GOLETA SANITARY DISTRICT

NPDES Monitoring and Reporting Program

2017 Annual Report

Quarterly and Annual Receiving Water Monitoring
Conducted by
Aquatic Bioassay and Consulting Laboratories, Inc.
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Submitted March 26, 2018

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Robert Hidalgo

Robert Hidalgo
Operations Manager
Goleta Sanitary District

Date: March 26, 2018

CHAPTER 1

INTRODUCTION

The Goleta Sanitary District (GSD) treatment plant operated under Clean Water Act Section 301(h) which waives secondary treatment requirements. On November 19, 2004 the California Regional Water Quality Control Board, Central Coast Region (RWQCB), adopted Waste Discharge Requirements (WDR) Order R3-2004-0129 and the United States Environmental Protection Agency (EPA), Region IX issued NPDES permit CA 0048150 to the Goleta Sanitary District (GSD). A settlement agreement was made a part of the NPDES 301(h) waiver permit issued in 2004. The settlement agreement required GSD to upgrade its wastewater treatment plant to full secondary treatment by November of 2014.

As required by waste discharge requirements GSD submitted an NPDES permit renewal application to the RWQCB and the EPA in March 2015. Although GSD continued to operate the wastewater treatment facility under the 301(h) waiver provision of the Clean Water Act, the final full secondary tie-in of the newly built structures to the existing plant was completed on May 15 to 16, 2013. The treatment plant operated under WDR Order No. R3-2010-0012 and NPDES Permit No. CA0048160 which became effective September 2010 until November 10, 2017 when WDR Order No. R3-2017-0021 went into effect. January through December 2017 the plant was operating utilizing the full secondary process.

As a condition of the prior NPDES permit, GSD was required to conduct an extensive monitoring and reporting program to assess compliance with limitations established by the California Ocean Plan and the federal Clean Water Act. Under conditions set forth in the prior permit, GSD was required to monitor the influent, effluent, biosolids (sludge), the outfall and diffuser, receiving water, bottom sediment, and biology to demonstrate that the discharge of wastewater did not cause adverse impacts on the ocean environment.

The Goleta wastewater treatment plant (WWTP) is located in an unincorporated coastal area of Santa Barbara County, California. Treated wastewater is discharged to the Pacific Ocean approximately one mile offshore of Goleta Beach County Park via a south-trending ocean outfall. The outfall lies within and extends outside of a small embayment formed by Goleta Point directly to the west.

The Goleta WWTP treats wastewater from the service areas of the Goleta Sanitary District (GSD), the Goleta West Sanitary District, the University of California at Santa Barbara, the Santa Barbara Municipal Airport, and certain Santa Barbara County facilities. Existing agreements among the agencies establish GSD as the owner of the joint wastewater treatment facilities and assign the responsibility of operation and maintenance of the facilities to GSD. However, each agency "owns" an "indeterminate, perpetual and exclusive capacity right" in the facilities and an "easement right of flow through" the facilities.

WASTEWATER TREATMENT PROCESS

The following discussion focuses on the principal features of GSD's full secondary process of wastewater and sludge treatment. The performance capacities and characteristics of the treatment plant are detailed in Chapter 2.

Treatment Plant Facilities

The Goleta Sanitary District Wastewater Treatment Plant is located at One William Moffett Place, in an unincorporated area of Santa Barbara County, CA. The plant site is approximately 10 miles west of the City of Santa Barbara, near the Pacific Coast. A regional view of the study area is shown in Figure 1-1.

On average, over the past 10 years, 2008 to 2017, the plant has discharged about 3.7 million gallons per day (MGD) of treated effluent to the open coastal waters of the Santa Barbara Channel via an ocean outfall. The treatment plant is currently discharging municipal wastewater in accordance with NPDES permit CA 0048160. The treatment plant's discharge meets the state water quality standards as set forth in the Water Quality Control Plan for Ocean Waters of California (California Ocean plan) and the federal Clean Water Act.

Facilities Description

The Goleta wastewater treatment plant underwent it's first substantial upgrade completed in June 1988. The upgraded plant was designed to assure compliance with monthly 30-day average discharge limitations of 63 mg/L for suspended solids and 98 mg/L for BOD under an average dry weather flow 9.0 MGD. The facility utilized a split-stream process of physical and biological treatment until December of 2013. The current biological treatment is provided by two trickling filters and an aeration basin to achieve full secondary treatment. The following sections describe the treatment process.

Collection System

Over 190 miles of pipelines collect wastewater that flows almost entirely by gravity to pump stations located in each agency's service area. These stations pump the flow to the treatment facility.

Pump Station and Headworks

Influent from the collection system of each agency is pumped to the treatment plant headworks where raw wastewater flows through two bar screens with ¼ inch screen spacing, which removes large debris. Influent is then routed to aerated grit tanks where sand and grit are allowed to settle out and pumped to screening washer/compactor units. This debris and grit is then transported via truck to a local landfill. Air collected from the influent pump stations and headworks is scrubbed in a biological odor reduction tower.

Primary Sedimentation

Wastewater then flows into one of three circular primary sedimentation basins (primary clarifiers) where solids settling to the bottom and floatable materials rising to the surface are mechanically collected and pumped to digesters.

Secondary Treatment

Secondary treatment involves three treatment elements: the biofilters, an aeration basin, and secondary sedimentation tanks. In the biofilter, primary effluent trickles over plastic media where bacteria feed on organic wastes, thus removing these wastes from the water. Effluent from the trickling filter flows to an aeration basin where air is injected and the effluent is mixed with recirculated sludge from the secondary sedimentation basins. The resulting biological action coagulates these fine particles and the organic solids settle out as sludge in two secondary sedimentation tanks. The waste activated sludge (WAS) is pumped to two mechanical thickeners and then is pumped to the three anaerobic digesters. A portion of the secondary process flow can be diverted to the reclamation facilities for tertiary treatment with gravity filters.

Chlorine Contact Channel

The secondary effluent flows to the head of the chlorine contact channel where sodium hypochlorite is injected to kill bacteria in the effluent. Prior to discharge into the ocean, sodium bisulfite is added for dechlorination, thus completing the disinfection process.

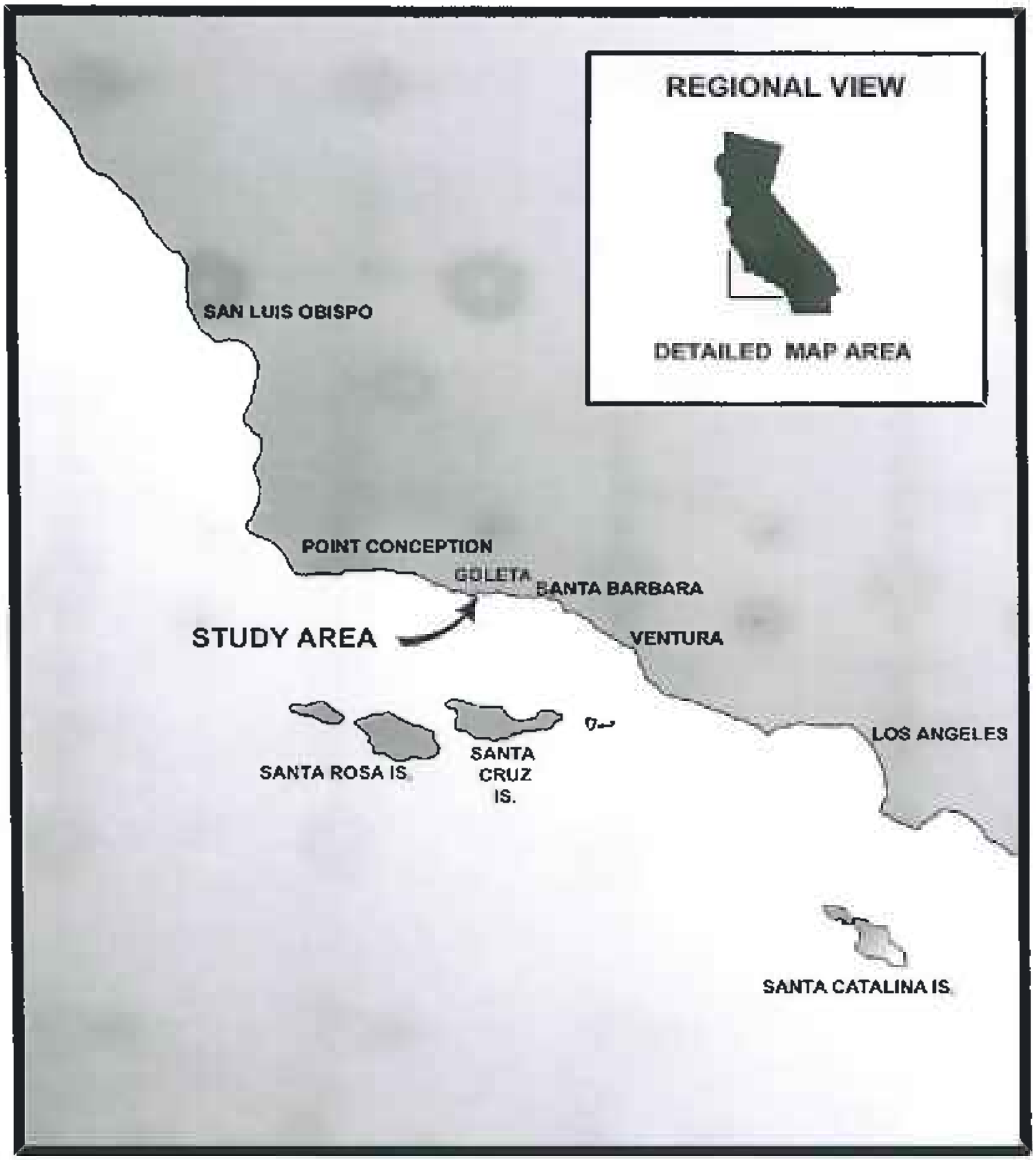
Sludge Treatment and Biosolids Disposal

Settleable solids and floatable materials from the primary clarifiers are treated in three heated anaerobic sludge digesters for at least 15 days. Anaerobic digestion decomposes organic material and produces digester gas composed primarily of methane. This digester gas fuels boilers used to heat sludge in the digesters. Sludge from the digesters then flows to one of two stabilization basins where it settles and bacteria can continue the organic decomposition. Stabilized sludge is dredged from the bottom of these basins and is dewatered by two screw presses. The digested supernatant from the three anaerobic digesters can also be diverted from the stabilization basins directly to the two screw presses for dewatering.

A small portion of the sludge is air dried in the sludge drying beds and converted into Class A biosolids, for use by the local community. The screw pressed biosolids, identified as Class B, were transported by Western Express Inc. to Liberty Composting Inc. located at 12421 Holloway Road, Lost Hills, CA 93249. The administrative office for Western Express Inc., is located at 1533 E. Shields Ave., Suite F, Fresno, CA 93607. Copies of the agreement with Liberty Composting and the agreement with Western Express are available upon request.

A complete biosolids report describing the treatment and disposal process is prepared each year and submitted to the EPA. The deadline for submittal of this report is Februay 19th of each year.

Figure 1-1. Regional View of the Goleta Valley



Reclamation Facilities

On September 13, 1991, the California Regional Water Quality Control Board, Central Coast Region approved Order No. 91-03 that permits the Goleta Sanitary District to produce up to 3.0 MGD of reclaimed water. The reclaimed water produced at the Goleta Sanitary District is distributed by the Goleta Water District for use within their service area. Reclaimed water is used for landscape irrigation and for incidental uses including construction dust control and compaction, and to flush toilets within several buildings located in Goleta. The Goleta Water District is regulated by separate water reclamation requirements.

Secondary effluent enters the reclamation facilities where a flash mixer disperses aluminum sulfate (alum) and polymer into the water. The flocculated suspension is then filtered through a bed of anthracite coal where the floc is removed. The filtered water then flows to a chlorine contact tank where sodium hypochlorite is added for disinfection. The highly chlorinated treated water then flows to a 3 million-gallon underground storage tank where it is stored until needed. Reclaimed water is distributed throughout the Goleta Valley by a distribution system operated and maintained by the Goleta Water District.

An annual report describing the reclamation treatment process, operational parameters, water quality, and production rates is prepared and sumbitted to the RWQCB by January 31st.

Ocean Outfall

The treated secondary effluent is discharged to the ocean through an outfall pipe that extends 5800 feet offshore and terminates at a depth of approximately 92 feet below Mean Lower Low Water (MLLW) level. At the pipe terminus, a multi-port diffuser with 36, four inch diameter ports mixes one part of effluent with approximately 122 parts of seawater (Tetra Tech, Inc. 1993) to achieve a high initial wastewater dilution.

Staff

Mr. Steve Wagner, P.E., currently serves as GSD's General Manager and District Engineer. The General Manager is responsible for overall operation and performance of the treatment plant.

Eleven state certified treatment plant operators operate the wastewater treatment plant under the direction of Mr. Robert Hidalgo, the District Operations Manager. Mr. Hidalgo also supervises the treatment plant's industrial waste staff. Mr. Chuck Smolnikar, supervises the maintenance staff and the laboratory is under the direction of Ms. Lena Cox, the Laboratory Manager. The grade and certification number of operations, maintenance, industrial waste control, and laboratory personnel employed during the 2017 operational year are shown in Table 1-1.

Table 1-1. Goleta Sanitary District Operation Staff, 2017

Staff	Grade	California Certification No.
Operators		
Robert Hidalgo	V	6905
Todd Frederick	V	27633
John Crisman	V	28857
Stephen Conklin	III	7065
Ricardo Lopez	III	10756
Francisco M. Lemus	III	10893
Pete Regis	III	28277
Jes Hulbert	I	28266
Morgan Lea	I	28400
River Ferrara	I	28488
Justin Graves	I	43450
Lab Analysts		
Lena Cox	IV	90334003
Jacob Broad	II	1308213493
Robert Hidalgo	I	741
Teresa Kistner	I	99076111
Todd Frederick	I	60731013
River Ferrara	I	1308214257
John Crisman	I	1308214787
Maintenance Technologist		
Carl Easter	III	1308213756
Alejandro Bautista	II	1308213795
Robert Hidalgo	I	1087
Electrical / Instrumentation		
Charles Smolnikar	II	60172004
Dept. of Industrial Relations – Electrician		
Charles Smolnikar	NA	107709
Mike Sullivan	NA	139336
Ramon Garza	NA	160174
Environmental Compliance		
Teresa Kistner	II	3014202
Biosolids Land Application Management		
Lena Cox	I	70711001

Monitoring and Reporting Program

The Goleta Sanitary District's monitoring and reporting program was conducted in accordance with the requirements of the NPDES permit CA0048160. The objectives of the monitoring program and this report are to:

- Document short- and long-term effects of discharge on receiving waters, sediment, biota, and beneficial uses of the receiving waters.
- Determine compliance with NPDES permit terms and conditions.
- Document training and certification of wastewater treatment facility operators.
- Assess treatment plant performance and the effectiveness of industrial pretreatment and toxics control programs.
- Evaluate the monitoring and reporting program and make recommendations for improving the program.

The receiving water monitoring program consists of assessing water quality and ocean sediment chemistry, evaluating community structures of benthic biota, bottom fish, and epibenthic macroinvertebrates, and determining the bioaccumulation of pollutants in various marine organisms. Table 1-2 summarizes the sampling schedule for various elements of the monitoring and reporting program conducted during 2017.

Table 1-2. Schedule for NPDES Monitoring, Goleta Sanitary District, 2017

Monitoring Program Component	Frequency	Schedule
Standard Wastewater Parameters	Daily - Weekly	As Specified
Influent and Effluent Metals	Monthly	Every Month except Dec
Acute Toxicity	Quarterly	Jan, April, July, and Oct
Chronic Toxicity	Quarterly	Jan, April, July, and Oct
Influent and Effluent Priority Pollutants	Annually	October
Surf-Zone Bacteria	Weekly	Every Month until 11/10/17
Receiving Water Bacteria	Quarterly	Jan, April, July, and Oct
Ocean Water Quality	Quarterly	Jan, April, July, and Oct
Benthic Sediments	Annually	October
Benthic Biota	Annually	October
Fish Trawls	Annually	October
Outfall Inspection	Annually	October
Bioaccumulation	Annually	October

Influent, effluent, and receiving water monitoring is conducted in accordance with U.S. Environmental Protection Agency approved test procedures as stipulated under Title 40 of the Code of Federal Regulations, Section 136 (40 CFR 136): *Guidelines establishing test procedures for the analysis of pollutants.* Water quality analyses for compliance monitoring are performed by analytical laboratories certified by the California Environmental Laboratory Accrediation Program. Bioassay testing is conducted in accordance with guidelines approved by the State Water Resources Control Board and the EPA.

In order to comply with a request from the Central Coast RWQCB in a letter dated June 27, 2008 the District is no longer submitting hard copies of NPDES reports to the RWQCB. All documents are converted into a searchable PDF format and are submitted electronically.

REPORT ORGANIZATION

This report summarizes data collected during the 2017 monitoring and reporting program, and analyzes this data to determine compliance with the discharge permit terms and conditions. Chapters in this report have been organized to parallel sections of the monitoring and reporting program. The chapter sequence also follows the flow of wastewater as it undergoes treatment in the plant, as it is discharged to the marine receiving waters, and as it encounters nearby sediments and resident biota. Chapter 10 presents a summary of the lift station and collection system overflows, the causes of the overflows, the corrective actions taken, and any corrective actions planned. Chapter presentation is as follows:

Chapter 1	Introduction
Chapter 2	Treatment Plant Performance
Chapter 3	Receiving Water Environment
Chapter 4	Physical Characteristics of Benthic Sediments
Chapter 5	Chemical Characteristics of Benthic Sediments
Chapter 6	Biological Characteristics of Benthic Sediments
Chapter 7	Fish Populations
Chapter 8	Chemical Characteristics of Fish and Mussel Tissue
Chapter 9	Outfall Dive Survey
Chapter 10	Collection System Summary
	Appendices

CHAPTER 2

TREATMENT PLANT PERFORMANCE

The performance of a wastewater treatment plant is measured by its ability to reduce influent contaminants to levels acceptable for discharge to the environment. Federal and state authorities mandate these levels of treatment in order to protect the marine environment. Proper operation of the Goleta Sanitary District's wastewater treatment plant is assured through the monitoring of several effluent parameters such as flow, total suspended solids, biochemical oxygen demand, residual chlorine, hydrogen-ion concentration (pH), turbidity, ammonia, settleable solids, oil and grease, and toxicity concentration. Metals, pesticides, and other priority pollutants are also analyzed to aid in determining the impact the wastewater discharge has on receiving waters, evaluating compliance with discharge permit limitations, and monitoring the effectiveness of the industrial pretreatment and toxic control program.

WASTEWATER CHARACTERIZATION

Goleta Sanitary District's NPDES monitoring program requires measurement of many parameters at frequencies ranging from continuous to once per year. During 2017, influent, effluent, biosolids (sludge), and surf zone samples were collected by treatment plant personnel, and analyzed by the Goleta Sanitary District wastewater treatment plant laboratory and various contract laboratories such as: Aquatic Bioassay Laboratories for ocean monitoring, Aquatic Testing Laboratories (ATL) for acute and chronic toxicity, FGL Environmental Laboratories and Vista Analytical Laboratory, Weck Laboratories as subcontractors to FGL. Treatment plant personnel monitored and analyzed wastewater for performance-evaluating parameters including wastewater flow, suspended solids, biochemical oxygen demand (BOD), pH, turbidity, settleable solids, ammonia, oil and grease, temperature, residual chlorine, coliform and enterococcus bacteria. Monthly analyses for influent and effluent metals were performed by FGL Environmental Laboratories of Santa Paula, CA. FGL Environmental Laboratories, and their certified subcontract laboratories performed annual analysis of priority pollutants and other parameters in influent, effluent, and biosolids samples. Influent and effluent samples were also analyzed for radioactivity. Bioassay tests for acute and chronic toxicity concentration were performed quarterly by Aquatic Testing Laboratory.

Analytical methodologies used by Goleta Sanitary District Laboratory and other contract laboratories used by GSD are based on approved U.S. Environmental Protection Agency (EPA) methods (EPA 1983; Federal Register 1984) and other methods in *Standard Methods for the Examination of Water and Wastewater, 21st ed.* (Standard Methods 2005). All methodologies employed during 2017 were approved for NPDES monitoring programs. Quality assurance and quality control procedures followed those presented in *Standard Methods for the Examination of Water and Wastewater, 21st edition.*

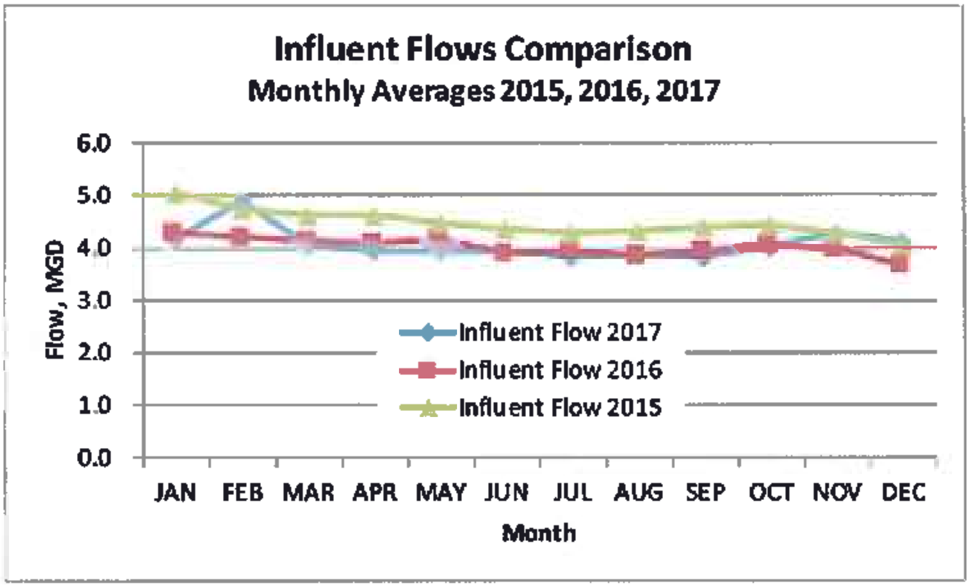
Results of the wastewater chemical analyses used to monitor proper operation of the treatment plant during 2017, and the respective discharge permit limitations, are presented in Tables 2-1 and Table 2-2. All monthly averaged data presented in these tables are calculated from daily values at the treatment plant, with the exception of removal efficiencies, which are calculated from the monthly averages of the respective influent and effluent parameters.

Influent Flow

The daily influent flow into the treatment plant was monitored continuously throughout 2017. Influent flow without the internal plant recirculated flow, averaged 4.1 million gallons per day (MGD) which is a 2% increase compared to the average of 4.0 MGD that was treated in 2016.

Overall, the average monthly influent flows for 2017 varied throughout the year, fluctuating from a low of 3.8 MGD in July to a high of 4.9 MGD in February. The decrease in average influent flow observed at the plant is likely due to water conservation implemented by residents in response to the drought conditions. See Figure 2-1 for a visual flow comparison.

Figure 2-1. Influent Flows Monthly Average Comparison for 2015, 2016 and 2017



The highest flows into the plant during 2017 occurred during the beginning of the year, and may be associated with heavy rains that occurred in February.

Since 2001 the Goleta West Sanitary District and Goleta Sanitary District have maintained an aggressive collection system rehabilitation program. Numerous sections of the collection system in both Districts have been relined or replaced to correct structural deficiencies while significantly reducing the inflow and infiltration (I&I) problems. However, even with the reduction of I&I the amount of rainfall during the year can affect the total amount of influent flow measured. The District's storm water pollution prevention plan requires all storm water collected from process areas to be treated before disposal. After several dry years the low ground water table and dry creeks can reduce the potential for ground water intrusion into the collection systems.

Effluent Flow

The effluent flow from the treatment plant was monitored continuously during 2017 and averaged 3.15 MGD for the year. The difference between the influent and effluent flow is due to the production of reclaimed water, which is not discharged into the ocean but is distributed throughout the community for landscape irrigation and other uses.

Figure 2-2. Influent and Effluent Flows 2017 Monthly Averages

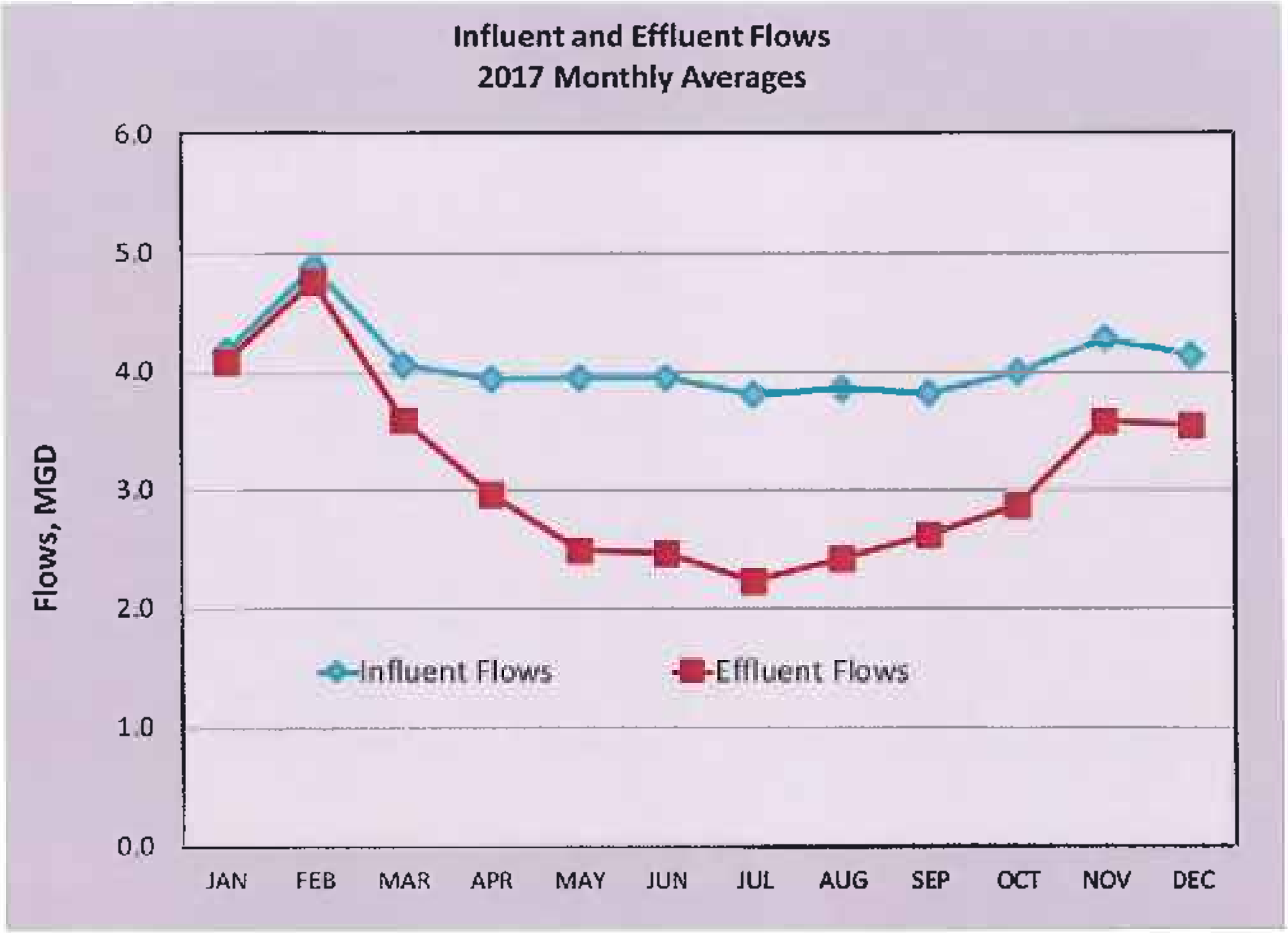


Figure 2-2 shows the monthly average influent and effluent flows for 2017. Higher wastewater effluent flow generally occurs during the winter months when influent flow is also the highest and recycling is minimal. The most important factor contributing to fluctuations in the effluent flow is the amount of wastewater that is processed into reclaimed water and used for irrigation. The lowest effluent flow occurred during July when the amount of flow discharged to the Pacific Ocean dropped to 2.2 MGD as depicted in Figure 2-2. The temporal variations in the monthly average effluent flow seen in 2017 fluctuated from a low of 2.24 MGD in July, when the daily production of reclaimed water was the highest production month of the year and averaged 1.57 MGD for the month to a high of 4.77 MGD during February when the reclaimed facility was on line for two days out of the month and a total of 3.0 million gallons were filtered. There was also significant rainfall during February with approximately 7.97 inches of rain. Figure 2-2 is a time history of the influent and effluent flows and Table 2-1 shows the actual monthly flow average values.

Table 2-1. Monthly Averages Flow, Suspended Solids and BOD, Goleta Sanitary District, 2017.

	Flow		Total Suspended Solids				Biochemical Oxygen Demand			
Month	Influent MGD	Effluent MGD	Influent mg/L	Effluent mg/L	Removal (%)	Mass Emission (lbs/day)	Influent mg/L	Effluent mg/L	Removal (%)	Mass Emission (lbs/day)
Jan	4.18	4.1	336	9.1	97.3	316	323	7.6	97.6	267
Feb	4.89	4.8	341	7.0	97.9	280	335	7.0	97.8	281
Mar	4.06	3.6	358	8.9	97.5	270	362	7.3	98.0	214
Apr	3.94	3.0	403	8.0	98.0	196	385	7.7	98.0	184
May	3.96	2.5	382	7.7	97.9	158	369	9.4	97.4	190
Jun	3.96	2.5	368	7.3	98.0	147	342	8.1	97.6	164
Jul	3.81	2.2	356	5.8	98.3	112	338	9.0	97.3	172
Aug	3.86	2.4	331	3.9	98.8	79	321	8.7	97.2	177
Sep	3.82	2.6	332	5.6	98.3	124	315	8.4	97.3	183
Oct	4.01	2.9	340	5.6	98.3	136	366	8.4	97.7	200
Nov	4.28	3.6	359	4.5	98.7	138	388	6.0	98.5	179
Dec	4.14	3.6	368	5.3	98.5	158	376	5.5	98.5	162
Average	4.08	3.2	356	6.6	98.1	176	352	7.8	97.7	198
Limit*	NL	7.64	NL	63	75	4010	NL	98	30	6240
Limit **	NL	7.64	NL	30	85	1912	NL	30	85	1912

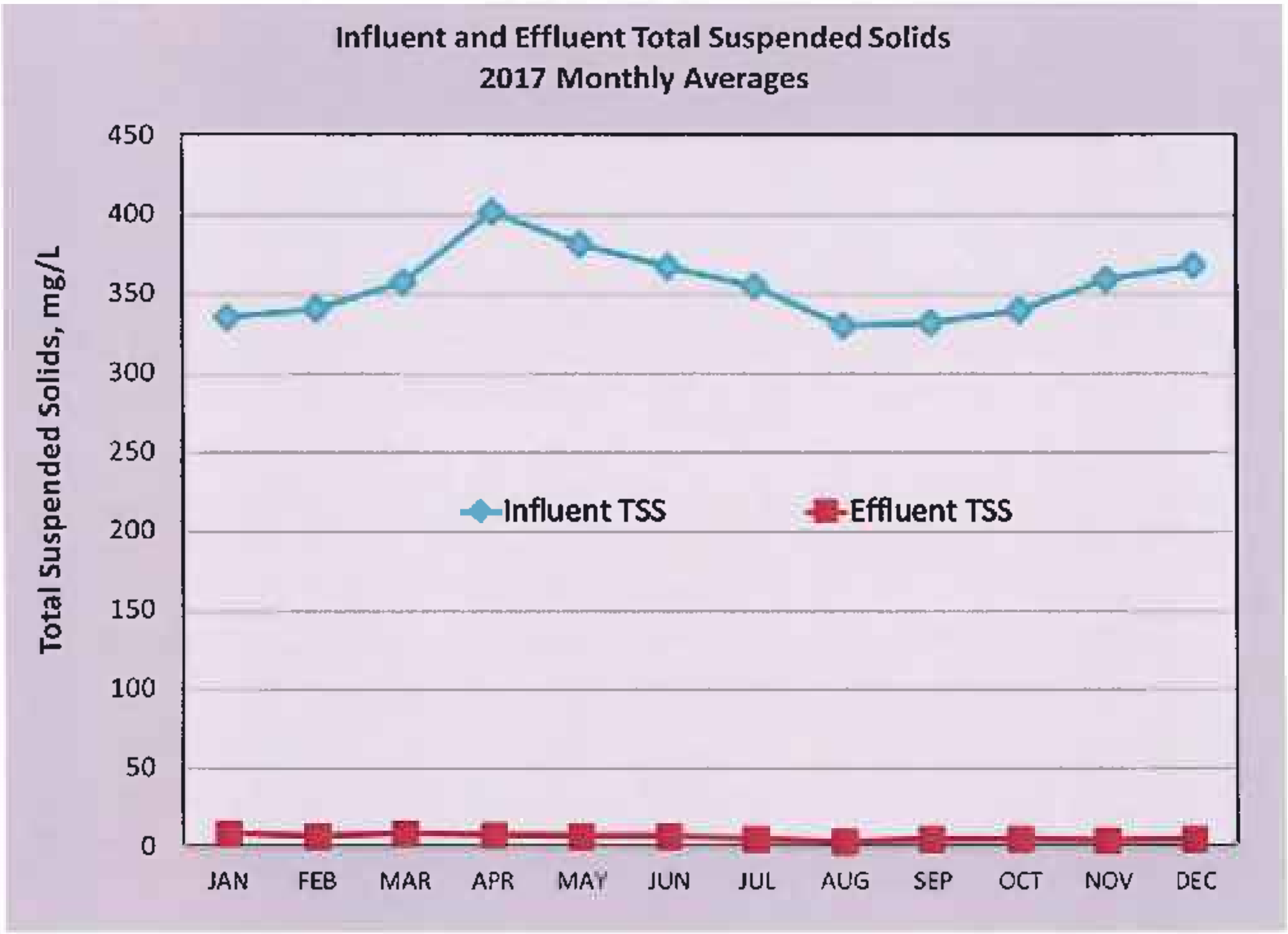
* Order No. R3-2010-0012 Limits ** Order No. R3-2017-0021 Limits *NL = No Limit*

Suspended Solids

Influent and effluent suspended solids were measured five days per week on 24-hour composite samples. The effectiveness of the treatment plant in removing suspended solids is demonstrated by the variation of influent solids versus the low-level and consistent output of effluent solids (see Figure 2-3). Influent suspended solids concentrations averaged 356 mg/L for the year a decrease of about 9% from the 2016 annual average of 392 mg/L. Figure 2-3 shows a spike in concentration of suspended solids that occurred during April of the year which became relatively constant throughout the remainder of the year. The treatment process reduced the concentration of total suspended solids in the effluent to an annual average of 6.6 mg/L a 3% annual increase of the 6.4 mg/L average of 2016.

All 30-day monthly averages were well below the 63-mg/L monthly average limitation. Overall removal efficiency for the year was an average of 98.1 percent, see Table 2-1.

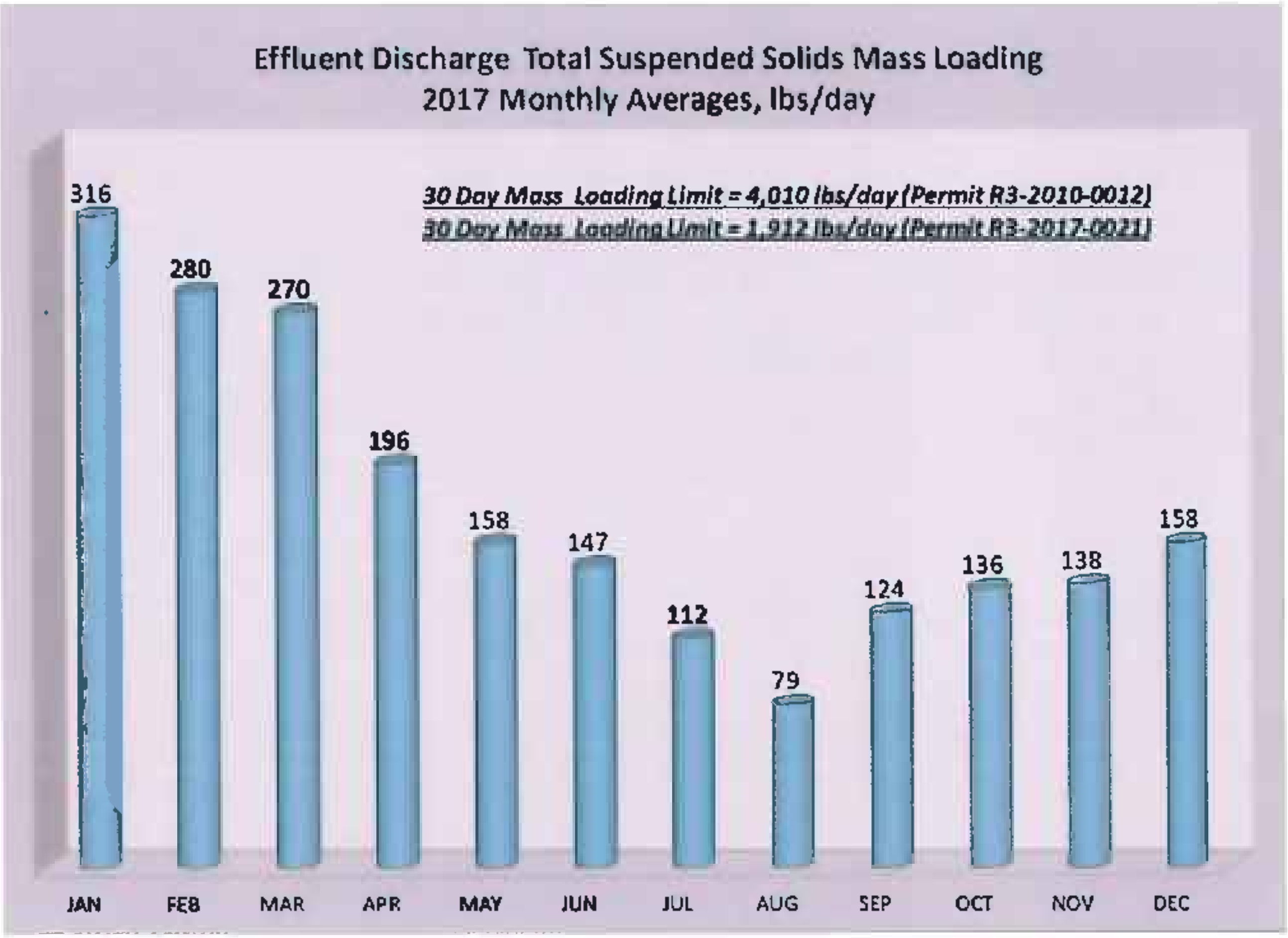
Figure 2-3. Influent and Effluent Total Suspended Solids 2017 Monthly Averages



Average monthly suspended solids mass loading rates for 2017 are represented graphically in Figure 2-4. The mass emission limit is based on average dry weather flow (ADWF) and is a limit applied to dry weather flows (DWF). There is no limit for mass emissions on wet weather flows.

The maximum average monthly mass emission loading for 2017 occurred in January at a high of 316 lbs/day, which is approximately 7.9 percent of the R3-2010-0012 permitted monthly 30-day average limit of 4,010 lbs/day. The maximum reported loading value in 2017 was about 16.5 precent of the current R3-2017-0021 monthly 30-day average limit of 1,912 lbs/day. Loading rates were well below the discharge limits throughout the year.

Figure 2-4. Effluent Discharge Total Suspended Solids Mass **Loading,** 2017 Monthly Averages, lbs/day



Biochemical Oxygen Demand

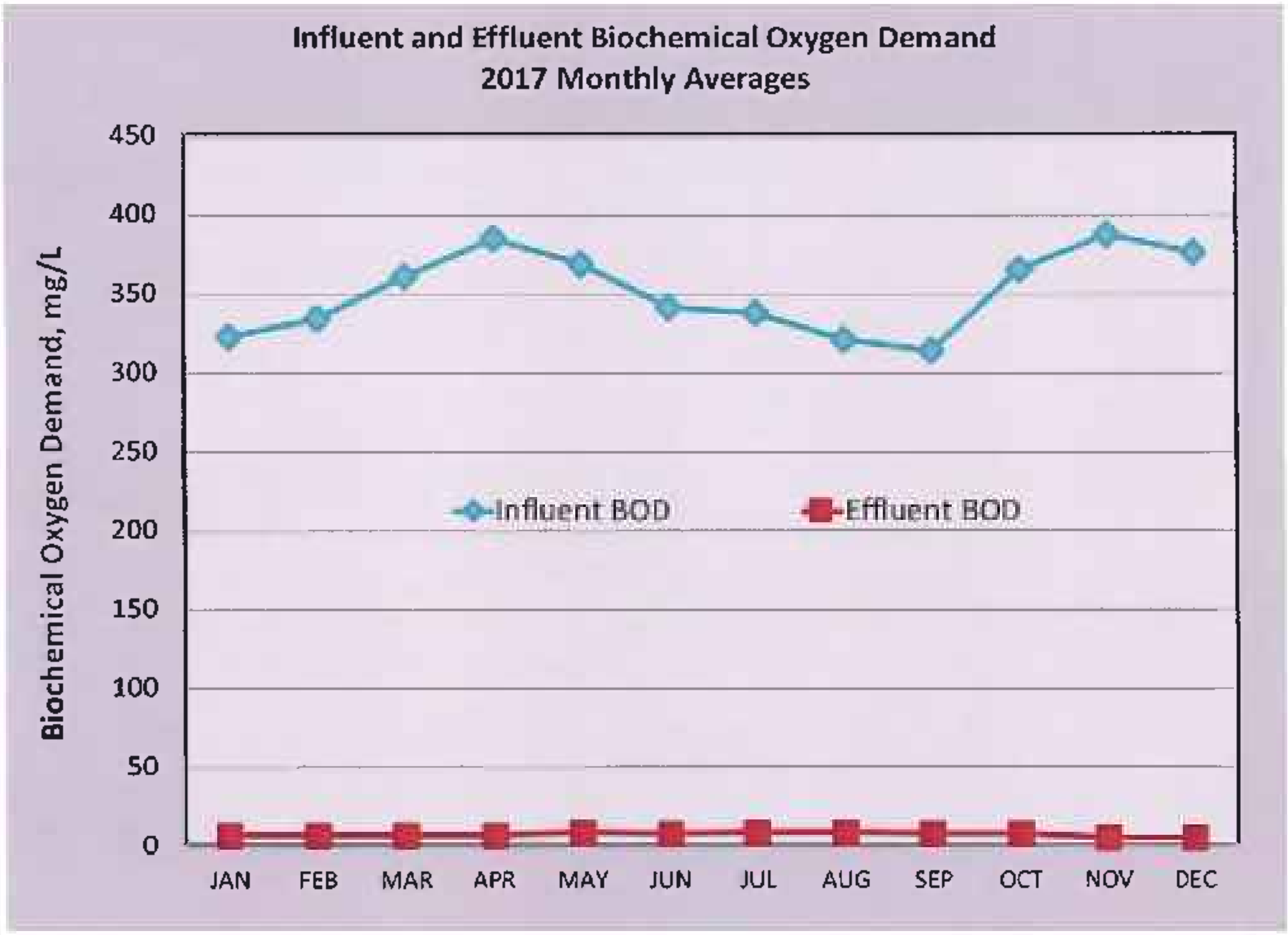
Biochemical oxygen demand (BOD) levels were measured on 24 hour composite samples of the influent and effluent, at least three and five days per week, respectively.

During 2017 influent BOD averaged 352 mg/L showing a decrease of 5.6% from the annual influent average of 373 for 2016. The influent BOD varied throughout the year, ranging from a monthly average low of 315 mg/L in September to a high of 388 mg/L in November.

A small variation in the monthly average final effluent BOD concentration was observed throughout the year with the annual average of 7.8 mg/L and the range extending from a low of 5.5 in December to a high of 9.4 in May, (Table 2-1). The difference between influent and effluent BOD represents an overall removal rate of 97.7 percent.

