0.096
RF2	3	Mixed rockfish	Muscle	Lipids	0.74	wt%	0.005
RF2	3	Mixed rockfish	Muscle	Manganese	0.113	mg/kg	0.007
RF2	3	Mixed rockfish	Muscle	Mercury	0.113	mg/kg	0.03
RF2	3	Mixed rockfish	Muscle	o,p-DDE	0.3E	ug/kg	
RF2	3	Mixed rockfish	Muscle	p,p-DDD	0.3E	ug/kg	
RF2	3	Mixed rockfish	Muscle	p,p-DDE	16.5	ug/kg	1.33
RF2	3	Mixed rockfish	Muscle	p,-p-DDMU	0.9E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 101	0.35E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 105	0.2E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 118	0.6E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 138	0.9E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 153/168	1.1E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 180	0.5E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 187	0.45E	ug/kg	
RF2	3	Mixed rockfish	Muscle	PCB 99	0.4E	ug/kg	
RF2	3	Mixed rockfish	Muscle	Selenium	0.264	mg/kg	0.06
RF2	3	Mixed rockfish	Muscle	Tin	0.362	mg/kg	0.24
RF2	3	Mixed rockfish	Muscle	Total DDT	17.1	ug/kg	
RF2	3	Mixed rockfish	Muscle	Total PCB	4.5	ug/kg	
RF2	3	Mixed rockfish	Muscle	Total Solids	21.3	wt%	0.4
RF2	3	Mixed rockfish	Muscle	Zinc	3.23	mg/kg	0.049
ZONE1	1	English sole	Liver	Aluminum	5.28	mg/kg	0.583
ZONE1	1	English sole	Liver	Arsenic	7.23	mg/kg	0.375
ZONE1	1	English sole	Liver	Barium	0.047	mg/kg	0.007
ZONE1	1	English sole	Liver	Cadmium	0.758	mg/kg	0.029
ZONE1	1	English sole	Liver	Chromium	0.327	mg/kg	0.08
ZONE1	1	English sole	Liver	Copper	1.9	mg/kg	0.068
ZONE1	1	English sole	Liver	Hexachlorobenzene	1.6E	ug/kg	
ZONE1	1	English sole	Liver	Iron	117	mg/kg	0.096

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	1	English sole	Liver	Lead	0.482	mg/kg	0.3
ZONE1	1	English sole	Liver	Lipids	13	wt%	0.005
ZONE1	1	English sole	Liver	Manganese	1.26	mg/kg	0.007
ZONE1	1	English sole	Liver	Mercury	0.13	mg/kg	0.03
ZONE1	1	English sole	Liver	o,p-DDE	3.9E	ug/kg	
ZONE1	1	English sole	Liver	p,p-DDD	5.1E	ug/kg	
ZONE1	1	English sole	Liver	p,p-DDE	150	ug/kg	13.3
ZONE1	1	English sole	Liver	p,-p-DDMU	6E	ug/kg	
ZONE1	1	English sole	Liver	PCB 101	7.4E	ug/kg	
ZONE1	1	English sole	Liver	PCB 105	3.3E	ug/kg	
ZONE1	1	English sole	Liver	PCB 110	6.1E	ug/kg	
ZONE1	1	English sole	Liver	PCB 118	9.8E	ug/kg	
ZONE1	1	English sole	Liver	PCB 128	3.3E	ug/kg	
ZONE1	1	English sole	Liver	PCB 138	18	ug/kg	13.3
ZONE1	1	English sole	Liver	PCB 149	9.4E	ug/kg	
ZONE1	1	English sole	Liver	PCB 153/168	25	ug/kg	13.3
ZONE1	1	English sole	Liver	PCB 180	14	ug/kg	13.3
ZONE1	1	English sole	Liver	PCB 183	4.5E	ug/kg	
ZONE1	1	English sole	Liver	PCB 187	15	ug/kg	13.3
ZONE1	1	English sole	Liver	PCB 194	4.3E	ug/kg	
ZONE1	1	English sole	Liver	PCB 206	3.2E	ug/kg	
ZONE1	1	English sole	Liver	PCB 49	1.7E	ug/kg	
ZONE1	1	English sole	Liver	PCB 66	2.2E	ug/kg	
ZONE1	1	English sole	Liver	PCB 70	1.5E	ug/kg	
ZONE1	1	English sole	Liver	PCB 99	6.6E	ug/kg	
ZONE1	1	English sole	Liver	Selenium	2.61	mg/kg	0.06
ZONE1	1	English sole	Liver	Silver	0.142	mg/kg	0.057
ZONE1	1	English sole	Liver	Tin	0.486	mg/kg	0.24
ZONE1	1	English sole	Liver	Total DDT	159	ug/kg	
ZONE1	1	English sole	Liver	Total PCB	135.3	ug/kg	
ZONE1	1	English sole	Liver	Total Solids	32.6	wt%	0.4
ZONE1	1	English sole	Liver	Zinc	86.9	mg/kg	0.049
ZONE1	2	English sole	Liver	Aluminum	2.78	mg/kg	0.583
ZONE1	2	English sole	Liver	Arsenic	4.79	mg/kg	0.375
ZONE1	2	English sole	Liver	Barium	0.031	mg/kg	0.007
ZONE1	2	English sole	Liver	Cadmium	0.649	mg/kg	0.029
ZONE1	2	English sole	Liver	Chromium	0.29	mg/kg	0.08
ZONE1	2	English sole	Liver	Copper	1.58	mg/kg	0.068
ZONE1	2	English sole	Liver	Iron	117	mg/kg	0.096
ZONE1	2	English sole	Liver	Lipids	12.1	wt%	0.005
ZONE1	2	English sole	Liver	Manganese	1.1	mg/kg	0.007
ZONE1	2	English sole	Liver	Mercury	0.042	mg/kg	0.03
ZONE1	2	English sole	Liver	o,p-DDE	2.7E	ug/kg	
ZONE1	2	English sole	Liver	p,p-DDD	3.4E	ug/kg	
ZONE1	2	English sole	Liver	p,p-DDE	110	ug/kg	13.3
ZONE1	2	English sole	Liver	p,-p-DDMU	3.6E	ug/kg	
ZONE1	2	English sole	Liver	PCB 101	6.3E	ug/kg	
ZONE1	2	English sole	Liver	PCB 105	2.5E	ug/kg	
ZONE1	2	English sole	Liver	PCB 110	4.3E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	2	English sole	Liver	PCB 118	7.1E	ug/kg	
ZONE1	2	English sole	Liver	PCB 128	3.5E	ug/kg	
ZONE1	2	English sole	Liver	PCB 138	14	ug/kg	13.3
ZONE1	2	English sole	Liver	PCB 149	7.2E	ug/kg	
ZONE1	2	English sole	Liver	PCB 153/168	19	ug/kg	13.3
ZONE1	2	English sole	Liver	PCB 180	12E	ug/kg	
ZONE1	2	English sole	Liver	PCB 183	4.1E	ug/kg	
ZONE1	2	English sole	Liver	PCB 187	12E	ug/kg	
ZONE1	2	English sole	Liver	PCB 194	3.9E	ug/kg	
ZONE1	2	English sole	Liver	PCB 206	3.3E	ug/kg	
ZONE1	2	English sole	Liver	PCB 49	1.2E	ug/kg	
ZONE1	2	English sole	Liver	PCB 66	1.7E	ug/kg	
ZONE1	2	English sole	Liver	PCB 70	1.2E	ug/kg	
ZONE1	2	English sole	Liver	PCB 99	5.6E	ug/kg	
ZONE1	2	English sole	Liver	Selenium	2.34	mg/kg	0.06
ZONE1	2	English sole	Liver	Silver	0.094	mg/kg	0.057
ZONE1	2	English sole	Liver	Tin	0.42	mg/kg	0.24
ZONE1	2	English sole	Liver	Total DDT	116.1	ug/kg	
ZONE1	2	English sole	Liver	Total PCB	108.9	ug/kg	
ZONE1	2	English sole	Liver	Total Solids	26.8	wt%	0.4
ZONE1	2	English sole	Liver	Zinc	38.4	mg/kg	0.049
ZONE1	3	English sole	Liver	Aluminum	3.55	mg/kg	0.583
ZONE1	3	English sole	Liver	Arsenic	4.11	mg/kg	0.375
ZONE1	3	English sole	Liver	Barium	0.036	mg/kg	0.007
ZONE1	3	English sole	Liver	Cadmium	0.807	mg/kg	0.029
ZONE1	3	English sole	Liver	Chromium	0.319	mg/kg	0.08
ZONE1	3	English sole	Liver	Copper	5.16	mg/kg	0.068
ZONE1	3	English sole	Liver	Hexachlorobenzene	1.1E	ug/kg	
ZONE1	3	English sole	Liver	Iron	115	mg/kg	0.096
ZONE1	3	English sole	Liver	Lead	1.06	mg/kg	0.3
ZONE1	3	English sole	Liver	Lipids	12	wt%	0.005
ZONE1	3	English sole	Liver	Manganese	1.16	mg/kg	0.007
ZONE1	3	English sole	Liver	Mercury	0.039	mg/kg	0.03
ZONE1	3	English sole	Liver	o,p-DDE	2.2E	ug/kg	
ZONE1	3	English sole	Liver	p,p-DDD	4E	ug/kg	
ZONE1	3	English sole	Liver	p,p-DDE	110	ug/kg	13.3
ZONE1	3	English sole	Liver	p,-p-DDMU	3.9E	ug/kg	
ZONE1	3	English sole	Liver	PCB 101	5.2E	ug/kg	
ZONE1	3	English sole	Liver	PCB 105	2.5E	ug/kg	
ZONE1	3	English sole	Liver	PCB 110	3.9E	ug/kg	
ZONE1	3	English sole	Liver	PCB 118	7.4E	ug/kg	
ZONE1	3	English sole	Liver	PCB 128	3.3E	ug/kg	
ZONE1	3	English sole	Liver	PCB 138	13E	ug/kg	
ZONE1	3	English sole	Liver	PCB 149	6.4E	ug/kg	
ZONE1	3	English sole	Liver	PCB 153/168	19	ug/kg	13.3
ZONE1	3	English sole	Liver	PCB 180	11E	ug/kg	
ZONE1	3	English sole	Liver	PCB 183	3.6E	ug/kg	
ZONE1	3	English sole	Liver	PCB 187	12E	ug/kg	
ZONE1	3	English sole	Liver	PCB 194	2.6E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	3	English sole	Liver	PCB 206	2.3E	ug/kg	
ZONE1	3	English sole	Liver	PCB 66	1.7E	ug/kg	
ZONE1	3	English sole	Liver	PCB 70	1.1E	ug/kg	
ZONE1	3	English sole	Liver	PCB 99	4.7E	ug/kg	
ZONE1	3	English sole	Liver	Selenium	2.67	mg/kg	0.06
ZONE1	3	English sole	Liver	Silver	0.321	mg/kg	0.057
ZONE1	3	English sole	Liver	Tin	0.262	mg/kg	0.24
ZONE1	3	English sole	Liver	Total DDT	116.2	ug/kg	
ZONE1	3	English sole	Liver	Total PCB	99.7	ug/kg	
ZONE1	3	English sole	Liver	Total Solids	29.2	wt%	0.4
ZONE1	3	English sole	Liver	Zinc	52.3	mg/kg	0.049
ZONE1	4	Pacific sanddab	Liver	Alpha (cis) Chlordane	7.6E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	Aluminum	4.16	mg/kg	0.583
ZONE1	4	Pacific sanddab	Liver	Arsenic	2.93	mg/kg	0.375
ZONE1	4	Pacific sanddab	Liver	Barium	0.059	mg/kg	0.007
ZONE1	4	Pacific sanddab	Liver	Cadmium	7.08	mg/kg	0.029
ZONE1	4	Pacific sanddab	Liver	Chromium	0.38	mg/kg	0.08
ZONE1	4	Pacific sanddab	Liver	Copper	4.59	mg/kg	0.068
ZONE1	4	Pacific sanddab	Liver	Hexachlorobenzene	2.7E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	Iron	128	mg/kg	0.096
ZONE1	4	Pacific sanddab	Liver	Lipids	32.3	wt%	0.005
ZONE1	4	Pacific sanddab	Liver	Manganese	0.84	mg/kg	0.007
ZONE1	4	Pacific sanddab	Liver	Mercury	0.082	mg/kg	0.03
ZONE1	4	Pacific sanddab	Liver	o,p-DDE	3.5E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	o,p-DDT	1.9E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	p,p-DDD	8.8E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	p,p-DDE	630	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	p,-p-DDMU	17	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	p,p-DDT	11E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 101	14	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 105	8.7E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 110	13E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 118	34	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 123	3.5E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 128	12E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 138	57	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 149	11E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 151	6.9E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 153/168	97	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 156	5.1E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 157	1.4E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 158	4.7E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 170	15	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 177	6.6E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 180	49	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 183	12E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 187	39	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	PCB 194	9.4E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 201	9.8E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	4	Pacific sanddab	Liver	PCB 206	5.2E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 49	2.1E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 66	3.3E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 70	2.7E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 74	2.1E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 87	3E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	PCB 99	19	ug/kg	13.3