The NPDES R3-2010-0012 permit effluent BOD monthly average limitation and the maximum at any time limitation are 98 mg/L and 150 mg/L, respectively. The current R3-2017-0021 permit limits have been lowered to a monthly average of 30 mg/L and weekly average of 45 mg/L. All BOD NPDES limitations were achieved throughout the year.

Figure 2-5. Influent and Effluent Biochemical Oxygen Demand 2017 Monthly Averages



In 2017, all effluent BOD mass emission values were below all limitations. The maximum monthly average mass emission was 281 lbs/day for February. The mass emission limit is based on average dry weather flow (ADWF) and is a limit, which is only applied to dry weather flows (DWF). There is no limit for mass emissions on wet weather flows. The mass emissions monthly average limitations in permit R3-2010-0012 were 6,240 lbs/day and the maximum at any time limitation of 9,560 lbs/day. The current mass emissions specified in permit R3-2017-0021 are a monthly average of 1,912 lbs/day and the average weekly limitation of 2,867 lbs/day. None of the permit limits were exceeded during 2017.

Table 2-2. Monthly Averages of Influent and Effluent Parameters, Goleta Sanitary District, 2017

	pH		Turbidity	Settleable Solids	Ammonia	Oil and Grease			Toxicity Acute	Toxicity Chronic
	Influent	Effluent	Effluent	Effluent	Effluent	Influent	Effluent	Mass Emission	Effluent	Effluent
Month	SU	SU	(NTU)	(mL/L/hr)	(mg/L)	(mg/L)	(mg/L)	(lbs/day)	(TUa)	(TUc)
Jan	8.0	7.0	3.2	0.12	<0.32	33.9	<4.0	<31.2	0.0	3.1
Feb	7.9	7.0	2.1	0.10	<0.32	35.8	<4.0	<147.8		
Mar	7.9	6.9	2.7	0.10	<0.32	37.0	<1.8	<54.5		
Apr	7.9	6.7	2.8	0.10	<0.32	33.2	<1.8	<47.7	0.0	3.1
May	7.9	6.9	2.6	0.11	<0.32	31.6	1.9	41.4		
Jun	7.7	6.6	2.6	0.10	<0.32	26.7	<1.8	<37.3		
Jul	7.7	6.6	2.8	0.10	<0.32	21.0	<1.8	<35.6	0.0	3.1
Aug	7.7	6.8	1.8	0.10	<0.32	34.8	<1.8	<35.4		
Sep	7.6	6.6	2.2	0.10	<0.32	31.3	<1.8	<42.1		
Oct	7.7	6.5	2.3	0.10	<0.32	27.4	2.5	65.8	0.0	3.1
Nov	7.7	6.7	2.0	0.10	<0.32	30.2	<1.8	<54.3		
Dec	7.7	6.7	2.3	0.10	NR	NR	2.1	65.0		
Average	7.8	6.8	2.5	0.10	<0.32	31.2	2.0	54.8	0.0	3.1
Limit	NL	6 to 9	75	1.0	74*	NL	25	1590	4.0*	123

*Reduced monitoring and limit removed in R3-2017-0021 permit NR = Not-Required NL = No Limit

Hydrogen-Ion Concentration (pH)

Influent and effluent pH levels were monitored five days per week to ensure that the effluent remained within an acceptable range when discharged into the ocean. Influent pH averaged 7.8 units for the year; effluent pH averaged 6.8 units. The NPDES effluent pH limitations are established as a minimum of 6.0 and a maximum of 9.0 pH units, all pH values were well within these limitations for 2017.

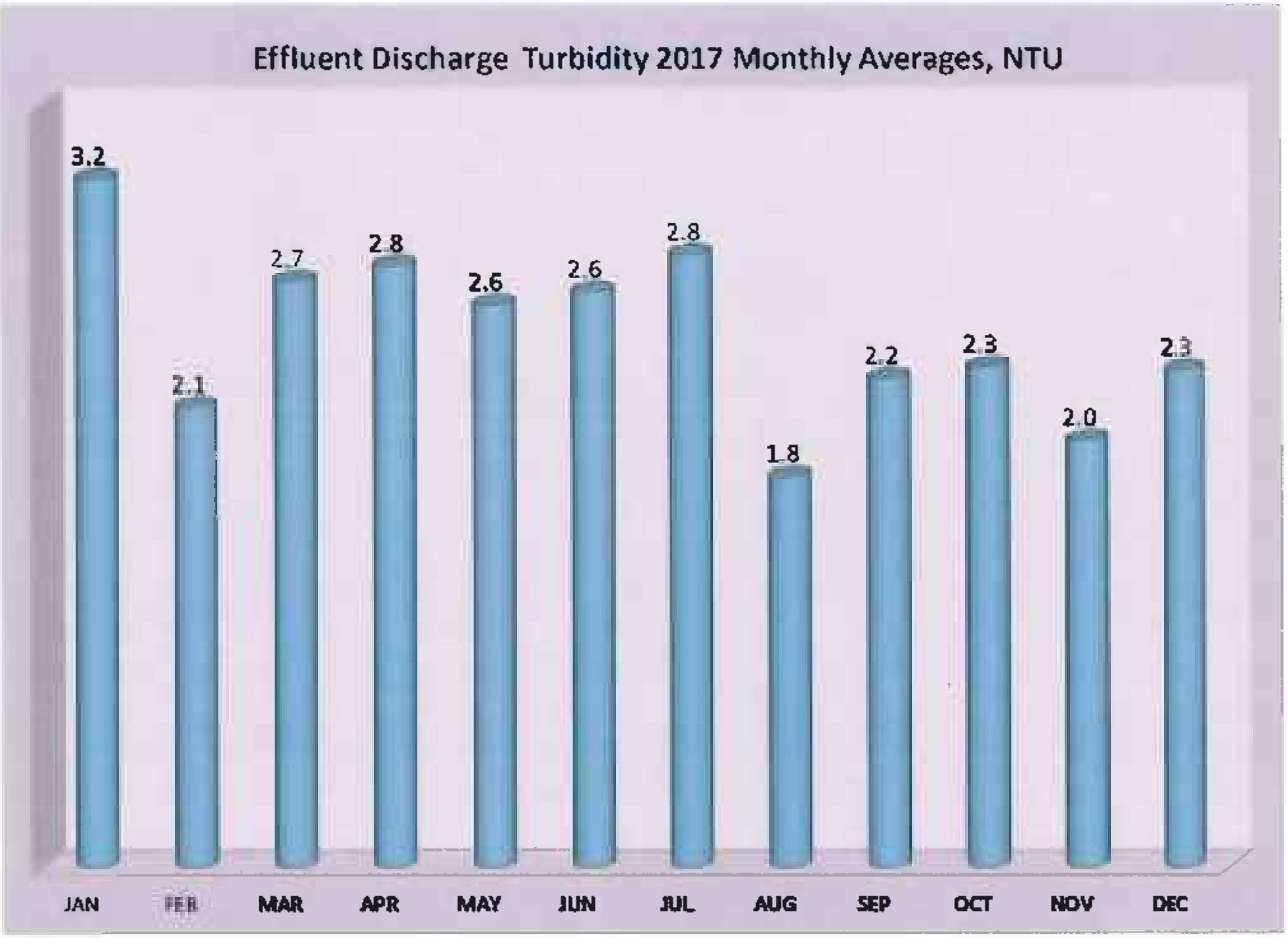
Ammonia

The effluent was monitored monthly during the required testing period, January through November, to determine the concentration of ammonia. The R3-2010-0012 permit specifies six-month median, daily maximum, and instantaneous maximum limitations of 74 mg/L, 300 mg/L, and 740 mg/L, respectively. The current permit, R3-2017-0021, does not include ammonia effluent limits or monthly testing requirements because no reasonable potential was determined for the pollutant during the permit renewal reasonable potential analysis. The monthly measured ammonia concentration was below the lowest calibration standard at 1.0 mg/L throughout the testing timeframe (Table 2-2). The monthly average for the year was below the method detection limit (MDL) of 0.32 mg/L. The values for ammonia were well below all their respective permit limitations.

Turbidity

Effluent turbidity was monitored five days per week. The permit limitations for effluent turbidity consists of a monthly average of 75 Nephelometric Turbidity Units (NTU), a weekly average of 100 NTU, and a maximum at any time limitation of 225 NTU. Effluent turbidity data are shown graphically in Figure 2-6. The maximum value at any time, 7.5 NTU, occurred on January 22 which was still well below the effluent limits. Monthly averages ranged from a low of 1.8 NTU to a high of 3.2 NTU. All values were significantly below their respective permit limitations.

Figure 2-6. Effluent Discharge Turbidity ***2017 Monthly Averages, NTU***



Acute Toxicity Concentration

All quarterly acute toxicity tests were performed on 24-hour composite effluent samples. The acute toxicity has a daily maximum limit of 4.0 acute toxicity units (TU_a). All four quarterly acute toxicity samples for 2017 were collected under the conditions of the NPDES WDR Order No. R3-2010-0012 which requires the District to use Topsmelt as the acute toxicity test species, replacing fathead minnow larvae. The annual average acute toxicity value was 0.0 TUa. (See Table 2-2). All values were below the permit limitation of 4 TUa. The R3-2017-0021 permit removed the monitoring requirement for the acute bioassay. The current permit maintained the chronic bioassay monitoring requirements but changed the effluent limit to a trigger value which is used to determine if a TRE (Toxicity Reduction Evaluation) should be conducted.

Chronic Toxicity Concentration

The effluent was analyzed for chronic toxicity (TU_C) on a quarterly basis in January, April, July, and October. The special testing conducted during 2011 to identify the most sensitive chronic toxicity organism showed that the abalone development test was the most sensitive. All results were well below the daily maximum limitation of 123 TU_C.

Settleable Solids

The effluent was monitored for settleable solids concentrations 5 days per week. The permit specifies that the monthly average, weekly average, and maximum at any time may not exceed 1.0 milliliters/liter/hour (ml/L/hr), 1.5 ml/L/hr, and 3.0 ml/L/hr, respectively. Monthly averages ranged from 0.10 ml/L/hr to 0.12 mL/L/hr. The maximum value at any time was 0.40 mL/L/hr which occurred on the 22nd of January. All values were well below their respective permit limitations.

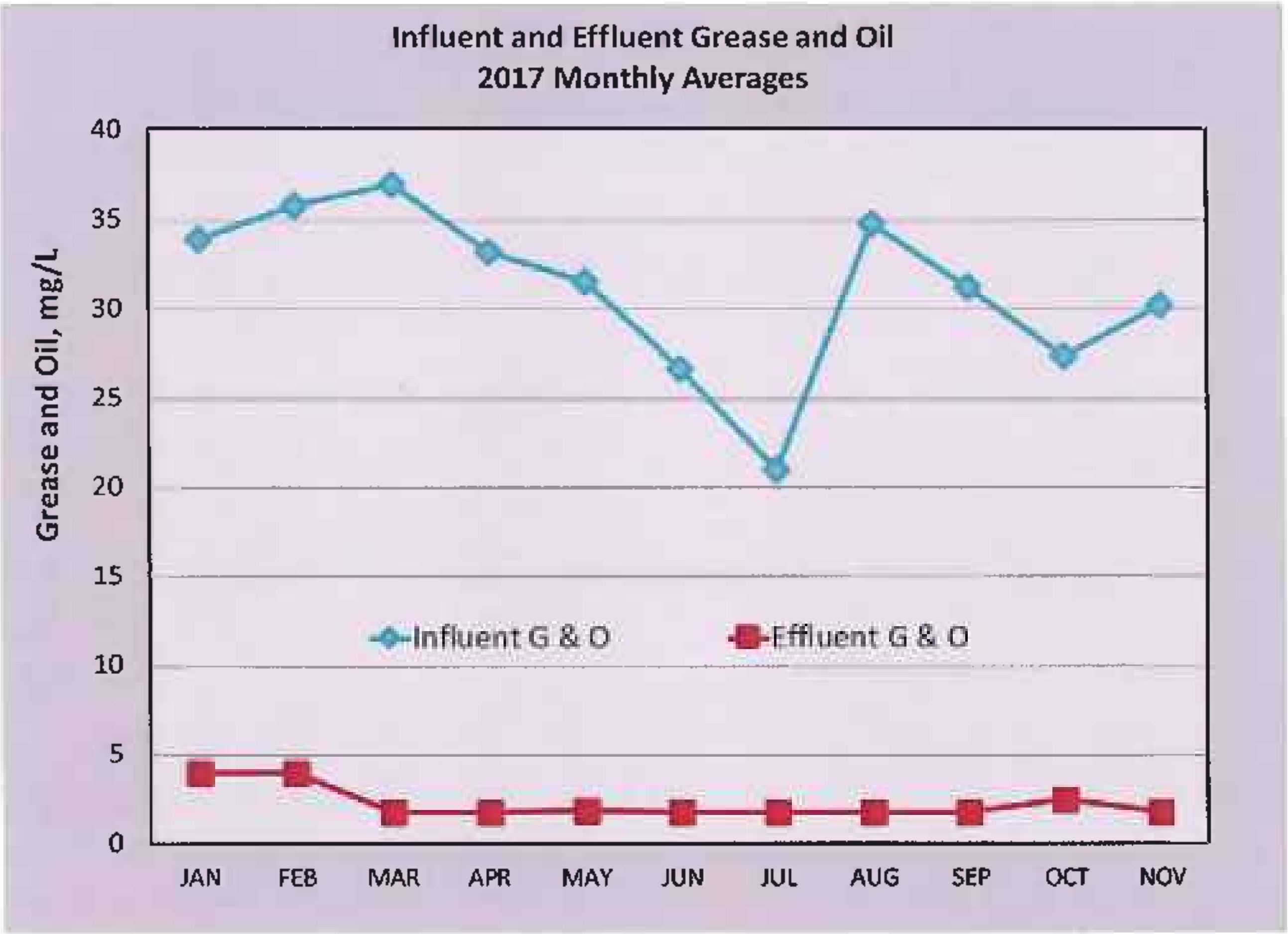
Oil and Grease

Influent and effluent oil and grease were monitored bi-weekly (once every two weeks) and weekly, respectively per the requirements of permit R3-2010-0012. Monthly average results are shown graphically in Figure 2-7. Prior to August 2007 Freon was the solvent used in the standard method to extract oil and greases from water samples. According to EPA regulations, in August 2007 the GSD laboratory ceased using Freon as the extraction solvent and began using hexane as the required solvent. The District continued to use the liquid-liquid extraction method, the only change at this time was the solvent. In December 2010, the GSD laboratory began analyzing for oil and grease using the approved standard solid phase extraction (SPE) method. The current permit, R3-2017-0021, eliminated the influent oil and grease monitoring requirement.

Influent grease and oil results were varied throughout the year. Average monthly concentrations spiked in February and March due to sample results close to 40 mg/L which caused the increase in the monthly average. The influent annual average value of 31.2 mg/L was reduced to an annual average of 2 mg/L in the final effluent resulting in a 93.6 percent annual average removal rate.

Effluent grease and oil concentrations were very consistent during 2017. All monthly, weekly, and maximum permit limits were met. Mass emissions values ranged from a monthly average low of 31.2 lbs/day in January to a high of 148 lbs/day in February. Both are well below the permit limitation of 1,590 lbs/day. Monthly average oil and grease concentrations in the effluent ranged from <4.0 mg/L or <1.8 which is below the method detection limit. The method detection limit changed in March 2017 because a new value was calculated. The high monthly average was in October with a result of 2.5 mg/L. See Table 2-2 for a visual representation of the monthly average results. All permit limitations for effluent oil and grease were met during 2017.

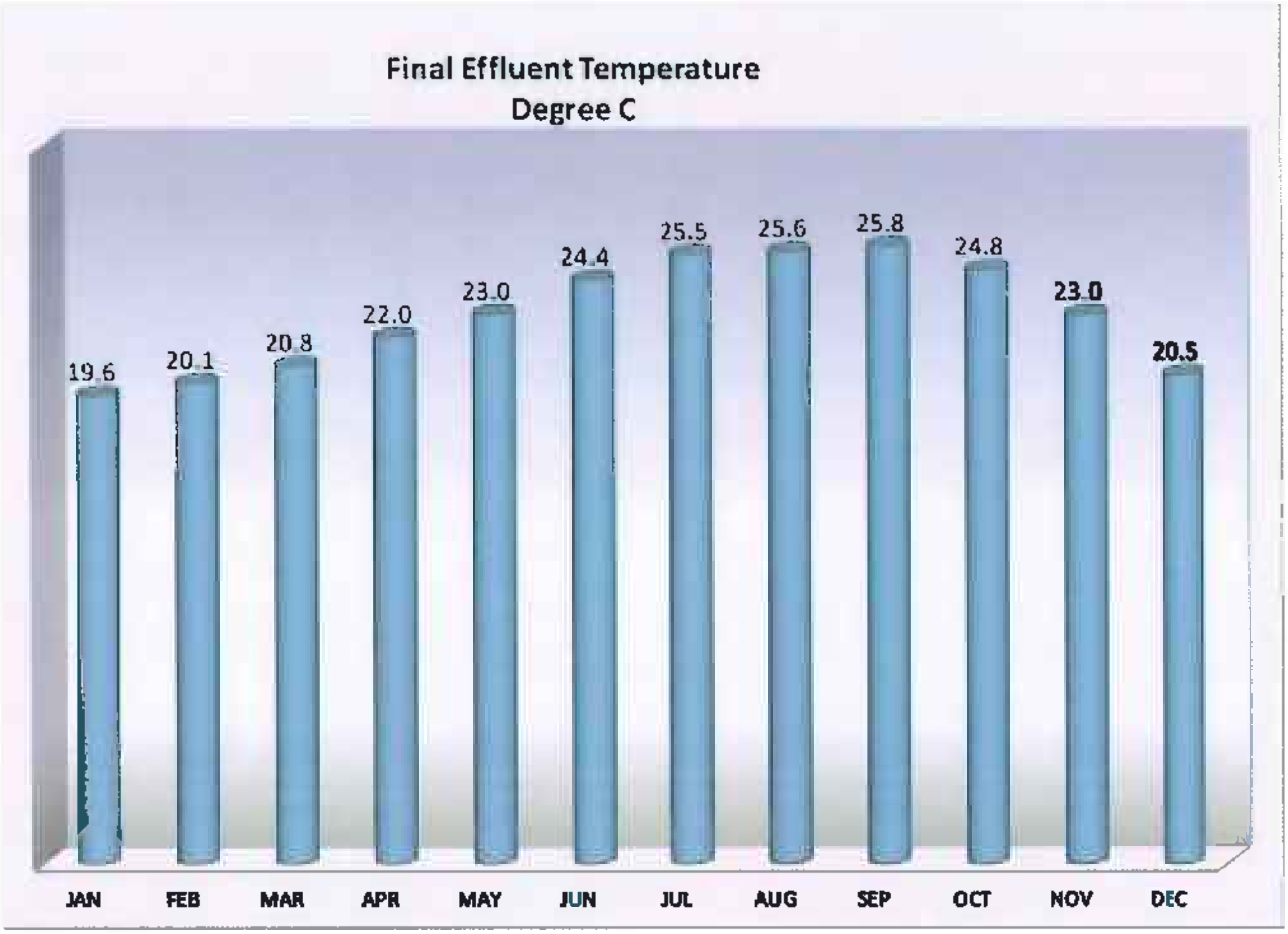
Figure 2-7. Influent and Effluent Grease and Oil 2017 Monthly Averages



Temperature

Effluent temperature was sampled five days per week throughout 2017. The data reflect a typical response to seasonal changes (Figure 2-8). The coolest temperatures occurred during January with average monthly temperatures of 19.6 ° C. A warming trend continued throughout the summer and fall months to reach a monthly averaged high of 25.5 ° C, 25.6 ° C, and 25.8 ° C in July, August and September respectively. As expected, the year ended with a cooling trend during November and December.

Figure 2-8. Effluent Discharge Temperature 2017 Monthly Averages



Wastewater Disinfection

Sodium hypochlorite is used to disinfect the treated wastewater at the Goleta Sanitary District. The sodium hypochlorite is flash mixed into the wastewater at the beginning of the chlorine contact channel. At an average effluent flow rate of 4 MGD, the chlorine is in contact with the wastewater for approximately 2½ hours (145 minutes).

The NPDES permit R3-2010-0012 specifies that the District must maintain a total chlorine residual of at least 5 mg/L at the end of the chlorine contact channel under total suspended solids peak loading conditions. The Goleta Sanitary District maintains its chlorine contact tank to provide maximum chlorination effectiveness at all times. The chlorine residual at the end of the chlorine contact channel averaged 6.6 mg/L during 2017. The average monthly values are reported in Table 2-3. The current R3-2017-0021 permit retained a daily monitoring requirement for this parameter but removed the minimum chlorine residual requirement due to the plant upgrade to a full secondary process.

After the disinfection process is complete, the sodium hypochlorite is neutralized (dechlorinated) by adding sodium bisulfite to the wastewater stream. This process lowers residual chlorine to levels that are environmentally safe, before discharge to the ocean such that the chlorine poses no risk to the receiving water environment. Treatment plant personnel continuously monitor the residual chlorine levels as required by the NPDES permit.

The permit limitations for residual chlorine in the effluent immediately prior to discharge and after dechlorination are as follows: 6-month median of 0.25 mg/L, daily maximum of 0.98 mg/L, and instantaneous maximum of 7.4 mg/L. After dechlorination, the monthly average residual chlorine levels were very consistent throughout the year; near or below the detection limit of 0.05 mg/L for all months. The monthly average values are shown in Table 2-3.

Effluent Coliform Bacteria

The effluent was analyzed five days a week for coliform bacteria. The monthly average values for total coliform, fecal coliform, and enterococcus bacteria detected in the effluent are presented in Table 2-3. Monthly average values ranged from 17.4 to 141 MPN/100 mL for total coliform and from 2.7 to 13.0 MPN/100 mL for fecal coliform. The permit prohibits more than 10 percent of the final effluent samples, in any thirty-day period, to exceed a total coliform density of 2,400 MPN/100mL with no sample exceeding a total coliform concentration of 16,000 MPN/100mL. The maximum total coliform concentration of >1,600 MPN/100mL was measured on July 19th. The result was reported as a potential violation due to the result exceeding the upper limit of the analytical method. Compliance could not be evaluated based on the result.

Effluent Enterococcus Bacteria

The effluent was also analyzed five days a week for enterococcus bacteria. The monthly mean values are presented in Table 2-3 and the values were consistently low throughout the entire year, thereby demonstrating the effectiveness of the chlorination process.

Table 2-3. Chlorine and Bacteria Monthly Averages, 2017

Month	Chlorine at the end of the CCC	Chlorine after Dechlorination	Total Coliform	Fecal Coliform	Enterococcus
	mg/L	mg/L	MPN/100mL		
January	5.8	0.05	37.6	8.3	2.4
February	5.5	0.07	55.7	7.5	1.5
March	5.8	0.05	17.4	3.9	1.3
April	7.4	<0.05	23.7	3.4	2.1
May	6.6	<0.05	34.9	3.7	1.4
June	6.8	<0.05	65.0	4.5	1.1
July	7.0	<0.05	98.5	4.1	2.9
August	6.8	<0.05	24.6	2.7	4.9
September	6.8	<0.05	33.0	2.9	9.6

Month	Chlorine at the end of the CCC	Chlorine after Dechlorination	Total Coliform	Fecal Coliform	Enterococcus
	mg/L	mg/L	MPN/100mL		
October	6.7	<0.05	120.0	13.0	38.9
November	6.7	<0.05	141.1	10.9	2.5
December	6.8	<0.05	93.7	4.0	1.0

SURF ZONE BACTERIA

The Goleta Sanitary District had an extensive bacteria monitoring program that measured the concentrations of enterococcus, total coliform, and fecal coliform groups of bacteria at the end of the treatment process immediately before discharge to the ocean, at the end of the pipeline in the zone of initial dilution, at far shore and near shore ocean sampling locations and in the surf zone at stations extending west from Goleta Point to 1,000 meters east of the outfall line. Table 2-4 summarizes the locations and frequency of all bacteria monitoring conducted at the Goleta Sanitary District as required by permit R3-2010-0012.

Table 2-4. Permit R3-2010-0012 Bacteria Monitoring Program

Location	Frequency of Total Coliform, Fecal Coliform and Enterococcus Bacteria Testing
Final Effluent prior to ocean discharge	5 days/week
Zone of Initial Dilution in the discharge plume at 25 m and 100 m from outfall pipe	Quarterly: 3 samples at each location; 1m below surface, mid-depth and 1 m above bottom
Far Shore (ocean) Stations; B1, B2, B3, B4, B5 and B6	Quarterly: 3 samples at each location; 1m below surface, mid-depth and 1 m above bottom
Near Shore (ocean) Stations; K1, K2, K3, K4 and K5	Quarterly: 3 samples at each location; 1m below surface, mid-depth and 1 m above bottom
Surf Zone Stations; A, A1, A2, B, C, D, E	Weekly

Final effluent samples and weekly receiving water surf zone samples were collected and analyzed in-house by GSD personnel the results of which are discussed in this chapter. Zone of initial dilution, far shore and near shore bacteria samples are collected and analyzed by ABC Laboratories of Ventura. Results of this testing is presented in chapter 3.

Approximately 315 samples were collected in 2017 from the surf zone and each sample is analyzed for total coliform, fecal coliform and enterococcus for a total of approximately 630 bacteria tests conducted during the year. These samples are collected and indicator organism concentrations are monitored in order to ensure that the beneficial uses of the Goleta Beach coastal area are protected. The following section discusses the 2017 bacterial trends found in the surf zone environment.

Surf-zone Stations.

Consistent with historical trends, bacteria monitoring at surf-zone stations usually yield more frequent and higher amounts of coliform bacteria than at the near shore and far shore (ocean) stations and even from the final effluent that is discharged to the ocean. The occurrence of bacteria in the shoreline monitoring area is often in response to the drainage, tidal flushing, and dredging of Goleta Slough. Over the years it has been determined that coastal bird populations, organic beach debris (including dog waste), and most importantly, the urban flushing effects of storm water runoff can be contributors to high surf zone bacteria concentrations. There has never been any indication that the treatment plant discharge has contributed to bacteria concentrations along the shoreline.

Goleta Slough, which is the confluence of the San Jose, Atascadero, and San Pedro creeks, is a slow-flowing, estuarine water body, which discharges directly into the Pacific Ocean between two of the Goleta Sanitary District's monitoring stations (stations D and E). Because the slough receives little flushing (except during storm runoff episodes) and is a rich waterfowl habitat, slough waters are relatively high in organics and coliform bacteria with respect to surf-zone waters.

Concentrations of bacteria at surf-zone stations in 2017 in general, were higher than that observed in the effluent, offshore and near shore ocean stations. This is consistent with the results of earlier years. Throughout the year, annual average levels of bacteria at surf-zone monitoring stations ranged from 16 to 223 MPN/100mL for total coliform, 3.9 to 134 MPN/100mL for fecal coliform bacteria and 10 to 76 MPN/100mL for enterococcus bacteria. Several maximum one-time exceedences occurred throughout the year and were reported in the corresponding monthly report. Table 2-5 is a summary of the 2017 surf zone exceedences.

Table 2-5. Surf Zone Exceedences 2017

Date	Station	Exceedence Limit (Result)	Possible Cause	Final Effluent Result
1/10/17	E	One time enterococcus >=104 MPN/100mL (228 MPN/100mL)	Beach Sand Replenishment Project	1.0 MPN/100mL
1/10/17	E	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	Beach Sand Replenishment Project	2.0 MPN/100mL
1/24/17	E	One time enterococcus >=104 MPN/100mL (341 MPN/100mL)	No clear reason	<1.0 MPN/100mL
2/9/17	E	One time enterococcus >= 104 MPN/100mL (2,359 MPN/100mL)	Heavy flow observed from Goleta Slough	<1.0 MPN/100mL
2/15/17	B	One time fecal coliform >= 400 MPN/100mL (920 MPN/100mL)	No clear reason	<1.8 MPN/100mL
2/15/17	E	One time enterococcus >= 104 MPN/100mL (201 MPN/100mL)	No clear reason	<1.0 MPN/100mL
3/23/17	E	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	No clear reason	2.0 MPN/100mL
7/5/17	D	One time fecal coliform >= 400 MPN/100mL (920 MPN/100mL)	No clear reason	4.5 MPN/100mL

Date	Station	Exceedence Limit (Result)	Possible Cause	Final Effluent Result
7/13/17	C	One time fecal coliform >= 400 MPN/100mL (920 MPN/100mL)	No clear reason	1.8 MPN/100mL
8/1/17	D	One time fecal coliform >= 400 MPN/100mL (920 MPN/100mL)	No clear reason	<1.8 MPN/100mL
8/29/17	D	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	No clear reason	2.0 MPN/100mL
9/5/17	D	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	No clear reason	<1.8 MPN/100mL
9/14/17	A2	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	Approximately 400 Birds observed on beach during sampling event.	<1.8 MPN/100mL
9/14/17	D	One time fecal coliform >= 400 MPN/100mL (540 MPN/100mL)	No clear reason	<1.8 MPN/100mL
10/4/17	B	One time fecal coliform >= 400 MPN/100mL (<1,600 MPN/100mL)	No clear reason	4.5 MPN/100mL
11/1/17	B	One time enterococcus >= 104 MPN/100mL (1,159 MPN/100mL)	Dredged material from Atascadero Creek being deposited near site B.	3.1 MPN/100mL
11/1/17	C	One time enterococcus >= 104 MPN/100mL (327 MPN/100mL)	Dredged material from Atascadero Creek being deposited near site B.	3.1 MPN/100mL
11/1/17	D	One time enterococcus >= 104 MPN/100mL (246 MPN/100mL)	Dredged material from Atascadero Creek being deposited near site B.	3.1 MPN/100mL

Throughout the year the final effluent samples analyzed previous to and on the surf zone collection days indicated no or very low concentrations of coliform and/or enterococcus bacteria, see Table 2-5.

Figure 2-9. Surf Zone Annual Average Bacteria Concentrations 2017

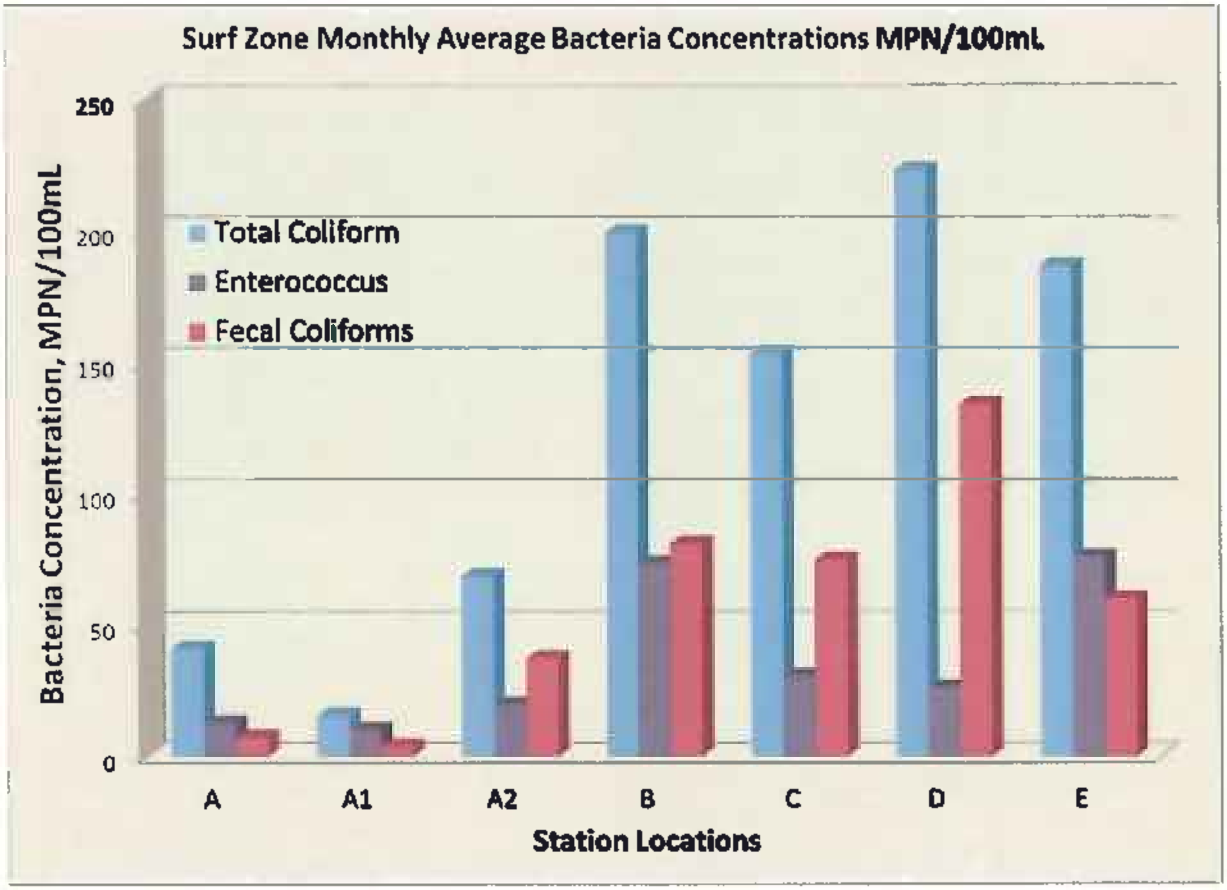


Figure 2-9 shows the impact of the Goleta Slough discharge on the surf zone samples. Goleta Slough empties between station location D and E. Station E shows some of the highest overall annual average bacteria concentrations for all three indicator organisms measured weekly. Station A, located at Campus Point, the furthest point west with the "cleanest" samples.

Effluent bacteria samples collected at the end of the treatment and disinfection process, during these same time periods showed low or undetected concentrations of bacteria discharged from the treatment plant demonstrating that the effluent was not a source for the high surf zone bacteria concentrations.

The impact of Goleta Slough on bacteria water quality in the surf zone of the study area has been documented for 22 years. This historical data has shown, year after year that the highest concentration of indicator organisms are found in and adjacent to the Goleta Slough mouth and are associated with storm water runoff.

Metals

Twenty four-hour composite samples of influent and effluent were collected monthly and analyzed for metals as required under permit R3-2010-0012 (Table 2-6). The current permit, R3-2017-0021, reduced the metals monitoring requirement from monthly to annually. The concentrations of metals in the effluent for 2017 (Table 2-6) were low or undetected and were well below all permit limitations. Although the wastewater treatment process is not particularly efficient at removing metals, hence the need for the pretreatment program. Metal concentrations in the influent were relatively consistent throughout the year.

Table 2-6. Influent and Effluent Metals (ug/L), Goleta Sanitary District, 2017

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Influent (ug/L)									
January	1.27	0.248	4.80	137	2.12	0.082	7.58	0.977	150
February	2.07	0.387	4.61	154	4.01	0.103	9.86	0.884	165
March	2.12	0.335	5.80	155	2.09	0.235	9.09	0.629	182
April	2.54	0.866	7.21	283	4.53	0.154	11.1	1.14	386
May	1.48	0.304	3.38	131	1.81	0.067	9.08	2.12	155
June	1.36	0.211	3.39	116	1.88	0.065	7.94	0.093	191
July	1.14	0.297	3.25	50.9	1.74	0.047	7.87	0.071	177
August	1.28	0.412	2.94	139	1.72	0.050	7.42	1.40	160
September	1.95	0.459	3.61	156	5.00	0.141	7.27	1.11	190
October	1.68	0.219	3.46	114	2.23	0.059	7.48	1.21	158
November	2.71	0.240	5.13	146	1.56	0.071	8.79	1.74	170
December	NR	NR	NR	NR	NR	NR	NR	NR	NR
Effluent (ug/L)									
January	0.73	<0.031	0.892	7.10	0.296	0.015	3.84	0.185	32.7
February	1.13	<0.031	0.967	9.31	1.21	<0.002	4.62	0.035	38.0
March	0.920	<0.031	0.661	7.42	0.101	0.017	3.25	<0.022	41.8
April	1.20	<0.031	0.522	7.69	0.112	0.022	3.73	<0.022	37.5
May	1.03	0.033	1.010	4.98	0.157	0.003	5.36	0.175	48.0
June	0.712	<0.031	1.080	11.7	0.181	0.007	3.92	0.022	41.6
July	0.948	0.104	2.390	8.85	1.66	0.002	7.13	0.041	59.9
August	0.858	<0.031	0.522	5.64	0.110	0.005	5.12	<0.022	41.9
September	0.963	<0.031	0.734	7.07	0.118	<0.002	4.98	0.094	61.9
October	0.978	<0.031	0.513	7.73	<0.013	0.010	4.75	<0.022	42.8
November	1.10	<0.031	1.46	6.07	0.164	0.008	4.81	0.030	42.2
December	NR	NR	NR	NR	NR	NR	NR	NR	NR
Effluent Limits (ug/L)									
6-month median	620	120	250	120	250	4.9	620	67	1,500

NR = Not Required

Priority Pollutants

The NPDES permit requires priority pollutant analyses to be performed on influent and effluent composite samples annually. Compounds detected in the influent and/or effluent samples are presented in Table 2-7; complete copies of all the laboratory reports listing all the chemical compounds and analytical methods are available for review at the Goleta Sanitary District laboratory. Sixteen compounds were detected in the influent and ten in the effluent. Concentrations of detected chemicals are all reported as parts per billion except for TCDD and radioactivity which the units are noted next to the parameter in the table.

Table 2-7. Detected Priority Pollutants, Goleta Sanitary District, 2017

Parameter, units	Influent, ug/L	Effluent, ug/L
Acetone	3200	ND
Antimony	1.49	1.23
Bis(2-Ethylhexyl)phthalate	1.47	ND
Bromoform	ND	0.355
Chloroform	9.0	58.7
Dibromochloromethane	0.404	8.51
Dichlorobromomethane	1.19	28.6
Diethylphthalate	1.50	ND
Methylene Chloride	2.09	ND
PAHs	0.06	ND
Phenol	31.2	ND
Phenols	85.3	ND
TCDD, equivalents, pg/L	0.182	0.0192
Selenium	2.68	1.53
Toluene	0.828	0.824
Radioactivity, gross Alpha pCi/L	1.86 ± 1.60	0.00 ± 1.39
Radioactivity, gross Beta pCi/L	24.2 ± 2.99	25.2± 2.99
ND = Not Detected		

Results of influent and effluent radioactivity determinations for 2017 are also presented in Table 2-7. Limits for radioactivity are defined in Title 17 of the California Code of regulations section 30269, which state limitations of $3x10^{-8}$ μCi/mL (or 30 pCi/L) for alpha emission and $3x10^{-6}$ μCi/mL (or 3000 pCi/L) for beta emission. Samples collected during 2017 were below these limitations.

DISCHARGE COMPLIANCE

Throughout 2017 the wastewater discharge from Goleta Sanitary District complied with all applicable permit effluent limitations. There was one exception on March 21st when the chlorine residual level fell below the required seven-day average level of 5 ppm at the chlorine contact tank with a reportable result of 4.8 ppm. However, the disinfection requirement was in place for primary blended effluent and the effluent bacteria results during that time supported the disinfection level was effective. All other monitored parameters were below their respective limitations as required by the permit. All metals, priority pollutants, and pesticides were low or undetected throughout the year.

OCEAN OUTFALL CONDITIONS

The outfall pipeline, diffuser section, and armor rock protection were inspected by divers from Aquatic Bioassay and Consulting Laboratories, Inc. in October 2017. A report was prepared documenting the inspection findings of the diffuser section and along the outfall pipeline and armor rock.

During the diffuser dive survey, 36 diffuser ports were carefully inspected for flow and general efficiency. The remainder of the outfall pipe was inspected for damage, leaks or evidence of leaks and general stability of the pipe and armor rock. Inspection of the outfall yielded no evidence of damage, holes, cracks, or erosion. The pipe and associated armor rock appeared stable with little or no displacement.

The complete report of the outfall dive survey is included as Chapter 9 of this report. Copies of the outfall dive on DVDs are available at the District for review.

CHAPTER 3

Receiving Water Environment

3.1. Scope and Period of Performance

This report covers the period of field and laboratory studies conducted from January 1, 2017 through December 31, 2017. The Aquatic Bioassay consulting team conducted water quality surveys in the vicinity of the of the Goleta Sanitary Districts outfall on February 25th, April 11th, August 2nd, and December 3rd, 2017. The team evaluated the local effect of the discharge within the immediate vicinity of the outfall terminus, and compared conditions there with those at control sites up-coast and down-coast of the outfall. During each field survey, the team recorded general observations of weather, etc., sampled for bacteria and water column variables (temperature, salinity, pH, transmissance and dissolved oxygen). On August 1st, the team deployed a series of caged mussel arrays for bioaccumulation analysis and on October 27th, the team retrieved the mussels. On October 24th, the team collected epibenthic fish and macroinvertebrates by otter trawl, and collected benthic sediments for physical, chemical, and infaunal analysis using a Van Veen Grab.

3.2. Station Locations and Descriptions

Water-column monitoring was conducted at ocean stations that are located at fixed distances from the midpoint of the diffuser (Figure 3-1). Stations B4 and B5 are located at the boundary of the zone of initial dilution (ZID), 25 meters (m) west and east of the diffuser, respectively. Station B2 and B3 are near-field stations located 500 and 250 m west of the diffuser, respectively. Station B1 is a far-field station located 1500 m west of the diffuser offshore Goleta Point. Station B6 is a reference station located 3000 m east of the diffuser. Plume stations WCZID and WC100 are respectively located 25 and 100 m away from the discharge in the direction of current flow. Nearshore Stations K1 through K5 are also at fixed distances west and east of the outfall in 20 m of water. Historically, the location of the 20-m depth contour represents the offshore limit of kelp beds in the study area.

Mussel arrays were deployed at Stations B3, B4, and B6. Trawl sampling was initiated at Stations B3 moving west for ten minutes and at Station B6 moving east for ten minutes (trawl stations TB3 and TB6, respectively).

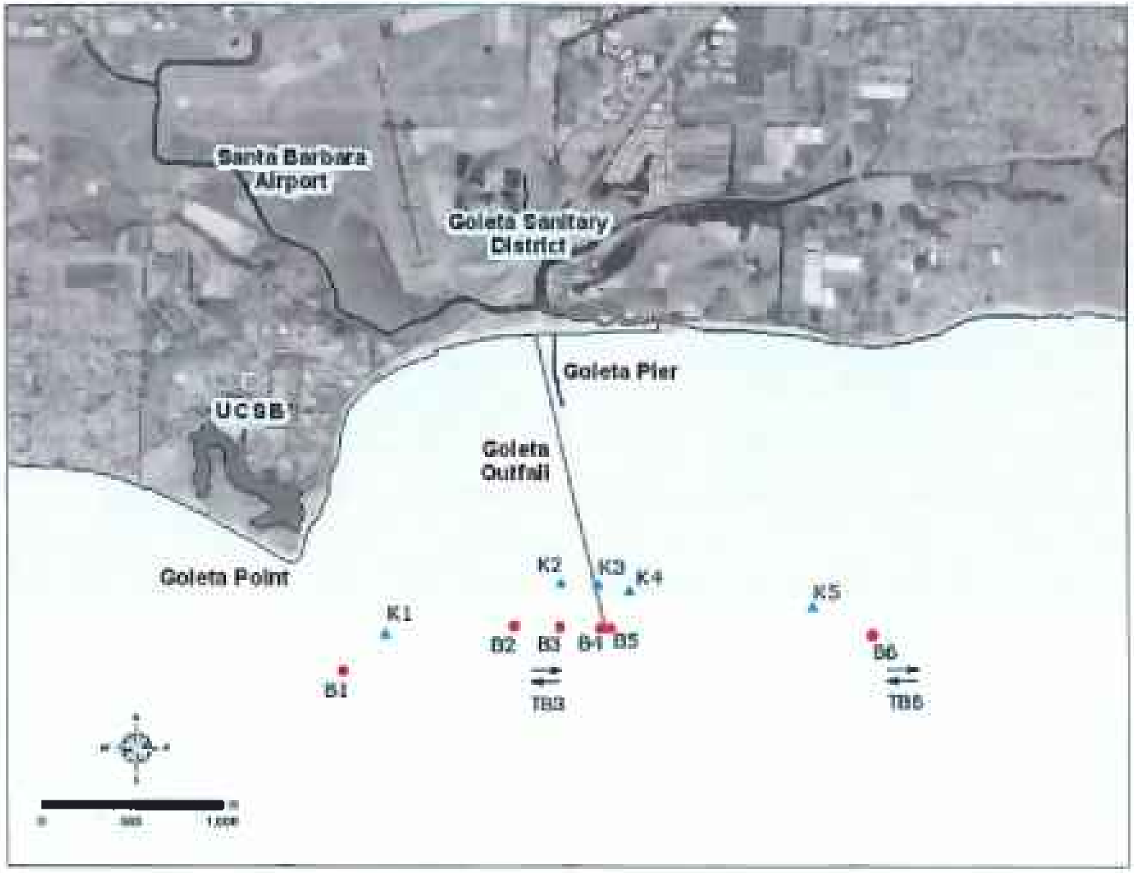


Figure 3-1. Goleta Sanitary District receiving water monitoring stations. Trawl stations are represented by arrows (--->).

3.3. Navigation and Positioning

The outfall diffuser and all sampling stations were located using a *Lowrance Global Map 2000* differential global positioning system (DGPS). DGPS positions were checked visually and by bottom-finder. Once the outfall terminus location was verified, a water quality analyzer cast was taken directly over the diffuser and water quality profiles were simultaneously downloaded to an onboard computer. Aquatic Bioassay biologists inspected the water quality traces for excursions from ambient such as higher temperature or lower salinity, dissolved oxygen, light transmissance, or pH. Any of these would reflect the presence of the wastewater plume. Once the plume was identified, a sail-drogue was deployed over the diffuser at the same depth as the discharge plume signature. The drogue was allowed to move with the current until an obvious direction and velocity could be determined. Stations WCZID (25 m from terminus) and WC100 (100 m from terminus) were then positioned along the drogue's line of travel.

3.4. Statistical Analysis

For this report, two types of statistical tests were performed; trend analysis using correlation coefficient analysis, and comparative analysis using t-tests and analysis of variance (ANOVA). For this report, statistical significance is highlighted at two levels. For most ecologists, a pattern that is strong enough so that there is only a one chance or less in 20 that it is random is said to be statistically significant. In other words, the probability (p) is that there is only a 5% chance (0.05) or less that the pattern is random ($p < 0.05$). A pattern that has only one chance in ten or less (but more than one chance in 20) is said to be "marginally significant". That is, the probability is less than 10% but greater than 5% of being random ($0.05 < p < 0.10$).

3.5.1. Correlation Coefficients. Correlation analysis compares two variables to determine if they tend to increase or decrease in the same way. If two measurements tend to vary in opposite ways, their correlation coefficient (r-value) will tend to have a negative sign. If two measurements tend to vary in the same way, their r-value will tend to have a positive sign.

In addition to its sign, the size of an r-value is important. r-values range from −1.000 to +1.000. An r-value of −1.000 means that the two measurements being compared vary exactly opposite from each other, an r-value of +1.000 means that the two measurements vary exactly in the same way, and an r-value of 0.000 means that the two measurements have no relationship to each other at all. Most r-values, however, fall somewhere among these three values. Depending upon the number of samples that are used to represent the true population, we have more confidence in our r-values when they are high. If an r-value is large enough so that the chance that the relationship could be random is only one in 20 or less ($p \leq 0.05$), we can have confidence that the relationship is probably real. We would have less confidence in a relationship between two variables if the probability was only one in ten ($0.05 < p \leq 0.10$) and no confidence if it was greater than ten ($0.10 < p$).

Based upon experience from past studies, we know that wastewater discharges can negatively impact the marine environment in very specific ways. If the outfall discharge is causing chemicals to accumulate in sediments and/or tissues, it follows that their concentrations would be higher nearer the diffuser than farther away. In this report, the distances of the stations from the diffuser were correlated against the concentration of the individual chemical components that were measured from these stations. Thus, the sign of the correlation coefficient between distance from outfall and chemical concentration would be *expected* if that chemical correlation was *negative*. That is, as the distance from the outfall becomes *larger*, the concentration of the compound becomes *smaller*. Another r-value that is expected to be negative is temperature. The effluent is always warmer than the ocean water, so temperatures, like chemicals, would be expected to become smaller with larger distances.

If the discharge were disrupting biological communities; abundance, diversity, etc., it would be expected to be lower near the outfall than farther away. Thus, population variables would be *expected* to correlate *positively* with distance from outfall, i.e. as distance becomes *larger* these variables would become *larger*. However, it is well documented that infauna populations can thrive near the nutrient enriching effects of ocean outfall where nutrients have enriched the area (Pearson and Rosenberg 1978). A positive and significant correlation between distance from the outfall abundance, numbers of species and diversity could signal that this is the case. Other r-values that are expected to be positive with distance are salinity, pH, dissolved oxygen, surface transparency, and light transmissance. This is because effluents are usually less saline, less clear, and lower in dissolved oxygen and pH than ocean water. If the discharge were affecting the receiving waters, an increasing pattern of these variables with distance from outfall would be expected.

In conclusion, variables that vary in patterns that are both expected and significant should be those which bear further scrutiny.

3.5.2. T-tests. This statistic is used to compare variables when there are only two. Unlike correlation coefficients, the trend with distance is not evaluated. For most variables, the mean of values near the outfall and the mean of values farther away will be different. The t-test determines whether or not that difference is statistically significant. Note that trend with distance or sign of the statistic is not of importance for this test. The question asked is only if they are different beyond what might be expected of random chance.

T-tests are used in this report for trawled fish and invertebrate population metrics and chemical compounds in fish tissue, since these variables were replicated and collected at two locations (i.e. TB3 and TB6). If the average difference in concentration of a chemical compound between these two stations is large enough that the probability is less than or equal to 5% ($p \leq 0.05$), the difference is said to be statistically significant. If the difference is large enough so that the probability is less than or equal to 10% but greater than 5% ($0.05 < p \leq 0.10$), the difference is said to be marginally significant. If the concentration of the compound is larger at the near-outfall station, and the t-test is significant, the pattern should be further evaluated.

3.5.3. Analysis of Variance (ANOVA). ANOVA is similar to the t-test, except it can be used test for significant differences among more than two stations. ANOVAs were used for population variables and tissue analysis of bivalves. ANOVA analysis requires two steps. In the first step, differences in a variable among stations are evaluated to determine if they are sufficiently large to be statistically significant ($p \leq 0.05$). If they are, then a second test must be performed to determine which stations' variables are significantly larger than which other station or stations. In this report, this second step is called the comparison of means. For example, a comparison of means stating: B1 > B2, B3 > B4, indicates that, for that particular variable, Station B1 is significantly larger than Stations B2, B3, and B4, and Stations B2 and B3 are also significantly larger than Station B4. For chemical contaminants, if stations near the outfall are significantly higher than stations farther away, that compound should be evaluated further. For population variables, the opposite is true.

3.6. General Oceanographic Conditions

With the exception of somewhat sporadic freshwater runoff from non-point sources, the aquatic conditions in the Goleta offshore area are controlled by the oceanographic conditions in the Southern California Bight. The mean circulation in the Southern California Bight is dominated by the northward-flowing Southern California Countercurrent, which may be considered as an eddy of the offshore, southward-flowing California Current (Daily, et. al. 1993). Nutrient rich, upwelled waters from the California Current can enter the western end of the Santa Barbara Channel promoting primary productivity (Dugdale and Wilkerson, 1989). The California Countercurrent transports nutrient poor, warmer water northward into the eastern Santa Barbara Channel (Hickey 1998). The California Countercurrent is seasonal in nature and is usually well developed in the summer and fall and weak (or absent) in winter and spring (SCCWRP 1973). This causes relatively nutrient-poor waters to predominate in the warmer water months and nutrient rich waters to predominate in the colder water months (Soule, et. al. 1997).

Superimposed upon annual trends are the sporadic occurrences of the El Nino Southern Oscillation (ENSO) that can be described as an oceanographic anomaly whereby particularly warm, nutrient-poor water moves northward from the tropics and overwhelms the typical upwelling of colder nutrient-rich water. The El Nino Watch (http://coastwatch.pfel.noaa.gov/erddap/index.html) program continuously monitors global sea surface temperatures. These temperature data are compared to the long-term sea surface temperatures generated from data collected from 1950 to 2017. Comparison of the monthly sea temperature with this long-term average creates a temperature anomaly so that the average monthly temperature falls either above or below the average. This anomaly allows us to determine how a given month or time period deviates from the long-term ocean temperature trend.

Water temperatures offshore Goleta indicated that a strong El Nino event was underway during 2017 with surface temperatures above the long-term average during each month (Figure 3-2). The greatest excursions above the average temperature occurred in March, July to October and December. For the months of January, February, April and May were water temperatures closer to the long-term average.

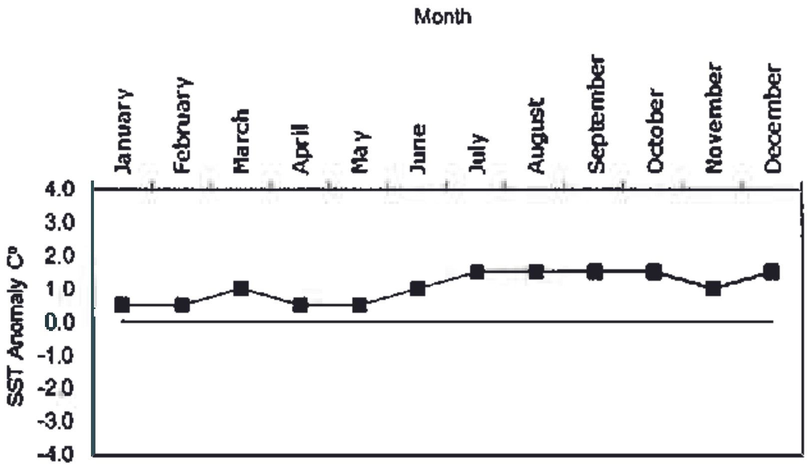


Figure 3-2. Sea surface anomaly temperatures for 2017 compared with long term trends.

3.7. Anthropogenic Inputs

In addition to the Goleta discharge, several other natural and anthropogenic sources could potentially impact the coastal area. Three marshes (Devereux Lagoon, Campus Lagoon, and Goleta Slough) and several creeks discharge into the local area. All are a potential source of contaminated water and sediments, coliform and enterococcus bacteria, and nutrients; particularly during the rainy season. Several sources of crude oil are also present. Natural seeps occur west of the diffuser in the vicinity of Coal Oil Point and Goleta Point, and offshore production activity occurs throughout the Santa Barbara Channel.

3.8. Rainfall

Total rainfall is not as important in terms of impacting an area as the timing of the rainfall, the amount in a given storm, and the duration of a storm (or consecutive storms). Relative to timing, the first major storm of the season will wash off the majority of the pollutants and nutrients accumulated on the land over the preceding dry period. An early, large, long duration storm would have the greatest impact on the waters. In addition, determining the impact of the rainfall and runoff is also a function of the timing of the sampling surveys. With a greater lag between runoff and survey sampling, mixing with oceanic waters would reduce observable impacts (Soule, et. al. 1996).

The rainfall reported in this document is for Santa Barbara Airport obtained from the Western Regional Climate Center in Reno, Nevada. Data is summarized in Table 3-2 and Figure 3-3, where periods of precipitation and water column survey days are highlighted. The rainfall for this period (19.76 inches) was like the average yearly rainfall since 1981 (18.96 inches) and was the fifth year of a severe drought in southern California. The wettest months were January (8.96 in) and February (8.97 in), followed by March (0.96 in). No rain fell in June, October or December. Rain in all other months ranged from 0.01 to 0.41 inches. February, April, July and October sampling had no rain events prior to sampling.

Table 3-2. Daily 2017 Santa Barbara Airport rainfall (inches) with dates of water column surveys bordered and rain days in gray.

Day/Month	January	February	March	April	May	June	July	August	September	October	November	December
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T	0.00	0.00	0.00	0.00
2	T	0.17	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
3	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
4	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	T	0.00
5	0.11	0.35	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.02	1.29	0.00	0.00	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.42	0.73	0.00	0.16	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.58	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.66	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
10	0.36	0.61	0.00	0.00	0.00	0.00	T	0.00	0.13	0.00	0.00	0.00
11	0.63	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
12	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
17	0.00	4.16	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.17	0.03	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.72	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	2.67	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.05	0.31	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	T	0.00	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		T		0.00	0.00		0.00	0.00	0.00
Monthly Total	**8.98**	**8.97**	**0.96**	**0.41**	**0.12**	**0.00**	**0.04**	**0.01**	**0.22**	**0.00**	**0.07**	**0.00**
Annual Total	**19.76**											

T =Trace, some precipitation fell but not enough to measure.

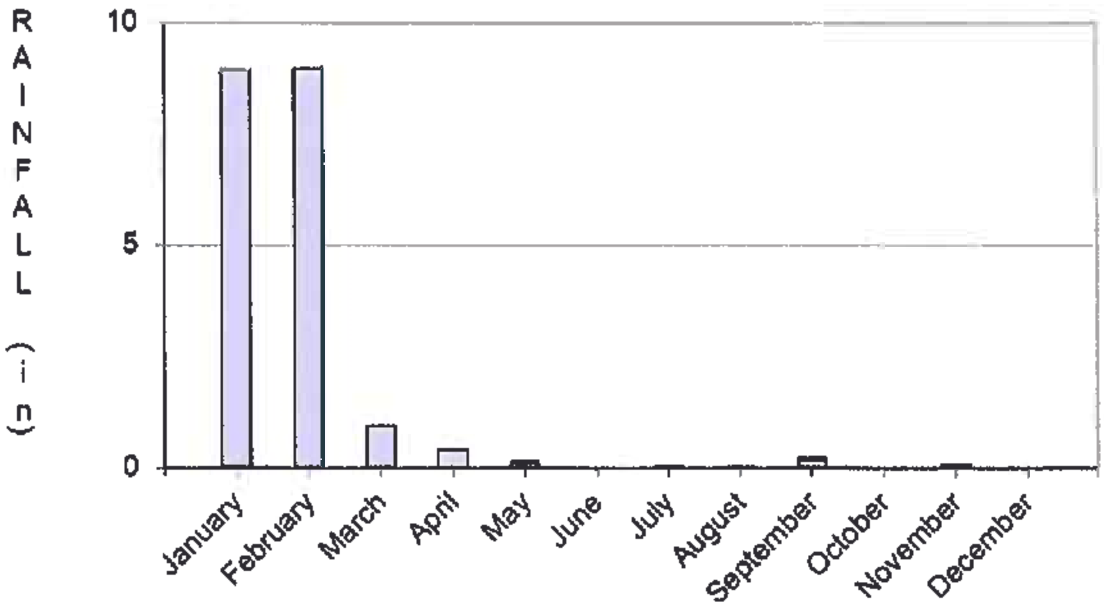


Figure 3-3. Santa Barbara rainfall for 2017.

3.9. Water Quality Materials and Methods

Sampling and data collection for water quality assessment was conducted quarterly at the 13 stations described above. Temperature, conductivity, salinity, dissolved oxygen, pH, and light transmissance were measured continuously through the water column using a SeaBird 25plus CTD Water Quality Analyzer with associated WetLabs 25-cm Transmissometer. All probes were calibrated immediately prior to each field excursion and, if any data were questionable, they were calibrated again immediately after the instruments were returned to the laboratory. Measurements of light penetration were measured using a Secchi disk. At all stations, water samples were collected at the surface with a Nauman sampler, at mid-depth, and above the bottom with a Niskin sampler.

Water was distributed into sterile 125 mL polypropylene bottles with Sodium Thiosulfate tablets for bacterial analysis. At all stations, temperature and pH were measured directly at the surface using an NBS traceable standard mercury thermometer and hand-held, buffer-calibrated pH meter (respectively). Extra water samples were also collected and set for dissolved oxygen and chloride titration in the field. These extra samples and measurements were used as a check and back up to the water quality analyzer.

All samples from all stations were placed in coolers containing wet ice and were returned to the Ventura laboratory the same day. Immediately upon return, the bacterial samples were set for total and fecal coliform and enterococcus bacteria via multiple-tube fermentation methods. Check samples were titrated for dissolved oxygen by Winkler titration and chloride (converted to salinity) by the argentometric titration. All water analyses were performed in accordance with *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association, 22nd Edition).

After all analyses were completed, the five water quality analyzer variables were correlated against the check samples measured or collected in the field: thermistor probe versus mercury thermometer, conductivity probe versus chloride titration, dissolved oxygen probe versus Winkler titration, field pH probe versus hand-held pH meter, and transmissometer versus Secchi disk (see Appendix Figure 10-1 for calibration curves). The Seabird Water Quality Analyzer was downloaded and water column graphs were generated. Two tables were also prepared containing the results of the physical, chemical, bacterial, and observational water measurements. Check sample correlations, water column graphs, and data tables were joined with a narrative report and were presented to the Water Quality Control Board quarterly. The results and conclusions of all water column measurements and analyses are presented and summarized in Section 3.10 below.

3.10. Results

3.10.1. Physical and Chemical Water Quality

3.10.1.1. Temperature

Coastal water temperatures vary considerably more than those of the open ocean. This is due to the relative shallowness of the water, inflow of freshwaters from the land, and upwelling. Seawater density is important in that it is a major factor in the stratification of waters. The transition between two layers of varying density is often distinct; the upper layer, in which most wind-induced mixing takes place, extends to a depth of 10 to 50 m in southern California waters.

During the winter months, there is little difference in temperature between surface and deeper waters, while in the summer a relatively strong stratification (i.e. thermocline) is evident because the upper layers become more heated than those near the bottom do. Thus, despite little difference in salinity between surface and bottom, changes in temperature during the summer result in a significant reduction of density at the surface. Stratified water allows for less vertical mixing. This is important because bottom waters may become lower in oxygen without significant replenishment from the surface (Soule et. al. 1997).

Spatial temperature patterns. Examination of 3D contours for each quarterly survey showed that the water column was slightly stratified in February (Figure 3-6 and Table 3-3), and the water column was isothermal during April survey (12.0 °C). Thermal stratification was strongest in August when water temperatures were ranged from 19.5 near the surface to 12.0 °C near the bottom, representing a 7.5 °C decrease from surface to bottom. In October, the water column was warm, but only slightly stratified.

Influences of the outfall were not evident in the temperature profiles during any survey (Table 3-3). Temperatures did not correlate with distance from the outfall in any survey. There were no significant temperature differences by t-test between near outfall and far field station groups during the four quarterly surveys.

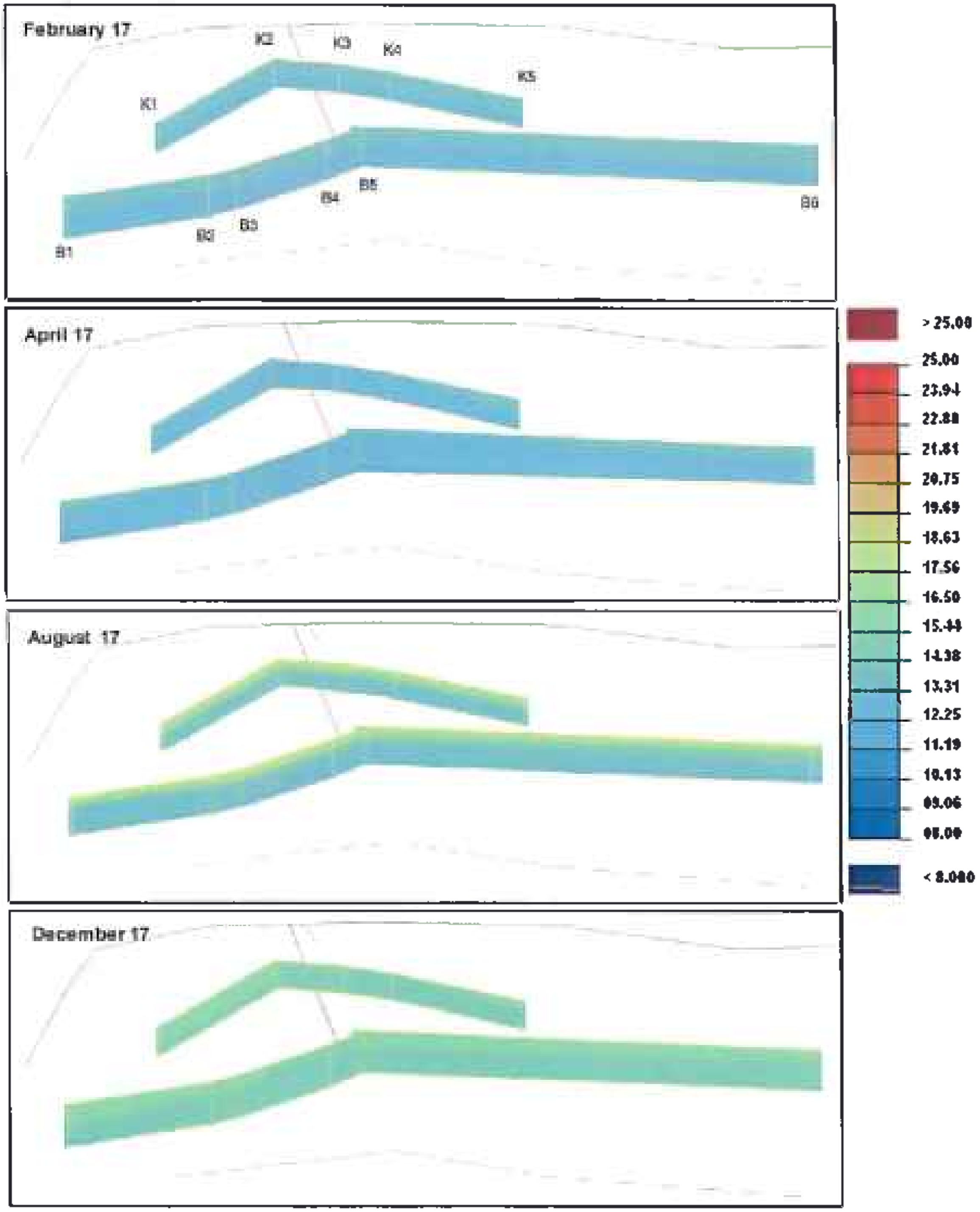


Figure 3-6. Temperature contours for the K Station (depth = 18 m) and B Station (depth = 28 m) water quality transects. The Goleta Sanitary District outfall is depicted as a red line. The color legend is presented to the right.

Table 3-3. Water quality parameter averages and ranges for all stations and depths combined for each quarterly survey. The statistical significance of quarterly measurements with distance from the outfall was tested by correlation analysis and by t-test.

Parameter	Month	Average	Range	Expected & Significant Correlation w/ Outfall?	Significant t-test w/ Outfall?
Temperature	February	13.2	12.1 - 13.9	No	No
	April	13.1	11.9 - 13.9	No	No
	August	14.9	12.6 - 18.5	No	No
	December	15.2	14.2 - 15.8	No	No
Salinity	February	33.3	33.1 - 33.6	No	No
	April	33.5	33.3 - 33.6	No	No
	August	33.6	32.8 - 34.9	No	No
	December	33.5	33.4 - 33.5	No	No
pH	February	8.1	7.9 - 8.2	No	No
	April	8.1	7.9 - 8.3	No	No
	August	8.1	7.9 - 8.3	No	No
	December	0.0	0.0 - 0.0	-	-
DO	February	6.7	5.3 - 7.7	No	No
	April	8.1	4.8 - 10.1	Yes	No
	August	6.6	5.0 - 8.4	No	No
	December	0.0	0.0 - 0.0	-	-
Transmissance	February	73.7	60.7 - 82.7	No	No
	April	75.4	69.2 - 80.2	No	No
	August	77.8	68.6 - 84.0	No	No
	December	79.8	51.8 - 86.6	No	No
Transparency	February	6.9	6.0 - 9.0	No	No
	April	7.6	6.5 - 8.5	No	No
	August	6.0	4.7 - 7.3	No	No
	December	9.9	7.0 - 12.0	No	No

3.10.1.2. Salinity

Salinity (a measure of the concentration of dissolved salts in seawater) is relatively constant throughout the open ocean; however, it can vary in coastal waters primarily because of the inputs of freshwater from the land or because of upwelling. In a five-year study conducted by the U.S. Navy Research and Development Center, more than 1000 samples were analyzed for salinity. The mean salinity was 33.75 parts per thousand (ppt), and the range of 90% of the samples in southern California fell between 33.57 and 33.92 ppt (SCCWRP 1973).

Despite the general lack of variability, salinity concentrations can be affected by many oceanographic factors. During spring and early summer months, northwest winds are strongest and drive surface waters offshore. Deeper waters, which are colder, more nutrient-rich, and more saline, are brought to the surface to replace water driven offshore (Emery 1960). El Nino (ENSO) events can also affect coastal salinities. During these events northern flowing waters move into the Bight with waters that are also more saline, but are warmer and lower in nutrients than ambient water. Major seasonal currents (i.e. California current, countercurrent, or undercurrent) can also affect ambient salinity to some degree (Soule et. al. 1997).

Spatial salinity patterns. Average salinity in the survey area was nearly identical in February, April and December ranging from 33.3 ppt to 33.6 ppt. The range of salinities in August was the greatest of all surveys (32.8 to 34.9 ppt). Salinity provided the best opportunity to detect the effluent plume which was evident in each survey as lower salinity water in a subsurface lens of slightly fresher water to the south of the outfall (near station B4). In August, when the water column was most strongly thermally stratified, there was a salinity maximum layer along the nearshore and offshore stations along the entire survey contour.

Salinity ranges and outfall effects. Table 3-3 shows the range of salinities for the 11 water column stations over the four quarterly sampling surveys. Salinities did not correlate with distance from the outfall and there were no significant salinity differences by t-test between near outfall and far field station groups for any of the four quarters.

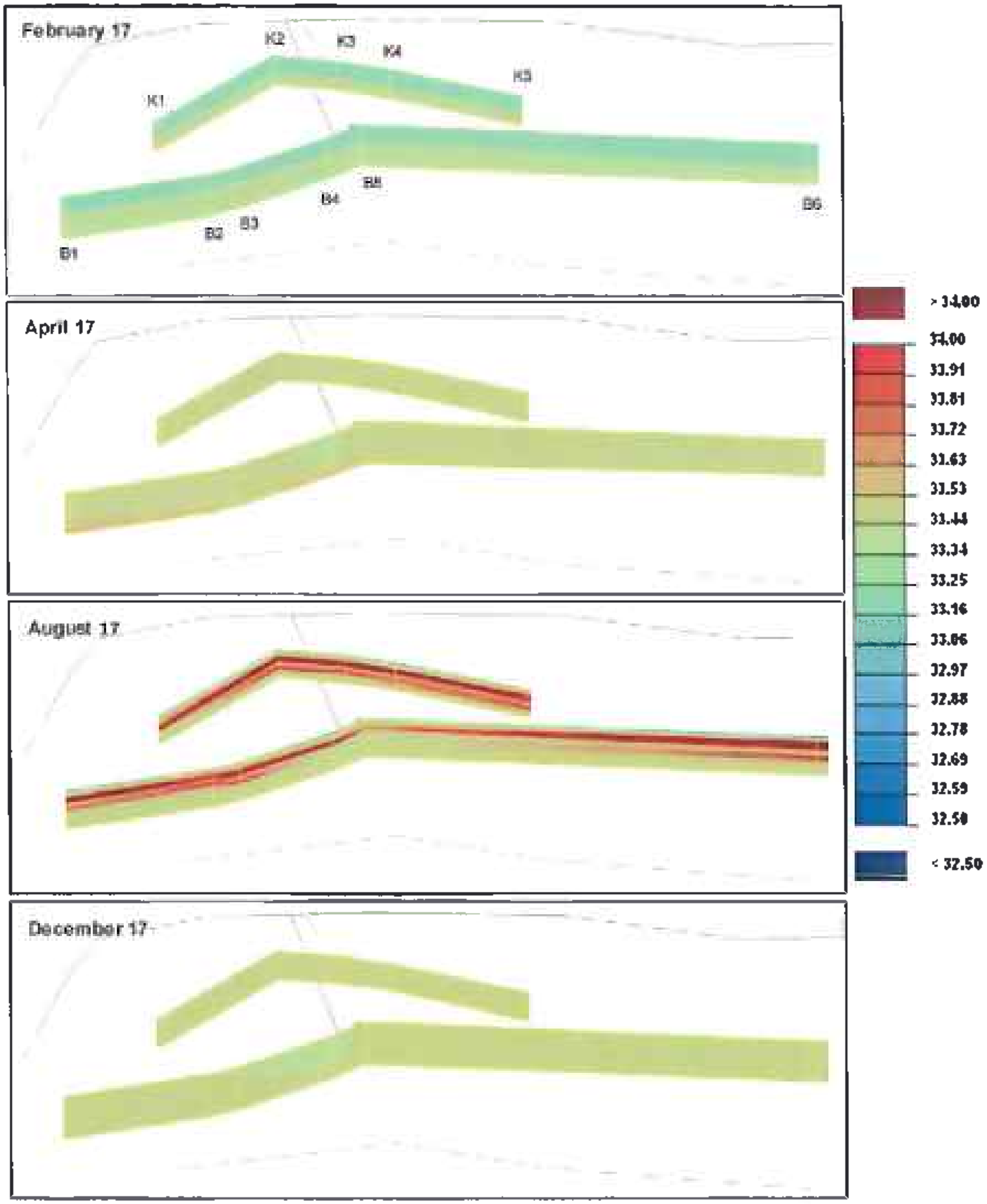


Figure 3-7. Salinity (ppt) contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.3. Hydrogen Ion Concentration (pH)

pH is defined as the negative logarithm of the hydrogen ion concentration. A pH of 7.0 is neutral, values below 7.0 are acidic, and those above 7.0 are basic (Horne 1969). Seawater in southern California is slightly basic, ranging between 7.5 and 8.6, although values in shallow open-ocean water are usually between 8.0 and 8.2 (SWQCB 1965). These narrow ranges are due to the strong buffering capacity of seawater, which rarely allows for extremes in pH.

Factors that can influence pH in the ocean are freshwater inputs, upwelling, and biological activity. Since freshwater pH values tend to be about 0.5 pH units less than seawater, any inflow from a freshwater source will tend to lower the pH slightly. When photosynthesis is greater than respiration, more carbon dioxide is taken up than generated, and pH may increase to higher values in the euphotic (i.e. light penetrating) zone. When respiration is greater than photosynthesis, more carbon dioxide is released than used and pH may decrease, especially when mixing is minimal such as in the oxygen minimum zone and towards the bottom (Soule et. al. 1997).

Spatial pH patterns. The pH sensor failed during the December survey, so no data are presented. Average pH across the other quarterly surveys ranged from 7.9 to 8.3 (Figure 3-8 and Table 3-3). pH was generally greatest near the surface during each survey. Elevated pH in surface waters in August was evidence of primary production. The effluent plume was evident near the outfall in April.

pH ranges and outfall effects. Table 3-3 shows the range of pH values for 11 water column stations for each of the four quarterly sampling surveys. There were no expected and significant correlations with distance to the outfall for any survey. The differences in pH between near and far field stations were far below California Ocean Plan (2009) standard of 0.2 pH units. This was the case for each of the quarterly surveys.

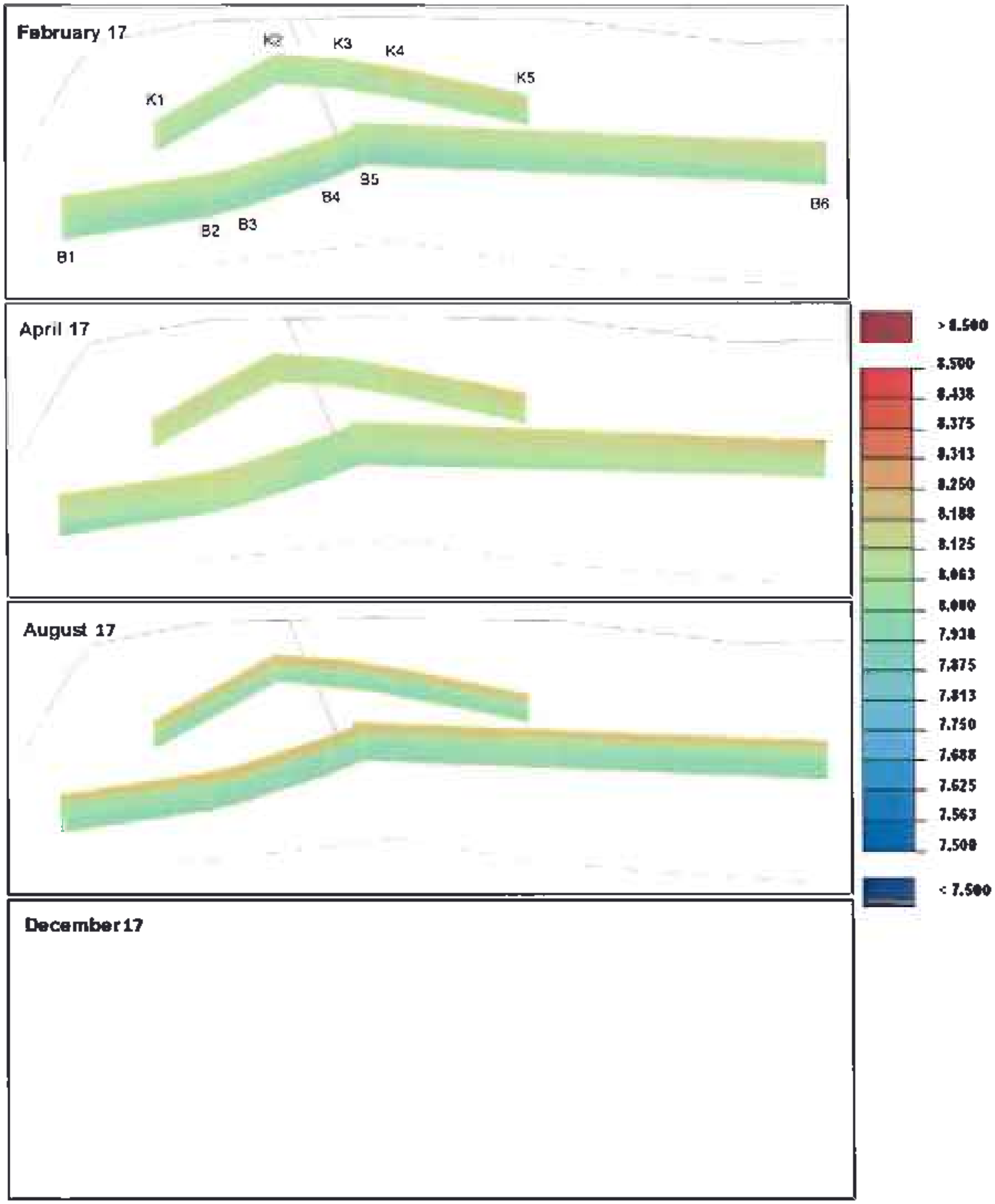


Figure 3-8. pH contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitation District outfall is depicted as a red line.

3.10.1.4. Dissolved Oxygen

The most abundant gases in the ocean are oxygen, nitrogen, and carbon dioxide. These gases are dissolved in seawater and are not in chemical combination with any of the materials composing seawater. Gases are dissolved from the atmosphere by exchange across the sea surface. The gases dissolved at the sea surface are distributed by mixing, advection (i.e. from currents), and diffusion. Concentrations are modified further by biological activity, particularly by plants and certain bacteria. In nature, gases dissolve in water until saturation is reached given sufficient time and mixing. The volume of gas that saturates a given volume of seawater is different for each gas and depends upon temperature, pressure, and salinity. An increase in pressure, or a decrease in salinity or temperature, causes an increase in gas solubility.

The amount of oxygen dissolved in the sea varies from zero to about 11 milligrams per liter. At the surface of the sea, the water is more or less saturated with oxygen because of the exchange across the surface and plant activity. In fact, when photosynthesis is at a maximum during a phytoplankton bloom, such as during a red tide event, it can become supersaturated (Anikouchine and Sternberg 1973). When these blooms die off, bacterial aerobic respiration during decomposition of these phytoplankton cells can rapidly reduce dissolved oxygen in the water. Dissolved oxygen typically decreases with depth due to respiration associated with the bacterial breakdown of organic material. However, if the water column is well mixed, oxygen will be fairly constant with depth. Temperature and/or salinity can affect the density structure of the water column and create barriers to vertical mixing.

<u>Spatial oxygen patterns.</u> The dissolved oxygen sensor failed in December. Dissolved oxygen concentrations in February and October were similar through the water column and ranged from least near the bottom (5.0 mg/L) to greatest near the surface (10.1 mg/L) (Figure 3-9 and Table 3-3). Elevated dissolved oxygen near the surface in August was evidence of strong primary production. The effluent plume was evident in April near the terminus of the outfall.

<u>Oxygen ranges and outfall effects.</u> Table 3-3 shows the range of oxygen concentrations for the 11 water column stations over the four quarterly sampling surveys. Dissolved oxygen did not correlate significantly with distance to the outfall for any of the three surveys, except in April. However, there were no significant differences by t-test among sites located near the outfall and those further away. This indicates that dissolved oxygen was not influenced by the outfall diffuser. Dissolved oxygen concentrations between stations located near and away from the outfall remained within the Ocean Plan standards (2009) throughout the year.

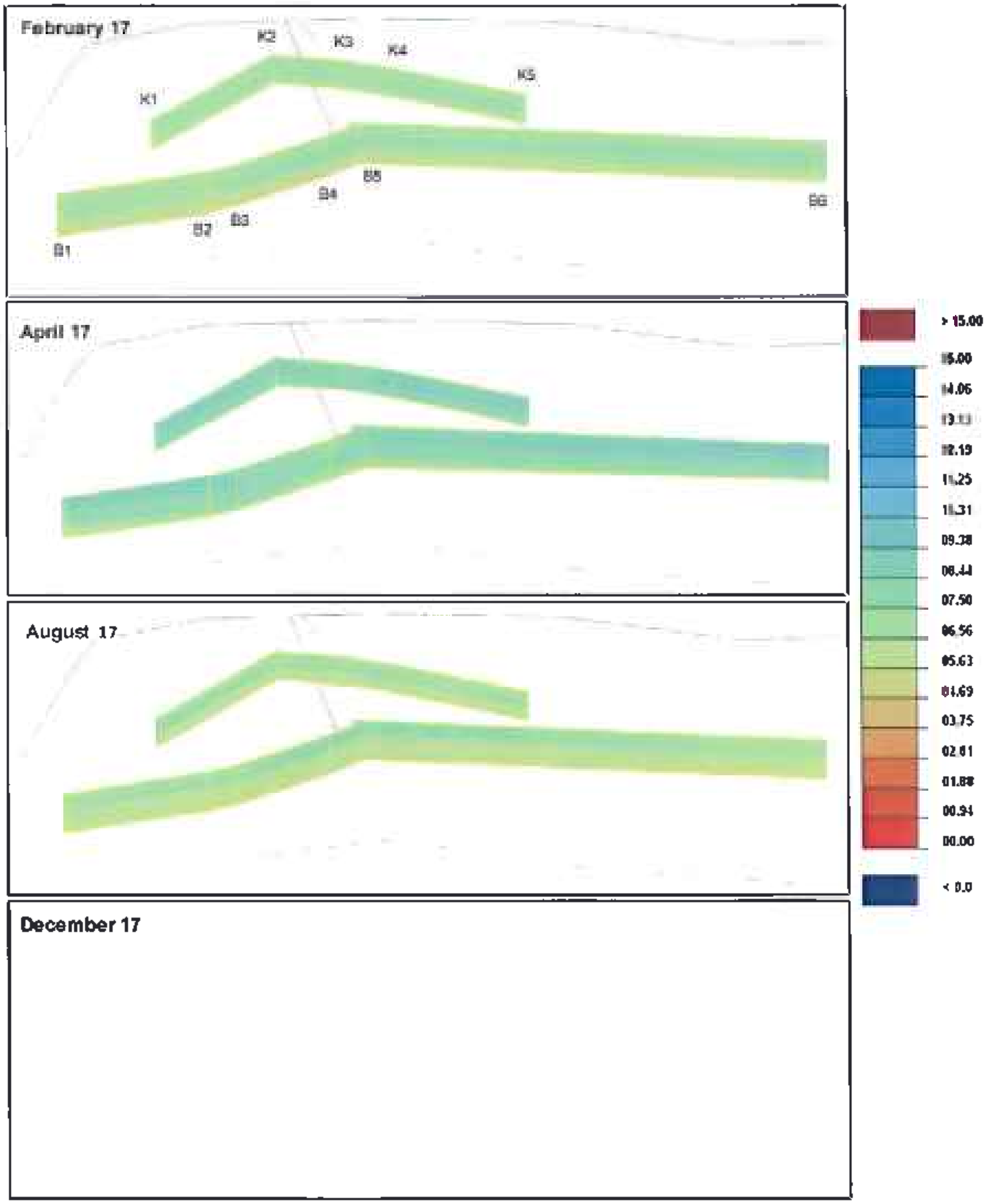


Figure 3-9. Dissolved oxygen contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.5. Light Transmissance

Water clarity in the ocean is important both for aesthetic and ecological reasons. Phytoplankton, as well as multicellular marine algae and flowering plants are dependent upon light for photosynthesis and therefore growth. Since nearly all higher-level organisms are dependent upon plants for survival (except those animals living in deep-ocean volcanic vents and similar environments), the ability of light to penetrate into the ocean depths is of great importance. Seasonally, water is usually least clear during spring upwelling and winter rain. In early summer, increased day length can promote plankton growth and reduce water clarity, as well. In late summer and fall, days are shorter and the rains that bring sediments into the marine environment have yet to begin. Therefore, late summer and early fall are typically the periods of greatest water clarity. Anthropogenic influences such as wastewater effluents, storm drainage discharges, and non-point runoff can also influence water quality on a local basis.

Water clarity is determined using two completely different measuring techniques. Surface transparency is measured using a weighted, white plastic, 30 cm diameter disk (called a Secchi Disk) attached to a marked line. The disk is simply lowered through the water column until it disappears, and the depth of its disappearance is recorded. Surface transparency is a good estimate of the amount of ambient light that is available to plankton since the depth to which light is available for photosynthesis is generally considered to be about 2.5 times the Secchi disk depth.

Light transmissance is measured using a transmissometer, which is a 0.25 m open tube with an electrical light source at one end and a sensor at the other. The amount of light that the sensor receives is directly dependent upon clarity of the water between them. Results are recorded as percent light transmissance. Since transmissance is independent of ambient sunlight, it can be used at any depth and under any weather conditions. Surface light transmissance is usually positively correlated with surface transparency.

Spatial transmissance patterns. Water clarity was good throughout the water column during each of the four quarterly surveys (Figure 3-10). Average transmissance across the four surveys ranged from 51.6% in December to 86.6%, also in December (Table 3-3). In February there was a layer of lower transmissance water at the bottom along the entire coast.

Transmissance ranges and outfall effects. Table 3-3 shows the range of transmissance for the 11 water column stations over the four sampling surveys. Comparisons among stations showed there was no significant correlation with distance to the outfall in any quarter. In all cases, there was never a reduction in transmissance between near and far field stations that exceeded the Ocean Plan (2009) standard of 10%.