ZONE1	4	Pacific sanddab	Liver	Selenium	1.29	mg/kg	0.06
ZONE1	4	Pacific sanddab	Liver	Silver	0.129	mg/kg	0.057
ZONE1	4	Pacific sanddab	Liver	Tin	0.629	mg/kg	0.24
ZONE1	4	Pacific sanddab	Liver	Total DDT	655.2	ug/kg	
ZONE1	4	Pacific sanddab	Liver	Total PCB	446.5	ug/kg	
ZONE1	4	Pacific sanddab	Liver	Total Solids	54.5	wt%	0.4
ZONE1	4	Pacific sanddab	Liver	Trans Nonachlor	9.7E	ug/kg	
ZONE1	4	Pacific sanddab	Liver	Zinc	27.4	mg/kg	0.049
ZONE1	5	Pacific sanddab	Liver	Alpha (cis) Chlordane	10.5E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Aluminum	6.47	mg/kg	0.583
ZONE1	5	Pacific sanddab	Liver	Arsenic	2.79	mg/kg	0.375
ZONE1	5	Pacific sanddab	Liver	Barium	0.04	mg/kg	0.007
ZONE1	5	Pacific sanddab	Liver	Cadmium	4.53	mg/kg	0.029
ZONE1	5	Pacific sanddab	Liver	Chromium	0.31	mg/kg	0.08
ZONE1	5	Pacific sanddab	Liver	Cis Nonachlor	6.95E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Copper	3.28	mg/kg	0.068
ZONE1	5	Pacific sanddab	Liver	Gamma (trans) Chlordane	1.8E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Hexachlorobenzene	3.3E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Iron	110	mg/kg	0.096
ZONE1	5	Pacific sanddab	Liver	Lipids	40	wt%	0.005
ZONE1	5	Pacific sanddab	Liver	Manganese	0.876	mg/kg	0.007
ZONE1	5	Pacific sanddab	Liver	Mercury	0.07	mg/kg	0.03
ZONE1	5	Pacific sanddab	Liver	Mirex	3.65E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	o,p-DDE	3.95E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	o,p-DDT	2.65E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	p,p-DDD	12E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	p,p-DDE	810	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	p,-p-DDMU	19.5	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	p,p-DDT	14	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 101	18.5	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 105	9.05E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 110	12.5E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 118	34	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 123	3.4E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 128	12.5E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 138	62.5	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 149	12E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 151	5.45E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 153/168	99	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 156	4.6E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 157	1.1E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 158	4.7E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	5	Pacific sanddab	Liver	PCB 167	2.6E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 170	13E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 177	6.9E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 180	46.5	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 183	12E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 187	38.5	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	PCB 194	7.95E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 201	9.7E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 206	4.35E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 49	2.95E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 66	3.75E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 70	3.15E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 74	2.5E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 87	4.55E	ug/kg	
ZONE1	5	Pacific sanddab	Liver	PCB 99	23	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	Selenium	1.07	mg/kg	0.06
ZONE1	5	Pacific sanddab	Liver	Silver	0.088	mg/kg	0.057
ZONE1	5	Pacific sanddab	Liver	Tin	0.714	mg/kg	0.24
ZONE1	5	Pacific sanddab	Liver	Total DDT	842.6	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Total PCB	460.7	ug/kg	
ZONE1	5	Pacific sanddab	Liver	Total Solids	56.6	wt%	0.4
ZONE1	5	Pacific sanddab	Liver	Trans Nonachlor	19	ug/kg	13.3
ZONE1	5	Pacific sanddab	Liver	Zinc	23.2	mg/kg	0.049
ZONE1	6	Pacific sanddab	Liver	Alpha (cis) Chlordane	7E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	Aluminum	5.2	mg/kg	0.583
ZONE1	6	Pacific sanddab	Liver	Arsenic	2.42	mg/kg	0.375
ZONE1	6	Pacific sanddab	Liver	Barium	0.036	mg/kg	0.007
ZONE1	6	Pacific sanddab	Liver	Cadmium	5.84	mg/kg	0.029
ZONE1	6	Pacific sanddab	Liver	Chromium	0.308	mg/kg	0.08
ZONE1	6	Pacific sanddab	Liver	Copper	2.28	mg/kg	0.068
ZONE1	6	Pacific sanddab	Liver	Hexachlorobenzene	3.5E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	Iron	86.6	mg/kg	0.096
ZONE1	6	Pacific sanddab	Liver	Lipids	36.5	wt%	0.005
ZONE1	6	Pacific sanddab	Liver	Manganese	0.845	mg/kg	0.007
ZONE1	6	Pacific sanddab	Liver	Mercury	0.062	mg/kg	0.03
ZONE1	6	Pacific sanddab	Liver	o,p-DDE	4.7E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	o,p-DDT	1.9E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	p,p-DDD	10E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	p,p-DDE	740	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	p,-p-DDMU	21	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	p,p-DDT	12E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 101	9.9E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 105	7.8E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 110	9.4E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 118	28	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	PCB 128	11E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 138	50	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	PCB 149	6.1E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 151	6.5E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	6	Pacific sanddab	Liver	PCB 153/168	82	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	PCB 156	4E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 170	13E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 180	41	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	PCB 183	11E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 187	35	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	PCB 194	8.5E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 201	8.3E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 206	4.7E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 49	2.4E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 66	3.3E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 70	2.3E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 74	1.8E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	PCB 99	17	ug/kg	13.3
ZONE1	6	Pacific sanddab	Liver	Selenium	0.942	mg/kg	0.06
ZONE1	6	Pacific sanddab	Liver	Silver	0.059	mg/kg	0.057
ZONE1	6	Pacific sanddab	Liver	Tin	0.785	mg/kg	0.24
ZONE1	6	Pacific sanddab	Liver	Total DDT	768.6	ug/kg	
ZONE1	6	Pacific sanddab	Liver	Total PCB	363	ug/kg	
ZONE1	6	Pacific sanddab	Liver	Total Solids	54.7	wt%	0.4
ZONE1	6	Pacific sanddab	Liver	Trans Nonachlor	13E	ug/kg	
ZONE1	6	Pacific sanddab	Liver	Zinc	22.9	mg/kg	0.049
ZONE1	7	Longfin sanddab	Liver	Alpha (cis) Chlordane	7.5E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	Aluminum	4.57	mg/kg	0.583
ZONE1	7	Longfin sanddab	Liver	Arsenic	12.4	mg/kg	0.375
ZONE1	7	Longfin sanddab	Liver	Barium	0.027	mg/kg	0.007
ZONE1	7	Longfin sanddab	Liver	Cadmium	4.27	mg/kg	0.029
ZONE1	7	Longfin sanddab	Liver	Chromium	0.247	mg/kg	0.08
ZONE1	7	Longfin sanddab	Liver	Copper	5.55	mg/kg	0.068
ZONE1	7	Longfin sanddab	Liver	Hexachlorobenzene	2.4E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	Iron	190	mg/kg	0.096
ZONE1	7	Longfin sanddab	Liver	Lipids	28.8	wt%	0.005
ZONE1	7	Longfin sanddab	Liver	Manganese	0.902	mg/kg	0.007
ZONE1	7	Longfin sanddab	Liver	Mercury	0.105	mg/kg	0.03
ZONE1	7	Longfin sanddab	Liver	Nickel	0.102	mg/kg	0.094
ZONE1	7	Longfin sanddab	Liver	o,p-DDD	1.1E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	o,p-DDE	7E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	o,p-DDT	1.5E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	p,p-DDD	12E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	p,p-DDE	480	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	p,-p-DDMU	11E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	p,p-DDT	39	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	PCB 101	9.3E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 105	9E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 110	12E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 118	32	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	PCB 123	2.9E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 128	12E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 138	56	ug/kg	13.3

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	7	Longfin sanddab	Liver	PCB 149	8.1E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 151	7E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 153/168	84	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	PCB 156	5.6E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 157	1.5E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 158	4.2E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 167	3.2E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 170	12E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 177	6.8E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 180	43	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	PCB 183	12E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 187	37	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	PCB 194	9E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 201	10E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 206	5.2E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 49	2.3E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 66	3.8E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 70	1.9E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 74	2.2E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 87	2.3E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	PCB 99	19	ug/kg	13.3
ZONE1	7	Longfin sanddab	Liver	Selenium	3.06	mg/kg	0.06
ZONE1	7	Longfin sanddab	Liver	Silver	0.219	mg/kg	0.057
ZONE1	7	Longfin sanddab	Liver	Tin	0.455	mg/kg	0.24
ZONE1	7	Longfin sanddab	Liver	Total DDT	540.6	ug/kg	
ZONE1	7	Longfin sanddab	Liver	Total PCB	413.3	ug/kg	
ZONE1	7	Longfin sanddab	Liver	Total Solids	40.6	wt%	0.4
ZONE1	7	Longfin sanddab	Liver	Trans Nonachlor	8.8E	ug/kg	
ZONE1	7	Longfin sanddab	Liver	Zinc	21.7	mg/kg	0.049
ZONE1	8	Longfin sanddab	Liver	Alpha (cis) Chlordane	17	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	Aluminum	8.63	mg/kg	0.583
ZONE1	8	Longfin sanddab	Liver	Arsenic	9.54	mg/kg	0.375
ZONE1	8	Longfin sanddab	Liver	Barium	0.045	mg/kg	0.007
ZONE1	8	Longfin sanddab	Liver	Cadmium	3.59	mg/kg	0.029
ZONE1	8	Longfin sanddab	Liver	Chromium	0.366	mg/kg	0.08
ZONE1	8	Longfin sanddab	Liver	Cis Nonachlor	10E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	Copper	5.67	mg/kg	0.068
ZONE1	8	Longfin sanddab	Liver	Hexachlorobenzene	2.1E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	Iron	181	mg/kg	0.096
ZONE1	8	Longfin sanddab	Liver	Lipids	20.4	wt%	0.005
ZONE1	8	Longfin sanddab	Liver	Manganese	0.85	mg/kg	0.007
ZONE1	8	Longfin sanddab	Liver	Mercury	0.1	mg/kg	0.03
ZONE1	8	Longfin sanddab	Liver	o,p-DDD	3.4E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	o,p-DDE	17	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	o,p-DDT	3.6E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	p,p-DDD	16	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	p,p-DDE	880	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	p,-p-DDMU	15	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	p,p-DDT	16	ug/kg	13.3

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	8	Longfin sanddab	Liver	PCB 101	20	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 105	12E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 110	18	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 118	49	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 123	4.8E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 128	17	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 138	85	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 149	21	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 151	9.4E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 153/168	130	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 156	7.6E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 157	1.9E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 158	5.6E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 167	4E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 170	18	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 177	11E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 180	63	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 183	18	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 187	52	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 194	10E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 201	14	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	PCB 206	5.3E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 49	1.7E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 52	6.5E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 66	5.1E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 70	1.5E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 74	3.2E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 87	5E	ug/kg	
ZONE1	8	Longfin sanddab	Liver	PCB 99	31	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	Selenium	3.47	mg/kg	0.06
ZONE1	8	Longfin sanddab	Liver	Silver	0.204	mg/kg	0.057
ZONE1	8	Longfin sanddab	Liver	Tin	0.617	mg/kg	0.24
ZONE1	8	Longfin sanddab	Liver	Total DDT	936	ug/kg	
ZONE1	8	Longfin sanddab	Liver	Total PCB	630.6	ug/kg	
ZONE1	8	Longfin sanddab	Liver	Total Solids	40	wt%	0.4
ZONE1	8	Longfin sanddab	Liver	Trans Nonachlor	28	ug/kg	13.3
ZONE1	8	Longfin sanddab	Liver	Zinc	21.4	mg/kg	0.049
ZONE1	9	Longfin sanddab	Liver	Alpha (cis) Chlordane	5.5E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Aluminum	5.96	mg/kg	0.583
ZONE1	9	Longfin sanddab	Liver	Arsenic	10.4	mg/kg	0.375
ZONE1	9	Longfin sanddab	Liver	Barium	0.034	mg/kg	0.007
ZONE1	9	Longfin sanddab	Liver	Cadmium	2.52	mg/kg	0.029
ZONE1	9	Longfin sanddab	Liver	Chromium	0.339	mg/kg	0.08
ZONE1	9	Longfin sanddab	Liver	Cis Nonachlor	5.7E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Copper	6.26	mg/kg	0.068
ZONE1	9	Longfin sanddab	Liver	Hexachlorobenzene	1.6E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Iron	175	mg/kg	0.096
ZONE1	9	Longfin sanddab	Liver	Lipids	20	wt%	0.005
ZONE1	9	Longfin sanddab	Liver	Manganese	0.902	mg/kg	0.007

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE1	9	Longfin sanddab	Liver	Mercury	0.111	mg/kg	0.03
ZONE1	9	Longfin sanddab	Liver	o,p-DDD	1E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	o,p-DDE	9.1E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	o,p-DDT	1.4E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	p,p-DDD	6.8E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	p,p-DDE	590	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	p,-p-DDMU	8.8E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	p,p-DDT	8E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 101	12E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 105	13E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 110	21	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 118	46	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 123	4.5E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 128	17	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 138	74	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 149	13E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 151	11E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 153/168	110	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 156	7.7E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 157	1.7E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 158	6.4E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 167	3.9E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 170	18	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 177	11E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 180	57	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 183	16	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 187	49	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 194	11E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 201	14	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	PCB 206	7E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 66	4.4E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 70	1.7E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 74	2.9E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	PCB 99	29	ug/kg	13.3
ZONE1	9	Longfin sanddab	Liver	Selenium	3.51	mg/kg	0.06
ZONE1	9	Longfin sanddab	Liver	Silver	0.272	mg/kg	0.057
ZONE1	9	Longfin sanddab	Liver	Tin	0.508	mg/kg	0.24
ZONE1	9	Longfin sanddab	Liver	Total DDT	616.3	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Total PCB	562.2	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Total Solids	42.8	wt%	0.4
ZONE1	9	Longfin sanddab	Liver	Trans Nonachlor	9.4E	ug/kg	
ZONE1	9	Longfin sanddab	Liver	Zinc	21.6	mg/kg	0.049
ZONE2	1	English sole	Liver	Aluminum	6.49	mg/kg	0.583
ZONE2	1	English sole	Liver	Arsenic	6.82	mg/kg	0.375
ZONE2	1	English sole	Liver	Barium	0.035	mg/kg	0.007
ZONE2	1	English sole	Liver	Cadmium	0.634	mg/kg	0.029
ZONE2	1	English sole	Liver	Chromium	0.289	mg/kg	0.08
ZONE2	1	English sole	Liver	Copper	1.2	mg/kg	0.068
ZONE2	1	English sole	Liver	Iron	106	mg/kg	0.096

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	1	English sole	Liver	Lead	0.488	mg/kg	0.3
ZONE2	1	English sole	Liver	Lipids	10.5	wt%	0.005
ZONE2	1	English sole	Liver	Manganese	1.11	mg/kg	0.007
ZONE2	1	English sole	Liver	Mercury	0.06	mg/kg	0.03
ZONE2	1	English sole	Liver	o,p-DDE	2.3E	ug/kg	
ZONE2	1	English sole	Liver	p,p-DDD	3.5E	ug/kg	
ZONE2	1	English sole	Liver	p,p-DDE	100	ug/kg	13.3
ZONE2	1	English sole	Liver	p,-p-DDMU	3.3E	ug/kg	
ZONE2	1	English sole	Liver	PCB 101	4.2E	ug/kg	
ZONE2	1	English sole	Liver	PCB 105	1.6E	ug/kg	
ZONE2	1	English sole	Liver	PCB 110	3.2E	ug/kg	
ZONE2	1	English sole	Liver	PCB 118	5.4E	ug/kg	
ZONE2	1	English sole	Liver	PCB 128	2.3E	ug/kg	
ZONE2	1	English sole	Liver	PCB 138	11E	ug/kg	
ZONE2	1	English sole	Liver	PCB 149	5.8E	ug/kg	
ZONE2	1	English sole	Liver	PCB 153/168	14	ug/kg	13.3
ZONE2	1	English sole	Liver	PCB 180	10E	ug/kg	
ZONE2	1	English sole	Liver	PCB 183	2.7E	ug/kg	
ZONE2	1	English sole	Liver	PCB 187	11E	ug/kg	
ZONE2	1	English sole	Liver	PCB 194	4E	ug/kg	
ZONE2	1	English sole	Liver	PCB 206	2.8E	ug/kg	
ZONE2	1	English sole	Liver	PCB 66	1.3E	ug/kg	
ZONE2	1	English sole	Liver	PCB 70	0.8E	ug/kg	
ZONE2	1	English sole	Liver	PCB 99	3.6E	ug/kg	
ZONE2	1	English sole	Liver	Selenium	2.05	mg/kg	0.06
ZONE2	1	English sole	Liver	Silver	0.118	mg/kg	0.057
ZONE2	1	English sole	Liver	Tin	0.467	mg/kg	0.24
ZONE2	1	English sole	Liver	Total DDT	105.8	ug/kg	
ZONE2	1	English sole	Liver	Total PCB	83.7	ug/kg	
ZONE2	1	English sole	Liver	Total Solids	33.1	wt%	0.4
ZONE2	1	English sole	Liver	Zinc	55	mg/kg	0.049
ZONE2	2	English sole	Liver	Aluminum	4.97	mg/kg	0.583
ZONE2	2	English sole	Liver	Arsenic	7	mg/kg	0.375
ZONE2	2	English sole	Liver	Barium	0.031	mg/kg	0.007
ZONE2	2	English sole	Liver	Cadmium	0.506	mg/kg	0.029
ZONE2	2	English sole	Liver	Chromium	0.302	mg/kg	0.08
ZONE2	2	English sole	Liver	Copper	1.72	mg/kg	0.068
ZONE2	2	English sole	Liver	Hexachlorobenzene	1.1E	ug/kg	
ZONE2	2	English sole	Liver	Iron	111	mg/kg	0.096
ZONE2	2	English sole	Liver	Lead	0.405	mg/kg	0.3