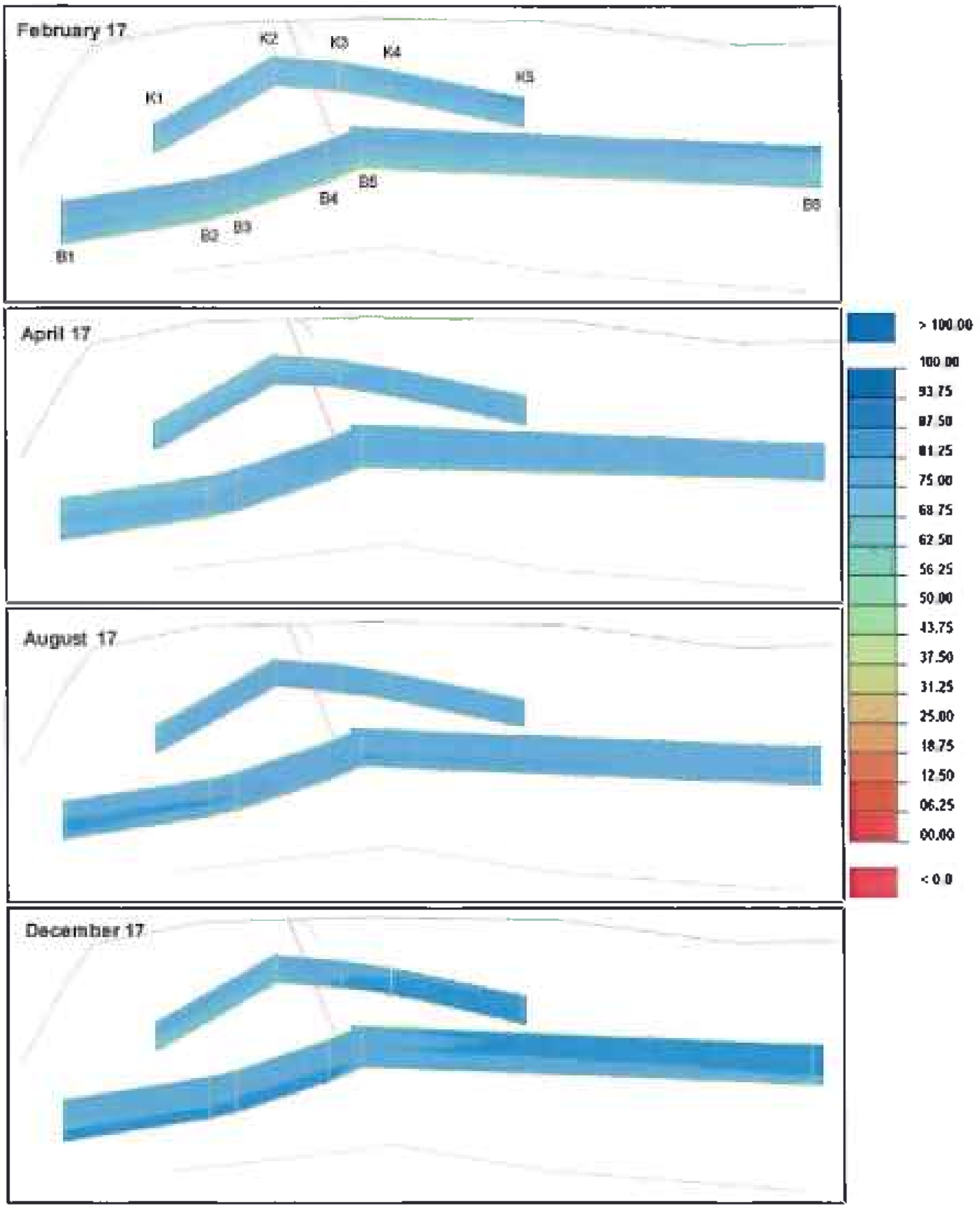


Figure 3-10. Transmissance (%) contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.6. Surface Transparency

As discussed in more detail in Section 3.10.1.5 above, surface transparency is recorded as the depth (m) at which a weighted, 30 cm, white plastic disk (Secchi Disk) disappears. Since only a single quarterly measurement is taken at each station, these data are presented as a line plot of transparency vs. quarter.

Transparency patterns and outfall effects. Figure 3-11 shows the range of transparency measurements for the 11 water column stations over the four sampling surveys. Average surface transparency ranged from 4.7 m in August to 12.0 m in December. Transparency did not correlate significantly with distance from the outfall in any quarter, nor by t-test among stations located near to and far from the outfall.

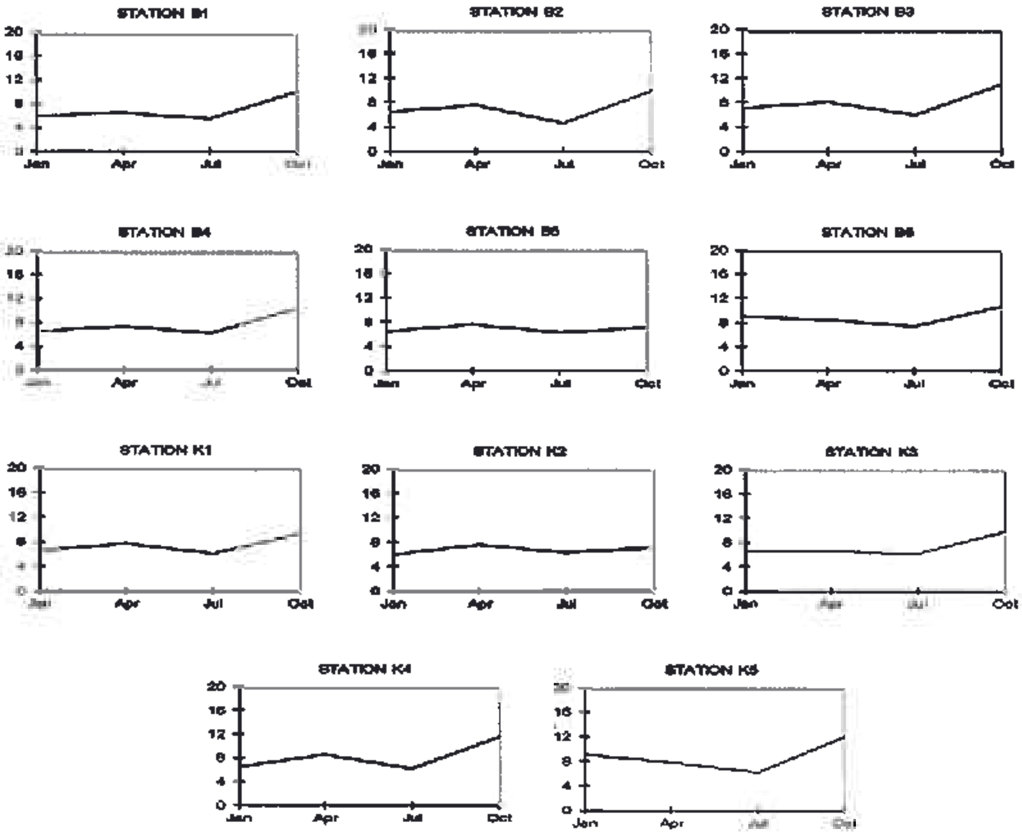


Figure 3-11. Average transparency vs. season for each of the 11 water quality stations.

3.10.2. Bacterial Water Quality

The three bacterial measurements of total coliforms, fecal coliforms and enterococcus, are used by health authorities to assess the potential risk of human exposure to pathogens in the aquatic environment (Soule 1997). The principle problem with these indicators is that analysis takes 72 hours, slowing the response of health officials to potentially hazardous conditions. Research has been underway to develop more rapid tests that are both sensitive and cost effective. Rainfall episodes have been closely associated with violations of all three bacterial standards, especially near areas where creeks or stormwater channels discharge into the ocean. At present, it is more prudent to post areas of potential or known contamination immediately following rain storm events than to wait for confirmation. Bacterial results are summarized in Tables 3-4 and 3-5.

3.10.2.1. Total Coliforms

Coliform bacteria (those inhabiting the colon) have been used for many years as indicators of fecal contamination; they were initially thought to be harmless indicators of pathogens at a time when waterborne diseases such as typhoid fever, dysentery and cholera were severe problems. Recently it was recognized that coliforms themselves might cause infections and diarrhea. However, the total coliform test is not effective in identifying human contamination because these bacteria may also occur as free living in soils, and are present in most vertebrate fecal material. The California Ocean Plan (SWRCB 2009) states that within 1,000 feet of shore, the single sample total coliform concentration cannot exceed 10,000 MPN/100 mL of water. Additionally, during a 30-day period the average concentrations cannot exceed 1,000 MPN/100 mL. Although no offshore stations are within 1000 feet of shore, this value was used as a criterion of concern.

<u>Total coliform patterns over the year.</u> Total coliform counts were very low during the year, ranging from <2 to 2 MPN/100 mL for all surveys (Table 3-4), except in April when counts were elevated at the surface and mid-depth at stations near Goleta Slough. Total coliforms exceeded the single sample standard (10,000 MPN/100 mL) in four samples (Table 3-5). Bacteria concentrations dropped toward the east and were lowest at stations located in the effluent plume (50 and 130 MPN/100 mL, respectively). This coupled with the fact that total coliform concentrations were below the method detection limit (<2 MPN/100 mL) at the bottom, indicates that the elevated total coliform concentrations were due to surface runoff, potentially from Goleta Slough.

Table 3-4. Annual summary of total and fecal coliforms and enterococcus bacteria (MPN/100 mL).

Sampling Station	Season	Offshore						Plume		Nearshore				
		BI	B2	B3	B4	B5	B6	WCZID	WC100	K1	K2	K3	K4	K5
SURFACE														
Total Coliform	Winter	20	<2	<2	<2	<2	2	<2	<2	20	<2	<2	<2	<2
	Spring	16000	2800	16000	2800	590	80	50	130	30	16000	5000	360	700
	Summer	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	2	2	<2	<2	<2	<2	<2	<2	<2
Fecal Coliform	Winter	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2
	Spring	1700	50	50	110	130	2	130	8	30	70	20	30	80
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	2	4	<2	2	4	<2	<2	<2	<2	<2	<2	<2	2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
MIDDLE														
Total Coliform	Winter	<2	20	2	<2	20	2	20	<2	20	2	20	<2	<2
	Spring	5000	3500	16000	130	5000	500	50	20	5000	30	8	1110	130
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Fecal Coliform	Winter	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	1300	30	23	130	170	20	8	<2	30	30	5	70	60
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	2	<2	2	4	2	<2	2	<2	<2	2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
BOTTOM														
Total Coliform	Winter	<2	<2	2	<2	<2	2	<2	<2	<2	<2	<2	<2	20
	Spring	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Fecal Coliform	Winter	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	5	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Table 3-5. Indicator bacteria geometric averages and ranges for all stations and depths combined for each quarterly survey. Measurements for the year were compared individually against single sample event, REC-1 bathing water standards.

Parameter	Month	Average	Range	Water Quality Standard	Standard Exceedances
Total Coliform	February	8	<2 - 20	10,000	0
	April	2903	<2 - 16000	10,000	4
	August	2	<2 - 2	10,000	0
	December	2	<2 - 2	10,000	0
Fecal Coliform	February	2	<2 - 2	400	0
	April	126	<2 - 1700	400	2
	August	2	<2 - 2	400	0
	December	2	<2 - 2	400	0
Enterococcus	February	2	<2 - 5	104	0
	April	2	<2 - 4	104	0
	August	2	<2 - 2	104	0
	December	2	<2 - 2	104	0

3.10.2.2. Fecal Coliforms

The fecal coliform test discriminates primarily between soil bacteria and those in warm blooded animals such as dogs, cats, birds, horses, barnyard animals, and humans. The California Ocean Plan (SWRCB 2009) states that within 1000 feet of shore, samples from each station shall have a density of fecal coliform organisms less than 400 MPN/100 mL of water for any single sample or average less than 200 for any 30-day period. Although no offshore stations are within 1000 feet of shore, this value was used as a criterion of concern.

<u>Fecal coliform patterns over the year.</u> Fecal coliform counts were very low during the year, ranging from <2 to 20 MPN/100 mL for all surveys (Table 3-4), except in April when counts were elevated at the surface and mid-depth at stations near Goleta Slough. Fecal coliforms exceeded the single sample standard (400 MPN/100 mL) in two samples (Table 3-5). Bacteria concentrations dropped toward the east and were lowest at stations located in the effluent plume (8 and <2 MPN/100 mL, respectively). This coupled with the fact that fecal coliform concentrations were below the method detection limit (<2 MPN/100 mL) at the bottom, indicates that the elevated coliform concentrations were due to surface runoff, potentially from Goleta Slough.

3.10.2.3. Enterococcus

Enterococcus bacteria include species that are found in human wastes and are related to the Streptococcus bacteria. At one time they were believed to be exclusive to humans, but other Streptococcus species occur in feces of cows, horses, chickens, and other birds. Enterococci die off rapidly in the environment, making them indicators of fresh contamination, but not exclusively from humans. The California Ocean Plan (SWRCB 2009) limitations within 1000 feet of shore are a 30-day average of 34 MPN/100 mL and a single sample limit of 104 MPN/100 mL.

Enterococcus bacteria patterns over the year. Unlike total and fecal coliforms, enterococcus bacteria count ranged from the method detection limit (<2 MPN/100 mL) to just above it (2 MPN/100 mL) during each survey (Table 3-4). Enterococcus concentrations at all stations and depths in the survey area were below the single sample Ocean Plan standard (2009) of 104 MPN/100 mL (Table 3-5).

3.11. Discussion

Quarterly water quality surveys were conducted offshore Goleta in February, April, August and December 2017. Measurements for temperature, salinity, pH, dissolved oxygen and water clarity showed that oceanographic conditions during the year were typical of nearshore areas in southern California. In addition, the Goleta outfall did not have a detectable effect on the water quality conditions in the survey area. The year was defined by the return of normal rainfall following six years of a historic drought in southern California.

Rainfall for this period (19.76 inches) just exceeded the average yearly rainfall since 1981 (18.96 inches). This rainfall meant normal nearshore surface runoff and may have resulted in the elevated bacteria counts in April. While the El Nino event present in 2016 was over, the sea surface anomaly was still 1 to 2 °C above the long-term average.

Salinity, normally the best opportunity to detect the effluent plume, showed the effluent plume signature in each of the four quarters just south of the terminus of the outfall.

Physical and chemical characteristic restrictions, which apply to waters outside of the zone of initial dilution, are addressed in the California Ocean Plan (2009):

- The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.

- The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials.

- Natural light shall not be significantly reduced at any point outside of the zone of initial dilution.

- Floating particulates and grease and oil shall not be visible.

- The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface.

- Waste discharged to the ocean must be essentially free of: 1) Material that is floatable or will become floatable upon discharge.

- The waste discharged to the ocean must be essentially free of: 4) Substances that significantly decrease the natural light to benthic communities and other marine life.

- Waste discharged to the ocean must be essentially free of: 5) Materials that result in aesthetically undesirable discoloration of the ocean.

The water quality parameters measured during the four quarterly surveys indicated that the outfall plume was not altering the condition of the water mass in the vicinity of the Goleta outfall. None of the above restrictions were exceeded outside the zone of initial dilution. pH and transmissance were within Ocean Plan (2009) standards during each of the four quarterly surveys.

Water color throughout the area was green to blue-green, and the discharge of oil or floating particulates were never observed in the survey area. Dissolved oxygen measurements taken near to and far from the outfall correlated significantly with distance to the outfall in April. However, dissolved oxygen was not significantly different among sites close to and far from the outfall.

Bacteriological standards are addressed in the Ocean Plan and NPDES discharge permit, however these standards relate primarily to shoreline waters used for recreation or shellfish harvesting (REC-1 bathing water standards). Total coliforms, fecal coliforms and enterococcus indicator bacteria concentrations were very low throughout the year in the Goleta survey area, except in April when total coliforms exceeded the standard four times and fecal coliforms exceeded the standards on two occasions. These elevated concentrations were probably due to surface runoff from Goleta Slough since concentrations were least in the effluent plume and below detection in bottom waters near the outfall terminus.

Bacterial concentrations in the other three surveys were mostly below detection and none of these exceeded the single sample Ocean Plan standard (2009) during the year.

In conclusion, evidence from the four-quarterly water column monitoring surveys conducted in 2017 indicate that the Goleta Sanitary District Wastewater Treatment Plant was in compliance with all water quality standards, and that the treatment plant was operating effectively.

CHAPTER 4

Physical Characteristics of the Benthic Sediments

4.1. Background

Marine sediments provide clues to the nature of the environment from which their constituent materials were derived, the transportation processes by which they arrived at the final site of deposition, and the physico-chemical and biological characteristics of the depositional environment. The Southern California Bight coastal shelf is characterized by sediments composed of varying combinations of sand, silt and clay. This is quite different in character from more northerly coastal reaches that are composed of rocky substrates. The distribution of benthic sediments can have a profound affect upon the diversity, abundance, and community structure of infaunal organisms and the accumulation of organic material and anthropogenic contaminants (Gray 1981). In general, finer sediments provide a more stable environment for benthic organisms, especially those that build tubes, burrow and feed there. Finer sediments, however, also tend to adsorb more organic and elemental contaminants than do coarser, sandier sediments. As a result, organisms that live closely associated with fine sediments can be exposed to higher concentrations of contaminants.

4.2. Materials and Methods

Benthic grab sampling was conducted in accordance with *Techniques for Sampling and Analyzing the Marine Macrobenthos* March 1978, EPA 600/3-78-030; *Quality Assurance and Quality Control (QA/QC) for 301 (h) Monitoring Programs: Guidance on Field and Laboratory Methods* May 1986, Tetra Tech; *The Southern California Bight Pilot Project Field Operations Manual* (SCCWRP 2008).

Samples were collected with a chain-rigged, tenth square-meter Van Veen Grab. At each station, the grab was lowered rapidly through the water column until near bottom, and then slowly lowered until contact was made. The grab was then slowly raised until clear of the bottom. Once on board, the grab was drained and initial qualitative observations of color, odor, consistency, etc. were recorded.

Sediments to be analyzed for physical properties were removed from the top 2 cm of the surface and placed in clean plastic Whirl-Pacs. These were analyzed for particle size distribution using a Horiba LA920 Particle Size Analyzer and in accordance with Standard Methods 2560 D (APHA, 2012). Sub-samples from each sediment sample were re-suspended in de-ionized water, and then injected into the analyzer. The analyzer is capable of measuring particle sizes ranging from silt and clay (<2 µm) up to course sand (2,000 µm). Results were recorded as the percentage each size distribution represented of the whole. When the LA920 detected particles in a sample that neared its upper detection limit (2,000 µm), a portion of the sample was dried at 105 °C, weighed, then sieved through a 2,000 µm mesh screen. Particles not passing through the screen were weighed and expressed as the percentage of particles in the sample >2,000 µm (gravel).

Data for each station were reduced to the median particle size (µm), percent fines and, the sorting index. The sorting index values range between sediments that have a very narrow distribution (very well sorted) to those which have a very wide distribution (extremely poorly sorted). This index is simply calculated as the 84th percentile minus the 16th percentile divided by two (Gray 1981). Well sorted sediments are homogeneous and are typical of high wave and current activity (high energy areas), whereas poorly sorted sediments are heterogeneous and are typical of low wave and current activity (low energy areas).

4.3. Results

4.3.1. Station Event and Sea State Conditions

Sediment sampling, trawling and mussel retrieval was conducted on October 24th, 2017 under clear skies, and calm to moderate conditions (Table 4-1). Wave height was two to three feet from the southwest and winds were two to eight knots.

4.3.2. Particle Size Distribution

Tables 4-2 and 4-3, and Figure 4-1 illustrate the overall particle size distributions from the six sediment-sampling stations. Detailed raw and summary data for particle size are presented in Appendix 10.3. Results are presented for each size range as the percent of the whole. Two sediment characteristics can be inferred from the graphs. Position of the midpoint of the curve will tend to be associated with the median particle size (Figure 4-1). If the midpoint tends to be toward the larger micron sizes, then it can be assumed that the sediments will tend to be coarser overall. If the midpoint is near the smaller micron sizes, then it can be assumed that the sediments are mostly finer. Sediment sizes that range from 2000 to 63 µm are defined as sand, sediments ranging from 63 to 4 µm are defined as silt, and sediments that are 4 µm or less are defined as very fine silt and clay (Wentworth Sediment Scale, see Gray 1981). There are also subdivisions within the categories (e.g. very fine sand, etc., see Table 4-3). A second pattern discernible from the graph is how homogeneous the distributions of sediments are. Sediments that tend to have a narrow range of sizes are considered homogeneous or well sorted. Others, which have a wide range of sizes, are considered to be heterogeneous or poorly sorted.

4.3.2.1. General Description

At total of 36 replicate samples were successfully collected at the six sampling sites for all biological and chemical analyses (Table 4-2). The penetration depth of each grab exceeded the 5 cm minimum depth required by the Southern California Bight protocol. Surface sediments were composed of fine sand. Surface color was brown and olive green and there was no odor at any station.

4.3.2.2. Median Particle Size

Median particle sizes are depicted in Table 4-3. Similar to past years, median particle sizes were categorized as very fine sand, except at stations B4 and B5 which was characterized as fine sand. Median particle sizes ranged from 88 to 141 µm.

4.3.2.3. Sorting Index & Percent Fines

Particle distributions ranged from very poorly sorted to moderately well sorted. Sorting indices ranged from 0.70 at B6 to 2.17 at B1 (Table 4-3). The percent fine sediments ranged from 7% at station B6 to 32% at station B1.

4.4. Discussion

Observational and analytical evaluations of the benthos in the vicinity of the Goleta outfall show that the sediments are heterogeneous and composed of fine to very fine sand. The percentage of fine sediments (silt and clay) ranged from 7% to 32% at each of the stations, which was in keeping with results from previous years. Hydrogen sulfide gas was not detected in any sample this year. Hydrogen sulfide is a byproduct of bacterial decomposition of organic material under anoxic conditions.

There were no apparent differences in particle size between the outfall stations and those further away. Evidence from this analysis suggests that the discharge is not contributing finer particles to the benthos near the outfall terminus.

Table 4-1. Goleta Sanitary District locations, survey information and weather conditions during the sediment and trawling survey.

Stations	BI	B2	B3	B4	B5	B6	TB3	TB6
Date	24-Oct-17	24-Oct-17	24-Oct-17	24-Oct-17	24-Oct-17	24-Oct-17	24-Oct-17	24-Oct-17
Time	11.56	11.18	10.43	10.07	9.22	8.40	13.21	16.20
Research Vessel	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*
Survey Program	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Trawl, Bioaccum	Trawl, Bioaccum
Dist. From Outfall (m)	1500	500	250	25	25	3000	250	3000
Direc. From Outfall (°M)	270	270	270	270	90	90	270	90
Depth (m)	32.0	27.0	27.2	26.1	25.4	15.6	18.9	20.4
Latitude (N)	34.39928	34.40193	34.40190	34.40190	34.40197	34.40522	34.40328	34.40298
Longitude (W)	119.84103	119.83068	119.82793	119.82653	119.82492	119.78858	119.82755	119.78797
Weather	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Tide	Incoming	Incoming	Incoming	Incoming	Incoming	Incoming	Outgoing	Outgoing
Swl. Ht. (ft)	3	3	2	2	2	2	3	3
Swl. Dir.	SW	SW	SW	SW	SW	SW	SW	SW
Wind Sp. (Kn)	6	4	2	2	2	2	8	5
Wind Dir.	W	W	NE	NE	NE	NE	W	W

Table 4-2. Sediment grab descriptions.

Station	Rep	Penetration (cm)	Surface Description	Surface Color	Odor	Analysis
B1	1	15.5	Fine Sand	Brown	None	Biology
B1	2	12.0	Fine Sand	Brown	None	Biology
B1	3	14.0	Fine Sand	Brown	None	Biology
B1	4	12.0	Fine Sand	Brown	None	Chemistry
B1	5	14.5	Fine Sand	Brown	None	Biology
B1	6	13.5	Fine Sand	Brown	None	Biology
B2	1	9.0	Fine Sand	Olive Green	None	Biology
B2	2	12.0	Fine Sand	Olive Green	None	Biology
B2	3	11.5	Fine Sand	Olive Green	None	Chemistry
B2	4	12.0	Fine Sand	Olive Green	None	Biology
B2	5	11.0	Fine Sand	Olive Green	None	Biology
B2	6	11.5	Fine Sand	Olive Green	None	Biology
B3	1	10.0	Fine Sand	Brown	None	Biology
B3	2	11.0	Fine Sand	Brown	None	Biology
B3	3	12.5	Fine Sand	Brown	None	Chemistry
B3	4	9.0	Fine Sand	Brown	None	Biology
B3	5	11.0	Fine Sand	Brown	None	Biology
B3	6	10.0	Fine Sand	Brown	None	Biology
B4	1	7.5	Fine Sand	Olive Green	None	Chemistry
B4	2	10.0	Fine Sand	Olive Green	None	Biology
B4	3	12.0	Fine Sand	Olive Green	None	Biology
B4	4	8.0	Fine Sand	Olive Green	None	Biology
B4	5	10.0	Fine Sand	Olive Green	None	Biology
B4	6	11.0	Fine Sand	Olive Green	None	Biology
B5	1	11.5	Fine Sand	Olive Green	None	Biology
B5	2	10.0	Fine Sand	Olive Green	None	Biology
B5	3	9.0	Fine Sand	Olive Green	None	Chemistry
B5	4	12.0	Fine Sand	Olive Green	None	Biology
B5	5	15.0	Fine Sand	Olive Green	None	Biology
B5	6	9.0	Fine Sand	Olive Green	None	Biology
B6	1	10.0	Fine Sand	Olive Green	None	Biology
B6	2	9.5	Fine Sand	Olive Green	None	Biology
B6	3	9.0	Fine Sand	Olive Green	None	Chemistry
B6	4	9.0	Fine Sand	Olive Green	None	Biology
B6	5	9.0	Fine Sand	Olive Green	None	Biology
B6	6	9.0	Fine Sand	Olive Green	None	Biology

Table 4-3. Grain size characteristics of each Goleta station.

Station	Median (microns) [1]	Category	Sorting Index [2.]	Sorting	% Fines
B1	88	very fine sand	2.17	very poorly sorted	32
B2	95	very fine sand	1.31	poorly sorted	20
B3	110	very fine sand	0.84	moderately sorted	14
B4	131	fine sand	1.44	poorly sorted	19
B5	141	fine sand	0.75	moderately sorted	10
B6	113	very fine sand	0.70	moderately well sorted	7

1. 0-4 = clay, 4-8 = very fine silt, 8-16 = fine silt, 16-31 = medium silt, 31-63 = coarse silt, 63-125 = very fine sand, 125-250 = fine sand, 250-500 = medium sand, 500-1000 = coarse sand.

2. <0.35 = very well sorted, 0.35-0.50 = well sorted, 0.50-0.71 = moderately well sorted, 0.71-1.00 = moderately sorted, 1.0-2.0 = poorly sorted, 2.0-4.0 = very poorly sorted, >4.0 = extremely poorly sorted.

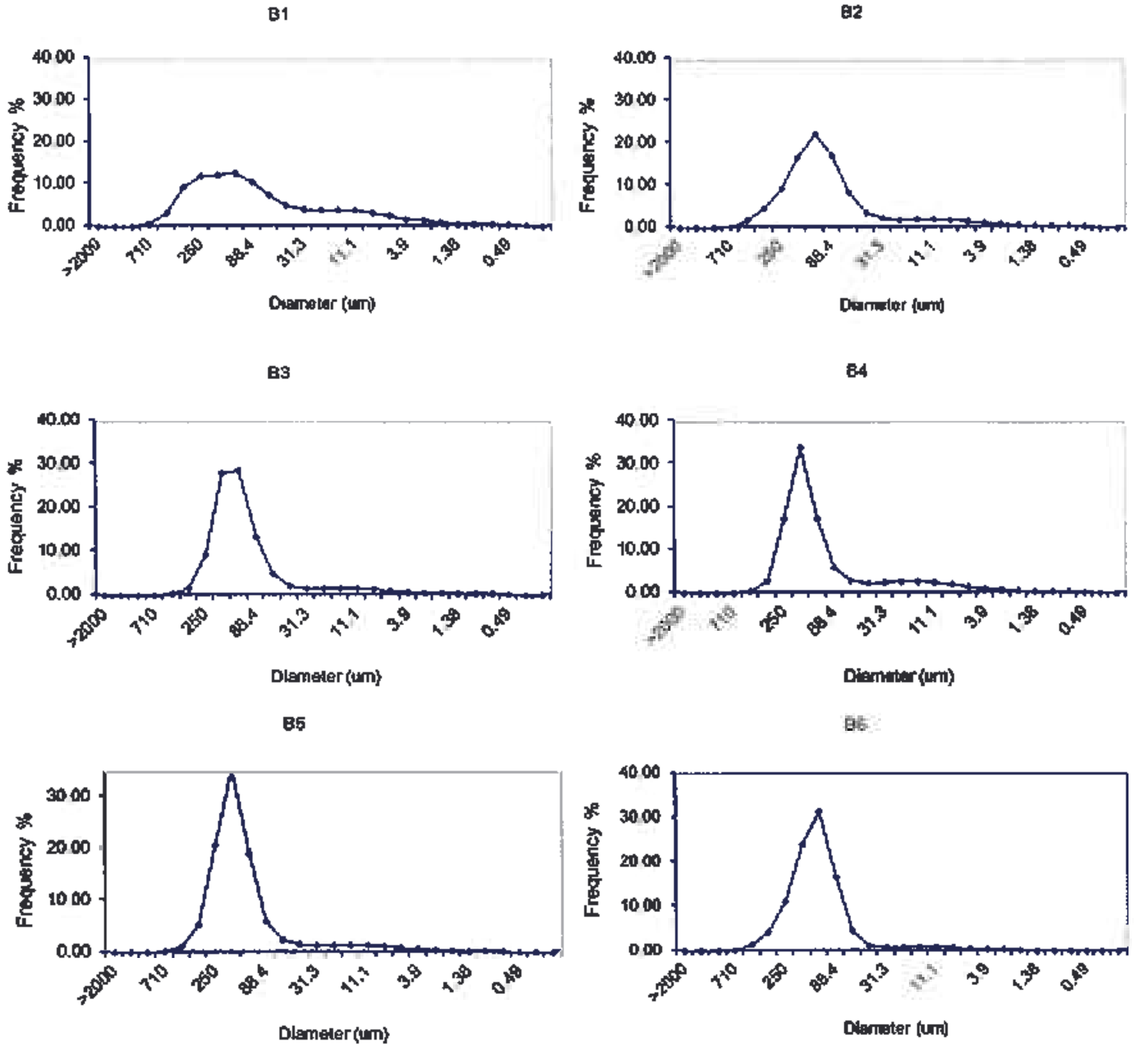


Figure 4-1. Particle size frequency (%) at each station in the Goleta survey area.

CHAPTER 5

Chemical Characteristics of Sediments

5.1. Background

Sources of potential contaminants discharged into the Southern California Bight include treated municipal and industrial wastewater, storm water runoff from urbanized areas, disposal of dredged materials, aerial fallout, oil and hazardous material spills, boating and other sources. Bottom sediments are often the fate of these contaminants, where they can reside for long periods of time, exerting effects at various levels of biological organization (SCCWRP 1998). Organic and metal contaminants tend to adsorb more readily on finer particles and can thus accumulate in areas of deposition. This accumulation of contaminants can impact resident organisms living both within the sediments and on the surface.

5.2. Materials and Methods

Field sampling for all benthic sediment components is described in Chapter 4, Section 4.2, Materials and Methods. Single sediment grabs were collected at stations B1 through B6 (Figure 5-1). Sediment portions to be chemically analyzed were removed from the top two centimeters of the grab sample with a stainless steel spatula and placed in pre-cleaned glass bottles with Teflon-lined caps. During all collections, the sides of the grab were avoided. Samples were immediately placed on ice and returned to the laboratory. PHYSIS Environmental Laboratories, located in Anaheim, California, performed all chemical analyses. Results were standardized to µg/g dry weight for undifferentiated organics and metals and µg/Kg dry weight for complex organics.

Since replicate field samples are not required, results were correlated against distance from the outfall diffuser. When appropriate, correlations were designated as significant ($p \leq 0.05$) or marginally significant ($0.05 < p \leq 0.10$, see Section 3.5.) and expected (negative) or unexpected (positive) (see Section 3.5.1). Since grain size can have an important effect on the ability of contaminants to adhere to particles, results were also correlated against percent fine particle size. The expected sign for particle size would be negative (increasing concentrations with smaller size).

As described in (Section 4.4.), areas west of the diffuser are known sources of natural oil seepages; therefore, results were also correlated against distance from Goleta Point. Like distance from outfall, the expected sign would be negative. Spearman's correlation was used to assess spatial trends (see Sokal and Rohlf 1981).

In order to determine long-term trends, 2016 data were compared to results from monitoring surveys that began in 1991 (Brown and Caldwell 1992, 1993, 1994, 1995, 1996, 1997, 1998; Aquatic Bioassay 1999 to 2015). Data were also compared to results of "reference" sediments from uncontaminated areas collected and analyzed by the Southern California Bight Regional Monitoring Program (SCBRMP) in 1998, 2003 and 2008. Finally, results were compared to the limits presented in two NOAA studies (NOAA 1990 and Long, et. al. 1995). In these studies, researchers compiled published information regarding the toxicity of chemicals to benthic organisms. The data for each compound were sorted, and the lower 10th percentile and median (50th) percentile were identified. The lower 10th percentile in the data was identified as an Effects Range-Low (ER-L) and the median was identified as an Effects Range-Median (ER-M).

Per the NPDES permit, all contaminants were "normalized" to percent fine sediments and percent total organic carbon (TOC) at each station. NOAA scientists have determined that normalizing data from sediments that contain less than 20% silt and clay can cause erroneously high results; therefore, results from samples containing less than 20% fine components should be viewed with caution (NOAA 1990).

5.3. Results

Table 5-1 lists all of the chemical constituents measured from samples collected at each of the six benthic sediment stations. These compounds have been separated here into three main groups: undifferentiated organic compounds, heavy metals, and complex organic compounds. Complex organic compounds are further divided into chlorinated pesticides, polychlorinated biphenyls (PCB's), and polynuclear aromatic hydrocarbons (PAH's). Appendix tables 10-4 and 10-5 present data normalized to percent fine sediments (silt and clay fractions) and percent TOC. Appendix table 10-6 lists the constituents minimum detection limits (MDL), reporting limits (RL) and methods. Figure 5-2 shows the average (± standard deviation) concentration for all Goleta stations combined, for each constituent measured from 1991 to present. Tables 5-4 and 5-5 compare the Goleta sediment chemistry results with the 1998, 2003 and 2008 SCBRMP surveys and the NOAA ER-L and ER-M values.

5.3.1 Undifferentiated Organics

The undifferentiated organics discussed in this report includes groups of compounds whose concentrations can help to determine the extent of anthropogenic contaminant loading in an area. These groups are discussed below:

- Total organic carbon (TOC) is a measure of the amount of carbon derived from plant and animal sources. It is a better measure of the portion of a sample derived from these sources than is percent volatile solids (Soule et al. 1996).
- Sources of oil and grease can be attributed to storm water runoff and ocean going vessels. The extent that people dump used motor oil into storm drains is unknown. Also, the Goleta outfall is located in an area of natural oil seeps, which may be a natural source.
- Total Kjeldahl Nitrogen (TKN) is the method used for the measure of organic nitrogen in water and sediments. Organic nitrogen is present due to the breakdown of animal products and includes such natural materials as proteins and peptides, nucleic acids, urea, and numerous synthetic organic materials (APHA 1995).
- Acid volatile sulfide (H_2S) is an indicator of organic decomposition occurring particularly in anoxic sediments and characterized by a rotten egg smell. No sediment reference values are available for sulfides.

5.3.1.1 Undifferentiated Organics Spatial Patterns

The concentrations for each of the undifferentiated organics measured for this survey are listed in Table 5-1. Similar to past years, the concentrations of oil and grease were greatest at Station B1 offshore Goleta Point (1,630 mg/L) and decreased toward the outfall with the lowest concentration measured at station B6 (295 mg/Kg). Total Kjeldahl nitrogen (TKN) concentrations were greatest at B4 and B5, near the outfall (578 and 518 mg/Kg, respectively) and was least at station B6 (264 mg/Kg). TOC concentrations were greatest near Goleta Point (9,500 ug/g) and least at B6 (3,800 ug/g). Acid volatile sulfide (AVS) was greatest at B3 (19.6 mg/Kg) and least at B6 (3.76 mg/Kg).

Of the undifferentiated organics, oil and grease, and TOC correlated unexpectedly (increased) with distance from the outfall, TKN and AVS correlated expectedly (decreased). Of these correlations with distance to the outfall, only TKN was significant ($p < 0.05$). All the undifferentiated organics correlated expectedly with distance to Goleta Point, but only oil and grease and TOC were significant. Each constituent correlated unexpectedly with particle size and oil and grease, and TOC correlations were significant.

5.3.1.2 Undifferentiated Organic Ranges Compared with Past Years

Each of the undifferentiated organics measured during this survey were within their reported range since 1991 (Figure 5-2). Acid volatile sulfides which were historically high in 2011, dropped to background levels in 2012 and remained low in 2017. Concentrations of oil and grease, TKN, TOC and acid volatile sulfides in 2016 were variable but within range of the past 20 years with no sustained increasing or decreasing trends evident.

5.3.1.3 Undifferentiated Organics Compared with Reference Surveys

The average concentrations of undifferentiated organics reported in this survey were compared to concentrations found during three southern California regional surveys conducted in 1998, 2003 and 2008 (Table 5-4 and 5-5). O&G, TKN and AVS were not measured during these surveys. Average TOC concentrations in the Goleta survey area were similar to or less than concentrations measured by the other surveys. ER-L and ER-M threshold limits are not available for these constituents.

5.3.2 Heavy Metals

Heavy metals in the marine environment are relatively ubiquitous and, with the exception of mercury, can normally be detected in sediments in low amounts. When anthropogenic sources increase sediment concentrations above levels that can be assimilated by benthic organisms, their assemblages can be impaired. For example:

- Aluminum is generally considered to be nontoxic to organisms in its elemental state and is one of the most common elements on earth.
- Antimony is used for alloys and other metallurgical purposes. The salts, primarily sulfides and oxides are employed in the rubber, textile, fireworks, paint, ceramic, and glass industries (SWRCB 1973). Acute and chronic toxicity of antimony to freshwater aquatic life occur at water concentrations as low as 9000 to 1600 ppm, and toxicity to algal species occurs at about 610 ppm. There is no saltwater criterion available for antimony (Long and Morgan 1990).
- Arsenic is carcinogenic and teratogenic (causing abnormal development) in mammals and is mainly used as a pesticide and wood preservative. Inorganic arsenic can affect marine plants at concentrations as low as 13 to 56 ppm and marine animals at about 2000 ppm (Long and Morgan 1990). The USEPA (1983) gives a terrestrial range of 1-50 ppm, with an average of 5 ppm.
- Cadmium is widely used in manufacturing for electroplating, paint pigment, batteries and plastics. Toxicity in water to freshwater animals ranges from 10 ppb to 1 ppm, as low as 2 ppm for freshwater plants, and 320 ppb to 15.5 ppm for marine animals (Long and Morgan 1990). The USEPA (1983) places the terrestrial range for cadmium at 0.01 to 0.7 ppm, with an average of 0.06 ppm.

- Chromium is widely used in electroplating, metal pickling, and many other industrial processes. Chromium typically occurs as either chromium (III) or chromium (VI), the latter being considerably more toxic. Acute effects to marine organisms range from 2,000 to 105,000 ppm for chromium (VI) and 10,300 to 35,500 ppm for chromium (III). Chronic effects range from 445 to 2,000 ppb for chromium (VI) and 2,000 to 3,200 ppb for chromium (III) (Long and Morgan 1990). The terrestrial range is 1 to 1,000 ppm with an average of 100 ppm (USEPA, 1983).
- Copper is widely used in anti-fouling paints. Saltwater animals are acutely sensitive to copper in water at concentrations ranging from 5.8 to 600 ppm. Mysid shrimp indicate chronic sensitivity at 77 ppm (Long and Morgan 1990).
- Iron is generally not considered toxic to marine organisms. Iron, in some organic forms, is a stimulator for phytoplankton blooms. Recent experiments in deep-sea productivity have shown a considerable increase in phytoplankton in normally depauperate mid-ocean waters when iron is added (Soule et al. 1996).
- Older paints and leaded gasoline are a major source of lead. Lead may be washed into the Harbor or become waterborne from aerial particulates. Adverse effects to freshwater organisms range from 1.3 to 7.7 ppm, although marine animals may be more tolerant (Long and Morgan 1990).
- Mercury is a common trace metal once used in industry and as a biocide. Acute toxicity to marine organisms in water ranges from 3.5 to 1678 ppm. Organic mercury may be toxic in the range of 0.1 to 2.0 ppm (Long and Morgan 1990).
- Nickel is used extensively in steel alloys and plating. Nickel is chronically toxic to marine organisms in seawater at 141 ppm (Long and Morgan 1990).
- Selenium is used as a component of electrical apparatuses and metal alloys and as an insecticide. Although there is no data available for selenium toxicity to marine organisms, the present protection criteria range is from 54 to 410 ppb (USEPA 1986). The normal terrestrial range is from 0.1 to 2.0 ppm with a mean of 0.3 ppm. Selenium and lead levels found and reported in Least Tern eggs from Venice Beach and North Island Naval Station in San Diego County were considered to be harmful to development (Soule et al. 1996).
- Silver has many uses in commerce and industry including photographic film, electronics, jewelry, coins, and flatware and in medical applications. Silver is toxic to mollusks and is sequestered by them and other organisms. Silver increases in the Southern California Bight with increased depth; high organic content and percent silt (Mearns et. al., 1991). The range in the rural coastal shelf is from 0.10 to 18 ppm, in bays and harbors from 0.27 to 4.0 ppm, and near outfalls 0.08 to 18 ppm (Soule et al. 1996). The normal terrestrial level ranges from 0.01 to 5.0 ppm, with a mean of 0.05 ppm.
- Soule and Oguri (1987, 1988) found the effects of tributyl tin can be toxic in concentrations as low as 50 parts per trillion in water. The terrestrial range for tin is 2 to 200 ppm, with a mean of 10 ppm. The California Department of Fish and Game considers tributyl tin to be the most toxic substance ever released in the marine environment. Tributyl tin may not be as bio-available in sediments as it is in seawater, and therefore may not affect the benthic biota in the same fashion.
- Zinc is widespread in the environment and is also an essential trace element in human nutrition. It is widely used for marine corrosion protection, enters the waters as airborne particulates, and occurs in runoff and sewage effluent. Acute

toxicity of zinc in water to marine fish begins at 192 ppm, and chronic toxicity to marine mysid shrimp can occur as low as 120 ppm (Long and Morgan 1990). The normal terrestrial range is from 10 to 300 ppm, with a mean of 50 ppm (Soule et al. 1996).

5.3.2.1 Heavy Metal Spatial Patterns

The concentrations for each of the heavy metals measured for this survey are listed in Table 5-1. Of the fourteen metals measured, all were above detection at each of the sites. Differences in the concentrations of each metal among sites were small. Nearly all of the fourteen metals correlated unexpectedly (increased) with distance from the outfall, and none correlated significantly. Each of the fourteen metals correlated expectedly with distance to Goleta Point, and arsenic, copper, lead, selenium and silver correlated significantly ($p < 0.05$). Each metal correlated expectedly with particle size, and nearly all correlated significantly.

5.3.2.2 Heavy Metal Ranges Compared with Past Years

Each of the heavy metals measured during this survey were within their reported range since 1991 and there were no clear increasing or decreasing concentration trends, especially in recent years (Figure 5-2).

5.3.2.3 Heavy Metals Compared with Reference Surveys

The average concentrations of 14 of the heavy metals measured in this survey were compared to concentrations found during three SCBRMP surveys in 1998, 2003 and 2008 (Tables 5-4). Of the metals where comparisons could be made, several slightly exceeded concentrations measured in other surveys (aluminum, arsenic, cadmium, chromium, copper, mercury, nickel, selenium and zinc) (Table 5-5).

5.3.2.4 Heavy Metals Compared with NOAA Effects Range Thresholds

Metals concentrations measured at each station in the Goleta survey area during 2015 were compared to the ER-L and ER-M threshold values (Table 5-4). All metal concentrations were below both the ER-L and ER-M threshold limits.

5.3.3 Complex Organics

5.3.3.1 Pesticides, PCB's and PAH's

Pesticides, PCBs and PAHs are contaminants that are widespread in the environment, are toxic to marine organisms when concentrations are increased and can cause reproductive failure in organisms at higher levels in the food chain. The sources and relative toxicity of each of these organic chemical groups are discussed below.