ZONE2	2	English sole	Liver	Lipids	9.96	wt%	0.005
ZONE2	2	English sole	Liver	Manganese	1.16	mg/kg	0.007
ZONE2	2	English sole	Liver	Mercury	0.074	mg/kg	0.03
ZONE2	2	English sole	Liver	o,p-DDE	2.5E	ug/kg	
ZONE2	2	English sole	Liver	p,p-DDD	3.5E	ug/kg	
ZONE2	2	English sole	Liver	p,p-DDE	96	ug/kg	13.3
ZONE2	2	English sole	Liver	p,-p-DDMU	2.8E	ug/kg	
ZONE2	2	English sole	Liver	PCB 101	4.5E	ug/kg	
ZONE2	2	English sole	Liver	PCB 105	2.1E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	2	English sole	Liver	PCB 110	3.7E	ug/kg	
ZONE2	2	English sole	Liver	PCB 118	6.3E	ug/kg	
ZONE2	2	English sole	Liver	PCB 128	2.1E	ug/kg	
ZONE2	2	English sole	Liver	PCB 138	12E	ug/kg	
ZONE2	2	English sole	Liver	PCB 149	5.7E	ug/kg	
ZONE2	2	English sole	Liver	PCB 153/168	15	ug/kg	13.3
ZONE2	2	English sole	Liver	PCB 180	9.9E	ug/kg	
ZONE2	2	English sole	Liver	PCB 183	3.5E	ug/kg	
ZONE2	2	English sole	Liver	PCB 187	11E	ug/kg	
ZONE2	2	English sole	Liver	PCB 194	3.6E	ug/kg	
ZONE2	2	English sole	Liver	PCB 206	2.4E	ug/kg	
ZONE2	2	English sole	Liver	PCB 66	1.1E	ug/kg	
ZONE2	2	English sole	Liver	PCB 70	0.9E	ug/kg	
ZONE2	2	English sole	Liver	PCB 99	3.6E	ug/kg	
ZONE2	2	English sole	Liver	Selenium	2.51	mg/kg	0.06
ZONE2	2	English sole	Liver	Silver	0.22	mg/kg	0.057
ZONE2	2	English sole	Liver	Tin	0.427	mg/kg	0.24
ZONE2	2	English sole	Liver	Total DDT	102	ug/kg	
ZONE2	2	English sole	Liver	Total PCB	87.4	ug/kg	
ZONE2	2	English sole	Liver	Total Solids	33.7	wt%	0.4
ZONE2	2	English sole	Liver	Zinc	57.7	mg/kg	0.049
ZONE2	3	English sole	Liver	Aluminum	6.95	mg/kg	0.583
ZONE2	3	English sole	Liver	Arsenic	5.35	mg/kg	0.375
ZONE2	3	English sole	Liver	Barium	0.038	mg/kg	0.007
ZONE2	3	English sole	Liver	Cadmium	0.655	mg/kg	0.029
ZONE2	3	English sole	Liver	Chromium	0.308	mg/kg	0.08
ZONE2	3	English sole	Liver	Copper	0.856	mg/kg	0.068
ZONE2	3	English sole	Liver	Iron	110	mg/kg	0.096
ZONE2	3	English sole	Liver	Lead	0.877	mg/kg	0.3
ZONE2	3	English sole	Liver	Lipids	10.2	wt%	0.005
ZONE2	3	English sole	Liver	Manganese	1.31	mg/kg	0.007
ZONE2	3	English sole	Liver	Mercury	0.061	mg/kg	0.03
ZONE2	3	English sole	Liver	o,p-DDD	0.9E	ug/kg	
ZONE2	3	English sole	Liver	o,p-DDE	25	ug/kg	13.3
ZONE2	3	English sole	Liver	p,p-DDD	6.4E	ug/kg	
ZONE2	3	English sole	Liver	p,p-DDE	700	ug/kg	13.3
ZONE2	3	English sole	Liver	p,-p-DDMU	19	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 101	17	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 105	7.6E	ug/kg	
ZONE2	3	English sole	Liver	PCB 110	12E	ug/kg	
ZONE2	3	English sole	Liver	PCB 118	23	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 128	8.2E	ug/kg	
ZONE2	3	English sole	Liver	PCB 138	38	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 149	18	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 151	5.4E	ug/kg	
ZONE2	3	English sole	Liver	PCB 153/168	53	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 156	4.8E	ug/kg	
ZONE2	3	English sole	Liver	PCB 158	3.9E	ug/kg	
ZONE2	3	English sole	Liver	PCB 167	2E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	3	English sole	Liver	PCB 170	9.2E	ug/kg	
ZONE2	3	English sole	Liver	PCB 177	7E	ug/kg	
ZONE2	3	English sole	Liver	PCB 180	34	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 183	8.1E	ug/kg	
ZONE2	3	English sole	Liver	PCB 187	27	ug/kg	13.3
ZONE2	3	English sole	Liver	PCB 194	7.3E	ug/kg	
ZONE2	3	English sole	Liver	PCB 201	7.9E	ug/kg	
ZONE2	3	English sole	Liver	PCB 206	4.4E	ug/kg	
ZONE2	3	English sole	Liver	PCB 49	1.6E	ug/kg	
ZONE2	3	English sole	Liver	PCB 66	4.1E	ug/kg	
ZONE2	3	English sole	Liver	PCB 70	2E	ug/kg	
ZONE2	3	English sole	Liver	PCB 74	1.9E	ug/kg	
ZONE2	3	English sole	Liver	PCB 87	5.1E	ug/kg	
ZONE2	3	English sole	Liver	PCB 99	14	ug/kg	13.3
ZONE2	3	English sole	Liver	Selenium	2.87	mg/kg	0.06
ZONE2	3	English sole	Liver	Silver	0.075	mg/kg	0.057
ZONE2	3	English sole	Liver	Tin	0.284	mg/kg	0.24
ZONE2	3	English sole	Liver	Total DDT	732.3	ug/kg	
ZONE2	3	English sole	Liver	Total PCB	326.5	ug/kg	
ZONE2	3	English sole	Liver	Total Solids	29.5	wt%	0.4
ZONE2	3	English sole	Liver	Zinc	54.2	mg/kg	0.049
ZONE2	4	Pacific sanddab	Liver	Alpha (cis) Chlordane	6.2E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Aluminum	7.95	mg/kg	0.583
ZONE2	4	Pacific sanddab	Liver	Arsenic	2.33	mg/kg	0.375
ZONE2	4	Pacific sanddab	Liver	Barium	0.058	mg/kg	0.007
ZONE2	4	Pacific sanddab	Liver	Cadmium	6.84	mg/kg	0.029
ZONE2	4	Pacific sanddab	Liver	Chromium	0.809	mg/kg	0.08
ZONE2	4	Pacific sanddab	Liver	Copper	4.63	mg/kg	0.068
ZONE2	4	Pacific sanddab	Liver	Hexachlorobenzene	3.4E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Iron	122	mg/kg	0.096
ZONE2	4	Pacific sanddab	Liver	Lipids	43.8	wt%	0.005
ZONE2	4	Pacific sanddab	Liver	Manganese	1.07	mg/kg	0.007
ZONE2	4	Pacific sanddab	Liver	Mercury	0.072	mg/kg	0.03
ZONE2	4	Pacific sanddab	Liver	o,p-DDE	3.5E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	o,p-DDT	1.4E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	p,p-DDD	8.2E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	p,p-DDE	350	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	p,-p-DDMU	11E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	p,p-DDT	7.6E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 101	8.1E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 105	5.2E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 110	7.2E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 118	16	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	PCB 128	6.9E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 138	31	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	PCB 149	6.3E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 153/168	44	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	PCB 156	2.8E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 158	2.2E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	4	Pacific sanddab	Liver	PCB 170	7.7E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 177	4E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 180	22	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	PCB 183	6.1E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 187	20	ug/kg	13.3
ZONE2	4	Pacific sanddab	Liver	PCB 194	4.2E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 201	5.7E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 206	3E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 49	1.7E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 66	2.5E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 70	2.3E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 74	1.4E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	PCB 99	11E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Selenium	1.55	mg/kg	0.06
ZONE2	4	Pacific sanddab	Liver	Silver	0.128	mg/kg	0.057
ZONE2	4	Pacific sanddab	Liver	Tin	0.46	mg/kg	0.24
ZONE2	4	Pacific sanddab	Liver	Total DDT	370.7	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Total PCB	221.3	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Total Solids	73.9	wt%	0.4
ZONE2	4	Pacific sanddab	Liver	Trans Nonachlor	7.4E	ug/kg	
ZONE2	4	Pacific sanddab	Liver	Zinc	30.3	mg/kg	0.049
ZONE2	5	Pacific sanddab	Liver	Alpha (cis) Chlordane	8.4E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Aluminum	7.07	mg/kg	0.583
ZONE2	5	Pacific sanddab	Liver	Arsenic	2.4	mg/kg	0.375
ZONE2	5	Pacific sanddab	Liver	Barium	0.05	mg/kg	0.007
ZONE2	5	Pacific sanddab	Liver	Cadmium	5.01	mg/kg	0.029
ZONE2	5	Pacific sanddab	Liver	Chromium	0.38	mg/kg	0.08
ZONE2	5	Pacific sanddab	Liver	Copper	3.79	mg/kg	0.068
ZONE2	5	Pacific sanddab	Liver	Hexachlorobenzene	4.3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Iron	133	mg/kg	0.096
ZONE2	5	Pacific sanddab	Liver	Lipids	49.7	wt%	0.005
ZONE2	5	Pacific sanddab	Liver	Manganese	0.919	mg/kg	0.007
ZONE2	5	Pacific sanddab	Liver	Mercury	0.062	mg/kg	0.03
ZONE2	5	Pacific sanddab	Liver	o,p-DDE	4.6E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	o,p-DDT	2.2E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	p,p-DDD	9.3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	p,p-DDE	440	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	p,-p-DDMU	15	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	p,p-DDT	9.5E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 101	9.1E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 105	5.7E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 110	8.5E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 118	20	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	PCB 128	7.5E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 138	34	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	PCB 149	7.9E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 151	4.9E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 153/168	54	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	PCB 156	2.9E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	5	Pacific sanddab	Liver	PCB 158	3.1E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 170	7.3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 177	4.3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 180	24	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	PCB 183	6.7E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 187	22	ug/kg	13.3
ZONE2	5	Pacific sanddab	Liver	PCB 194	4.7E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 201	6.3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 206	3.5E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 49	1.9E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 66	3E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 70	2.5E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 74	0.8E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	PCB 99	12E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Selenium	1.49	mg/kg	0.06
ZONE2	5	Pacific sanddab	Liver	Silver	0.086	mg/kg	0.057
ZONE2	5	Pacific sanddab	Liver	Tin	0.723	mg/kg	0.24