- DDT is a pesticide that has been banned since the early 1970's, but the presence of non-degraded DDT suggests that either subsurface DDT is being released during erosion and runoff in storms, or that fresh DDT is still in use and finding its way into coastal waters (Soule et al. 1996). DDT has been found to be chronically toxic to bivalves as low as 0.6 ppb in sediment. Toxicity of two of DDT's breakdown products, DDE and DDD, were both chronically toxic to bivalve larvae as low as about 1 ppb (Long and Morgan 1990).
- Of the non-DDT pesticides, concentrations of chlordane between 2.4 and 260 ppm in water are acutely toxic to marine organisms. Heptachlor is acutely toxic in water from 0.03 to 3.8 ppm. Heptachlor epoxide, a degradation product of heptachlor, is

acutely toxic to marine shrimp at 0.04 ppm in water. Dieldrin is acutely toxic to estuarine organisms from 0.7 to 10 ppb. Endrin shows acute toxicity within a range of 0.037 to 1.2 ppb. Aldrin is acutely toxic to marine crustaceans and fish between 0.32 and 23 ppb. The EPA freshwater and saltwater criteria for aldrin are 3.0 and 1.3 ppb, respectively (Long and Morgan 1990). No toxicity data were found for any of the other chlorinated compounds measured during this survey.

- Although PCBs are not pesticides, their similarity to other chlorinated hydrocarbons makes their inclusion in this section appropriate. Before being banned in 1970, the principal uses of PCBs were for dielectric fluids in capacitors, as plasticizers in waxes, in transformer fluids, and hydraulic fluids, in lubricants, and in heat transfer fluids (Laws 1981). Arochlor 1242, a PCB congener, was acutely toxic in water to marine shrimp in ranges of 15 to 57 ppm (Long and Morgan 1990).
- The major sources of polynuclear aromatic hydrocarbons (PAH's) are believed to be the combustion of fossil fuels and petroleum or oil shales. PAH impact is characterized by altered community structure, abundance, and diversity near the pollutant source (Daily, et.al. 1993).

5.3.3.2 Pesticide, PCB, and PAH Spatial Patterns

Pesticides, PCB and PAH concentrations at the six sampling stations are listed in Table 5-1 and complex organic derivatives are listed in appendix table 10-7. Total DDTs were below detection at the outfall stations (B4 and B5) and B6, and were greatest at station B1 near Goleta Point (5.0 ug/Kg). Total DDT correlated unexpectedly with distance to the outfall and non-significantly. Each of the other chlorinated hydrocarbons was at or below detection. In addition, PCBs and Aroclors were all below detection.

Similar to past years, total PAHs were above detection at each site in the survey area, with concentrations ranging from 58.0 ug/Kg at station B1 to 7.6 at station B6. Total PAHs correlated unexpectedly and insignificantly with the distance to the outfall. PAHs correlated expectedly and non-significantly with distance from Goleta Point.

5.3.3.3 Pesticide, PCB and PAH Ranges Compared with Past Years

Total DDT pesticides, chlorinated hydrocarbons and PAH concentrations were within the range of previous years (Figure 5-2).

5.3.3.4 Pesticides, PCB's and PAH's Compared with Reference Surveys

The average concentrations of chlorinated pesticides (DDTs), PCBs and PAHs measured during the 2017 survey were compared to concentrations found during three southern California reference site surveys conducted in 1998, 2003 and 2008 (Table 5-4). DDT and PAHs were the same or less in Goleta sediments compared to the Bight surveys.

5.3.3.5 DDT Pesticides & PCB's Compared with NOAA Effects Range Thresholds

Pesticide, PCB and PAH concentrations measured in the Goleta survey area were compared to the NOAA ER-L and ER-M threshold values (Table 5-4). Each group of constituents was well below these thresholds, except DDT which slightly exceeded the ER-L.

5.4 Discussion

Results from this survey support past studies in that the Goleta outfall discharge has little or no impact upon the chemical composition of local sediments. In order to confirm this, results from the chemical analysis of the benthos were compared among stations, compared to past surveys in the area, compared to other studies performed in southern California, and compared to levels known to have caused toxicity or other environmental impacts to resident marine infauna.

To determine if contaminant trends were significant across stations, results for each variable were correlated against three independent variables: distance from outfall diffuser, distance from Goleta Point, and median particle size. Goleta Point is a documented area of particularly heavy crude oil seepage. Since the diffuser is located relatively close to the Point (approximately 1,500 meters east) it is prudent to attempt to partition out the potential influences of seepages from the impact of the discharge. Correlation against particle size is important because it is well known that metals and other contaminants often adhere more readily to finer particles, and differences among stations may be due to differences in amount of fine material (Gray 1981).

Metal concentrations in the Goleta survey area were similar across sites and were slightly influenced by distance from Goleta Point and particle size, similar to many previous surveys (Aquatic Bioassay 1997 to 2016). The concentration of each metal increased at sites furthest from the outfall. Of the fourteen metals measured, nearly all correlated unexpectedly with distance to the outfall, but not significantly. Several metals correlated significantly with distance to Goleta Point and unexpectedly and significantly with particle size.

Of the complex organic compounds measured, total DDTs and PAHs were above detection at most of the six stations, while total PCBs were not detected. Total DDTs were greatest near Goleta Point and did not correlate with distance to the outfall. As in past surveys, total PAHs were greatest near Goleta Point and declined on a gradient toward the outfall.

This year's results were compared to past measures made in the Goleta survey area since 1991. Concentrations of sediment contaminants have remained relatively stable over time and in 2017 were within the ranges of past years. Acid volatile sulfides (AVS) which were greater on average in 2011 compared to any survey in the past 20 years, returned to normal background concentrations in 2012 and remained low thru 2017. Metals and organic contaminants remained either low or below detection in 2017. Total DDTs were within the range of past years.

This year's results were compared to sediment contaminant concentrations measured during the 1998, 2003 and 2008 SCBRMP surveys on the inner shelf (depth < 30m) and near SPOTWs (SCBRMP 1998, 2003 and 2008). Of the metals where comparisons could be made, several slightly exceeded concentrations measured in other surveys (aluminum, arsenic, cadmium, chromium, copper, mercury, nickel). Concentrations of each group of organics were similar to or less than those measured on the inner shelf and near SPOTWs in during each of the SCBRMP reference surveys.

The Goleta data were also compared to NOAA's Effects Range Low (ER-L) and Effects Range Median (ER-M) criteria. Based upon historical research, sediments with levels of chemical contaminants exceeding ER-L values have a "potential" of affecting sensitive benthic infauna or the sensitive live stages of the more tolerant organisms. Sediments containing contaminants that exceed ER-M values will "probably" have a negative impact upon several groups of infauna organisms. In 2017 each constituent was well below the ER-L thresholds and far below the ER-M thresholds. The only exception to this was total DDT which slightly exceeded the ER-L. This indicates that Goleta sediments were not likely to have had an adverse effect on the benthic infauna community.

In summary, of the 22 constituents measured in Goleta sediments during the 2017 survey, none correlated expectedly and significantly with distance from the outfall. Since the concentration of the pollutants emanating from the plant are very low or below detection, the detection of contaminants in the vicinity of the outfall is likely due to other anthropogenic inputs such as runoff from Goleta Slough, areal deposition or naturally occurring processes such as the release of oil from the seeps located offshore of Goleta Point. Comparison of Goleta sediments with historical reference data from the southern California Bight showed that most constituents were similar to or below baseline concentrations. Additionally, all sediment chemical concentrations were below those levels thought to cause toxicity to sensitive infauna organisms.

Figure 5-1. Benthic sediment sampling locations (Stations B1 – B6) in the Goleta survey area.

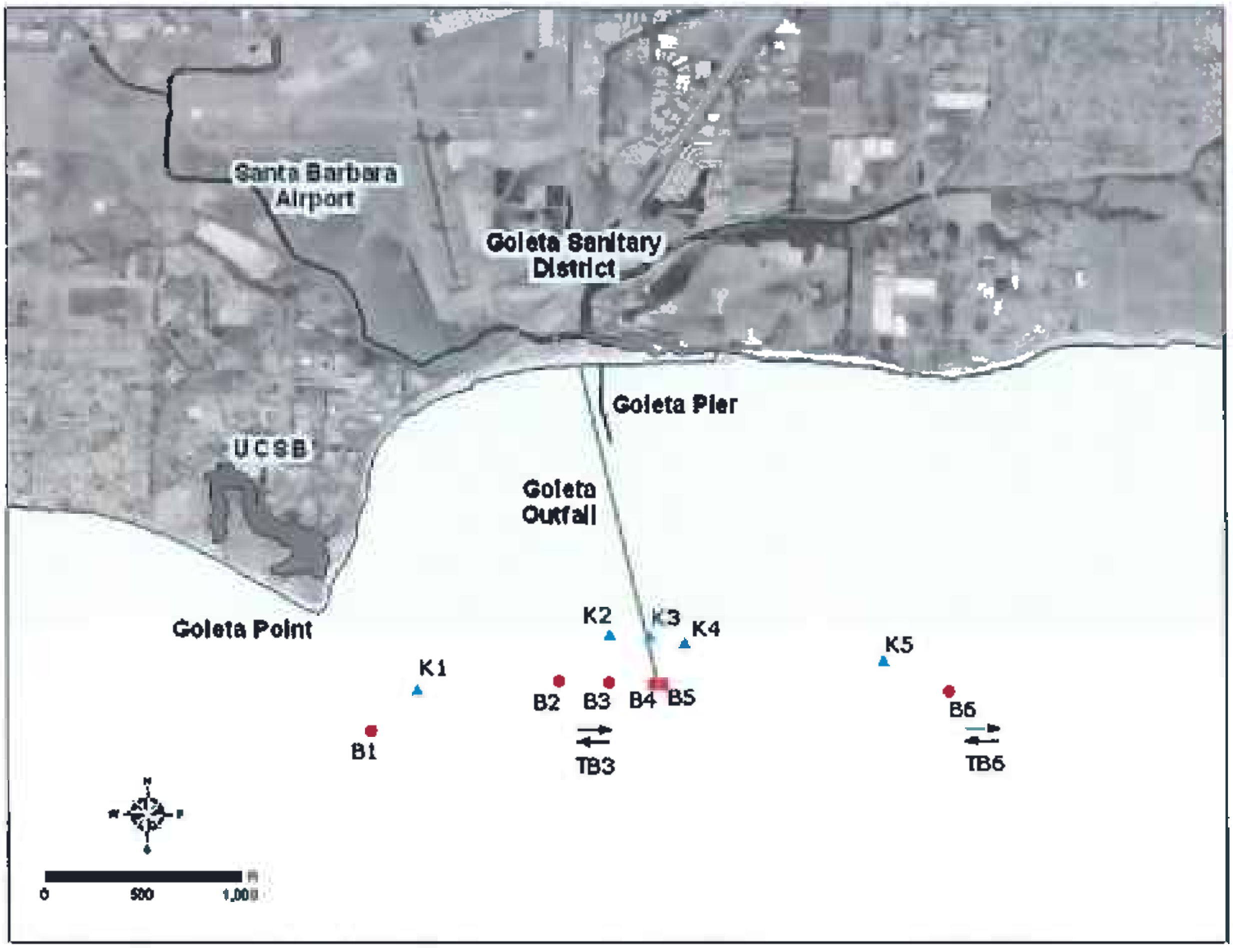


Table 5-1. Sediment contaminant concentrations (dry weight) in the Goleta survey area.

Constituent[1]	Sediment Stations B1	B2	B3	B4	B5	B6	Mean	S.D.	Correlations Outfall	Point	Prt Sz
Undifferentiated Organics											
Oil and Grease (detection = 100 µg/g)[3]	1630	1110	549	356	398	295	723	534	0.12	-0.94	0.83
TKN (detection = 43 µg/g)	377	503	483	578	518	264	454	114	-0.87	-0.49	0.12
TOC (detection = 100 µg/g)[3]	9600	8100	4000	4800	3900	3800	5683	2480	0.03	-0.94	1.00
AVS (detection = 0.05 µg/g)[3]	7.33	12.90	19.60	21.30	11.90	3.75	12.80	6.80	-0.75	-0.20	0.26
Heavy Metals											
Aluminum (detection = 1.0 µg/g)[3]	12900	11000	6830	7760	6780	7570	8807	2538	0.46	-0.71	0.83
Antimony (detection = 0.025 µg/g)	0.16	0.15	0.10	0.13	0.11	0.11	0.125	0.025	-0.03	-0.64	0.87
Arsenic (detection = 0.025 µg/g)	6.46	5.26	4.13	5.17	4.59	3.83	4.91	0.95	-0.17	-0.82	0.96
Cadmium (detection = 0.0025 µg/g)	0.48	0.49	0.42	0.37	0.32	0.35	0.41	0.07	-0.03	-0.61	0.77
Chromium (detection = 0.0025 µg/g)	34.30	30.00	20.80	22.40	20.90	22.10	25.08	5.68	0.18	-0.60	0.87
Copper (detection = 0.0025 µg/g)[3]	7.06	6.09	3.59	4.81	4.09	2.55	4.70	1.68	-0.06	-0.83	0.94
Iron (detection = 1.0 µg/g)[3]	13700	11400	7420	8220	7800	7000	9257	2683	-0.06	-0.83	0.84
Lead (detection = 0.0025 µg/g)	5.20	4.38	3.09	3.64	3.44	2.55	3.71	0.94	-0.20	-0.85	0.86
Mercury (detection = 0.00001 µg/g)	0.0206	0.0185	0.0162	0.0201	0.0178	0.0152	0.018	0.002	-0.39	-0.79	0.86
Nickel (detection = 0.01 µg/g)	16.90	16.60	10.90	10.60	10.30	9.22	12.79	4.02	0.00	-0.72	0.86
Selenium (detection = 0.025 µg/g)	0.45	0.40	0.31	0.32	0.26	0.22	0.32	0.08	-0.19	-0.83	0.96
Silver (detection = 0.01 µg/g)[3]	0.21	0.14	0.11	0.11	0.09	0.07	0.12	0.05	0.07	-0.89	0.99
Tin (detection = 0.025 µg/g)	0.82	0.88	0.64	0.93	0.88	0.80	0.80	0.12	0.03	-0.31	0.60
Zinc (detection = 0.025 µg/g)[3]	34.80	30.20	20.10	22.00	21.10	18.80	24.18	6.88	0.49	0.11	0.75
Complex Organics (ng/g dry weight)[2] **Chlorinated Pesticides**											
DDTs[3]	5.0	3.5	1.7	0.0	0.0	0.0	1.70	2.14	0.40	-0.94	0.82
HCHs	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
Chlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
Aldrin (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Dieldrin (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Heptachlor (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Heptachlor epoxide (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Mirex (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Hexachlorobenzene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00

Bold = Marginally significant ($0.05 < p < 0.10$)
Bold = Significant ($p < 0.05$)
1. Minimum detection limits, reporting limits and methods are listed in Appendix 10.4
2. Complex organic derivatives are listed in Appendix 10.4.
3. Non-normal data. Correlations by nonparametric Spearman's rho.

Table 5-1. continued

	Sediment Stations								Correlations		
Constituent[1]	B1	B2	B3	B4	B5	B6	Mean	S.D.	Outfall	Point	Prt Sz
Polychlorinated Biphenyls											
PCBs	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
Aroclors	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
Polycyclic Aromatic Hydrocarbons											
PAHs[3]	58.0	28.1	14.0	2.[illegible]	5.5	7.6	1[illegible].30	21.02	0.64	-0.77	0.60
1-Methylnaphthalene (detection = 1.0 µg/Kg)	1.5	1.0	1.0	1.0	1.0	1.0	1.08	0.20	0.26	-0.62	0.83
1-Methylphenanthrene (detection = 1.0 µg/Kg)[3]	3.4	2.1	1.3	1.0	1.0	1.1	1.65	0.85	0.65	-0.81	0.67
2,3,5-Trimethylnaphthalene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
2,6-Dimethylnaphthalene (detection = 1.0 µg/Kg)[3]	2.4	1.0	1.0	1.0	1.0	1.0	1.23	0.57	0.40	-0.65	0.65
2-Methylnaphthalene (detection = 1.0 µg/Kg)[3]	2.2	1.0	1.0	1.0	1.0	1.0	1.20	0.49	0.40	-0.65	0.65
Acenaphthene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Benz[a]anthracene (detection = 1.0 µg/Kg)[3]	10.8	4.8	1.8	1.0	1.0	1.0	3.37	3.90	0.40	-0.94	0.82
Benzo(b)fluoranthene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Benzo(e)pyrene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Benzo(g,h,i)perylene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.00	0.00	0.00
Biphenyl (detection = 1.0 µg/Kg)[3]	5.8	1.5	1.3	1.0	1.0	1.0	1.93	1.91	0.40	-0.94	0.82
Fluoranthene (detection = 1.0 µg/Kg)[3]	11.0	9.1	4.6	1.2	2.1	2.0	5.00	4.12	0.38	-0.83	0.66
Naphthalene (detection = 1.0 µg/Kg)	6.[illegible]	1.2	1.2	1.0	1.0	1.0	2.05	2.36	0.38	-0.80	0.77
Perylene (detection = 1.0 µg/Kg)[3]	62.6	27.8	9.6	4.2	5.0	4.0	17.20	19.57	0.12	-0.94	0.63

Bold = Marginally significant ($0.05 < p < 0.10$)
Bold = Significant ($p < 0.05$)
1. Minimum detection limits, reporting limits and methods are listed in Appendix 10.4
2. Complex organic derivatives are listed in Appendix 10.4.
3. Non-normal data. Correlations by nonparametric Spearman's rho.

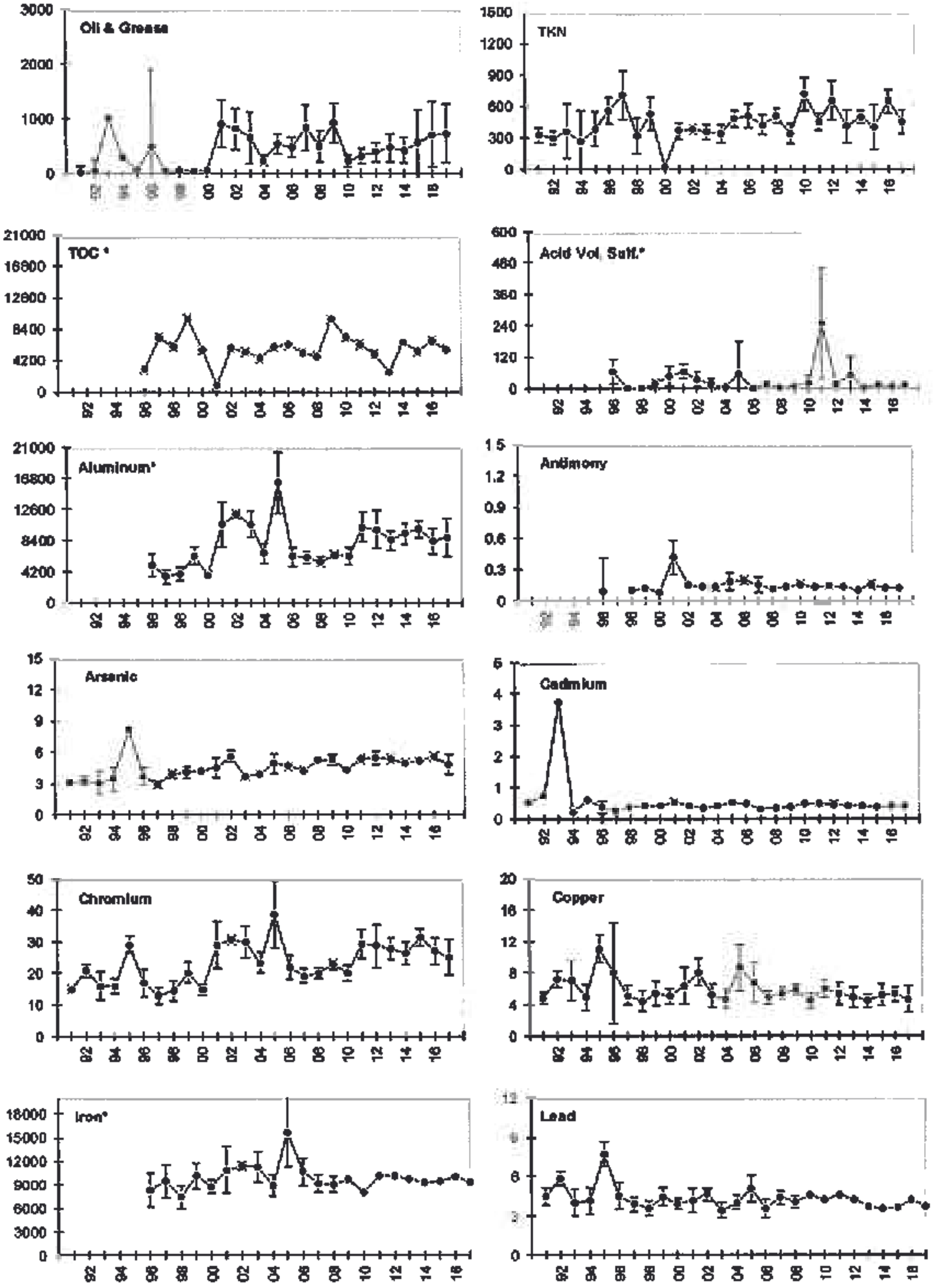


Figure 5-2. Average concentrations (±SD) of sediment contaminants measured between 1991 and 2017 in the Goleta survey area. TOC, acid volatile sulfide, aluminum, iron, selenium and tin were not measured from 1991 to 1995.

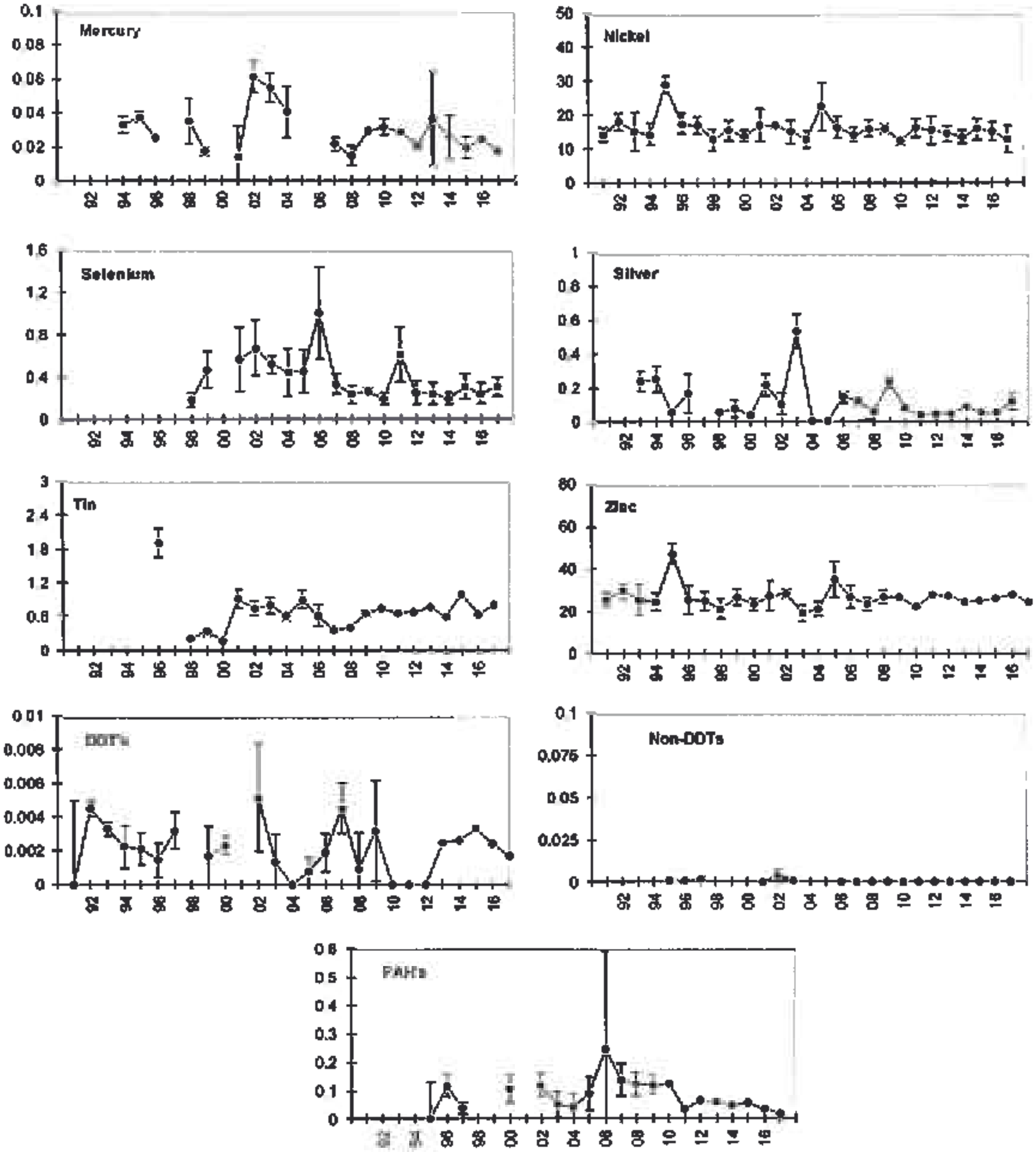


Figure 5-2. (continued)

Table 5-2. Comparison of sediment contaminants found in the Goleta survey area to the Southern California Bight Regional Monitoring Program (SCBRMP) data from 1998, 2003, 2008 and 2013; and, the NOAA status and trends ERL and ERM threshold values. The SCBRMP survey includes comparisons against stations located near SPOTWs and shallow water reference sites.

	GOLETA S.D.		SCBRMP (2013)[1]				SCBRMP (2008)[2]				SCBRMP (2003)[3]				SCBRMP (1998)[4]		NOAA (1990)[4], Long et al. (1995)[5]	
			Inner Shelf		So Cal Bight		Inner Shelf		So Cal Bight		Inner Shelf		Small POTW		SPOTW	Shallow		
Constituent	Mean	Range	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	Mean	ER-L	ER-M
Undifferentiated Organics																		
Oil and Grease	723	295 - 1530	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TKN	454	264 - 578	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOC	5663	3800 - 9500	2600	400	21000	3000	66000	4100	30000	100	2700	800.00	8400	1800	[illegible]	4200	—	—
AVS	12.8	3.8 - 21.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heavy Metals																		
Aluminum	8907	6780 - 12900	7000	1000	20000	1594	5258	720	15372	1594	9212	2233	13244	3886	—	—	—	—
Antimony	0.13	0.10 - 0.16	0.43	0.11	0.90	0.16	0.12	0.02	0.28	0.04	0.14	0.04	0.15	0.02	1.09	1.59	2	25
Arsenic	4.91	3.83 - 6.46	2.4	0.3	4.00	0.50	4.3	1.2	8.70	1.20	4.2	1.4	4.6	0.67	7.67	4.39	8.2	70
Cadmium	0.41	0.32 - 0.49	0.60	0.11	1.30	0.30	0.23	0.03	0.90	0.12	0.20	0.06	0.22	0.05	0.28	0.26	1.2	9.6
Chromium	25.06	20.60 - 34.30	17	2.0	57.0	5.0	18	3.8	58.0	9.9	27	6.8	27	5.8	24.72	19.02	81	370
Copper	4.70	2.55 - 7.06	3.7	0.6	26.00	3.00	4.4	0.8	23.00	5.80	8.8	1.8	9.0	2.5	17.41	6.62	34	270
Iron	9257	7000 - 13700	11000	1000	25000	1100	10239	2233	28218	3125	[illegible]	2784	16256	3654	—	—	—	—
Lead	3.71	2.56 - 5.20	4.3	0.5	11.00	1.00	5.0	1.3	12.00	1.40	4.7	1.1	4.90	0.81	15.92	10.14	46.7	218
Mercury	0.018	0.015 - 0.021	0.04	0.02	0.089	0.020	0.02	0.01	1.800	2.600	0.03	0.01	0.05	0.03	0.050	0.036	0.15	[illegible]
Nickel	12.79	9.22 - 16.90	9.7	1.2	33.00	2.90	9	1.7	27.00	2.80	13	3.8	11	2.0	13.85	15.60	20.9	51.6
Selenium	0.32	0.22 - 0.45	0.07	0.02	1.30	0.40	0.44	0.11	3.50	2.60	[illegible]	0.22	0.55	0.12	0.97	0.47	—	—
Silver	0.12	0.07 - 0.21	0.22	0.31	0.41	0.11	0.12	0.09	0.91	0.40	0.13	0.06	0.14	0.06	0.12	0.19	1.0	3.7
Tin	0.80	0.64 - 0.93	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Zinc	24.18	16.60 - 34.90	29	4.0	88.00	6.00	26	6.6	71.00	5.90	34	7.8	40	8.0	52.14	33.69	150	410
Complex Organics																		
DDTs	0.0017	0.0000 - 0.0050	0.0120	0.0160	0.1300	0.0880	0.0023	0.0004	0.1280	0.0970	0.0023	0.0004	0.0012	[illegible]	0.020	0.038	0.00158	0.0461
HCHs	0.0000	0.0000 0.0000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chlordane	0.0000	0.0000 - 0.0000	0.0000	0.0001	0.0002	0.0002	0.0005	0.0001	0.0016	0.0008	0.00001	0.00001	[illegible]	[illegible]	—	—	—	—
PCBs	0.0000	0.0000 - 0.0000	0.0005	0.0003	0.0052	0.0030	0.0002	0.0000	0.1700	0.0067	0.0024	0.00001	0.0001	0.00001	0.004	0.005	0.0227	0.18
PAHs	0.0193	0.0026 - 0.0580	0.0240	0.0060	0.1200	0.0290	0.0512	0.0449	0.2880	0.0390	0.0312	0.0449	0.0249	0.0087	0.118	0.073	4.022	44.792

1. SCCWRP, 2012; 2. SCCWRP, 2006; 3. SCCWRP 2003; 4. Long and Morgan, 1990; 5. Long et al., 1995.

Table 5-3. Summary of sediment contaminant spatial trends and concentrations found in the Goleta survey area to the Southern California Bight Regional Monitoring Program (SCBRMP) data from 1998, 2003, 2008 and 2013; and, the NOAA status and trends ERL and ERM threshold values.

Constituent	Expected Correlation w/ Dist from Outfall	Expected & Significant Correlation	Exceeds Reference Survey?								Exceeds	
			2013 Inner Shelf	20013 So Cal Bight	2008 Inner Shelf	2008 So Cal Bight	2003 Inner Shelf	2003 BPOTW	1998 BPOTW	1998 Shallow	ER-L?	ER-M?
Oil and Grease	No	No	—	—	—	—	—	—	—	—	—	—
TKN	Yes	Yes	—	—	—	—	—	—	—	—	—	—
TOC	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	—	—
AVS	Yes	No	—	—	—	—	—	—	—	—	—	—
Aluminum	No	No	Yes	No	Yes	No	No	No	—	—	—	—
Antimony	Yes	No	No	No	Yes	No	No	No	No	No	No	No
Arsenic	Yes	No	Yes	Yes	Yes	No	No	Yes	No	Yes	No	No
Cadmium	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No	No
Chromium	No	No	Yes	No	Yes	No	No	No	Yes	Yes	No	No
Copper	Yes	No	Yes	No	Yes	No	No	No	No	No	No	No
Iron	Yes	No	No	No	No	No	No	No	—	—	—	—
Lead	Yes	No	No	No	No	No	No	No	No	No	No	No
Mercury	Yes	No	No	No	Yes	No	No	No	No	No	No	No
Nickel	No	No	Yes	No	Yes	No	No	Yes	No	No	No	No
Selenium	Yes	No	Yes	No	No	No	No	No	No	No	No	No
Silver	No	No	No	No	No	No	No	No	No	No	No	No
Tin	No	No	—	—	—	—	—	—	—	—	—	—
Zinc	No	No	No	No	Yes	No	No	No	No	No	No	No
DDTs	No	No	No	No	Yes	No	No	Yes	No	No	Yes	No
HCHs	No	No	—	—	—	—	—	—	—	—	—	—
Chlordane	No	No	No	No	No	No	No	No	—	—	No	No
PCB'S	No	No	No	No	No	No	No	No	No	No	No	No
PAH'S	No	No	Yes	No	No	No	No	Yes	No	No	No	No

CHAPTER 6

Benthic Infauna

6.1. Background

The benthic infauna community is composed of those species living in or on the bottom (benthos). This community is very important to the quality of the habitat because it provides food for the entire food web including juvenile and adult fishes that are bottom feeders. Usually polychaete annelid worms, molluscans, and crustaceans dominate the benthic fauna in shallow, silty, sometimes unconsolidated, habitats. In areas where sediments are contaminated or frequently disturbed by natural events such as storms or by manmade events, nematode round worms, oligochaete worms, or tolerant polychaetes or mollusks may dominate the fauna temporarily. Storms can cause organisms to be washed away or buried under transported sediment, or can cause changes in the preferred grain size for particular species. Excessive runoff may lower normal salinities, and thermal regime changes offshore may disturb the composition of the community. Some species of benthic organisms with rapid reproductive cycles or great fecundity can out-compete other organisms in recolonization, at least temporarily after disturbances, but competitive succession may eventually result in replacement of the original colonizers with more dominant species.

6.2. Materials and Methods

Field sampling for all benthic sediment components is described in Chapter 4. Sediments to be analyzed for infauna content were sieved through 1.0 millimeter screens. The retained organisms and larger sediment fragments were then washed into four-liter plastic bottles, relaxed with a magnesium sulfate solution, and preserved with 10% buffered formalin. Five replicates were collected from six benthic infauna stations (B1, B2, B3, B4, B5, and B6; see Figure 3-1). Screened and preserved sediments collected in the field were delivered to the Ventura laboratory for counting, sorting, and identification. Infauna were sorted out by Aquatic Bioassay staff biologists and separated into five groups: echinoderms, mollusks, polychaetes, crustaceans, and miscellaneous. For each station, organisms were counted per group in accordance with *Techniques for Sampling and Analyzing the Marine Macrobenthos* EPA 600/3-78-300, March 1978; *Quality Assurance and Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods*, Tetra Tech 1986; and *Southern California Bight Pilot Project Field Operations Manual*, 2013. Each sorted sample was re-checked by a second biologist for representatives not found during the first inspection. Infauna was identified by SCAMIT taxonomists Tony Phillips for and polychaetes, mollusks and other phyla, Dean Pasko for crustaceans and Megan Lily of the City of San Diego for echinoderms. A complete list of infauna is included in Appendix 10.6. Aquatic Bioassay maintains and updates standardized type collections and voucher specimens for most southern California infauna.

Following enumeration of infauna organisms by species, the total and phyla group numbers of individuals, and numbers of separate species were compiled for each station replicate. In addition, several required biological indices were calculated: Shannon Weiner species diversity (H'), Margelef's richness index (d), Simpson's species diversity (SI), Schwartz's dominance (D), the infauna trophic index (ITI) and

Benthic Response Index (BRI). Analysis of Variance (ANOVA) was used to compare average metrics values among stations. Species compositions were compared using numerical classification and ordination. Brief descriptions of the indices are presented below.

Shannon Diversity. The Shannon Diversity Index (H') (Shannon and Weaver 1963) is defined as:

$$H' = -\sum_{j=1}^{s} \{(nj/N)\ \text{Ln}\ (nj/N)\},$$

where: nj = number of individuals of the jth species,
s = number of species in the sample,
N = number of individuals in the sample.

Margalef's Richness. Margalef's Species Richness Index (d) (Margalef 1958) is:

$$d = s-1 / \text{Ln}\ N,$$

where: s = number of species in the sample,
N = number of individuals in the sample.

Simpson's Diversity. The Simpson' Diversity Index (SI) (Simpson 1949) is:

$$SI = 1 - \sum_{i=1}^{s} (p_i)^2,$$

where: p_i = proportion of individuals of the *i*th species in the community.

Schwartz' Dominance. Schwartz's Dominance Index (D) is defined as the minimum number of species required accounting for 75% of the individuals in a sample (Schwartz 1978).

Infauna Trophic Index. This index measures the prevailing feeding modes of benthic infauna. Higher values denote southern California species assemblages dominated by suspension feeders, which are more characteristic of unpolluted environments. Lower index values denote assemblages dominated by deposit feeders more characteristic of areas near major outfalls (Word 1980):

$$ITI = -33.33\ \{n_2 + (2)(n_3) + (3)(n_4) / n_1 + n_2 + n_3 + n_4\},$$

where: $n_1,\ldots,n_4$ = numbers of individuals in species trophic groups 1,...,4, respectively.

Benthic Response Index. The BRI is the abundance-weighted average pollution tolerance of species occurring in a sample (Smith *et al.* 2001). The general index formula is:

$$BRI_s = \frac{\sum_{i=1}^{n} a_{si}^{f} p_i}{\sum_{i=1}^{n} a_{si}^{f}} \qquad (1)$$

where BRI_s is the BRI value for sampling unit s, n is the number of species in s, p_i is the pollution tolerance of species i, a_{si} is the abundance of species i in s, and f is an exponent used to transform the abundance values. The primary objective of BRI development is to assign pollution tolerance scores p_i to species based on their position on a pollution gradient. Once assigned, the scores can be used to assess the condition of the benthic community by calculating the BRI. A reference threshold, below which natural benthic assemblages normally occur, was identified at an index value of 31, the point on the pollution vector where pollution effects first resulted in a net loss of species. Three additional thresholds of response to disturbance were defined at index values of 42, 53 and 73, representing points at which 25%, 50%, and 80% of the species present at the reference threshold were lost.

Analysis of Variance (ANOVA). ANOVA's were used to compare population variables and sediment chemistry concentrations among stations. ANOVA analysis requires two steps. In the first step, differences in a variable among stations are evaluated to determine if they are sufficiently large to be statistically significant ($p \leq 0.05$). If they are, then a second test must be performed to determine which stations are significantly different from another station or stations. In this report, this second step is called the comparison of means. For example, a comparison of means stating: OS1 > OS2, OS3 > OS4, indicates that, for that particular variable, Station OS1 is significantly larger than Stations OS2, OS3, and OS4, and Stations OS2 and OS3 are also significantly larger than Station OS4. For chemical contaminants, if stations near the outfall are significantly higher than stations farther away, that compound should be evaluated further. For population variables, the opposite is true.

Cluster Analysis. Cluster analysis was used to define groups of samples, based on species presence and abundance, which belong to the same community without imposing an *a priori* community assignment. Identified clusters were then evaluated to define the habitat to which they belong. In cluster analysis, samples with the greatest similarity are grouped first. Additional samples with decreasing similarity are then progressively added to the groups. The percentage dissimilarity (Bray-Curtis) metric (Gauch, 1982; Jongman et al., 1995) was used to calculate the distances between all pairs of samples. The cluster dendogram was formed using the unweighted pair-groups method using arithmetic averages (UPGMA) clustering algorithm (Sneath and Sokal, 1973). All steps were completed using the computer program MVSP (Multivariate Statistical Package, v3.12, 2000). Only the most commonly occurring species were used in the analysis, in this case only those that occurred at more than one station and season.

For normal (station by station) classifications, the Bray-Curtis Index is:

$$\text{B.C.} = \sum_{i=1}^{s} \min (P_{ij}, P_{ik}),$$

where: P_{ij} = proportion of species i collected at station j,

P_{ik} = proportion of species i collected at station k,
s = number of species.

For inverse (species group by species group) classifications:

$$B.C. = \sum_{i=1}^{N} \min (P_{ij}, P_{ik}),$$

where now: P_{ij} = proportion collected at station i of species j,
P_{ik} = proportion collected at station i of species k,
N = number of stations.

Ordination analysis. Ordination analysis displays the sampling stations as points in a multidimensional space. The distances between the stations (points) in the space are proportional to the dissimilarity of the communities found at the respective stations. The different dimensions of the ordination space, called axes, define independent gradients of biological change in the community data. The projections of the station points onto the various axes are called scores. The axes are ordered so that the first axis displays a maximal amount of community change; the second axis defines a maximal amount of the remaining community change, and so on for subsequent axes. Often most of the relevant community changes are displayed in a few ordination axes.

6.3. Results

6.3.1. Benthic Infauna

6.3.1.1. Infauna Abundance

The simplest measure of resident animal health is the abundance of infauna collected per sampling effort. Measures of abundance include biomass and numbers of individuals, which is partially dependent upon the volume of sediment collected in the grab. For this survey, abundance was determined to be all of the non-colonial animals collected from one replicate Van Veen Grab (0.1 square meter surface area) and retained on a 1.0 mm screen (note that abundance per square meter can be easily calculated by multiplying individuals per grab by ten). Five replicates were collected from six sediment stations.

Spatial infauna abundance patterns. Infauna abundances at the six sediment sampling stations are listed in Table 6-1. Numbers of individuals were significantly greatest by ANOVA near the outfall at B4 (average = 649) and B5 (average = 630), and were least at station B2 (average = 200). Numbers of individuals correlated unexpectedly and non-significantly with distance from the outfall, unexpectedly and non-significantly with distance from Goleta Point, and unexpectedly and non-significantly with particle size. Low abundances in one replicate at B1 and three replicates at B2 were associated with sediments that smelled of petroleum. Goleta Point, where these stations are located, has natural oil seeps and these samples may have been taken directly over a vent.

Infauna abundance patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty five years. The average numbers of individuals increased between 1990 and 1994 and then steadily declined through 1999. Low values during 1998 and 1999 may reflect the El Nino conditions present then. In 2000, values began to increase through 2002 (average = 700), dipped in 2003, and then nearly doubled to historic highs during the period between 2004 and 2006 (average = 1566). Infauna abundances declined in 2007 and 2008 to levels similar to the years previous to 2004. From 2009 thru 2013, abundances remained relatively stable (average ~ 1,000). From 2014 through 2017 another El Nino event was underway and abundances once again dropped to levels like years prior to 2004.

Infauna abundance values compared with other surveys. Table 6-2 compares abundance and other variables with reference control stations from the Southern California Bight Regional Monitoring Program (SCBRMP) surveys conducted in 1998, 2003 and 2008. Average numbers of individuals collected in the Goleta survey area were greater than the averages measured at reference site locations in each of the SCBRMP surveys.

6.3.1.2. Infauna Species

Another simple measure of population health is the number of separate infauna species collected per sampling effort (i.e. one Van Veen Grab). Because of its simplicity, numbers of species is often underrated as an index. If the sampling effort and area sampled are the same for each station, however, this index can be one of the most informative. In general, stations with higher numbers of species per grab tend to be in areas of healthier communities.

Spatial infauna species patterns. Infauna species at the six sediment sampling stations are listed in Table 6-1. Numbers of species were greatest at station B4 (average = 144) at the outfall and decreased to the east and west with lowest numbers of taxa found at station B2 (average = 54). Numbers of species correlated unexpectedly and non-significantly with distance from the outfall, unexpectedly and non-significantly with Goleta Point, and expectedly and non-significantly with particle size.

Infauna species patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty five years. Similar to numbers of individuals, numbers of species increased between 1991 and 1994 and then steadily declined through 1999 possibly owing to an El Nino effect. Since 2000 the average number of species has steadily increased through 2006 when it reached a historic high (average = 181). Since 2006 the average number of species has steadily declined thru 2014 (average = 101), but increased to historic highs from 2015 to 2016. In 2017 numbers of species declined somewhat.

Infauna species values compared with other surveys. Table 6-2 compares numbers of species and other variables with reference control stations from SCBRMP surveys conducted in 1998, 2003 and 2008. Ranges for Goleta species counts were greater than ranges measured in each of the SCCWRP reference site surveys.

6.3.1.3. Infauna Diversity

Species diversity indices are similar to numbers of species; however they often contain an evenness component, as well. For example, two samples may have the same numbers of species and the same numbers of individuals. However, one station may have most of its numbers concentrated into only a few species while a second station may have its numbers evenly distributed among its species. The diversity index would be higher for the latter station. The diversity indices required in the Goleta permit are the Shannon Diversity Index, Margalef Richness Index, and Simpson Diversity Index. Since all of these indices are calculated from the same measures (numbers of individuals and numbers of species), they often show the same patterns, and are, thus, probably somewhat redundant (Table 6-1). Infauna population metrics are presented by station. Comparisons are made using correlation analysis and ANOVA.

Spatial infauna diversity patterns. Infauna diversities at the six sediment-sampling stations are listed in Table 6-1. Diversity, as measured by Shannon's, Margalef's, and Simpson's indices were similar across sites and uniformly elevated in the survey area. Each was greatest at station B4 near the outfall terminus, significantly so for Margalef's Richness by ANOVA ($p < 0.05$). None of the correlations with distance to the outfall were significant for Shannon, Margalef's or Simpson's Diversity.

Infauna diversity patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty years. Shannon Diversity has been high in the Goleta survey area during the entire time period, with averages ranging between 3.5 to over 4.0 thru 2017. Diversity was just below 4.0 through the 1990's and then began a slight decrease to a low in 2005. In 2006 diversity began to increase thru 2007 and 2008, and reached a high in 2009 and 2010, before decreasing again in 2011 and 2012. In 2016, average diversity reached an historic high for the 25-year period ($H' = 4.2$). In 2017, diversity declined to pre 2016 levels.

Infauna diversity values compared with other surveys. Table 6-2 compares the Shannon Diversity Index reference stations from the SCBRMP surveys conducted in 1998, 2003 and 2008. Shannon Diversity measured in the Goleta survey area was similar in 2017 when compared to each of the SCBRMP reference site surveys. Neither Margalef's nor Simpson's indices were calculated during the two SCCWRP programs.

6.3.1.4. Infauna Dominance

The Schwartz Dominance Index is defined as the minimum number of species required to account for 75% of the individuals in a sample. The infauna environment tends to be healthier when the dominance index is high, and it tends to correlate with species diversity.

Spatial infauna dominance patterns. Dominance at the six sediment-sampling stations is listed in Table 6-1. Dominance was greatest at B4 near the outfall (average = 38), and least at B2 (average = 17). Dominance correlated unexpectedly and non-significantly with distance from the outfall, expectedly and non-significantly with distance from Goleta Point, and unexpectedly and non-significantly with sediment particle size.

Infauna dominance patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty five years. Dominance has been high in the Goleta survey area during the entire time period, ranging between 23 and 41. Dominance ranged between 35 and 40 through the 1990's and then began a slight decrease to a low in 2005. After 2010 dominance decreased thru 2014 and then reached historic highs in 2015 and 2016 (average = 41). In 2017 dominance decreased somewhat.

Infauna dominance values compared with other surveys. Table 6-2 compares the dominance at reference sites from the SCBRMP surveys conducted in 1998, 2003 and 2008. Dominance in the Goleta survey area in 2017 was greater than the SCBRMP reference site surveys.

6.3.1.5. Infauna Trophic Index

The Infauna Trophic Index (SCCWRP 1978, 1980) was developed to measure the feeding modes of benthic infauna. Higher values denote California species assemblages dominated by suspension feeders, which are more characteristic of unpolluted environments. Lower index values denote assemblages dominated by deposit feeders more characteristic of sediments high in organic pollutants (e.g. near major ocean outfalls). SCCWRP has also provided definitions for ranges of infauna index values. Values that are 60 or above indicate "normal" bottom conditions. Values between 30 and 60 indicate "change", and values below 30 indicate "degradation". The infauna trophic index is based on a 60-meter depth profile of open ocean coastline in southern California. Therefore, its results should be interpreted with some caution when applied to Goleta's shallower stations (24 m).

Spatial Infauna Trophic Index patterns. Infauna Trophic Index (ITI) scores at the six sediment-sampling stations is listed in Table 6-1. ITI values correlated unexpectedly and non-significantly with distance from the outfall, expectedly and non-significantly with distance from Goleta Point, and unexpectedly and non-significantly with particle size. ITI scores at all stations were above levels defining benthic communities that are changed (60) and far above levels defining benthic communities that are degraded (30). The greatest ITI score was measured at the B3.

Infauna Trophic Index patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty years. Average ITI values have remained stable across years and were similar in 2017 to past surveys.

Infauna Trophic Index values compared with other surveys. The ITI was not calculated for the SCBRMP (1998, 2003 and 2008). This index has been replaced as a measure of biological condition by the Benthic Response Index (BRI).

6.3.1.6 Benthic Response Index

The Benthic Response Index (BRI) measures the condition of a benthic assemblage, with defined thresholds for levels of environmental disturbance (Smith et al. 2001). The pollution tolerance of each species is assigned based upon its distribution of abundance along a pre-established environmental gradient. To give index values an ecological context and facilitate their interpretation, four thresholds of biological response to pollution were identified. The thresholds are based on changes in biodiversity along a pollution gradient. A reference threshold, below which natural benthic assemblages normally occur, was identified at an index value of 31, the point on the pollution vector where pollution effects first resulted in a net loss of species. Three additional thresholds of response to disturbance were defined at index values of 42, 53 and 73, representing points at which 25%, 50%, and 80%, respectively, of the species present at the reference threshold were lost.

Spatial BRI patterns. BRI scores correlated expectedly (decreased) and non-significantly with distance to the outfall, expectedly and significantly with distance to Goleta Point, and non-significantly with particle size (Table 6-1). Average BRI scores were significantly greatest by ANOVA. BRI scores at Station B2 were significantly greatest compared to all other stations. Except for B2, scores were below 31 indicating there was no net loss of reference species in the survey area. This indicates that the sites in the Goleta survey area are similar to other shallow reference site locations in the Southern California Bight.

6.3.1.6. Cluster & Ordination Analysis

Patterns of species composition in the receiving environment's infauna community were evaluated by comparing normal (station x station) and inverse (species group x species group) classifications using the Bray-Curtis pair-wise similarity index. As Bray-Curtis Index values between station groups approach zero, the population of animals that make up the community at those sites becomes more the same. A station dendrogram was constructed from the resulting pattern matrix (Figure 6-2). For the 2017 survey, rare species were excluded from the analysis so that 255 species that occurred at > three sites were retained for analysis (96% of the total number of individuals collected).

Stations clustered into three groups (Figure 6-2). The greatest Bray-Curtis distance between any two station nodes was approximately 50%, which indicates moderate differences in species abundances and composition between sites. Station group 1 included stations B1 and B2, group 2 included stations B3 and B5, and group 3 included only B6.

Of the twenty relatively abundant species collected in each cluster group, only two were shared across cluster groups (Table 6-3). The most common species in the survey area were those typically found in coastal nearshore waters.

When the biological metrics for each station cluster group were averaged together they showed that the infauna population in cluster groups 3 (B6) had lower abundances, taxa richness, BRI and Shannon Diversity (Table 6-4). There was no clear outfall related pattern.

6.4. Discussion

Results from this infauna survey support past studies that indicated that the ocean outfall discharge does not appear to be strongly impacting the resident benthic infauna community. This was confirmed by statistically comparing results among stations both near and far from the diffuser, comparing results with historical surveys, comparing results with other studies performed in Southern California, and comparing stations by cluster analyses.

Evaluation of the biological metrics for the 2017 survey showed that metrics were greatest near the outfall and least near Goleta Point. In past surveys, there was usually an increased taxa and diversity near Goleta Point may have been due to the increased availability of organic material emanating from the oil seeps that are present there (Pearson and Rosenberg 1978). In 2017 infauna replicate samples at B1 and B2, near Goleta Point, had extremely low numbers of taxa and abundances. These low numbers were associated with a strong petroleum smell in these samples indicating the grabs were collected directly over a vent. These results indicate the difficulty with interpreting the results of hypothesis testing on infauna abundance data. To try to elucidate these patterns and assess what, if any, impacts might be occurring to the infauna community, two indices were calculated and cluster analysis was employed.

The Infaunal Trophic Index (ITI) assesses the health of the benthic community using trophic level feeding strategies. In 2017 ITI scores at all stations were well above levels defining benthic communities that are changed (60) and far above levels defining benthic communities that are degraded (30). ITI scores in the survey area ranged from least (80) at station B1 and B3, to least at outfall station B4 (74). The ITI has been employed to assess the health of benthic communities since the early 1980's. However, its use to assess communities residing at depths less than 60 m has been criticized.

The averaged Benthic Response Index (BRI) scores (Smith et al. 2001) were below 31 indicating that there was no net loss of reference species in the survey area. The BRI approach differs from other multimetric techniques in using multivariate ordination as the basis for assigning pollution tolerance scores. The primary objective of the BRI is to assign pollution tolerance scores to species based on their position on a pollution gradient. Once assigned, the scores can be used to assess the condition of the benthic community. The BRI was developed using hundreds of infauna samples collected from throughout the southern California bight, at sites that were both degraded and in reference condition.

Biological metrics calculated for the 2017 survey were compared to results of past surveys at the same sampling locations since 1990. Each of the metrics measured in 2017 were within the ranges of past surveys.

Cluster analysis showed that the dissimilarity among both station and species groups were very low across the survey area. The three station clusters identified were at most 50% different from one another based on infauna abundances and taxa composition. Of the top twenty most abundant species in the survey area, 2 were shared by the two cluster groups.

To further investigate the potential influence of the Goleta outfall on the infauna community, ordination analysis was conducted on infauna data sets collected from 2004 to 2017 (Figure 6-3). Ordination analysis showed that the largest portion of the variation in the infauna community during the period could be described by ordination axis 1 (21%) which was closely associated with survey year. Stations clustered together on axis 1 by year with 2004 thru 2010 infauna communities furthest from stations collected during 2011 thru 2017. This indicates that larger oceanographic conditions are defining the abundances and composition of species in the survey area. There was no clear outfall related gradient on either axis 1 or axis 2 which described 11% of the variation in the community.

The biological metrics for each site and survey were averaged by historic cluster group and showed there was very little difference across cluster groups indicating a relatively stable infauna population through time (Table 6-5).

Finally, Goleta results were compared to measurements made of the inner continental shelf throughout southern California. All infauna population variables were comparable to or greater than those measured in regional surveys conducted by the SCBRMP in 1998, 2003 and 2008.

Although there are no specific numerical limitations regarding infauna animals, the California Ocean Plan (SWRCB 2007) states that:

The rate of deposition of inert solids and the characteristics of inert solids in the ocean shall not be changed such that benthic communities are degraded.

The dissolved sulfide concentration of waters in and near sediments shall not be significantly increased above that present under natural conditions.

The concentration of substances set forth in Chapter IV, Table B, in marine sediments shall not be increased to levels which would degrade indigenous biota.

The concentration of organic materials in marine sediments shall not be increased to levels which would degrade marine life.

Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.

Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded.

Waste management systems that discharge to the ocean must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

Waste discharged to the ocean must be essentially free of: "2) Settleable material or substances that may form sediments which will degrade benthic communities or other aquatic life."

Waste discharged to the ocean must be essentially free of: "3) Substances which will accumulate to toxic levels in marine waters, sediments or biota."

Based upon spatial and temporal comparisons and analogies with other studies, the results of the infauna survey indicate that the discharge is in compliance with the general limitations and that it causes no adverse impact.

Table 6-1. Infauna population indices by replicate for each of the six Goleta survey area stations. Comparisons are made using correlation analysis and ANOVA ($p < 0.05$).

	Offshore Stations					
Constituent	B1	B2	B3	B4	B5	B6
INDIVIDUALS[1]						
Repl. 1	1	330	273	765	559	249
Repl. 2	495	635	600	609	680	275
Repl. 3	623	7	193	625	649	297
Repl. 4	686	13	334	446	548	255
Repl. 5	469	17	225	601	514	240
Mean =	455	200	325	649	630	263
Std. Dev. =	259	279	163	144	148	23
Lower Conf. Int. =	219	-44	182	523	500	243
Upper Conf. Int. =	691	445	468	776	760	283
Overall Mean = 420		r (outfall)= -0.35		r (point) = -0.22		r (prt.sz.) = 0.06
Overall S.D. = 248		H = 13.6		Comp. of means = B4, B5 > B2, B3, B6		
SPECIES[1]						
Repl. 1	1	112	76	154	132	87
Repl. 2	134	140	138	168	133	90
Repl. 3	132	5	67	136	152	92
Repl. 4	150	6	108	125	127	85
Repl. 5	135	7	74	139	129	80
Mean =	110	54	93	144	135	87
Std. Dev. =	62	66	30	17	10	5
Lower Conf. Int. =	56	-4	66	130	126	83
Upper Conf. Int. =	164	112	119	159	143	91
Overall Mean = 103.8		r (outfall) = -0.22		r (point) = -0.12		r (prt.sz.) = 0.01
Overall S.D = 47.6		H = 12.1		Comp. of means = B2, B3, B6 < B4		
SHANNON DIVERSITY						
Repl. 1	0	4.14	3.65	4.21	4.14	3.98
Repl. 2	4.15	4.15	4.06	4.29	3.86	3.96
Repl. 3	4.01	1.48	3.4	4	4.27	3.98
Repl. 4	4.17	1.29	4.11	4.11	3.95	3.95
Repl. 5	4.14	1.65	3.71	4.18	3.99	3.92
Mean =	3.29	2.54	3.79	4.16	4.04	3.96
Std. Dev. =	1.84	1.47	0.30	0.11	0.16	0.02
Lower Conf. Int. =	1.68	1.25	3.53	4.06	3.90	3.94
Upper Conf. Int. =	4.91	3.83	4.05	4.25	4.18	3.98
Overall Mean = 3.83		r (outfall) = -0.001		r (point) = 0.21		r (prt.sz.) = -0.28
Overall S.D. = 1.05		H = 8.76		Comp. of means = N/A		
MARGALEF RICHNESS						
Repl. 1	1.00	19.14	13.37	23.04	20.71	15.59
Repl. 2	21.44	21.54	21.42	24.94	19.47	15.85
Repl. 3	20.36	2.06	12.54	20.97	23.32	15.98
Repl. 4	22.82	1.95	18.41	20.33	19.96	15.16
Repl. 5	21.79	2.12	13.48	21.57	20.51	14.41
Mean =	17.48	9.36	15.84	22.17	20.80	15.40
Std. Dev. =	9.25	10.06	3.88	1.85	1.49	0.63
Lower Conf. Int. =	9.37	0.54	12.44	20.55	19.49	14.84
Upper Conf. Int. =	25.59	18.18	19.25	23.79	22.10	15.95
Overall Mean = 16.84		r (outfall) = -0.17		r (point) = -0.06		r (prt.sz.) = -0.04
Overall S.D. = 6.82		H = 12.66		Comp. of means = B2, B3, B6 < B4		

Bold = Marginally Significant ($0.05 < p < 0.10$)
Bold & Gray = Significant ($p < 0.05$)

1. The van Veen Grab collects samples one tenth of one square meter in area. To determine individuals per meter, multiply by ten.
2. Non-normal data: correlation coefficients and ANOVA's from non-parametric tests (Spearman's rho and Kruskal-Wallace H, respectively).

Table 6-1. continued

Constituent	Offshore Stations B1	B2	B3	B4	B5	B6
SIMPSON DIVERSITY						
Repl. 1	0.00	4.14	3.65	4.21	4.14	3.98
Repl. 2	4.15	4.15	4.08	4.29	3.86	3.96
Repl. 3	4.01	1.48	3.40	4.00	4.27	3.98
Repl. 4	4.17	1.29	4.11	4.11	3.95	3.95
Repl. 5	4.14	1.65	3.71	4.18	3.99	3.92
Mean =	3.29	2.54	3.79	4.16	4.04	3.96
Std. Dev. =	1.84	1.47	0.30	0.11	0.16	0.02
Lower Conf. Int. =	19.20	22.03	20.29	19.68	24.65	21.34
Upper Conf. Int. =	26.20	24.95	25.23	21.70	27.68	22.39
Overall Mean = 3.631	r (outfall) = -0.001		r (point) = 0.21		r (prt.sz.) = -0.28	
Overall S.D. = 1.052	H = 8.76		Comp. of means = N/A			
SCHWARTZ DOMINANCE						
Repl. 1	1	39	27	43	34	32
Repl. 2	36	36	35	42	27	31
Repl. 3	35	4	23	31	42	32
Repl. 4	37	3	36	37	34	32
Repl. 5	43	3	25	39	34	31
Mean =	30	17	29	38	34	32
Std. Dev. =	17	19	6	5	5	1
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 30.13	r (outfall) = -0.02		r (point) = 0.07		r (prt.sz.) = -0.10	
Overall S.D. = 12.00	H = 7.68		Comp. of means = N/A			
INFAUNAL INDEX						
Repl. 1	0	77	82	70	77	76
Repl. 2	81	79	79	77	73	83
Repl. 3	83	78	80	78	79	78
Repl. 4	80	70	80	78	82	81
Repl. 5	81	79	83	74	77	74
Mean =	65	77	81	76	78	78
Std. Dev. =	36	4	2	4	3	4
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 75.70	r (outfall) = -0.07		r (point) = 0.21		r (prt.sz.) = -0.30	
Overall S.D. = 14.70	H = 7.83		Comp. of means = N/A			
BENTHIC RESPONSE INDEX						
Repl. 1	12	29	27	27	26	21
Repl. 2	34	29	25	27	25	18
Repl. 3	31	58	26	24	26	19
Repl. 4	32	42	25	27	28	17
Repl. 5	33	44	24	26	24	22
Mean =	28	41	25	26	26	19
Std. Dev. =	9.3	12.2	1.2	1.3	1.2	2.0
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 27.62	r (outfall) = -0.32		r (point) = -0.39		r (prt.sz.) = 0.36	
Overall S.D. = 8.73	H = 18.73		Comp. of means = B2 > B3, B5, B6; B1, B4 > B6			

Bold = Marginally Significant ($0.05 < p < 0.10$)

Bold & Gray = Significant ($p < 0.05$)

1. The van Veen Grab collects samples one tenth of one square meter in area. To determine individuals per meter, multiply by ten.
2. Non-normal data: correlation coefficients and ANOVA's from non-parametric tests (Spearman's rho and Kruskal-Wallace H, respectively).

Figure 6-1. Infauna community variables, station (n = 6) means and standard deviations since 1990.

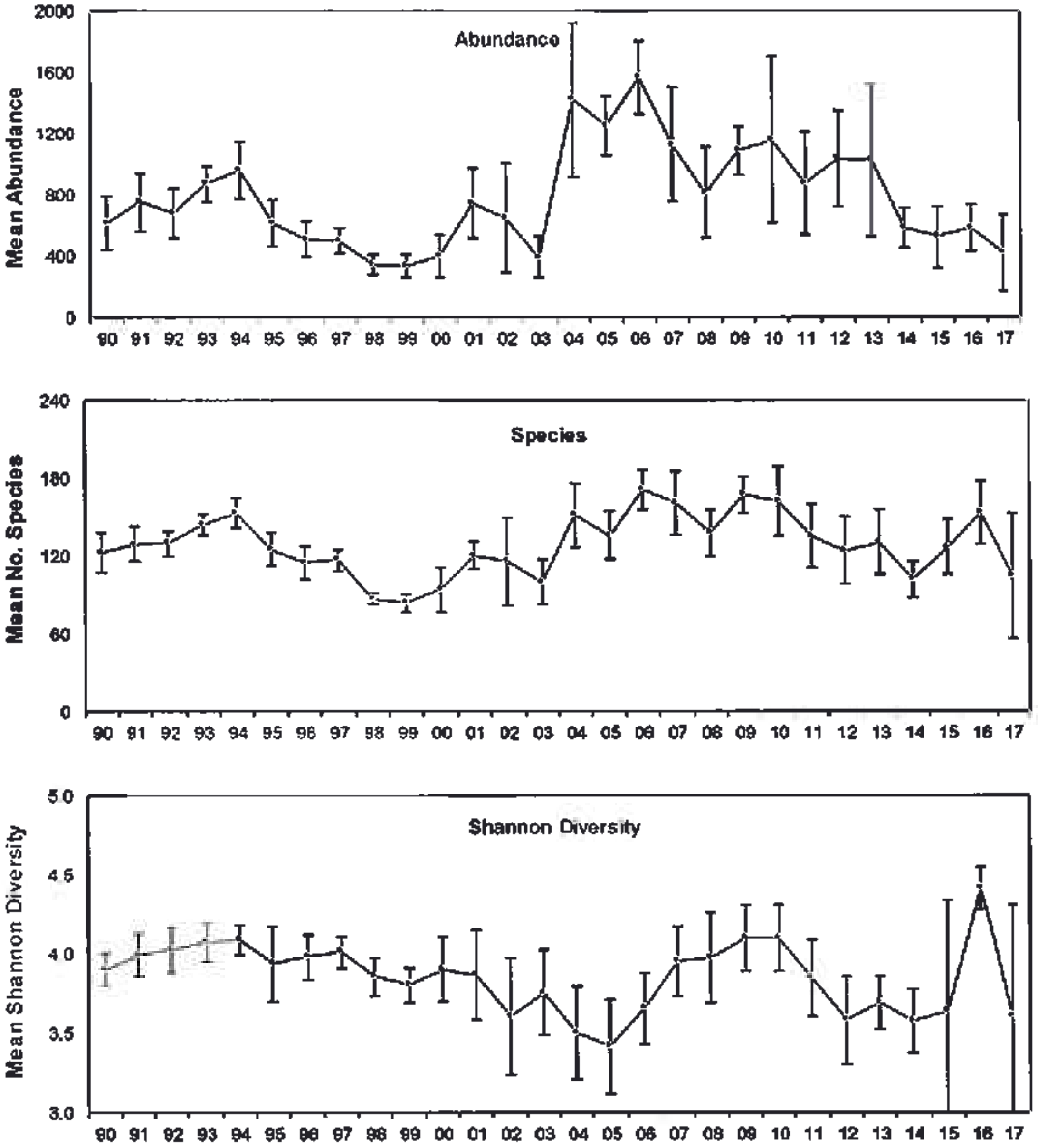


Figure 6-1. (continued).

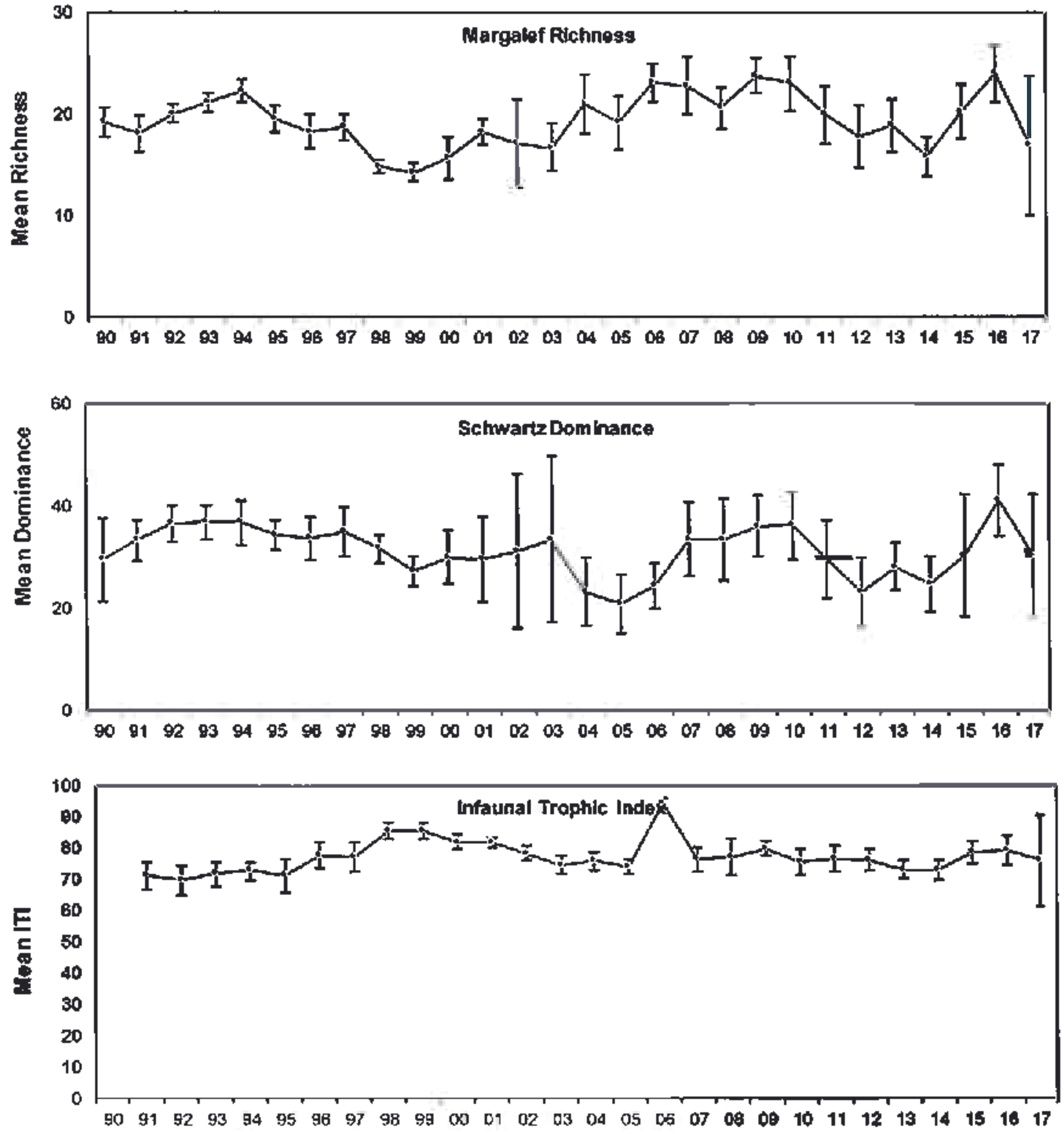


Table 6-2. Comparison of Goleta infauna variables with results from other studies (per 0.1 m²).

	Goleta 2017		SCBRMP 1998		SCBRMP 2003 Inner Shelf		SCBRMP 2008 Inner Shelf	
Variable	Mean	Range	Mean	Range	Mean	±95% CI	Mean	SE
Number of Individuals	420	1 - 880	365	35 - 1696	283	30	348	22
Number of Species	104	1 - 168	85	18 - 162	62	5	65	4
Shannon Diversity Index	3.6	0.0 - 4.3	3.60	2.00 - 4.40	3.48	0.09	3.63	0.06
Dominance	30.1	1.0 - 43.0	—	— - —	23	2	27	1

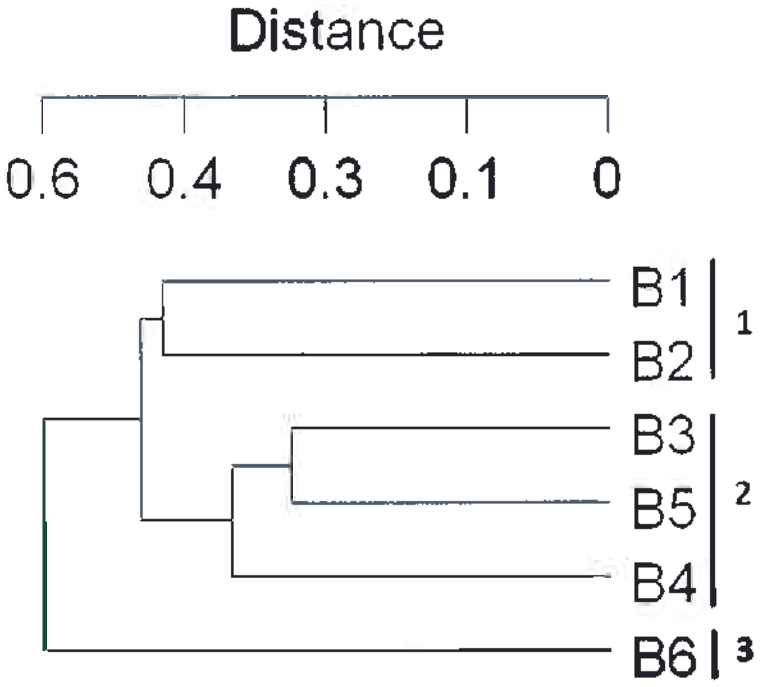


Figure 6-2. Station dendrogram based on cluster analysis (UPGMA, Sneath and Sokal 1973). The Bray-Curtis dissimilarity index was used to calculate the distances among stations and species (Gauch 1982, Jongman et. al. 1995).

Table 6-3. Average abundances of the top twenty species for each cluster group in 2017.

	Cluster Group		
Species	1	2	3
Streblosoma crassibranchia	43	19	
Marphysa disjuncta	33		
Kirkegaardia cryptica	29	23	
Euphilomedes carcharodonta	23	61	
Leptochelia dubia Cmplx	21	42	7
Cossura sp A	21	32	
Typosyllis hyperioni	20		
Ampelisciphotis podophthalma	14		
Mediomastus sp 6	14		
Phoronis sp	13		
Nereis sp A	12		20
Kurtiella tumida	12		3
Sthenelanella uniformis	11		
Mediomastus sp	10	134	5
Ephesiella brevicapitis	10		
Caprella mendax	9		
Poecilochaetus martini	9		
Spiophanes duplex	9		
Prionospio jubata	8	45	
Gadila aberrans	8		
Foxiphalus obtusidens		107	14
Amphideutopus oculatus		55	7
Rhepoxynius stenodes		45	
Chaetozone columbiana		40	
Kirkegaardia siblina		39	7
Rudilemboides stenopropodus		37	5
Levinsenia gracilis		26	
Oligochaeta		22	
Ampelisca brevisimulata		21	7
Tellina sp B		21	
Westwoodilla tone		21	
Eudymeninae sp A		20	
Ampelisca cristata microdentata		18	13
Nematoda			11
Tellina modesta			11
Amphicteis scaphobranchiata			7
Laonice cirrata			6
Praxillella pacifica			6
Glycinde armigera			5
Carinoma mutabilis			4
Paraprionospio alata			4
Prionospio pygmaeus			4
Scalibregma californicum			3

Table 6-4. Biological metrics for each station in 2017 averaged by cluster group.

Station	Cluster Group	Number of Species	Total Abundance	BRI	ITI	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B1	1	241	476	31	80	0.81	38.93	52	4.46	0.98
B2	1	187	207	[illegible]	77	0.84	34.89	47	4.38	0.98
	average	214	341	[illegible]	79	0.83	36.91	50	4.42	0.98
B3	2	193	334	26	80	0.81	33.04	43	4.28	0.97
B4	2	279	665	26	74	0.79	42.77	48	4.47	0.98
B5	2	256	639	26	77	0.80	39.78	45	4.42	0.98
	average	243	546	26	77	0.80	38.53	45	4.39	0.98
B6	3	196	268	21	78	0.83	34.88	42	4.38	0.98

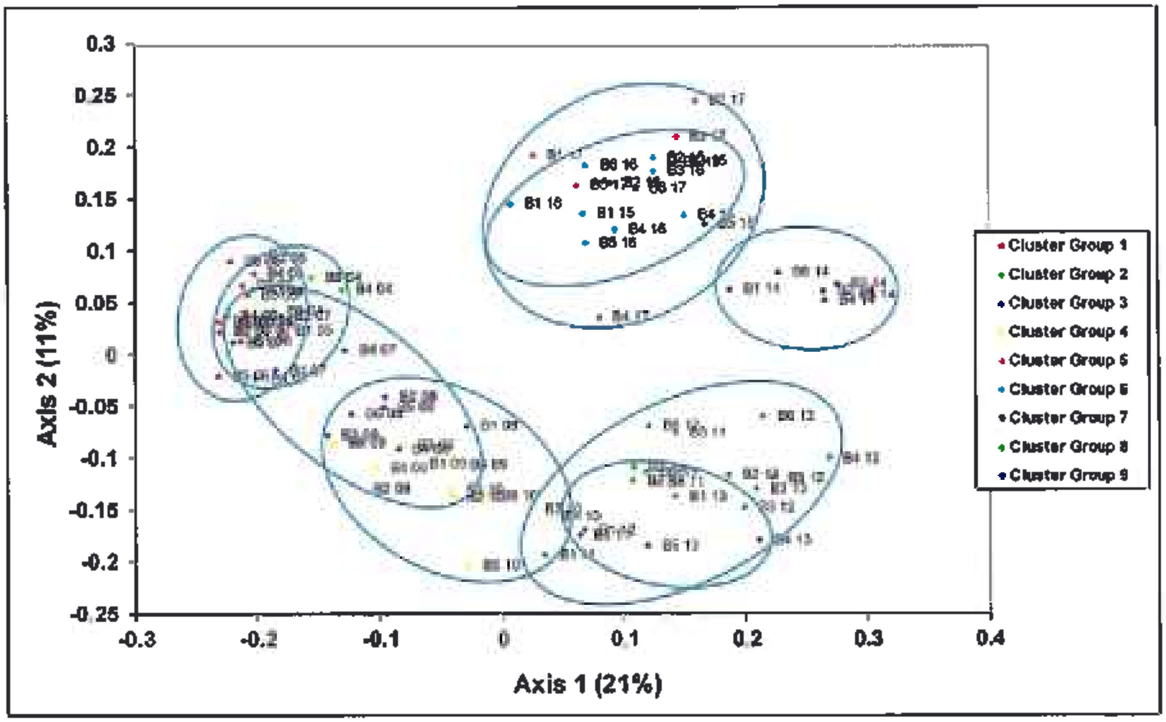


Figure 6-3. Plot of ordination scores for infauna communities at stations measured from 2004 to 2017.

Table 6-5. Biological metrics for each station for each year individually from 2004 thru 2016 and averaged by cluster group.

Station/Year	Cluster Group	BRI	ITI	Number of Species	Total Abundance	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B1 05	1	29	82	320	1132	0.73	45.36	39	4.22	0.96
B1 06	1	29	77	308	1283	0.70	42.90	32	4.03	0.95
B2 05	1	31	75	249	1187	0.60	35.03	15	3.33	0.88
B2 06	1	30	77	302	1477	0.63	41.25	21	3.60	0.90
B3 05	1	29	80	289	1412	0.65	39.71	25	3.69	0.90
B3 06	1	30	78	302	1729	0.66	40.38	25	3.74	0.92
B4 05	1	30	75	265	1072	0.60	37.84	20	3.33	0.85
B4 06	1	31	75	293	1545	0.62	39.77	22	3.54	0.89
B5 05	1	28	80	306	1162	0.64	43.22	29	3.66	0.88
B5 06	1	29	76	318	1734	0.65	42.50	28	3.76	0.92
B6 05	1	29	82	271	1060	0.64	38.76	27	3.58	0.88
B6 06	1	29	79	293	1246	0.64	40.97	26	3.66	0.89
	average	30	78	293	1337	0.65	40.64	26	3.68	0.80
B1 04	2	32	76	369	2169	0.61	47.93	22	3.62	0.92
B2 04	2	29	81	331	1592	0.68	44.76	29	3.93	0.94
B3 04	2	29	79	249	1359	0.62	34.38	20	3.43	0.88
B4 04	2	30	77	242	1076	0.57	34.52	16	3.10	0.81
B5 04	2	27	81	262	1127	0.66	37.14	31	3.68	0.89
B6 04	2	25	86	260	926	0.89	37.92	34	3.85	0.92
	average	29	80	286	1373	0.84	39.44	26	3.60	0.89
B1 07	3	30	76	318	1012	0.76	45.61	51	4.37	0.97
B1 08	3	26	81	254	579	0.82	39.77	54	4.55	0.98
B2 07	3	31	82	251	708	0.79	38.10	44	4.34	0.97
B2 08	3	30	82	226	672	0.81	34.56	41	4.38	0.98
B3 07	3	32	76	264	1361	0.68	36.45	27	3.80	0.94
B3 08	3	29	80	262	1090	0.73	37.32	33	4.07	0.96
B4 07	3	31	72	249	1012	0.70	35.84	30	3.87	0.95
B4 08	3	31	63	238	852	0.72	35.13	31	3.96	0.95
B5 07	3	30	78	281	1183	0.72	39.57	36	4.04	0.95
B5 08	3	28	79	247	741	0.74	37.23	36	4.08	0.96
B6 07	3	29	81	321	1232	0.73	44.97	39	4.21	0.96
B6 08	3	27	80	259	907	0.72	37.88	36	4.02	0.95
	average	29	78	264	946	0.74	38.65	38	4.14	0.96
B1 09	4	27	79	315	1173	0.74	44.43	42	4.25	0.96
B1 10	4	27	75	300	1205	0.75	42.15	42	4.28	0.97
B2 09	4	29	78	289	1004	0.77	41.67	44	4.38	0.97
B2 10	4	27	75	285	897	0.79	43.24	47	4.51	0.98
B3 09	4	28	81	278	1102	0.73	39.55	35	4.11	0.96
B3 10	4	28	76	276	972	0.78	39.98	44	4.40	0.98
B4 09	4	28	81	251	933	0.73	36.56	33	4.03	0.96
B4 10	4	30	72	272	981	0.74	39.34	36	4.17	0.97
B5 09	4	27	82	296	1112	0.72	42.06	36	4.12	0.95
B5 10	4	28	80	355	1919	0.70	46.83	38	4.13	0.96
B6 09	4	26	82	269	1005	0.80	38.77	45	4.47	0.98
B6 10	4	25	80	268	833	0.78	39.70	45	4.34	0.97
	average	27	79	289	1095	0.75	41.19	41	4.27	0.97
B1 17	5	31	82	241	476	0.81	38.93	52	4.46	0.98
B2 17	5	29	78	187	207	0.84	34.89	47	4.38	0.98
B3 17	5	25	80	193	334	0.81	33.04	43	4.28	0.97
B4 17	5	25	75	279	865	0.79	42.77	48	4.47	0.98
B5 17	5	25	77	258	639	0.80	39.78	45	4.42	0.98
B6 17	5	20	78	196	268	0.83	34.88	42	4.36	0.98
	average	26	79	226	432	0.81	37.38	46	4.40	0.98

Table 6-5. continued.

Station/Year	Cluster Group	BRI	ITI	Number of Species	Total Abundance	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B1 15	6	27	75	256	53	4.86	64.86	1	26.99	-4.15
B1 16	6	27	79	289	719	0.84	43.79	60	4.73	0.99
B2 15	6	26	76	219	100	3.00	47.30	2	16.17	0.05
B2 16	6	27	76	259	528	0.85	41.16	59	4.74	0.99
B3 15	6	25	82	219	91	2.57	48.33	5	13.86	0.65
B3 16	6	24	75	244	401	0.86	40.54	61	4.74	0.99
B4 15	6	25	82	243	87	2.72	54.24	4	14.85	0.64
B4 16	6	25	82	289	842	0.85	44.55	70	4.82	0.99
B5 15	6	26	76	247	73	3.10	57.37	4	17.07	0.48
B5 16	6	25	79	269	729	0.83	43.69	62	4.69	0.98
B6 15	6	25	81	230	132	2.14	46.87	4	11.61	0.70
B6 16	6	25	82	267	562	0.85	42.01	56	4.72	0.99
	average	26	79	254	343	1.96	47.89	32	10.76	0.36
B4 11	7	28	73	243	729	0.76	36.72	41	4.15	0.96
B4 13	7	28	74	268	1027	0.76	38.50	36	4.26	0.97
B5 11	7	31	75	247	720	0.77	37.39	38	4.23	0.97
B5 13	7	31	73	314	1658	0.71	42.22	33	4.09	0.96
	average	30	74	268	1034	0.75	38.71	37	4.18	0.97
B1 11	8	28	73	328	1303	0.75	45.59	45	4.32	0.97
B1 12	8	28	73	335	1438	0.76	45.94	44	4.39	0.97
B1 13	8	28	71	280	931	0.78	40.81	43	4.39	0.97
B2 11	8	28	77	243	967	0.72	35.20	31	3.98	0.95
B2 12	8	28	74	263	1173	0.73	37.07	33	4.05	0.96
B2 13	8	28	69	254	910	0.73	37.13	32	4.02	0.95
B3 11	8	28	82	228	816	0.70	33.86	25	3.81	0.95
B3 12	8	27	75	259	1107	0.71	36.81	28	3.96	0.96
B3 13	8	27	72	248	827	0.75	36.77	35	4.15	0.96
B4 12	8	25	81	215	772	0.69	32.18	21	3.71	0.94
B5 12	8	23	79	222	830	0.68	32.86	19	3.65	0.94
B6 11	8	26	78	245	614	0.78	38.00	44	4.31	0.97
B6 12	8	26	74	228	842	0.68	33.70	26	3.68	0.91
B6 13	8	25	74	205	559	0.76	32.24	32	4.06	0.95
	average	27	75	254	935	0.73	37.01	33	4.03	0.95
B1 14	9	26	69	233	594	0.78	36.33	46	4.27	0.97
B2 14	9	27	70	201	546	0.72	31.74	24	3.80	0.95
B3 14	9	27	75	187	530	0.73	29.65	26	3.84	0.95
B4 14	9	26	75	216	526	0.74	34.32	32	3.98	0.96
B5 14	9	26	73	210	511	0.75	33.52	32	4.02	0.96
B6 14	9	27	73	214	671	0.70	32.72	25	3.78	0.95
	average	27	73	210	563	0.74	33.05	31	3.95	0.96

CHAPTER 7

Trawled Fish and Invertebrate Populations

7.1. Background

Demersal fishes and megabenthic invertebrates (species living closely associated with the seafloor) are widely distributed on the soft-bottom habitats along the southern California shelf. This diverse community is composed of approximately 100 species of fish and several hundred species of invertebrates (Allen 1982, Allen et al. 1998, Moore and Mearns 1978). Since these populations are generally sedentary, they can act as indictors of human impacts on the soft bottom habitat. As a result, trawl programs have been part of the monitoring activities of both large and small municipal dischargers for nearly thirty years. The goal of the Goleta Sanitary District's trawl program is to look for population changes near the ocean outfall.

7.2. Materials and Methods

Trawl sampling was conducted in accordance with *Use of Small Otter Trawls in Coastal Biological Surveys*, EPA 600/3-78/083, August 1978; *Quality Assurance and Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods*, Tetra Tech 1986; and the *Southern California Bight Project Field Operations Manual*, 2008. Duplicate ten-minute trawls were taken at a uniform speed of 2.0 - 2.5 knots with a 7.6 m Marinovich otter trawl. Care was taken to not trawl over previous transects or grab sampling sites. For each trawl, all fish and macroinvertebrates were identified, counted, measured, and weighed. Collection observations, such as algae or cobble in the trawl, were recorded. Fish abnormalities, such as fin rot, parasites, or tumors, were also noted. Species abundance lists were compiled for all trawl samples. All fish and invertebrates were identified by Jim Mann. All animals collected for tissue dissection were placed in plastic zip-lock bags in coolers over ice during transit.

Following enumeration of trawl organisms by species, the total and animal group biomasses, numbers of individuals, and numbers of separate species were compiled for each station replicate. In addition, several required biological indices were calculated: Shannon-Weiner species diversity (H'), Margalef's richness index (d), Simpson's species diversity (SI), and Schwartz's dominance (D). These indices are described in detail in Chapter 6, in Section 6.2, Materials and Methods. Since there were only two stations sampled, no clustering or numerical classification analyses could be calculated. Stations were compared by t-test (see Materials and Methods section above).

7.3. Results

The demersal fish and macrobenthic invertebrate community was compared among two trawl stations using measures of population abundance and diversity. These included numbers of individuals, numbers of species, species diversity, and species dominance. In addition, ranges of these variables were compared to surveys conducted in past years. Duplicate trawls were taken at two locations, one near Station B3 (TB3) and the other near Station B6 (TB6) (Figure 6-1).

7.3.1. Trawled Fish

7.3.1.1. Fish Community Metrics

The averaged fish community metrics and biomass for replicate trawls are presented in Table 7-1, with results by replicate presented in Appendix 10.7 (Tables 10-9 and 10-10). A total of 316 individual fish were collected from both stations combined during the 2017 survey, with the average numbers of individuals at TB3 (78) and TB6 (80) nearly identical (Table 7-1). There was no statistically significant difference in average abundances between sites ($p > 0.05$; Table 7-1). The average numbers of species collected at TB3 (17) was slightly less than TB6 (20). Average biomass was less at TB3 (1.63 Kg) compared to TB6 (10.46 Kg), but there was no significant difference between sites. Shannon Diversity, Simpsons Diversity, Margalef's Richness and Dominance were low at each site and were not significantly different between sites.

7.3.1.2. Species Composition

As with past years, the fish caught in the 2017 trawls were typical of those found on most southern California near shore soft bottom habitats (Table 7-2). A total of 17 and 20 unique taxa were collected at stations TB3 and TB6, respectively. The most abundant species collected at TB3 were the speckled sanddab (*Citharichthys stigmaeus)* and hornyhead turbot (*Pleuronichthys verticalis*). The most abundant species at TB6 were speckled sanddabs and California lizardfish (*Synodus lucioceps*).