ZONE2	5	Pacific sanddab	Liver	Total DDT	465.6	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Total PCB	256.6	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Total Solids	56.4	wt%	0.4
ZONE2	5	Pacific sanddab	Liver	Trans Nonachlor	9.7E	ug/kg	
ZONE2	5	Pacific sanddab	Liver	Zinc	28	mg/kg	0.049
ZONE2	6	Pacific sanddab	Liver	Alpha (cis) Chlordane	6.5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Antimony	0.561	mg/kg	0.478
ZONE2	6	Pacific sanddab	Liver	Arsenic	2.6	mg/kg	0.375
ZONE2	6	Pacific sanddab	Liver	Barium	0.043	mg/kg	0.007
ZONE2	6	Pacific sanddab	Liver	Cadmium	5.52	mg/kg	0.029
ZONE2	6	Pacific sanddab	Liver	Chromium	0.273	mg/kg	0.08
ZONE2	6	Pacific sanddab	Liver	Copper	4.91	mg/kg	0.068
ZONE2	6	Pacific sanddab	Liver	Hexachlorobenzene	3.2E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Iron	101	mg/kg	0.096
ZONE2	6	Pacific sanddab	Liver	Lipids	33.2	wt%	0.005
ZONE2	6	Pacific sanddab	Liver	Manganese	0.907	mg/kg	0.007
ZONE2	6	Pacific sanddab	Liver	Mercury	0.063	mg/kg	0.03
ZONE2	6	Pacific sanddab	Liver	o,p-DDE	3.4E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	o,p-DDT	1.2E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	p,p-DDD	7.4E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	p,p-DDE	440	ug/kg	13.3
ZONE2	6	Pacific sanddab	Liver	p,-p-DDMU	12E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	p,p-DDT	7.2E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 101	8.5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 105	5.1E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 110	6.4E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 118	15	ug/kg	13.3
ZONE2	6	Pacific sanddab	Liver	PCB 128	7.1E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 138	30	ug/kg	13.3
ZONE2	6	Pacific sanddab	Liver	PCB 149	6.2E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 151	3.5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 153/168	46	ug/kg	13.3

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	6	Pacific sanddab	Liver	PCB 156	2.2E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 158	2.1E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 170	7.9E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 177	3.3E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 180	23	ug/kg	13.3
ZONE2	6	Pacific sanddab	Liver	PCB 183	6.5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 187	21	ug/kg	13.3
ZONE2	6	Pacific sanddab	Liver	PCB 194	5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 201	6.4E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 206	3.5E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 49	1.8E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 66	2.3E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 70	1.9E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 74	1.3E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	PCB 99	11E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Selenium	1.12	mg/kg	0.06
ZONE2	6	Pacific sanddab	Liver	Silver	0.125	mg/kg	0.057
ZONE2	6	Pacific sanddab	Liver	Tin	0.755	mg/kg	0.24
ZONE2	6	Pacific sanddab	Liver	Total DDT	459.2	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Total PCB	227	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Total Solids	55.1	wt%	0.4
ZONE2	6	Pacific sanddab	Liver	Trans Nonachlor	9E	ug/kg	
ZONE2	6	Pacific sanddab	Liver	Zinc	24.8	mg/kg	0.049
ZONE2	7	Longfin sanddab	Liver	Alpha (cis) Chlordane	18	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	Arsenic	16.7	mg/kg	0.375
ZONE2	7	Longfin sanddab	Liver	Barium	0.043	mg/kg	0.007
ZONE2	7	Longfin sanddab	Liver	Cadmium	2.79	mg/kg	0.029
ZONE2	7	Longfin sanddab	Liver	Chromium	0.228	mg/kg	0.08
ZONE2	7	Longfin sanddab	Liver	Cis Nonachlor	19E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	Copper	8.99	mg/kg	0.068
ZONE2	7	Longfin sanddab	Liver	Gamma (trans) Chlordane	4.9E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	Hexachlorobenzene	3.8E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	Iron	183	mg/kg	0.096
ZONE2	7	Longfin sanddab	Liver	Lipids	42.8	wt%	0.005
ZONE2	7	Longfin sanddab	Liver	Manganese	1.05	mg/kg	0.007
ZONE2	7	Longfin sanddab	Liver	Mercury	0.085	mg/kg	0.03
ZONE2	7	Longfin sanddab	Liver	Mirex	48	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	o,p-DDD	2.8E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	o,p-DDE	28	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	o,p-DDT	6.4E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	p,p-DDD	29	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	p,p-DDE	2090	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	p,-p-DDMU	51	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	p,p-DDT	35	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 101	57	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 105	28	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 110	30	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 118	120	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 123	10E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	7	Longfin sanddab	Liver	PCB 128	49	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 138	250	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 149	65	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 151	14	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 153/168	420	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 156	18	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 158	16	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 167	12E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 170	55	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 177	41	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 180	210	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 183	55	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 187	170	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 189	1.6E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 194	23	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 201	35	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 206	13.3E	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	PCB 49	3.6E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 52	6.7E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 66	9.7E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 70	6.6E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 74	7.7E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 87	9.4E	ug/kg	
ZONE2	7	Longfin sanddab	Liver	PCB 99	63	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	Selenium	3.94	mg/kg	0.06
ZONE2	7	Longfin sanddab	Liver	Silver	0.343	mg/kg	0.057
ZONE2	7	Longfin sanddab	Liver	Tin	0.592	mg/kg	0.24
ZONE2	7	Longfin sanddab	Liver	Total DDT	2191.2	ug/kg	
ZONE2	7	Longfin sanddab	Liver	Total PCB	1799.6	ug/kg	
ZONE2	7	Longfin sanddab	Liver	Total Solids	42.3	wt%	0.4
ZONE2	7	Longfin sanddab	Liver	Trans Nonachlor	65	ug/kg	13.3
ZONE2	7	Longfin sanddab	Liver	Zinc	28	mg/kg	0.049
ZONE2	8	Longfin sanddab	Liver	Alpha (cis) Chlordane	4.8E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	Arsenic	9.6	mg/kg	0.375
ZONE2	8	Longfin sanddab	Liver	Barium	0.036	mg/kg	0.007
ZONE2	8	Longfin sanddab	Liver	Cadmium	2.2	mg/kg	0.029
ZONE2	8	Longfin sanddab	Liver	Chromium	0.231	mg/kg	0.08
ZONE2	8	Longfin sanddab	Liver	Copper	4.32	mg/kg	0.068
ZONE2	8	Longfin sanddab	Liver	Hexachlorobenzene	2.4E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	Iron	165	mg/kg	0.096
ZONE2	8	Longfin sanddab	Liver	Lipids	22	wt%	0.005
ZONE2	8	Longfin sanddab	Liver	Manganese	0.84	mg/kg	0.007
ZONE2	8	Longfin sanddab	Liver	Mercury	0.053	mg/kg	0.03
ZONE2	8	Longfin sanddab	Liver	o,p-DDD	1.6E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	o,p-DDE	14	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	o,p-DDT	1.5E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	p,p-DDD	10E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	p,p-DDE	720	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	p,-p-DDMU	12E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	8	Longfin sanddab	Liver	p,p-DDT	7.4E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 101	12E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 105	11E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 110	17	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 118	40	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 123	4.3E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 128	16	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 138	68	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 149	13E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 151	10E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 153/168	110	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 156	7.4E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 157	1.8E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 158	5.8E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 170	16	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 177	10E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 180	56	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 183	15	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 187	46	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 194	10E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 201	14	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	PCB 206	5.9E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 49	2.1E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 66	6E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 70	1.9E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 74	2.9E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	PCB 99	25	ug/kg	13.3
ZONE2	8	Longfin sanddab	Liver	Selenium	4.37	mg/kg	0.06
ZONE2	8	Longfin sanddab	Liver	Silver	0.156	mg/kg	0.057
ZONE2	8	Longfin sanddab	Liver	Tin	0.611	mg/kg	0.24