7.3.1.3. Fish Community Metrics Compared to Past Surveys

Fish assemblage community metrics for 2017 were compared to previous Goleta area surveys starting in 1991 (Figure 7-1). The numbers of individuals collected in 2017 was within the range of past surveys. Fish biomass was again very low during 2017 and similar to the past 20 years. The slow decline in numbers of species that had occurred from 2013 to 2016, was reversed in 2017 when the greatest number of fish species were collected since the program began. Shannon Diversity and dominance were low and similar to past surveys.

7.3.1.4. Fish Community Metrics Compared to Reference Surveys

Fish community metrics for the 2017 Goleta survey were compared to fish assemblage data collected in the northern region on the inner continental shelf in the southern California bight during the 2008 Southern California Bight Regional Monitoring Survey (SCBRMP) (SCCWRP 2011; Table 7-3). Number of individuals, number of species, Shannon Diversity and biomass were all well within the range fish assemblages found in the vicinity of the northern region inner shelf.

7.3.1.5. Fish Length

Fish size class distributions. The size frequency distributions for all fish collected from trawl samples are presented in Appendix 10.7 (Table 10.7-1). The size frequency distributions for one of the historically most abundant species in the survey area (speckled sanddabs, *Citharicthys stigmaeus*) are presented in Figure 7-2. Across years, sanddab lengths ranged from 3 to 13 cm at both stations, with 2017 having slightly more individuals in the 6 cm size class at both stations. At TB3, near the outfall, the numbers of fish collected were relatively evenly spread across size classes for all years, except in 2007 and 2012 when large numbers of individuals in the 7 and 8 cm size classes were captured. The majority of sanddabs collected 2004, 2007, 2009 and 2012 at TB6 were in 6 to 8 cm size classes

Table 7-1. Trawled fish - Summary of biological metrics of fish collected at Stations TB3 and TB6. Comparison between sites by two sample T-test ($p < 0.05$).

Fish						
Station	TB3		TB6		T-test	
Metric	Avg	SD	Avg	SD	t score	p =
Individuals[1]	78	58	80	42	0.39	1.00
Species[1]	17	0	20	0	-1.30	0.19
Biomass (kg)[1]	1.63	1.47	10.46	12.65	-0.39	0.70
Shannon Diversity[1]	1.91	0.24	1.84	0.49	0.39	1.00
Simpson Diversity[1]	0.74	0.13	0.72	0.19	0.39	1.00
Margalef Richness[1]	3.89	0.77	4.45	0.58	-0.39	0.70
Schwartz Dominance[1]	5	1	4	1	0.00	1.00

Bold - Marginally Significant ($0.05 < p < 0.10$)
Bold - Significant ($p < 0.05$)
1. Non-normal data: T-test by Mann-Whitney U test

Table 7-2. Trawled fish abundance and biomass sorted from most to least abundant.

Trawl TB3				Trawl TB6			
Scientific Name	Common Name	Mean Abund	Mean Weight (kg)	Scientific Name	Common Name	Mean Abund	Mean Weight (kg)
Citharichthys stigmaeus	speckled sanddab	40	0.21	*Citharichthys stigmaeus*	speckled sanddab	40	0.27
Pleuronichthys verticalis	hornyhead turbot	8	0.19	*Synodus lucioceps*	California lizardfish	11	0.38
Sebastes caurinus	copper rockfish	6	0.06	*Zaniolepis latipinnis*	longspine combfish	6	0.18
Citharichthys sordidus	Pacific sanddab	4	0.12	*Genyonemus lineatus*	white croaker	4	0.26
Synodus lucioceps	California lizardfish	4	0.31	*Xystreurys liolepis*	fantail sole	4	0.06
Icelinus quadriseriatus	yellowchin sculpin	3	<0.1	*Icelinus quadriseriatus*	yellowchin sculpin	3	<0.1
Heterostichus rostratus	giant kelpfish	3	<0.1	*Pleuronichthys verticalis*	hornyhead turbot	3	<0.1
Xystreurys liolepis	fantail sole	2	0.09	*Sebastes caurinus*	copper rockfish	3	<0.1
Zaniolepis latipinnis	longspine combfish	2	<0.1	Citharichthys xanthostigma	longfin sanddab	2	<0.1
Citharichthys xanthostigma	longfin sanddab	2	0.07	*Cymatogaster aggregata*	shiner perch	1	<0.1
Paralabrax clathratus	kelp bass	1	<0.1	*Heterostichus rostratus*	giant kelpfish	1	<0.1
Pleuronichthys decurrens	curlfin sole	1	0.05	*Citharichthys sordidus*	Pacific sanddab	1	<0.1
Porichthys myriaster	specklefin midshipman	1	0.08	*Myliobatis californica*	bat ray	1	0.45
Porichthys notatus	plainfin midshipman	1	<0.1	*Paralabrax clathratus*	kelp bass	1	<0.1
Phanerodon furcatus	white seaperch	1	<0.1	*Paralichthys californicus*	California halibut	1	0.39
Raja inornata	California skate	1	0.08	*Pleuronichthys ritteri*	spotted turbot	1	0.15
Squatina californica	Pacific angel shark	1	0.22	*Porichthys myriaster*	specklefin midshipman	1	<0.1
Comosite Weight*			0.21	*Porichthys notatus*	plainfin midshipman	1	<0.1
				Symphurus atricaudus	California tonguefish	1	<0.1
				Squatina californica	Pacific angel shark	1	8.00
				Comosite Weight*			0.33

*Species <0.1 kg are weighed together as a composite weight.

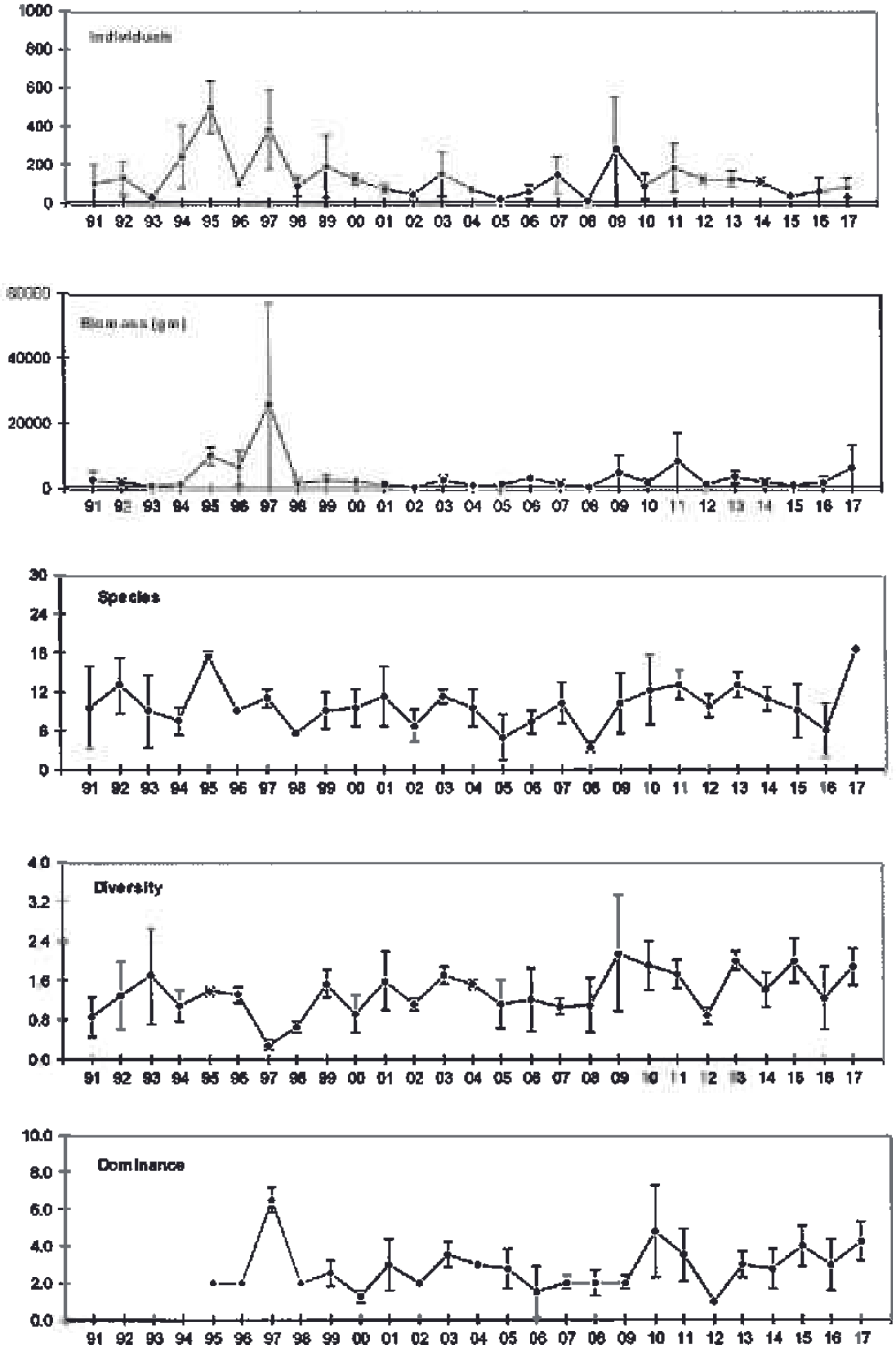


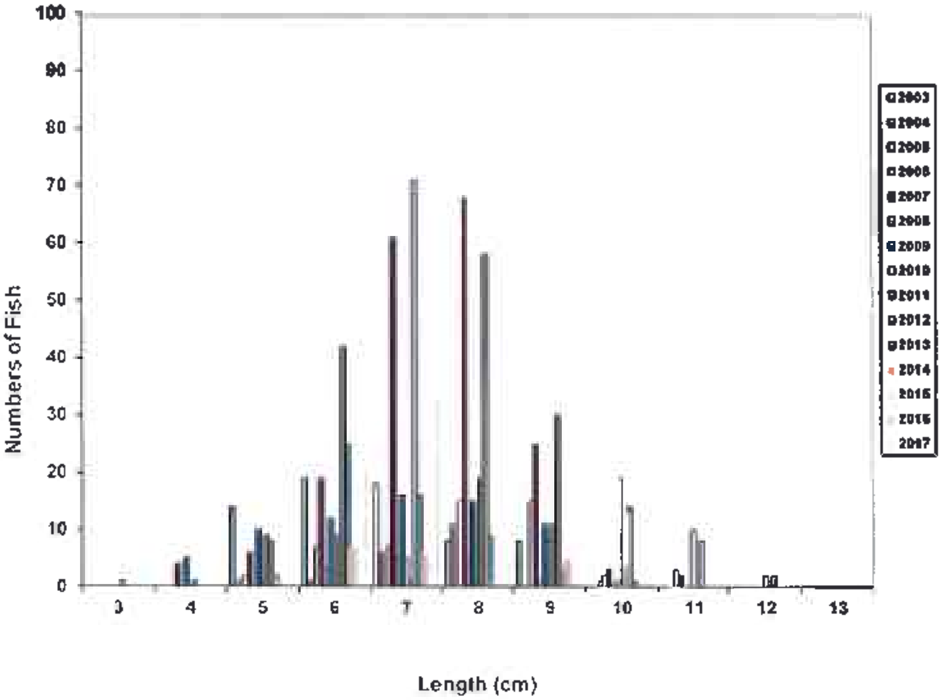
Figure 7-1. Fish community metric annual averages (± SD) for Goleta trawl transect data (n=2) since 1991.

Table 7-3. Comparison of trawl fish metrics with results from the Southern California Regional Survey, Bight 2008 (from SCCWRP Technical Report 972).

Metric	Trawl Fish		
	Goleta Range	Bight 13 Inner Shelf[1]	Below Range?
Biomass (kg)	1.63 - 10.46	0.4 - 40.8	No
Individuals	78 - 80	25 - 1,013	No
Species	17 - 20	4 - 18	No
Shannon Diversity	1.84 - 1.91	0.33 - 2.11	No

1. Walther *et al.*, 2017

Station TB3



Station TB6

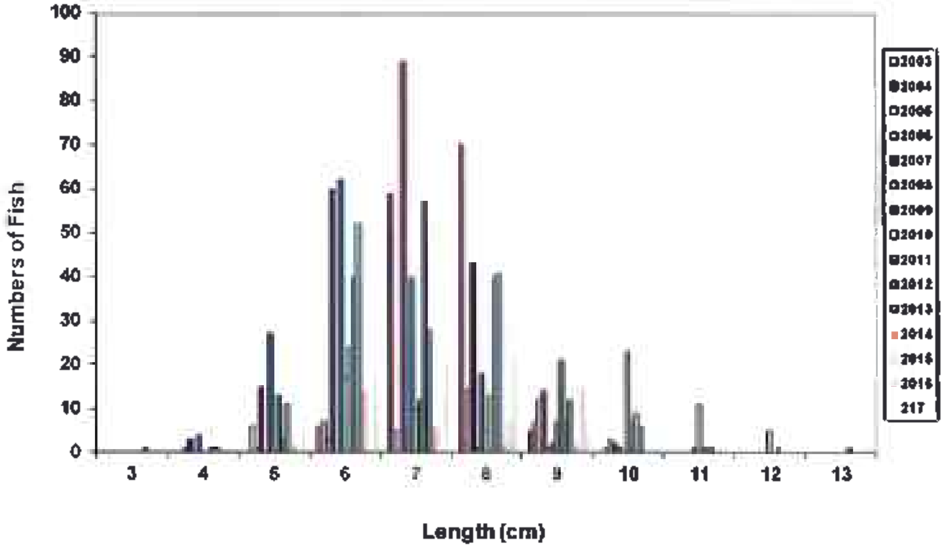


Figure 7-2. Length (cm) frequency distributions for speckled sanddabs (*Citharicthys stigmaeus*) collected from 2003 to 2017 from stations TB3 and TB6 in the Goleta survey area.

7.3.2. Trawl Macroinvertebrates

7.3.2.1. Macroinvertebrate Community Metrics

The averaged macroinvertebrate community metrics and biomass for replicate trawls are presented in Table 7-4, with results by replicate presented in Appendix 10.7 (Tables 10-11 and 10-12). A total of 53 individual invertebrates were collected from both stations combined during the 2017 survey. An average of 20 macroinvertebrates was collected at station TB3 compared to 7 at TB6 and there was no significant difference between sites (Table 7-4). Average numbers of species collected averaged 4 at station TB3 and 3 at station TB6, with no significant difference between sites. Biomass was 0.07 Kg at TB3 and 0.1 Kg at TB6 and there was no significant difference. Shannon Diversity, Simpson Diversity and Margalef Richness were low at both stations and there were no significant differences between sites.

7.3.2.2. Species Composition

As with past years, the invertebrates in the 2017 trawls were typical of those found on most southern California near shore soft bottom habitats (Table 7-5). A total of 6 unique taxa were collected in the survey area. The most abundant species collected in the survey area were the peanut rock shrimp (*Sicyonia penicillata*).

7.3.2.3 Macroinvertebrate Community Metrics Compared to Past Surveys

Macroinvertebrate community metrics for 2017 were compared to previous Goleta area surveys starting in 1991 (Figure 7-2). The numbers of individuals was similar from previous surveys, while biomass dropped. Numbers of species was similar to recent surveys, while Shannon Diversity and Dominance continued to increase from historic lows in 2015. These three metrics declined in 1998 from historic highs and have been relatively stable since. The reasons for these reductions are unclear.

7.3.2.4. Macroinvertebrate Community Metrics Compared to Reference Surveys

Macroinvertebrate community metrics for the 2017 Goleta survey were compared to invertebrate assemblage data collected in the northern region on the inner continental shelf in the southern California bight during the 2008 Southern California Bight Regional Monitoring Survey (SCBRMP) (SCCWRP 2011; Table 7-6). Biomass, numbers of individuals, numbers of species, and Shannon Diversity were all within the range or fish assemblages found in the northern region inner shelf.

Table 7-4. Trawled inverts - Summary of biological metrics of invertebrates collected at Stations TB3 and TB6. Comparison between sites by two sample T-test ($p > 0.05$).

Invertebrates						
Station	TB3		TB6		T-test	
Metric	Avg	SD	Avg	SD	t score	p =
Individuals[1]	20	5	7	3	1.16	0.25
Species[1]	4	0	3	1	1.22	0.22
Biomass (kg)[1]	0.07	0.10	0.10	0.13	0.00	1.00
Shannon Diversity[1]	1.00	0.09	0.75	0.35	0.39	0.70
Simpson Diversity[1]	0.57	0.05	0.46	0.19	0.39	0.70
Margalef Richness	1.02	0.09	0.77	0.20	1.16	0.25
Schwartz Dominance[1]	2	0	2	1	0.50	0.62

Bold - Marginally Significant ($0.05 < p < 0.10$)
Bold - Significant ($p < 0.05$)
1. Non-normal data: T-test by Mann-Whitney U test.

Bold - Marginally Significant ($0.05 < p < 0.10$)
Bold - Significant ($p < 0.05$)
1. Non-normal data: T-test by Mann-Whitney U test.

Table 7-5. Trawled invertebrate abundance and biomass sorted from most to least abundant.

Trawl TB3				Trawl TB6			
Scientific Name	Common Name	Mean Abund	Mean Weight (kg)	Scientific Name	Common Name	Mean Abund	Mean Weight (kg)
Sicyonia penicillata	peanut rock shrimp	11	<0.1	*Sicyonia penicillata*	peanut rock shrimp	3	<0.1
Crangon nigromaculata	blackspotted bay shrim	4	<0.1	*Astropecten californicus*	California sand star	2	<0.1
Octopus rubescens	red octopus	4	0.07	*Crangon nigromaculata*	blackspotted bay shrim	1	<0.1
Lytechinus pictus	white sea urchin	1	<0.1	*Octopus rubescens*	red octopus	1	<0.1
Ophiothrix spiculata	Pacific spiny brittlestar	1	<0.1	*Aplysia californica*	purple sea hare	1	0.10
Comosite Weight*			<0.1	Comosite Weight*			<0.1

*Species <0.1 kg are weighed together as a composite weight.

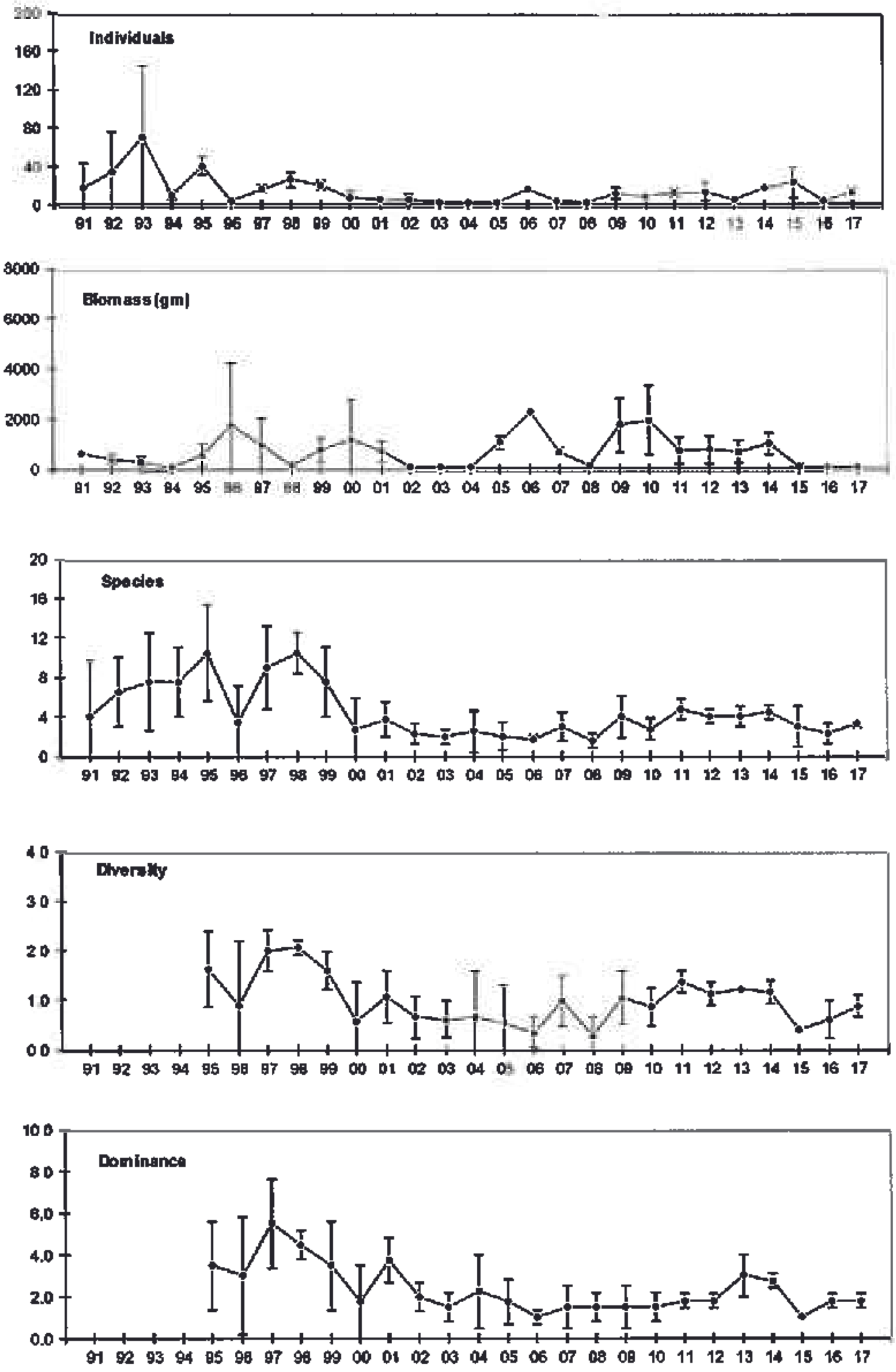


Figure 7-2. Invertebrate community metric annual averages (± SD) for Goleta trawl transect data (n=2) since 1991.

Table 7-6. Comparison of trawl invertebrate metrics with results from the Southern California Regional Survey, Bight 2013 (from SCCWRP Technical Report 972).

Metric	Trawl Invertebrate		
	Goleta Range	Bight 13 Inner Shelf[1]	Below Range?
Biomass (kg)	0.07 - 0.10	0.0 - 11.0	No
Individuals	7 - 20	5 - 921	No
Species	3 - 4	2 - 13	No
Shannon Diversity	0.75 - 1.00	0.11 - 1.25	No

1. Walther *et al.*, 2017

7.4. Discussion

Results from this trawl survey support past studies that indicated that the discharge from the Goleta Sanitary District's ocean outfall does not appear to be impacting the resident fish or macroinvertebrate communities. This was confirmed by comparing results among stations both near and far from the diffuser, comparing results with historical surveys, and comparing results with other studies being performed in southern California.

A total of 316 individual fish and 53 individual invertebrates were collected from both stations combined during the 2017 survey. There were no statistically significant differences ($p < 0.05$) between stations near to and far from the outfall when metrics for fish or invertebrate total abundance, number of species, biomass, diversity and dominance were compared. Both fish and invertebrate population indices measured in 2017 (including abundance, numbers of species and biomass) were within the range of reference sites sampled during the 2008 Southern California Bight Regional Monitoring Program.

As with past years, the fishes and macroinvertebrates caught in the 2017 trawls were typical of those found on most southern California near shore soft bottom habitats. A total of 17 and 20 individual fish taxa were collected at stations TB3 and TB6, respectively. The most abundant species collected at station TB3 and TB6 was the speckled sanddab (*Citharichtys stigmaeus)*. A total of 6 unique invertebrate taxa were collected in the survey area. The most abundant species collected in the survey area was the peanut rock shrimp (*Sicyonia penicillata*).

When the 2017 trawled fish and invertebrate results were compared against past surveys, average abundances, numbers of species, biomass, diversity and dominance were within the ranges of the previous twenty years. This was especially true of the trawled fish community. In contrast, the trawled invertebrate community has been very similar for each biological metric over the past ten years, but prior to 2001 the numbers of invertebrate taxa and diversity were much greater. The reasons for the decrease in trawled invertebrate diversity are unclear. Since an outfall related impact has never been detected, it is probable that some larger oceanographic condition has influenced this community. Frequent cold-water upwelling events which are typical of this coastal region, coupled with warm water El Nino events over the past 15 years may be playing a significant role in the recruitment to and stability of this community.

Although there are no specific numerical limitations regarding trawl animals, the California Ocean Plan (1997) states that:

- The rate of deposition of inert solids and the characteristics of inert solids in the ocean shall not be changed such that benthic communities are degraded.

- The concentration of substances set forth in Chapter IV, Table B, in marine sediments shall not be increased to levels which would degrade indigenous biota.

- The concentration of organic materials in marine sediments shall not be increased to levels which would degrade marine life.

- Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.

- Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded.

- Waste management systems that discharge to the ocean must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

- Waste discharged to the ocean must be essentially free of: "2) Settleable material or substances that may form sediments which will degrade benthic communities or other aquatic life."

Based upon spatial and temporal comparisons and analogies with other studies, results of the trawl survey indicate that the discharge is in compliance with the general limitations and that it causes no adverse impact.

CHAPTER 8

Fish and Bivalve Tissue Bioaccumulation

8.1. Background

Outfall discharges can potentially increase contaminant concentrations in sediments and the water column to the extent that marine plant and animal communities are altered, reduced, or eliminated. Harvested fish or invertebrate flesh may become contaminated and unfit for human consumption. Bioaccumulation is a process whereby contaminants are assimilated by organisms, retained and bioconcentrated over time. The degree of bioconcentration is different among species and among toxicants. Biomagnification may also occur when predators eat organisms, resulting in the concentration of contaminants in higher levels of the food chain. In this way, higher-level predators, such as large fish, birds, and mammals can experience chronic toxicity, reproductive failure, or even mortality.

8.2. Materials and Methods

The measure of contaminants in animal tissues was performed with both fish (speckled sanddabs, *Citharichthys stigmaeus*) and invertebrates (California bivalves, *Mytilus californianus*) using two completely different collection procedures.

Speckled sanddabs were collected by otter trawl procedures, which are described in Section 7 above. Sanddabs collected in the population trawls were kept, and additional trawls were continued until sufficient total biomass for tissue analysis had been collected. Animals from each of two stations (TB3 between the diffuser and Goleta Point and TB6 at the down coast field control) were placed in plastic zip-lock bags and covered with ice in coolers. Immediately upon return to the laboratory, dorsal muscle and livers were removed from each animal, using standard clean room techniques, and placed in new pre-cleaned glass jars with Teflon-lined caps. All tissue samples were then stored in a freezer until ready to be shipped to the chemistry laboratory (PHYSIS Laboratories in Anaheim, California). Analytical methods were similar to sediments, except that special extraction and clean-up techniques were used to eliminate lipid interferences commonly found in marine animal tissues.

Bivalves were collected from Anacapa Island, California, an area anticipated to be very low in anthropogenic contamination. Prior to deployment these bivalves were cleaned of all debris and growth and held in a pre-cleaned seawater tank at 15° C until use. Bivalves were deployed using three arrays, each composed of a float, line, and anchor. Bivalve cages, made of plastic mesh netting, were attached to the middle of the arrays, so that the bivalves could be suspended at about mid-depth (16 m). The arrays were deployed in duplicate at Stations B3, B4, and B6; located 250, 25, and 3000 m (respectively) from the diffuser. The duplicate array at each station was suspended on a sub-surface buoy and attached to the first array with a 100 meter long line that was weighted to the bottom. Prior to deployment of the arrays in July, laboratory control bivalves were randomly selected and tissues were resected and frozen. In October, each of the three bivalve arrays was successfully retrieved.

Once bivalves were removed from the array, they were placed on ice and returned to the laboratory. Exposed bivalves, as well as bivalves from the original population were cleaned, measured, and weighed. Their tissues were resected, stored, and analyzed, as above.

For the purposes of statistical analysis, all analytes from each of four groups (DDT and its derivatives (i.e. DDD and DDE), PCB's, PAH's, and non-DDT chlorinated pesticides) were combined. Results for individual analytes are presented in Appendix 10-16 and 10-17. All data were converted to mg/Kg or µg/Kg, dry weight and statistically compared among stations using either t-test for two stations or analysis of variance (ANOVA) for three or more stations (see Section 3.4). When assumptions of parametric statistics could not be met (such as non-normality or excessive variability), the tests were replaced with nonparametric analogues (Aspin-Welch Unequal Variance Test, Mann-Whitney U, and Kruskal-Wallace Rank Test, respectively). Significance was noted when $p \leq 0.05$ and marginal significance was noted when $0.05 < p \leq 0.10$). *A posteriori* tests were utilized for significant ANOVA results to determine which stations were significantly different (see Zar 1996 or Sokal and Rohlf 1981 for a general description of statistical testing).

To compare tissue concentrations to the Office of Environmental Health Hazard Assessment (OEHHA) thresholds (OEHAA 2008) and NOAA Status and Trends mussel watch historical surveys (Kimbrough et al. 2008), Goleta tissue data were converted to wet weight units.

8.3. Results

Table 8-1 lists the physical and general descriptions of the animals utilized in the Goleta bioaccumulation study. Appendix Tables 10-13 and 10-14 lists lengths and weights of organisms, as well as tissue weights. Tables 8-2 to 8-4 and Figures 8-1 and 8-2 present average concentrations for each chemical constituent measured in the three types of animal tissues at each Station. Appendix Table 10-15 lists each constituent by replicate and averages by stations. Figures 8-3 through 8-5 compare historical contamination trends in the three tissue types. Tables 8-5 to 8-6 compare the Goleta tissue chemistry results with reference surveys and state OEHHA thresholds and NOAA status and trends tissue levels. Appendix 10-16 and 10-17 lists the concentrations of the derivatives of total DDT, non-DDT chlorinated hydrocarbons, total PCBs, and total PAHs. General descriptions of all chemical constituents have been presented earlier in Chapter 5, and so will not be repeated here.

8.3.1. Spatial contaminant patterns in tissues

Speckled sanddabs

A total of 79 speckled sanddabs (*Citharichthys stigmaeus*) were collected for tissue dissections from trawl transects TB3 (n = 38) and TB6 (n = 41), respectively (Table 8-1). Average standard lengths (72.8 and 73.2 mm, respectively) and weights (8.8 each) were similar.

Of the ten metals measured in sanddab muscle tissue all were above detection (Table 8-2 and Figure 8-1). Arsenic, copper, mercury, nickel, selenium and zinc were significantly greater by t-test ($p< 0.01$) at station TB3, nearest from the outfall, compared to concentrations at TB6. Of the groups of complex organic compounds measured in sanddab muscle tissue, total DDT, total PAHs and PCBs were all above method detection limits. Total DDTs were significantly greater in muscle tissue at

TB3 (12.1 ug/L) compared to TB6 (7.6 ug/L) ($p < 0.05$). There were no significant differences between stations for any other organic.

Of the ten metals measured in sanddab liver, all were above detection (Table 8-3 and Figure 8-1). Arsenic, cadmium and selenium concentrations were significantly greater at TB3 by t-test ($p < 0.05$). Of the complex organic compounds, HCHs were below detection while total DDTs, chlordane, total PCBs, Arochlors and PAHs were above detection. Total DDT and several PAH congeners were significantly greater at TB6 by t-test ($p < 0.05$).

Bivalves

Of the ten metals measured in bivalve *(Mytilus californianus)* tissue, all were above detection (Table 8-4, Figure 8-1). Arsenic was significantly greater at B6 compared to B4 and B3 by ANOVA ($p < 0.05$). Lead was significantly less at TB4. Of the complex organic compounds measured in bivalve tissue, total DDTs, total PCBs and total PAHs were above detection, while each of the other constituents were just at or below detection. Only two congeners of PAHs were significantly different among stations by ANOVA ($p <0.05$).

8.3.2 Tissue contaminant concentrations compared with past years

Speckled Sanddabs

The average concentration of contaminants in sanddab muscle and liver tissues remained within range of previous years, except arsenic in livers which had increased two-fold in 2016, but returned within normal ranges in 2017 (Figures 8-3 and 8-4). Increases in sanddab muscle concentrations of chromium, nickel and silver reported for the 2009 survey returned to lower concentrations in 2010 and remained low thru 2017. PCB concentrations in fish liver tissue have been highly variable since 2007 (range = 0 to 0.3 ug/L), remained relatively low in 2017.

Bivalves

The average concentration of each contaminant in bivalve tissues in 2017 was like the previous several years (Figure 8-5).

8.3.3 Tissue contaminant concentrations compared with other surveys, State Thresholds & EPA Ranges

The concentrations of the contaminants measured in sanddab and bivalve tissues during the 2017 survey were compared to the concentrations measured at other sites throughout southern California (Table 8-5 and 8-6). Where comparisons were available, sanddab muscle and liver tissues, and mussel tissues were below or within the range of contaminant concentrations reported from other surveys (see references in Table 8-5 and 8-6 footnotes). Sanddab and muscle tissue concentrations of metals and organic constituents did not exceed OEHHA consumption thresholds. Finally, mussel tissue concentrations were in the 'low' range reported by the NOAA Status and Trends Mussel Watch program.

8.4. Discussion

Results from this survey support past studies showing that the Goleta outfall discharge appears not to effect the concentrations of contaminants in the tissues of fish and invertebrates residing in the survey area. Results from the chemical analysis of tissues were compared among stations, compared to past surveys in the area, compared to other studies performed in southern California, and compared to State thresholds and Federal ranges for concentrations of contaminants in animal tissue. Results for each variable were statistically compared among stations by either t-test or analysis of variance (ANOVA).

The sampling design for fish differed from the design for bivalve arrays. The bivalve sampling plan included a laboratory control (unexposed bivalves from Anacapa Island, CA) and bivalves exposed at three site locations: one station down coast (field control), one station nearest the outfall, and one station up coast and nearest Goleta Point. For fish, there was no laboratory control, and fish were collected from only two locations: one station down coast of the outfall corresponding to the field control, and one up coast of the outfall corresponding to the station nearest Goleta Point.

A total of 15 chemical compounds or groups of compounds were analyzed in speckled sanddab muscle tissue from the two trawl locations. Sanddab muscle tissue metals were all above detection, while total DDT and total PAHs were each above method detection. Arsenic, copper, mercury, nickel, selenium, zinc and total DDTs were significantly greater at TB3 nearest the outfall.

In sanddab liver tissues each metal was above detection at each site, and arsenic, cadmium, and selenium concentrations were significantly greater at TB3. Of the complex organic compounds, HCHs were below detection while total DDTs, chlordane, total PCBs, Arochlors and PAHs were above detection. Total DDT and several PAH congeners were significantly greater at TB6 by t-test ($p < 0.05$).

A total of 15 chemical compounds or groups of compounds were analyzed in the whole-body tissues of bivalves. Arsenic was significantly greater at B6 compared to B4 and B3, while lead was significantly less at TB4. Of the complex organic compounds measured in bivalve tissue, total DDTs, total PCBs and total PAHs were above detection, while each of the other constituents were just at or below detection. Only two congeners of PAHs were significantly different among stations.

Comparison of the 2017 tissue concentrations from the Goleta survey area against results from the past twenty years revealed that in all cases contaminant concentrations were similar to or less than in past years. Increases in sanddab muscle chromium, nickel and silver reported for the 2009 survey returned to lower concentrations in 2010 and remained low thru 2017.

The concentrations of the contaminants measured in sanddab and bivalve tissues during the 2016 survey were compared to the concentrations measured at other sites throughout southern California. Where comparisons were available, sanddab muscle and liver tissues, and mussel tissues were below or within the range of contaminant concentrations reported from other surveys. Sanddab and bivalve tissue concentrations of metals and organic constituents did not exceed OEHHA consumption thresholds. Since the speckled sanddab is not caught for human consumption due to its small size, comparison of its tissue burdens against the OEHHA standard is included to provide context. Finally, bivalve tissue concentrations were in the 'low' range reported by the NOAA Status and Trends Mussel Watch program (Kimbrough et al. 2008).

Although there are no specific numerical limitations regarding trawl animals, the California Ocean Plan (1997) states that:

The natural taste, odor, and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.

The concentration of organic materials in fish, shellfish or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.

Based upon spatial and temporal patterns and comparisons with other studies, results of the bioaccumulation survey indicate that the discharge is in compliance with the general limitations that it causes no adverse impact.

Table 8-1. Numbers of animals, length (mm), weight (g) and tissues weight (g) in fish and bivalve tissue collected in the Goleta survey area.

		Fish Muscle		Fish Liver		Bivalves			
Constituent	Replicate	T3	T6	T3	T6	Control	B3	B4	B6
Number of Animals		38	41	38	41	60	56	56	59
Average Standard Length (mm)	Mean =	72.8	73.2	72.8	73.2	62.6	63.6	63.5	64.6
	S.D. =	9.5	8.8	9.5	8.8	8.3	5.7	6.1	7.2
Average Weight/Animal (g)	Mean =	7.2	7.2	7.2	7.2	19.2	25.6	26.2	25.5
	S.D. =	3.7	3.2	3.7	3.2	6.1	6.9	7.1	8.3
Average Tissue Weight (g)	Mean =	1.2	1.2	0.2	0.2	6.1	9.3	10.3	10.6
	S.D. =	0.6	0.6	0.1	0.1	2.0	2.6	3.6	3.7

Table 8-2. Mean concentrations of speckled sanddab (*Citharichthys stigmaeus*) muscle collected in the Goleta survey area. Comparisons of means determined by T-test ($p < 0.05$).

	Fish Muscle								
	TB3			TB6			T-Test		
Constituent	mean	±	SD	mean	±	SD	n	t	p
Metals (µg/dry g)									
Arsenic	9.497	±	0.133	6.277	±	0.055	3	38.70	<0.01
Cadmium	0.033	±	0.006	0.027	±	0.006	3	1.41	0.23
Chromium[2]	0.527	±	0.099	0.373	±	0.006	3	1.77	0.08
Copper	2.043	±	0.045	1.260	±	0.046	3	21.10	<0.01
Lead[2]	0.040	±	0.000	0.027	±	0.006	3	1.89	0.06
Mercury	0.103	±	0.002	0.067	±	0.003	3	15.19	<0.01
Nickel	0.157	±	0.006	0.047	±	0.012	3	14.76	<0.01
Selenium	1.707	±	0.136	1.217	±	0.112	3	4.81	0.01
Silver[2]	0.030	±	0.010	0.020	±	0.000	3	1.29	0.20
Zinc[2]	24.000	±	0.954	17.267	±	0.115	3	1.77	0.08
Complex Organics (ng/dry Kg)									
DDTs[1]	12.1	±	0.6	7.6	±	0.6	3	9.41	<0.01
Chlordane[1]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
HCHs[1]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Mirex	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs[1]	3.5	±	1.2	1.3	±	0.3	3	NA	NA
Arochlors	0.0	±	0.0	0.0	±	0.0	3	NA	NA
PAHs[1,2]	51.4	±	8.1	31.1	±	0.5	3	1.75	0.08
1-Methylnaphthalene	1.0	±	0.0	1.0	±	0.0	3	-1.80	0.18
1-Methylphenanthrene	4.2	±	1.1	3.2	±	0.3	3	1.52	0.20
2-Methylnaphthalene	2.4	±	1.0	1.7	±	0.3	3	1.08	0.34
2,3,5-Trimethylnaphthalene[2]	1.3	±	0.3	1.0	±	0.0	3	1.28	0.20
2,6-Dimethylnaphthalene	1.8	±	0.2	1.2	±	0.3	3	1.98	0.12
Acenaphthene[2]	1.3	±	0.5	1.0	±	0.1	3	0.00	1.00
Biphenyl	9.7	±	9.1	7.6	±	6.0	3	0.33	0.76
Benz(a)anthracene[2]	26.5	±	4.8	14.1	±	0.5	3	1.75	0.08
Benzo(b)fluoranthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo(e)pyrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo(g,h,i)perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene[2]	8.1	±	2.3	5.7	±	0.2	3	1.77	0.08
Napthalene	13.2	±	8.2	10.1	±	8.8	3	0.45	0.68
Perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA

1. Complex Organic derivatives are listed in Table 10-16.
2. Non-normal data. Statistics by Mann-Whitney U Test.

Table 8-3. Mean concentrations of Speckled sanddab (*Citharichthys stigmaeus*) liver collected in the Goleta survey area. Comparisons of means determined by T-test ($p < 0.05$).

	Fish Liver								
	TB3			TB6			T-Test		
Constituent	mean	±	SD	mean	±	SD	n	t	p
Metals (µg/dry g)									
Arsenic	8.757	±	0.897	5.720	±	0.614	3	4.84	0.01
Cadmium	3.513	±	0.254	2.907	±	0.272	3	2.83	0.05
Chromium	0.770	±	0.165	0.513	±	0.131	3	2.12	0.10
Copper	10.767	±	0.379	11.467	±	0.451	3	-2.06	0.11
Lead	0.337	±	0.040	0.303	±	0.032	3	1.12	0.33
Mercury	0.028	±	0.005	0.023	±	0.001	3	1.81	0.13
Nickel	0.020	±	0.000	0.020	±	0.000	3	NA	NA
Selenium	4.150	±	0.550	3.110	±	0.262	3	2.86	0.04
Silver	0.143	±	0.015	0.140	±	0.000	3	1.00	1.00
Zinc	58.567	±	3.291	45.300	±	0.624	3	6.88	0.00
Complex Organics (ng/dry Kg)									
DDTs [1]	574.0	±	10.4	655.0	±	15.7	3	-7.44	<0.01
Chlordane[1,2]	62.1	±	4.3	50.1	±	8.7	3	2.15	0.10
HCHs[1]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	4.5	±	0.7	5.0	±	0.4	3	-1.08	0.35
Mirex	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs[1]	123.4	±	2.7	134.7	±	6.7	3	-2.63	0.06
Arochlors[1]	160.0	±	9.8	167.3	±	8.2	3	-0.98	0.38
PAHs[1,2]	1070.5	±	45.4	1185.4	±	73.1	3	-2.31	0.08
1-Methylnaphthalene	7.8	±	2.3	13.6	±	2.0	3	-3.34	0.03
1-Methylphenanthrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2-Methylnaphthalene	15.2	±	4.0	30.9	±	5.7	3	-3.93	0.02
2,3,5-Trimethylnaphthalene[2]	7.3	±	0.7	1.0	±	0.0	3	1.86	0.06
2,6-Dimethylnaphthalene	4.2	±	0.6	8.6	±	1.7	3	-4.24	0.01
Acenaphthene[2]	1.0	±	0.0	26.1	±	3.1	3	-1.86	0.06
Biphenyl	17.0	±	27.7	66.9	±	59.6	3	-1.32	0.26
Benz[a]anthracene	933.0	±	42.5	999.0	±	62.6	3	-1.51	0.21
Benzo[b]fluoranthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[e]pyrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[g,h,i]perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene	21.5	±	3.4	17.0	±	3.8	3	1.54	0.20
Naphthalene	24.8	±	41.3	104.0	±	90.1	3	-1.38	0.24
Perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA

1. Complex Organic derivatives are listed in Table 10-16.
2. Non-normal data. Statistics by Mann-Whitney U Test.

Table 8-4. Heavy metals and complex organics in California bivalve (*Mytilus californianus*) tissues. Comparisons of means by ANOVA ($p < 0.05$).