ZONE2	8	Longfin sanddab	Liver	Total DDT	754.5	ug/kg	
ZONE2	8	Longfin sanddab	Liver	Total PCB	527.1	ug/kg	
ZONE2	8	Longfin sanddab	Liver	Total Solids	46.4	wt%	0.4
ZONE2	8	Longfin sanddab	Liver	Trans Nonachlor	9.5E	ug/kg	
ZONE2	8	Longfin sanddab	Liver	Zinc	21.4	mg/kg	0.049
ZONE2	9	Longfin sanddab	Liver	Alpha (cis) Chlordane	4.05E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	Arsenic	8.19	mg/kg	0.375
ZONE2	9	Longfin sanddab	Liver	Barium	0.052	mg/kg	0.007
ZONE2	9	Longfin sanddab	Liver	Cadmium	1.88	mg/kg	0.029
ZONE2	9	Longfin sanddab	Liver	Chromium	0.267	mg/kg	0.08
ZONE2	9	Longfin sanddab	Liver	Copper	6.37	mg/kg	0.068
ZONE2	9	Longfin sanddab	Liver	Hexachlorobenzene	1.95E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	Iron	159	mg/kg	0.096
ZONE2	9	Longfin sanddab	Liver	Lipids	18.4	wt%	0.005
ZONE2	9	Longfin sanddab	Liver	Manganese	0.858	mg/kg	0.007
ZONE2	9	Longfin sanddab	Liver	Mercury	0.054	mg/kg	0.03
ZONE2	9	Longfin sanddab	Liver	o,p-DDD	0.9E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	o,p-DDE	9.25E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	p,p-DDD	7.1E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE2	9	Longfin sanddab	Liver	p,p-DDE	705	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	p,-p-DDMU	7.35E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	p,p-DDT	6.4E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 101	7.7E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 105	9.9E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 110	10.5E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 118	33.5	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 123	3.15E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 128	14.5	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 138	66.5	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 149	9.25E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 151	8.35E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 153/168	105	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 156	6.65E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 158	4.6E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 167	3.65E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 170	18.5	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 177	9.25E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 180	58	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 183	16.5	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 187	49	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 194	12.5E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 201	14	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	PCB 206	6.2E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 66	4.2E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 70	1.35E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 74	2.45E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 87	1.65E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	PCB 99	22	ug/kg	13.3
ZONE2	9	Longfin sanddab	Liver	Selenium	3.48	mg/kg	0.06
ZONE2	9	Longfin sanddab	Liver	Silver	0.259	mg/kg	0.057
ZONE2	9	Longfin sanddab	Liver	Tin	0.777	mg/kg	0.24
ZONE2	9	Longfin sanddab	Liver	Total DDT	728.65	ug/kg	
ZONE2	9	Longfin sanddab	Liver	Total PCB	498.85	ug/kg	
ZONE2	9	Longfin sanddab	Liver	Total Solids	46.2	wt%	0.4
ZONE2	9	Longfin sanddab	Liver	Trans Nonachlor	12E	ug/kg	
ZONE2	9	Longfin sanddab	Liver	Zinc	23	mg/kg	0.049
ZONE3	1	Pacific sanddab	Liver	Alpha (cis) Chlordane	5.75E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	Arsenic	1.63	mg/kg	0.375
ZONE3	1	Pacific sanddab	Liver	Barium	0.047	mg/kg	0.007
ZONE3	1	Pacific sanddab	Liver	Cadmium	5.51	mg/kg	0.029
ZONE3	1	Pacific sanddab	Liver	Chromium	0.211	mg/kg	0.08
ZONE3	1	Pacific sanddab	Liver	Copper	4.13	mg/kg	0.068
ZONE3	1	Pacific sanddab	Liver	Hexachlorobenzene	4.4E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	Iron	88.2	mg/kg	0.096
ZONE3	1	Pacific sanddab	Liver	Lipids	45.7	wt%	0.005
ZONE3	1	Pacific sanddab	Liver	Manganese	1.16	mg/kg	0.007
ZONE3	1	Pacific sanddab	Liver	Mercury	0.056	mg/kg	0.03
ZONE3	1	Pacific sanddab	Liver	o,p-DDE	3.4E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	1	Pacific sanddab	Liver	o,p-DDT	1.8E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	p,p-DDD	10E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	p,p-DDE	435	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	p,-p-DDMU	13E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	p,p-DDT	9.45E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 101	19.5	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 105	10.5E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 110	16	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 118	39	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 123	3.65E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 128	11E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 138	53	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 149	8.45E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 151	6.75E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 153/168	84.5	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 156	6E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 158	5.2E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 167	3E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 170	10.5E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 177	4.9E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 180	37.5	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 183	9.45E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 187	29.5	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	PCB 194	6.75E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 201	6.7E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 206	4.35E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 49	3.05E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 52	6E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 66	3.6E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 70	3.35E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 74	2.7E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 87	5.2E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	PCB 99	23	ug/kg	13.3
ZONE3	1	Pacific sanddab	Liver	Selenium	0.736	mg/kg	0.06
ZONE3	1	Pacific sanddab	Liver	Silver	0.061	mg/kg	0.057
ZONE3	1	Pacific sanddab	Liver	Tin	0.655	mg/kg	0.24
ZONE3	1	Pacific sanddab	Liver	Total DDT	459.65	ug/kg	
ZONE3	1	Pacific sanddab	Liver	Total PCB	423.1	ug/kg	
ZONE3	1	Pacific sanddab	Liver	Total Solids	56.5	wt%	0.4
ZONE3	1	Pacific sanddab	Liver	Trans Nonachlor	7.1E	ug/kg	
ZONE3	1	Pacific sanddab	Liver	Zinc	22.4	mg/kg	0.049
ZONE3	2	Pacific sanddab	Liver	Alpha (cis) Chlordane	6.9E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	Arsenic	1.92	mg/kg	0.375
ZONE3	2	Pacific sanddab	Liver	Barium	0.044	mg/kg	0.007
ZONE3	2	Pacific sanddab	Liver	Cadmium	6.67	mg/kg	0.029
ZONE3	2	Pacific sanddab	Liver	Chromium	0.223	mg/kg	0.08
ZONE3	2	Pacific sanddab	Liver	Cis Nonachlor	5.5E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	Copper	4.57	mg/kg	0.068
ZONE3	2	Pacific sanddab	Liver	Hexachlorobenzene	4.1E	ug/kg	

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	2	Pacific sanddab	Liver	Iron	74.9	mg/kg	0.096
ZONE3	2	Pacific sanddab	Liver	Lipids	39.5	wt%	0.005
ZONE3	2	Pacific sanddab	Liver	Manganese	1.14	mg/kg	0.007
ZONE3	2	Pacific sanddab	Liver	Mercury	0.097	mg/kg	0.03
ZONE3	2	Pacific sanddab	Liver	o,p-DDE	8.7E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	o,p-DDT	3.6E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	p,p-DDD	12E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	p,p-DDE	1780	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	p,-p-DDMU	19	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	p,p-DDT	11E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 101	29	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 105	14	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 110	24	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 118	47	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 123	4.7E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 128	20	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 138	95	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 149	17	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 151	14	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 153/168	140	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 156	6.1E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 158	5.8E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 167	3.6E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 170	17	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 177	10E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 180	71	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 183	14	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 187	58	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 194	10E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 201	15	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	PCB 206	3.4E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 44	2.1E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 49	4.3E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 52	9.7E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 66	5E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 70	5.5E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 74	3.2E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 87	8E	ug/kg	
ZONE3	2	Pacific sanddab	Liver	PCB 99	39	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	Selenium	1.05	mg/kg	0.06
ZONE3	2	Pacific sanddab	Liver	Silver	0.076	mg/kg	0.057
ZONE3	2	Pacific sanddab	Liver	Tin	0.663	mg/kg	0.24
ZONE3	2	Pacific sanddab	Liver	Total DDT	1815.3	ug/kg	
ZONE3	2	Pacific sanddab	Liver	Total PCB	695.4	ug/kg	
ZONE3	2	Pacific sanddab	Liver	Total Solids	53.8	wt%	0.4
ZONE3	2	Pacific sanddab	Liver	Trans Nonachlor	21	ug/kg	13.3
ZONE3	2	Pacific sanddab	Liver	Zinc	27.8	mg/kg	0.049
ZONE3	3	Pacific sanddab	Liver	Alpha (cis) Chlordane	6E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	Arsenic	1.29	mg/kg	0.375

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	3	Pacific sanddab	Liver	Barium	0.042	mg/kg	0.007
ZONE3	3	Pacific sanddab	Liver	Cadmium	5.95	mg/kg	0.029
ZONE3	3	Pacific sanddab	Liver	Chromium	0.234	mg/kg	0.08
ZONE3	3	Pacific sanddab	Liver	Cis Nonachlor	4.3E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	Copper	3.23	mg/kg	0.068
ZONE3	3	Pacific sanddab	Liver	Hexachlorobenzene	4E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	Iron	75.3	mg/kg	0.096
ZONE3	3	Pacific sanddab	Liver	Lipids	47.6	wt%	0.005
ZONE3	3	Pacific sanddab	Liver	Manganese	0.992	mg/kg	0.007
ZONE3	3	Pacific sanddab	Liver	Mercury	0.093	mg/kg	0.03
ZONE3	3	Pacific sanddab	Liver	o,p-DDE	2.5E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	o,p-DDT	2.7E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	p,p-DDD	8.3E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	p,p-DDE	370	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	p,-p-DDMU	11E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	p,p-DDT	9.1E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 101	19	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 105	8.2E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 110	13E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 118	35	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 123	3.2E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 128	11E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 138	56	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 149	11E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 151	6.2E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 153/168	93	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 156	5E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 157	1.2E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 158	4.3E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 167	2.6E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 170	12E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 177	4.5E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 180	39	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 183	10E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 187	32	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	PCB 194	7.1E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 201	8.1E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 206	3.8E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 44	1.4E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 49	3.4E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 52	5E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 66	3.8E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 70	3E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 74	2.5E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	PCB 99	24	ug/kg	13.3
ZONE3	3	Pacific sanddab	Liver	Selenium	1.03	mg/kg	0.06
ZONE3	3	Pacific sanddab	Liver	Silver	0.061	mg/kg	0.057
ZONE3	3	Pacific sanddab	Liver	Tin	0.561	mg/kg	0.24
ZONE3	3	Pacific sanddab	Liver	Total DDT	392.6	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	3	Pacific sanddab	Liver	Total PCB	428.3	ug/kg	
ZONE3	3	Pacific sanddab	Liver	Total Solids	55.8	wt%	0.4
ZONE3	3	Pacific sanddab	Liver	Trans Nonachlor	7.2E	ug/kg	
ZONE3	3	Pacific sanddab	Liver	Zinc	23.9	mg/kg	0.049
ZONE3	4	English sole	Liver	Arsenic	7.95	mg/kg	0.375
ZONE3	4	English sole	Liver	Barium	0.031	mg/kg	0.007
ZONE3	4	English sole	Liver	Cadmium	0.605	mg/kg	0.029
ZONE3	4	English sole	Liver	Chromium	0.216	mg/kg	0.08
ZONE3	4	English sole	Liver	Copper	0.897	mg/kg	0.068
ZONE3	4	English sole	Liver	Hexachlorobenzene	0.9E	ug/kg	
ZONE3	4	English sole	Liver	Iron	119	mg/kg	0.096
ZONE3	4	English sole	Liver	Lead	0.698	mg/kg	0.3
ZONE3	4	English sole	Liver	Lipids	14.4	wt%	0.005
ZONE3	4	English sole	Liver	Manganese	0.988	mg/kg	0.007
ZONE3	4	English sole	Liver	Mercury	0.062	mg/kg	0.03
ZONE3	4	English sole	Liver	o,p-DDD	1.4E	ug/kg	
ZONE3	4	English sole	Liver	o,p-DDE	3.1E	ug/kg	
ZONE3	4	English sole	Liver	p,p-DDD	6.1E	ug/kg	
ZONE3	4	English sole	Liver	p,p-DDE	160	ug/kg	13.3
ZONE3	4	English sole	Liver	p,-p-DDMU	4.3E	ug/kg	
ZONE3	4	English sole	Liver	PCB 101	11E	ug/kg	
ZONE3	4	English sole	Liver	PCB 105	4.2E	ug/kg	
ZONE3	4	English sole	Liver	PCB 110	9.6E	ug/kg	
ZONE3	4	English sole	Liver	PCB 118	14	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 128	6.1E	ug/kg	
ZONE3	4	English sole	Liver	PCB 138	24	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 149	14	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 151	3.4E	ug/kg	
ZONE3	4	English sole	Liver	PCB 153/168	37	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 156	3E	ug/kg	
ZONE3	4	English sole	Liver	PCB 158	2.3E	ug/kg	
ZONE3	4	English sole	Liver	PCB 167	1.7E	ug/kg	
ZONE3	4	English sole	Liver	PCB 170	6.2E	ug/kg	
ZONE3	4	English sole	Liver	PCB 177	5.9E	ug/kg	
ZONE3	4	English sole	Liver	PCB 180	23	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 183	6.2E	ug/kg	
ZONE3	4	English sole	Liver	PCB 187	21	ug/kg	13.3
ZONE3	4	English sole	Liver	PCB 194	6.6E	ug/kg	
ZONE3	4	English sole	Liver	PCB 201	6E	ug/kg	
ZONE3	4	English sole	Liver	PCB 206	4.9E	ug/kg	
ZONE3	4	English sole	Liver	PCB 44	0.8E	ug/kg	
ZONE3	4	English sole	Liver	PCB 49	2.7E	ug/kg	
ZONE3	4	English sole	Liver	PCB 66	2.5E	ug/kg	
ZONE3	4	English sole	Liver	PCB 70	2.1E	ug/kg	
ZONE3	4	English sole	Liver	PCB 74	1.1E	ug/kg	
ZONE3	4	English sole	Liver	PCB 87	3.2E	ug/kg	
ZONE3	4	English sole	Liver	PCB 99	9.3E	ug/kg	
ZONE3	4	English sole	Liver	Selenium	2.94	mg/kg	0.06
ZONE3	4	English sole	Liver	Silver	0.076	mg/kg	0.057

Appendix D.3 *continued*
Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	4	English sole	Liver	Tin	0.419	mg/kg	0.24
ZONE3	4	English sole	Liver	Total DDT	170.6	ug/kg	
ZONE3	4	English sole	Liver	Total PCB	231.8	ug/kg	
ZONE3	4	English sole	Liver	Total Solids	32.9	wt%	0.4
ZONE3	4	English sole	Liver	Zinc	44.2	mg/kg	0.049
ZONE3	5	English sole	Liver	Arsenic	6.1	mg/kg	0.375
ZONE3	5	English sole	Liver	Barium	0.03	mg/kg	0.007
ZONE3	5	English sole	Liver	Cadmium	0.681	mg/kg	0.029
ZONE3	5	English sole	Liver	Chromium	0.172	mg/kg	0.08
ZONE3	5	English sole	Liver	Copper	3.51	mg/kg	0.068
ZONE3	5	English sole	Liver	Hexachlorobenzene	1.6E	ug/kg	
ZONE3	5	English sole	Liver	Iron	116	mg/kg	0.096
ZONE3	5	English sole	Liver	Lead	0.921	mg/kg	0.3
ZONE3	5	English sole	Liver	Lipids	5.23	wt%	0.005
ZONE3	5	English sole	Liver	Manganese	1.13	mg/kg	0.007
ZONE3	5	English sole	Liver	Mercury	0.047	mg/kg	0.03
ZONE3	5	English sole	Liver	p,p-DDE	47	ug/kg	13.3
ZONE3	5	English sole	Liver	PCB 101	6E	ug/kg	
ZONE3	5	English sole	Liver	PCB 105	2.2E	ug/kg	
ZONE3	5	English sole	Liver	PCB 110	4.5E	ug/kg	
ZONE3	5	English sole	Liver	PCB 118	6.6E	ug/kg	
ZONE3	5	English sole	Liver	PCB 138	9.6E	ug/kg	
ZONE3	5	English sole	Liver	PCB 149	5.6E	ug/kg	
ZONE3	5	English sole	Liver	PCB 153/168	13E	ug/kg	
ZONE3	5	English sole	Liver	PCB 180	5.1E	ug/kg	
ZONE3	5	English sole	Liver	PCB 187	7.5E	ug/kg	
ZONE3	5	English sole	Liver	PCB 206	1.5E	ug/kg	
ZONE3	5	English sole	Liver	PCB 66	1.3E	ug/kg	
ZONE3	5	English sole	Liver	PCB 70	1.1E	ug/kg	
ZONE3	5	English sole	Liver	PCB 99	4.3E	ug/kg	
ZONE3	5	English sole	Liver	Selenium	3.21	mg/kg	0.06
ZONE3	5	English sole	Liver	Silver	0.127	mg/kg	0.057
ZONE3	5	English sole	Liver	Total DDT	47	ug/kg	
ZONE3	5	English sole	Liver	Total PCB	68.3	ug/kg	
ZONE3	5	English sole	Liver	Total Solids	23.2	wt%	0.4
ZONE3	5	English sole	Liver	Zinc	32.9	mg/kg	0.049
ZONE3	6	Longfin sanddab	Liver	Alpha (cis) Chlordane	5.1E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	Antimony	0.543	mg/kg	0.478
ZONE3	6	Longfin sanddab	Liver	Arsenic	13.4	mg/kg	0.375
ZONE3	6	Longfin sanddab	Liver	Barium	0.04	mg/kg	0.007
ZONE3	6	Longfin sanddab	Liver	Cadmium	3.93	mg/kg	0.029
ZONE3	6	Longfin sanddab	Liver	Chromium	0.3	mg/kg	0.08
ZONE3	6	Longfin sanddab	Liver	Copper	9.41	mg/kg	0.068
ZONE3	6	Longfin sanddab	Liver	Hexachlorobenzene	2.5E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	Iron	166	mg/kg	0.096
ZONE3	6	Longfin sanddab	Liver	Lipids	27.1	wt%	0.005
ZONE3	6	Longfin sanddab	Liver	Manganese	1.03	mg/kg	0.007
ZONE3	6	Longfin sanddab	Liver	Mercury	0.111	mg/kg	0.03
ZONE3	6	Longfin sanddab	Liver	o,p-DDD	1.3E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE3	6	Longfin sanddab	Liver	o,p-DDE	9.3E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	o,p-DDT	1.6E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	p,p-DDD	8.9E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	p,p-DDE	660	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	p,-p-DDMU	11E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	p,p-DDT	7.9E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 101	42	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 105	31	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 110	48	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 114	1.8E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 118	120	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 123	11E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 128	36	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 138	160	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 149	25	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 151	20	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 153/168	230	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 156	18	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 157	3.3E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 158	15	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 167	8.4E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 170	26	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 177	14	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 180	94	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 183	25	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 187	76	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 194	15	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 201	19	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 206	8.9E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 49	7.1E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 52	18	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 66	14	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	PCB 70	4.9E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 74	6.7E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 87	9.2E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	PCB 99	78	ug/kg	13.3
ZONE3	6	Longfin sanddab	Liver	Selenium	3.73	mg/kg	0.06
ZONE3	6	Longfin sanddab	Liver	Silver	0.265	mg/kg	0.057
ZONE3	6	Longfin sanddab	Liver	Tin	0.652	mg/kg	0.24
ZONE3	6	Longfin sanddab	Liver	Total DDT	689	ug/kg	
ZONE3	6	Longfin sanddab	Liver	Total PCB	1185.3	ug/kg	
ZONE3	6	Longfin sanddab	Liver	Total Solids	40.3	wt%	0.4
ZONE3	6	Longfin sanddab	Liver	Trans Nonachlor	8.2E	ug/kg	
ZONE3	6	Longfin sanddab	Liver	Zinc	26	mg/kg	0.049
ZONE4	1	Pacific sanddab	Liver	Alpha (cis) Chlordane	2.9E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Aluminum	2.25	mg/kg	0.583
ZONE4	1	Pacific sanddab	Liver	Arsenic	1.83	mg/kg	0.375
ZONE4	1	Pacific sanddab	Liver	Barium	0.039	mg/kg	0.007
ZONE4	1	Pacific sanddab	Liver	Cadmium	4.14	mg/kg	0.029

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE4	1	Pacific sanddab	Liver	Chromium	0.282	mg/kg	0.08
ZONE4	1	Pacific sanddab	Liver	Copper	3.53	mg/kg	0.068
ZONE4	1	Pacific sanddab	Liver	Hexachlorobenzene	2.4E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Iron	45.4	mg/kg	0.096
ZONE4	1	Pacific sanddab	Liver	Lipids	33.3	wt%	0.005
ZONE4	1	Pacific sanddab	Liver	Manganese	0.832	mg/kg	0.007
ZONE4	1	Pacific sanddab	Liver	Mercury	0.048	mg/kg	0.03
ZONE4	1	Pacific sanddab	Liver	p,p-DDD	2.7E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	p,p-DDE	160	ug/kg	13.3
ZONE4	1	Pacific sanddab	Liver	p,-p-DDMU	5.5E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	p,p-DDT	4.1E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 101	4.5E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 105	2E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 118	6.9E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 128	2E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 138	10E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 153/168	16	ug/kg	13.3
ZONE4	1	Pacific sanddab	Liver	PCB 180	7.5E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 183	1.9E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 187	6.7E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 194	1.3E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 206	0.7E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 66	0.8E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 70	1.3E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 74	0.7E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	PCB 99	4.1E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Selenium	0.786	mg/kg	0.06
ZONE4	1	Pacific sanddab	Liver	Tin	0.318	mg/kg	0.24
ZONE4	1	Pacific sanddab	Liver	Total DDT	166.8	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Total PCB	66.4	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Total Solids	49.6	wt%	0.4
ZONE4	1	Pacific sanddab	Liver	Trans Nonachlor	5.8E	ug/kg	
ZONE4	1	Pacific sanddab	Liver	Zinc	20.4	mg/kg	0.049
ZONE4	2	Pacific sanddab	Liver	Alpha (cis) Chlordane	4.8E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Aluminum	4.14	mg/kg	0.583
ZONE4	2	Pacific sanddab	Liver	Antimony	1.02	mg/kg	0.478
ZONE4	2	Pacific sanddab	Liver	Arsenic	1.56	mg/kg	0.375
ZONE4	2	Pacific sanddab	Liver	Barium	0.059	mg/kg	0.007
ZONE4	2	Pacific sanddab	Liver	Cadmium	9.92	mg/kg	0.029
ZONE4	2	Pacific sanddab	Liver	Chromium	0.403	mg/kg	0.08
ZONE4	2	Pacific sanddab	Liver	Copper	4.56	mg/kg	0.068
ZONE4	2	Pacific sanddab	Liver	Hexachlorobenzene	3.4E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Iron	52.9	mg/kg	0.096
ZONE4	2	Pacific sanddab	Liver	Lipids	41.5	wt%	0.005
ZONE4	2	Pacific sanddab	Liver	Manganese	0.993	mg/kg	0.007
ZONE4	2	Pacific sanddab	Liver	Mercury	0.087	mg/kg	0.03
ZONE4	2	Pacific sanddab	Liver	o,p-DDE	1.7E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	o,p-DDT	1.9E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	p,p-DDD	4.1E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE4	2	Pacific sanddab	Liver	p,p-DDE	300	ug/kg	13.3
ZONE4	2	Pacific sanddab	Liver	p,-p-DDMU	16	ug/kg	13.3
ZONE4	2	Pacific sanddab	Liver	p,p-DDT	8.5E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 101	6.3E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 105	3.2E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 110	5.9E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 118	11E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 128	3.6E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 138	17	ug/kg	13.3
ZONE4	2	Pacific sanddab	Liver	PCB 153/168	25	ug/kg	13.3
ZONE4	2	Pacific sanddab	Liver	PCB 180	10E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 183	3E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 187	10E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 194	1.9E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 206	1.6E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 49	1.2E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 66	1.6E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 70	1.8E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 74	0.9E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	PCB 99	6.7E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Selenium	1.12	mg/kg	0.06
ZONE4	2	Pacific sanddab	Liver	Silver	0.082	mg/kg	0.057
ZONE4	2	Pacific sanddab	Liver	Tin	0.971	mg/kg	0.24
ZONE4	2	Pacific sanddab	Liver	Total DDT	316.2	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Total PCB	110.7	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Total Solids	49.8	wt%	0.4
ZONE4	2	Pacific sanddab	Liver	Trans Nonachlor	5.2E	ug/kg	
ZONE4	2	Pacific sanddab	Liver	Zinc	28.2	mg/kg	0.049
ZONE4	3	Pacific sanddab	Liver	Alpha (cis) Chlordane	6.7E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	Aluminum	3.68	mg/kg	0.583
ZONE4	3	Pacific sanddab	Liver	Arsenic	2.14	mg/kg	0.375
ZONE4	3	Pacific sanddab	Liver	Barium	0.049	mg/kg	0.007
ZONE4	3	Pacific sanddab	Liver	Cadmium	10.1	mg/kg	0.029
ZONE4	3	Pacific sanddab	Liver	Chromium	0.326	mg/kg	0.08
ZONE4	3	Pacific sanddab	Liver	Copper	4.07	mg/kg	0.068
ZONE4	3	Pacific sanddab	Liver	Hexachlorobenzene	4.2E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	Iron	73.6	mg/kg	0.096
ZONE4	3	Pacific sanddab	Liver	Lipids	47.9	wt%	0.005
ZONE4	3	Pacific sanddab	Liver	Manganese	0.764	mg/kg	0.007
ZONE4	3	Pacific sanddab	Liver	Mercury	0.102	mg/kg	0.03
ZONE4	3	Pacific sanddab	Liver	o,p-DDE	2.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	o,p-DDT	1.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	p,p-DDD	6E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	p,p-DDE	350	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	p,-p-DDMU	13E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	p,p-DDT	8.7E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 101	11E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 105	8.9E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 110	13E	ug/kg	

Appendix D.3 *continued*

Summary of detected parameters in each PLOO station sampled during October 2004.

Station/Zone	Rep	Species	Tissue	Parameter	Value	Units	MDL
ZONE4	3	Pacific sanddab	Liver	PCB 118	28	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	PCB 128	8.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 138	40	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	PCB 149	6.5E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 151	5.3E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 153/168	52	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	PCB 156	5E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 158	3.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 167	1.9E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 170	7.1E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 177	3.5E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 180	21	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	PCB 183	5.5E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 187	17	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	PCB 194	3.1E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 201	3.9E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 206	1.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 49	2.1E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 66	2.3E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 70	2.2E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 74	1.6E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 87	3.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	PCB 99	14	ug/kg	13.3
ZONE4	3	Pacific sanddab	Liver	Selenium	0.82	mg/kg	0.06
ZONE4	3	Pacific sanddab	Liver	Silver	0.057	mg/kg	0.057
ZONE4	3	Pacific sanddab	Liver	Tin	0.734	mg/kg	0.24
ZONE4	3	Pacific sanddab	Liver	Total DDT	369.3	ug/kg	
ZONE4	3	Pacific sanddab	Liver	Total PCB	273.1	ug/kg	
ZONE4	3	Pacific sanddab	Liver	Total Solids	59.2	wt%	0.4
ZONE4	3	Pacific sanddab	Liver	Trans Nonachlor	8.8E	ug/kg	
ZONE4	3	Pacific sanddab	Liver	Zinc	23.7	mg/kg	0.049

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