	Bivalve Tissue											
	B3			B4			B6			ANOVA		
Constituent	mean	±	SD	mean	±	SD	mean	±	SD	n	F	p
Metals (µg/dry g)												
Arsenic	10.233	±	0.569	9.713	±	0.758	9.860	±	0.219	3	0.68	0.54
Cadmium	2.073	±	0.097	1.933	±	0.047	2.303	±	0.021	3	25.98	<0.01
Chromium	0.893	±	0.040	0.900	±	0.092	0.840	±	0.089	3	0.54	0.61
Copper	5.627	±	0.274	5.340	±	0.520	5.080	±	0.113	3	1.88	0.23
Lead	0.833	±	0.021	0.748	±	0.028	0.787	±	0.012	3	15.47	<0.01
Mercury^2	0.019	±	0.001	0.019	±	0.001	0.018	±	0.001	3	0.16	0.92
Nickel	0.437	±	0.068	0.430	±	0.026	0.523	±	0.032	3	3.83	0.08
Selenium	2.597	±	0.240	2.440	±	0.092	2.740	±	0.212	3	1.83	0.24
Silver^2	0.123	±	0.008	0.127	±	0.006	0.137	±	0.006	3	4.60	0.10
Zinc	109.867	±	3.055	100.600	±	5.242	104.333	±	0.577	3	5.03	0.05
Complex Organics (ng/dry Kg)												
DDTs^1	13.2	±	0.7	14.1	±	1.0	12.8	±	1.2	3	1.46	0.31
Chlordane^1	1.7	±	1.5	1.6	±	2.0	1.9	±	0.4	3	0.02	0.99
HCHs^1	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Mirex	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs^1	0.7	±	0.6	0.5	±	0.8	0.5	±	0.9	3	0.07	0.93
Arochlors^1	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0	3	NA	NA
PAHs^1	233.2	±	30.8	226.6	±	43.1	215.8	±	18.3	3	0.22	0.81
1-Methylnaphthalene	2.0	±	0.4	1.4	±	0.3	1.3	±	0.3	3	2.76	0.18
1-Methylphenanthrene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2-Methylnaphthalene	5.5	±	1.3	4.1	±	0.8	4.4	±	0.8	3	1.98	0.22
2,3,5-Trimethylnaphthalene	2.0	±	0.3	2.4	±	0.1	4.2	±	0.8	3	16.03	0.02
2,6-Dimethylnaphthalene^2	1.4	±	0.2	1.2	±	0.2	1.4	±	0.5	3	0.60	0.58
Acenaphthene	1.8	±	0.8	1.6	±	0.6	1.2	±	0.4	3	0.67	0.55
Biphenyl	16.8	±	12.4	9.8	±	8.3	3.7	±	3.0	3	1.69	0.26
Benz[a]anthracene	202.0	±	29.1	199.7	±	42.1	178.0	±	18.6	3	0.49	0.64
Benzo[b]fluoranthene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[a]pyrene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[g,h,i]perylene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene	5.9	±	1.1	8.2	±	0.7	9.8	±	1.0	3	9.84	0.01
Naphthalene	22.0	±	17.6	13.1	±	11.4	4.2	±	4.7	3	1.54	0.29
Perylene^2	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	0.30	0.86

1. Complex Organic derivatives are listed in Table 10-17.
2. Non-normal data. Statistics by Kruskal-Wallis Test.

Figure 8-1. Metal concentrations (mg/dry Kg) measured in fish muscle and liver tissues (Stations TB3 and TB6), and bivalves (Stations B3, B4, B6 and lab control).

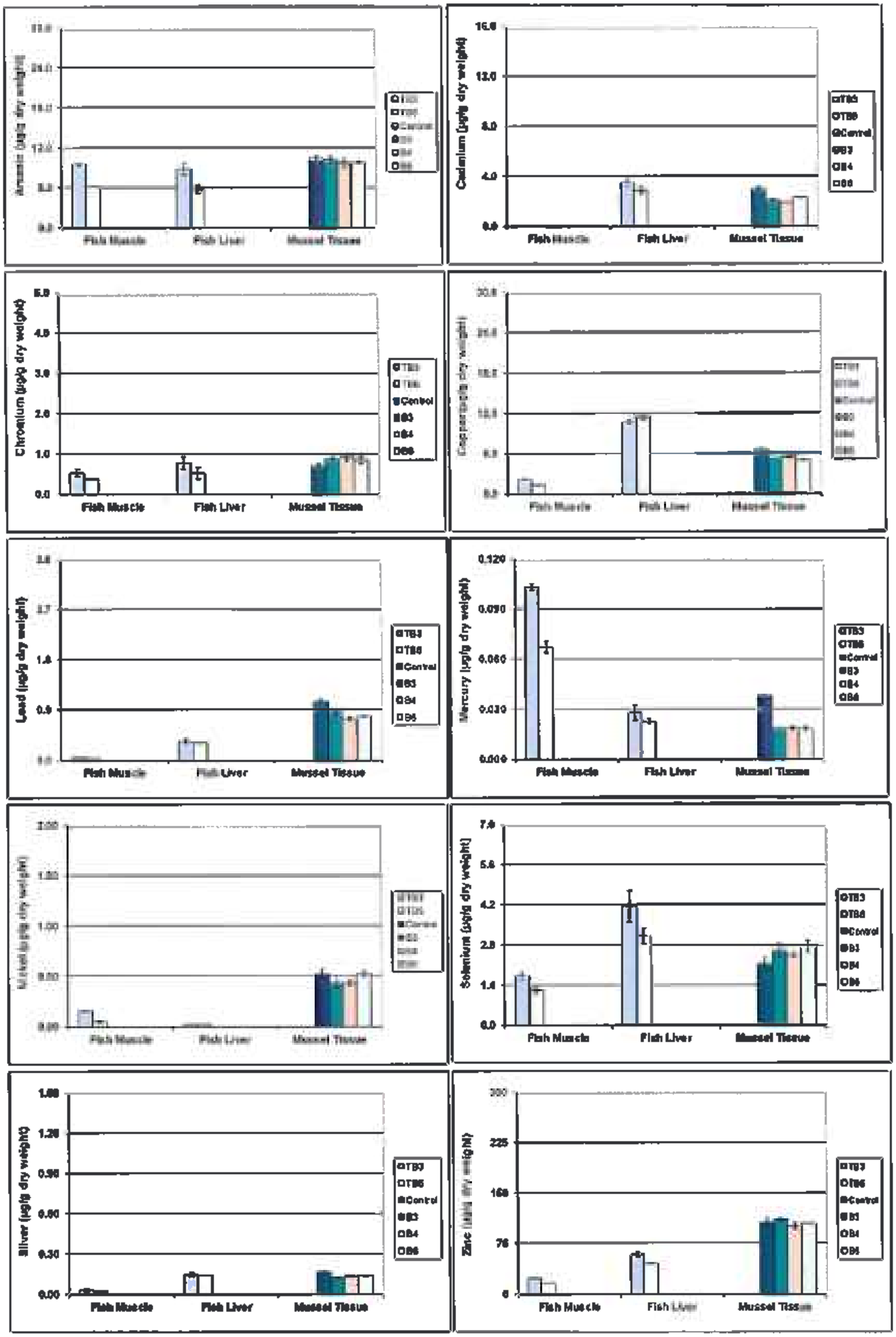


Figure 8-2. Organic concentrations (µg/dry Kg) measured in fish muscle and liver tissues (Stations TB3 and TB6), and mussels (B3, B4, B6 and lab control).

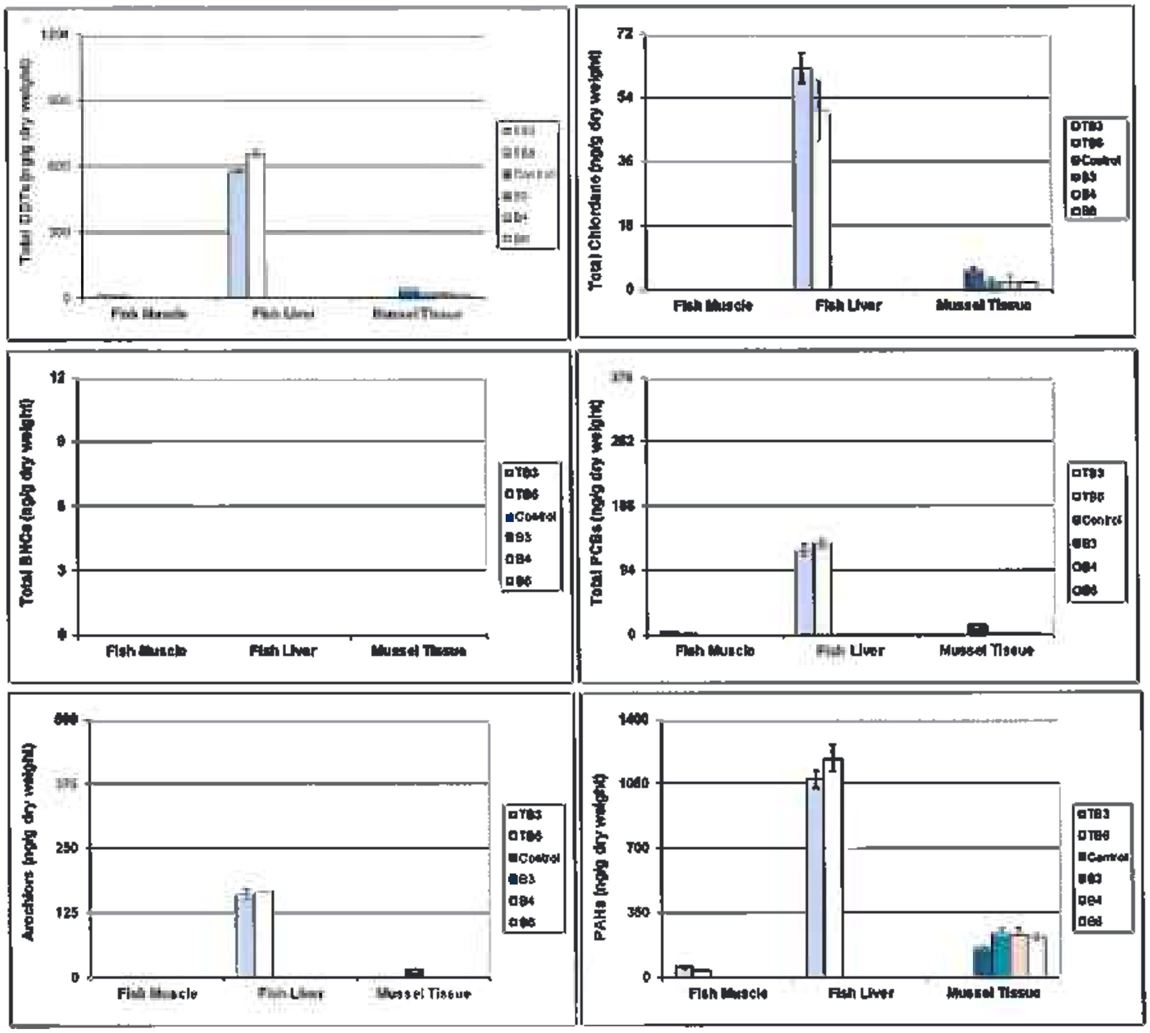


Figure 8-3. Contaminants (mg/dry Kg) measured in Speckled sanddab muscle (*Citharichthys stigmaeus*) from Goleta since 1991 (mean ± SD, n=6).

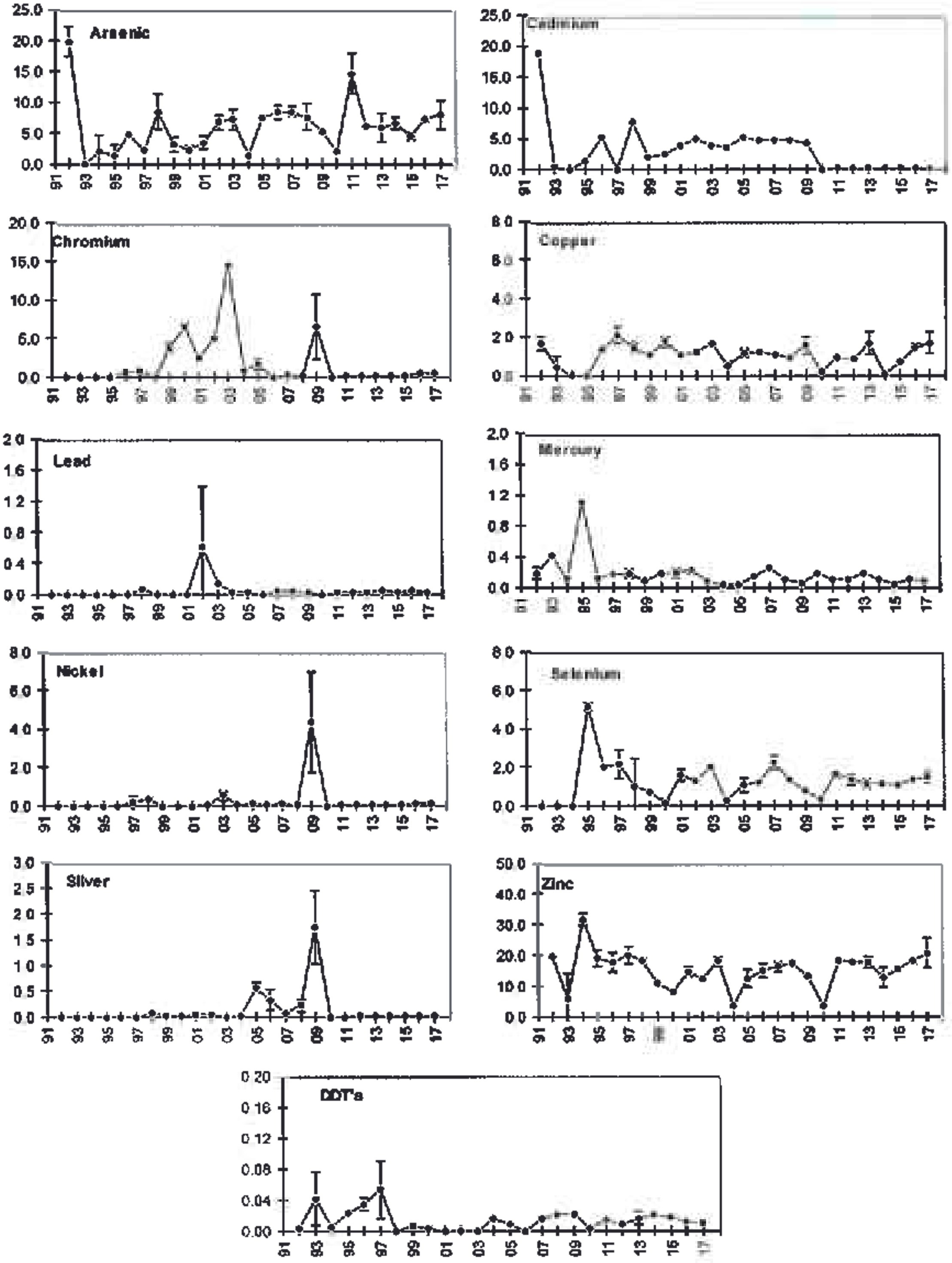


Figure 8-4. Contaminants (mg/dry Kg) measured in Speckled sanddab liver (*Citharichthys stigmaeus*) from Goleta since 1991 (mean ± SD).

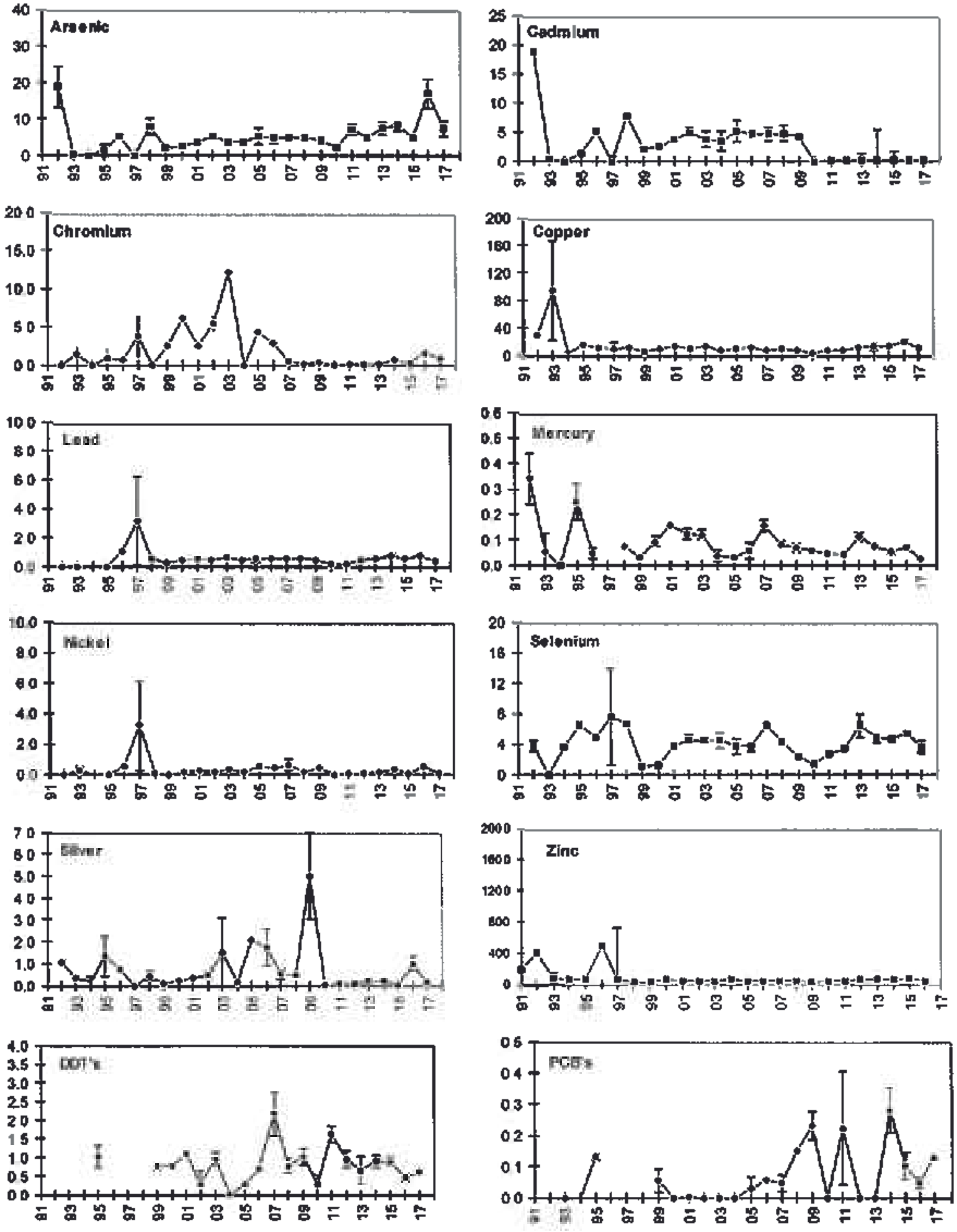


Figure 8-5. Contaminants (mg/dry Kg) measured in whole bivalves (*Mytilus californianus*) from Goleta since 1991 (mean ± SD, n = 3).

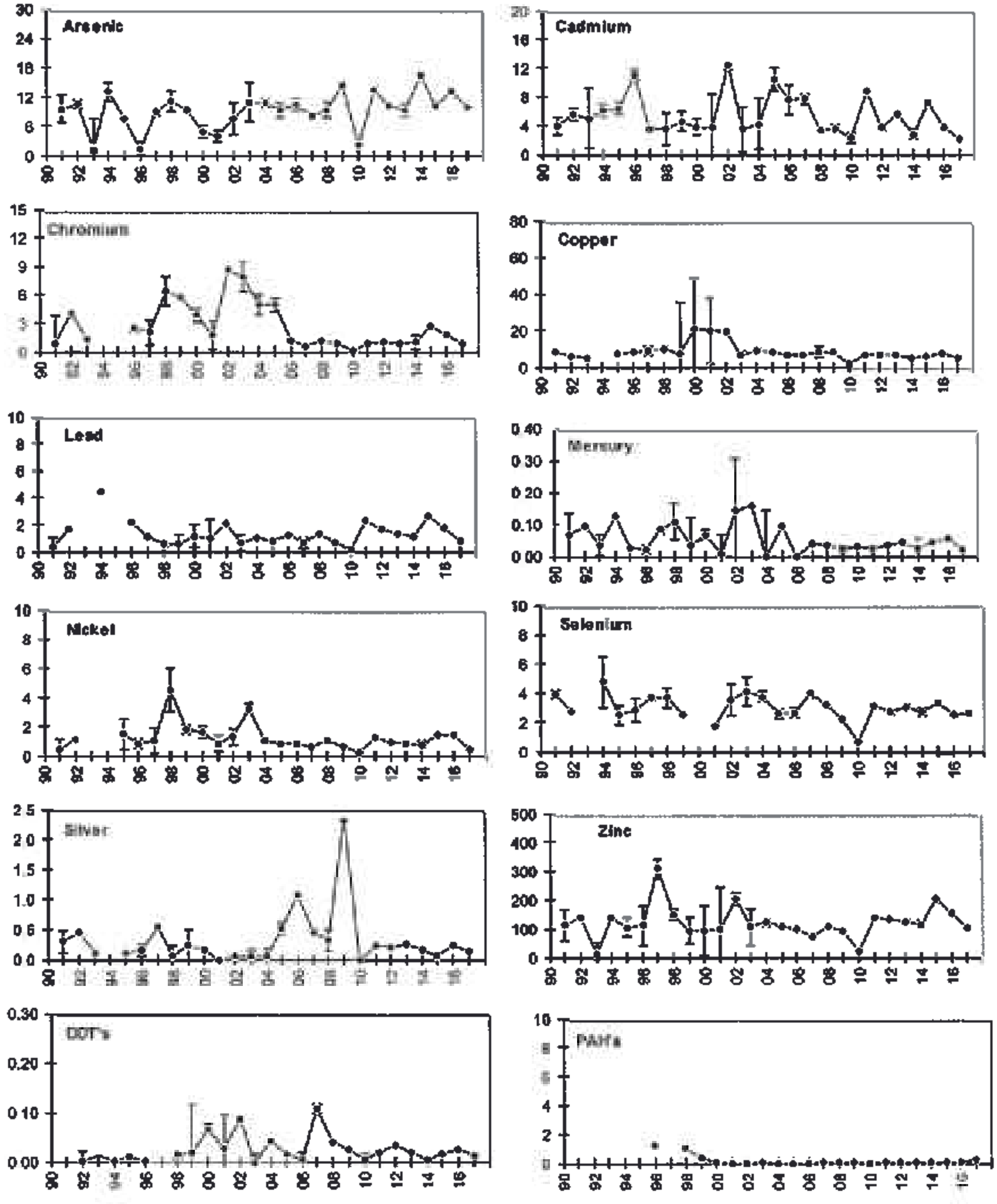


Table 8-5. Comparison of Goleta tissue chemistry with results from other studies (ug/wet g) and state and federal limits.

	GOLETA S.D.		Reference	OEHHA[2]	
	µg/g Wet Weight		µg/g Wet Weight	µg/g Wet Weight	
Constituent	Means	Ranges	Stations[1]	FCG[3]	ATL[4]
Fish Muscle					
Arsenic	1.380	1.092 - 1.682	42.2 - 57.8	—	—
Cadmium	0.005	0.004 - 0.007	<0.01 - 0.045	---	---
Chromium	0.079	0.065 - 0.112	0.08 - 2.8	---	---
Copper	0.269	0.212 - 0.366	0.45 - 2.4	—	—
Lead	0.006	0.004 - 0.007	1.2	—	—
Mercury	0.015	0.011 - 0.018	0.36 - 0.78	0.22	≤0.07[5]
Nickel	0.018	0.007 - 0.028	0.4 - 5.1	—	—
Selenium	0.256	0.196 - 0.326	2.8 - 3.95	7.4	≤2.5
Silver	0.004	0.004 - 0.007	<0.005 - 1.4	—	—
Zinc	3.611	3.010 - 4.358	12.4 - 30.5	—	—
DDTs	0.0017	0.0013 - 0.0022	0.005 - 2.15	0.021	≤0.52
Chlordane	0.0000	0.0000 - 0.0000	—	0.0056	≤0.052
PCBs	0.0004	0.0002 - 0.0007	0.005 - 2.7	0.0036	≤0.021
PAHs	0.0072	0.0054 - 0.0099	—	—	—
Fish Liver					
Arsenic	2.95	2.06 - 3.98	---	—	—
Cadmium	1.31	1.12 - 1.49	—	—	—
Chromium	0.26	0.16 - 0.39	0.5	—	—
Copper	4.52	4.27 - 4.84	—	—	—
Lead	0.13	0.11 - 0.15	—	—	—
Mercury	0.01	0.01 - 0.01	—	—	—
Nickel	0.01	0.01 - 0.01	—	—	—
Selenium	1.48	1.18 - 1.93	—	—	—
Silver	0.06	0.05 - 0.07	—	—	—
Zinc	21.14	18.15 - 24.75	—	—	—
DDTs	0.2501	0.2287 - 0.2739	28	—	—
Chlordane	0.0228	0.0165 - 0.0273	---	—	—
PCBs	0.0525	0.0494 - 0.0570	4	—	—
PAHs	0.4591	0.4201 - 0.5060	—	—	—

1. Sources: SWRCB 1978, 1988 (EDL 85); SCCWRP 1975, 1976, 1977, 1982, 1998c, Short & Harris 1996, Brown & Caldwell 1997; NOAA 1991, OEHHA 1991
2. OEHHA, 2008
3. Fish Contamination Goal (FCG)
4. Advisory Tissue Levels (ATLs) , most conservative tissue consumption threshold based on cancer or non-cancer risk.
5. Mercury ATL for women aged 18-45 years & children aged 1-17 years (OEHHA 2008)

Table 8-6. Comparison of mussel tissue chemistry with results from other studies (ug/wet g).

	GOLETA S.D.		Reference	OEHHA [2]		NOAA Status & Trends, 1986 to 2005		
	µg/g Wet Weight		µg/g Wet Weight	µg/g Wet Weight		µg/g Wet Weight		
Constituent	Means	Ranges	Stations[1]	FCG[3]	ATL[4]	low	medium	high
Mussel Tissue								
Arsenic	1.68	1.47 - 1.80	16.0 - 23.8	—	—	5 - 11	12 - 22	23 - 41
Cadmium	0.39	0.31 - 0.52	1.9 - 54	—	—	0 - 3	4 - 9	10 - 20
Chromium	0.14	0.11 - 0.16	1.23 - 3.9	—	—	—	—	—
Copper	0.95	0.81 - 1.14	4.0 - 21.8	—	—	5 - 16	17 - 39	40 - 857
Lead	0.14	0.12 - 0.18	1.09 - 11	—	—	0 - 3	4 - 6	7 - 13
Mercury	0.00	0.00 - 0.01	0.01 - 0.4	0.22	≤0.07 [5]	0.00 - 0.17	0.18 - 0.35	0.36 - 1.28
Nickel	0.08	0.06 - 0.10	3.2 - 5.3	—	—	0 - 5	6 - 14	15 - 44
Selenium	0.41	0.32 - 0.60	2.70 - 4.57	7.4	≤2.5	—	—	—
Silver	0.02	0.02 - 0.03	0.36 - 0.7	—	—	—	—	—
Zinc	17.53	16.82 - 18.85	133 - 336	—	—	48 - 139	140 - 320	321 - 11500
DDTs	0.0033	0.0020 - 0.0072	0.017 - 0.35	0.21	≤0.52	0 - 0.112	0.113 - 0.286	0.287 - 0.520
Chlordane	0.0005	0.0000 - 0.0010	—	0.0056	≤0.19	0 - 0.008	0.009 - 0.020	0.021 - 0.049
PCBs	0.0006	0.0000 - 0.0025	0.017 - 0.35	0.0036	≤0.021	0.003 - 0.153	0.154 - 0.478	0.479 - 1.413
PAHs	0.0346	0.0245 - 0.0435	0.81	—	—	0.063 - 1.187	1.118 - 4.434	4.435 - 7.581

1. Sources: SWRCB 1978, 1988 (EDL 85); SCCWRP 1975, 1976, 1977, 1982, 1998c; Short & Harris 1996; Brown & Caldwell 1997; NOAA 1991, OEHHA 1991
2. OEHHA, 2008
3. Fish contaminant goals; based on cancer and non-cancer risk using an 8 oz/week consumption rate.
4. Advisory tissue levels; based on cancer and non-cancer risk using an 8 oz/week consumption rate (OEHHA 2008).

9.0 Introduction

Aquatic Bioassay biologists conducted underwater dive surveys and underwater videos of the outfall pipe and diffuser from the Goleta Sanitary District Wastewater Treatment Plant on October 25th, 2017. The purposes of the survey were to inspect the physical integrity of the outfall pipe and associated armor rock and note any impediments to flow from the 36 diffuser ports. Aquatic Bioassay biologists also assessed the presence of attached and mobile marine organisms that were associated with the outfall and the diffuser.

9.1 Materials and Methods

Five divers, using Sony 2100 Camcorders enclosed in Gates underwater housings with attached NiteRider underwater lights, conducted the survey. Once the outfall had been located by global positioning (GPS) and bottom finder, a buoy, attached to a line and a weight, was deployed over the side. Divers entered the water, descended down the line, swam to the diffuser terminus, and began filming. At the end of each dive, a lift float was deployed as a marker for the subsequent dive. On deck between dives, the camera was removed from the housing, the footage was inspected, batteries were replaced, and the housing was reassembled. A total of five dives were completed for the video: diffuser, west and east ports (100 ft. to 70 ft.); deep outfall (70 ft. to 40 ft.); middle outfall (40 ft. to 20 ft.), and shallow outfall (20 ft. to surf zone).

The footage was downloaded to computer files, edited using *Adobe Premiere* software, and then transferred to DVD. DVDs were then reviewed by the survey team to assess conditions of the outfall. The video is arranged from the deepest part of the dives (outfall terminus) to the shallowest part of the dives (outfall beginning).

9.2 Results

Outfall dive surveys were conducted between approximately 0830 and 1630 hours on October 25th, 2017 aboard the research vessel *Hey Jude*. Weather conditions were fair with a no wind and 2 to 3 ft. swell from the southwest (225 °). There was a thermocline at approximately 6 meters. Water color was blue and green with high turbidity and surge. Visibility at the terminus of the diffuser (100 feet) and throughout the dive was 0 to 1/3 meter. The poor visibility made it difficult to observe flora and fauna on the video, and made it necessary to film the outfall close-up.

9.2.1 Diffuser Section (Depth: 100 TO 70 ft)

9.2.1.1 Physical Description

The pipe survey was conducted in the October in hopes that water quality would be optimal for taking video footage of the pipe. This year's visibility was extremely poor, ranging from 0 to 1/3 meters. The diffuser section contains 34 lateral and two terminal discharge ports. The lateral ports are alternately arranged 17 on each side of the diffuser. The end of the pipe is closed except for the two terminal ports, which are situated one above the other. There were no obstructions on the upper port of the terminus cap, and the flow from both the upper and lower terminal ports was strong.

Lateral ports were observed and videotaped, starting on the west side of the pipe, then the terminus, and moving shoreward on the east side of the pipe until the most shoreward east port was occupied at the beginning of the diffuser. Minor shell debris was removed from several ports, however all the lateral ports were flowing freely. Along the length of the diffuser pipe, no evidence of leaks, damage, erosion, holes, or cracks were observed.

An approximately one meter high bed of armor rock supports the diffuser section. Intermittent observations of the supporting armor rock revealed a stable bed of rock with little displacement throughout the diffuser section. Probably during initial construction, the diffuser section appears to have been rotated counter-clockwise (as if one were facing the terminus). Thus, the line across east and west diffuser ports is not parallel to the sea floor, and west ports are about 30 cm lower than east ports. Armor rock covers the outfall from the shoreward beginning of the diffuser to the shoreward beginning of the outfall in very shallow water. The thickness of the armor rock is about one meter.

9.2.1.2 Biological Description

Because of the depth and relative low light at the diffuser (100 ft), algal species are typically scarce. Algae that were present included the kelp *Desmarestia ligulata* a tubular and leafy red alga (Rhodophyta), crustose coralline algae (Corallinaceae) and the Turkish Towel (*Gigartina sp.*). Among invertebrates; brown cup coral (*Paracyathus sternsi*), colonial strawberry anemones (*Corynactis californica*), red gorgonian (*Lophogorgia chilensis*) and various species of colonial hydroids and bryozoans dominated. Tube worms and especially the strawberry anemones were commonly observed surrounding the diffuser ports. Batstars (*Patiria miniata*), giant sea stars (*Pisaster giganteus*), Garabaldi (*Hypsypops rubicundus*), and kelp bass (*Paralabrax clathratus)* were observed either on the pipe, or in its immediate vicinity.

9.2.2 Deep Outfall Section (Depth: 70 TO 40 ft)

9.2.2.1 Physical Description

Throughout the dive survey, the outfall was completely covered by approximately one-meter layer of armor rock. Visibility was poor in this section. The rock covered pipe extended vertically from the sea floor for about 2 to 3 meters and laterally for about 6 to 7 meters. The armor rock bed appeared stable with little displacement throughout this section. No obvious leaks or discoloration were observed from the armor rock covering the top or sides of the outfall pipe.

9.2.2.2 Biological Description

On this section, crustose coralline alga (Corallinaceae), foliose red algae (*Gigartina sp.*) and several species of brown algae (Phaeophyta) dominated the algal community. Among invertebrates, the most abundant were the colonial strawberry anemones (*Corynactis californica*), red gorgonian (*Lophogorgia chilensis*), several species of bryozoans, and the giant keyhole limpets (*Megathura crenulata*). Several fish species were observed including, black perch (*Embiotoca jacksoni),* sheepshead

(*Semicossyphus pulcher*), giant kelpfish (*Heterostichus rostratus*) and blacksmith (*Chromis punctipinnis*).

9.2.3 Middle and Shallow Outfall Section (Depth: 40 TO Surf Zone)

9.2.3.1 Physical Description

As with the previous section, this outfall section was covered by about one meter of armor rock. The armor rock covered pipe extended horizontally and laterally as above. The armor rock bed appeared stable with little displacement throughout this section. No obvious leaks or discoloration were observed from the armor rock covering the top or sides of the outfall pipe.

9.2.3.2 Biological Description

Dominant algae in this pipe section included foliose red algae (*Gigartina sp.*) and crustose coralline algae and giant kelp (*Macrocysitis pyrifera*). Among the macroinvertebrates, the giant keyhole limpets (*Megathura crenulata*), red urchin (*Strongylocentrotus franciscanus*) and red gorgonian (*Lophogorgia chilensis*) were most dominant. Fish species observed at this depth included kelp bass (*Paralabrax clathratus*), black perch (*Embiotoca jacksoni*), and halfmoon (*Medialuna californiensis*).

Discussion

During the diffuser dive survey, 36 diffuser ports were carefully inspected for flow and general efficiency. This year, none of the diffuser ports were obstructed with debris and all of the ports were flowing freely. The remainder of the outfall pipe was inspected for damage, leaks or evidence of leaks and general stability of the pipe and armor rock. Inspection of the outfall yielded no evidence of damage, holes, cracks, or erosion. The pipe and associated armor rock appeared stable with little or no displacement.

The outfall continues to support a rocky reef community typical of other areas on the central California coast. A visual survey yielded numerous different species of kelp, macroinvertebrates, and fishes. A number of species of fish were represented by juvenile or larval forms, which indicates that recruitment has been occurring. Fish appeared healthy, with no evidence of deformities, tumors, fin rot, or lesions.

CHAPTER 10

COLLECTION SYSTEM ANNUAL SUMMARY

Background

Sanitary sewer overflows associated with the Goleta Sanitary District's collection system are subject to the online reporting and notification requirements set forth in the Statewide General Waste Discharge Requirements for Sanitary Sewer Systems Order NO. 2006-0003-DWQ. The Goleta Sanitary District has enrolled under the statewide waste discharge requirement for sanitary sewer systems.

GSD completed the Sanitary Sewer Management Plan (SSMP) in December 2006 and reviews and revises the SSMP annually, as needed. The District's SSMP was updated in September of 2013 in accordance with SWRCB Order No. WQ 2013-0058 – EXEC MRP.

This annual report summarizes all lift station and collection system overflows that occurred during 2017 and includes, if any, the cause, corrective actions taken and corrective actions planned. In conjunction with the annual report the District will conduct the annual SSMP update. The update is a part of the wastewater collection system management plan and requires the District to conduct an internal audit to evaluate the wastewater collection system management plan and delineate steps the District will take to correct any deficiencies that are found.

Annual Reporting Requirement

This chapter is included as part of the wastewater treatment plant annual report.

Summary of 2017 Spills

Lift Station Overflows

There were no lift station overflows that occurred within the Goleta Sanitary District service area during 2017.

Collection System Overflows

There were three (3) collection system overflows that occurred within the Goleta Sanitary District service area during 2017.

SSO #1 SSO Event ID 832804 February 13, 2016 near Calle Real and El Sueno Rd. Category 3 SSO of 800 gallons that did not reach a storm drain or waterway. The cause was vandalism. Corrective measures include installation of a locking manhole lid on the upstream manhole.

SSO #2 SSO Event ID 834728 April 25, 2017 near Nogal Rd. and Nueces Dr. bike path. Category 1 SSO of 2,500 gallons that reached Cieneguitas Creek. The cause was debris and a "Rain Stopper" that had fallen into the manhole channel. Corrective measures include the raising of the upstream manhole and the installation of a locking lid.

SSO #3 SSO Event ID 838689 July 13, 2017 in an easement near Via Los Padres. Category 3 SSO of 600 gallons that did not reach a storm drain or waterway. The cause was root intrusion. Corrective measures include removal of the roots, replacing a section of the sewer line and the scheduling of this line for CIPP rehabilitation.

Discussion

The Goleta Sanitary District's wastewater collection system management plan has been completed and complies with all of the requirements of MRP No. R3-2010-0012 and R3-2017-0021. All detailed tasks have been addressed in a timely manner and the collection system has complied with all requirements of the monitoring and reporting program.

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10.2. Water Quality Correlation Data

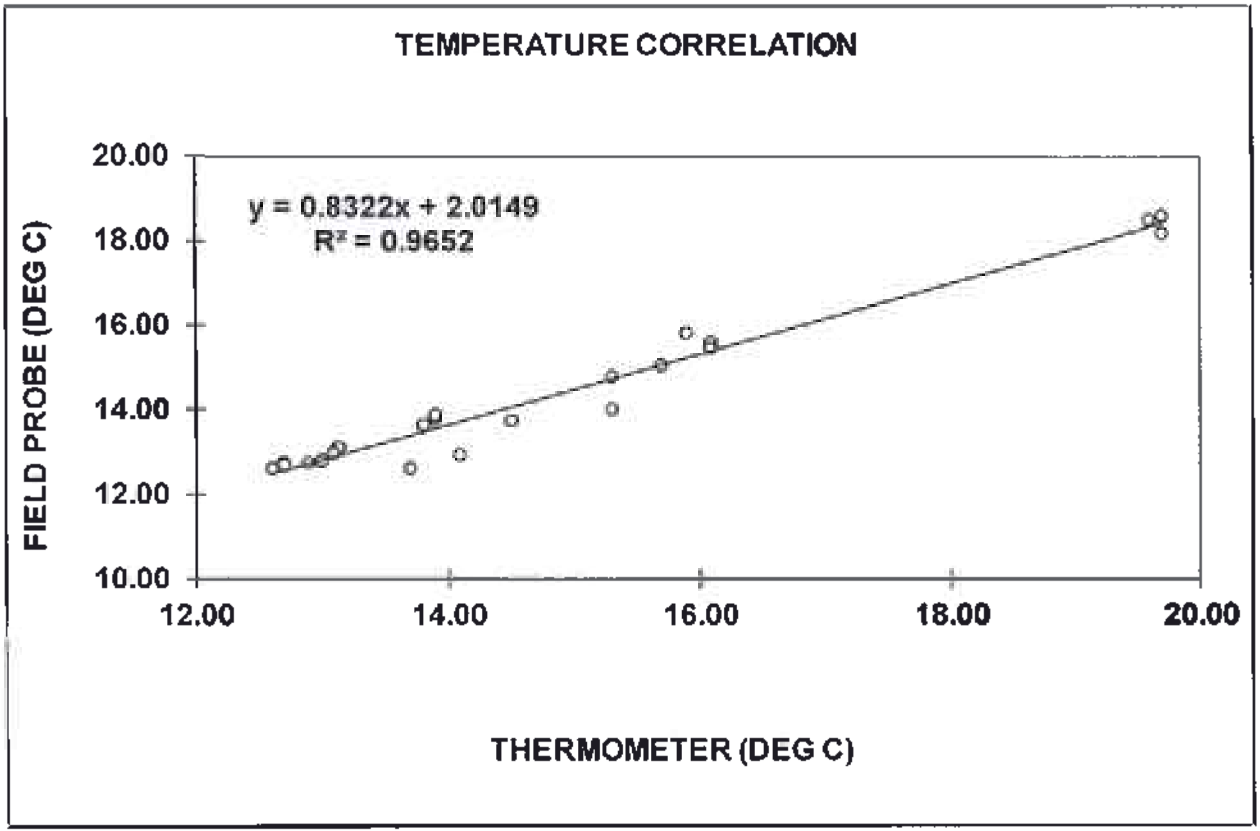

Figure 10-1. Correlations between CTD probes and analysis of discrete water samples measured using field probes.

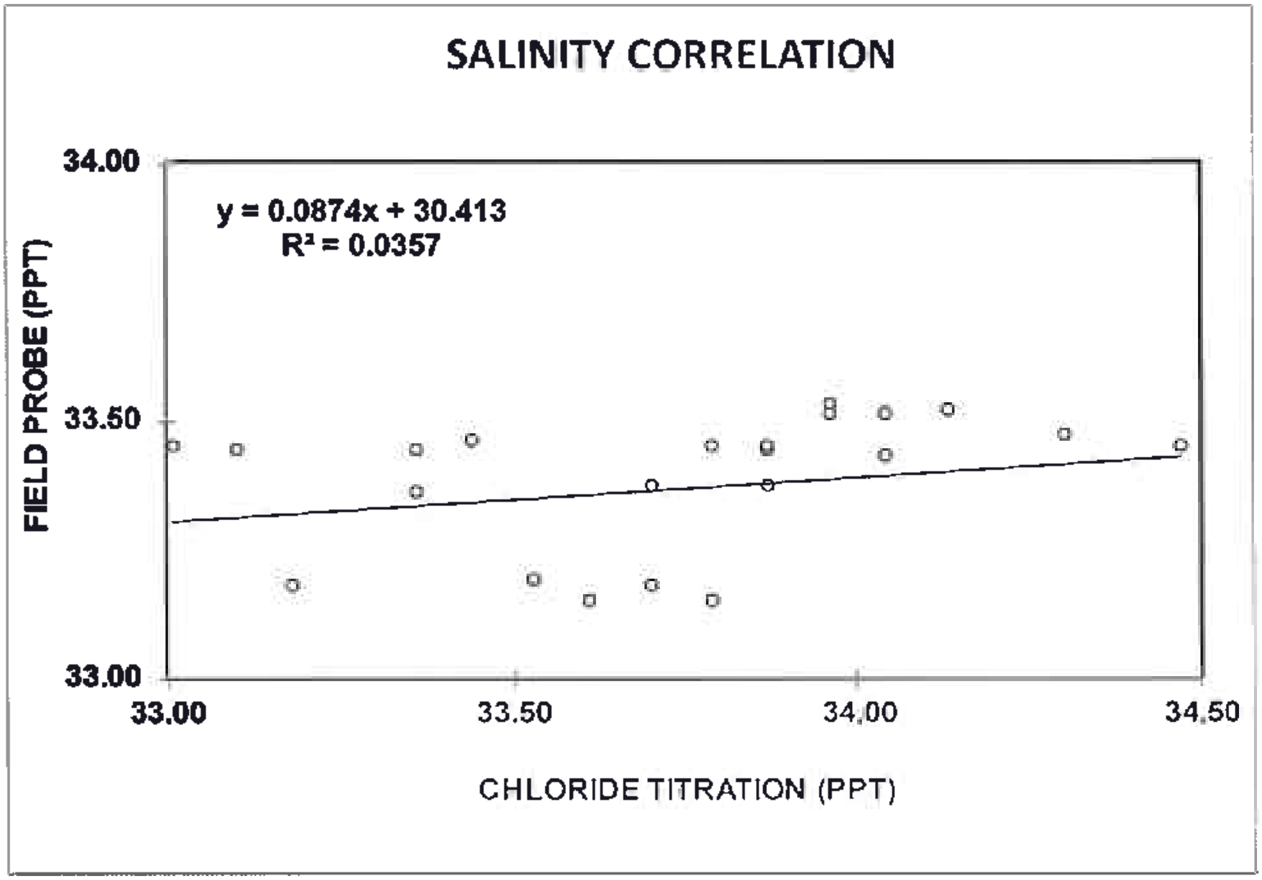

Figure 10-1. (continued)

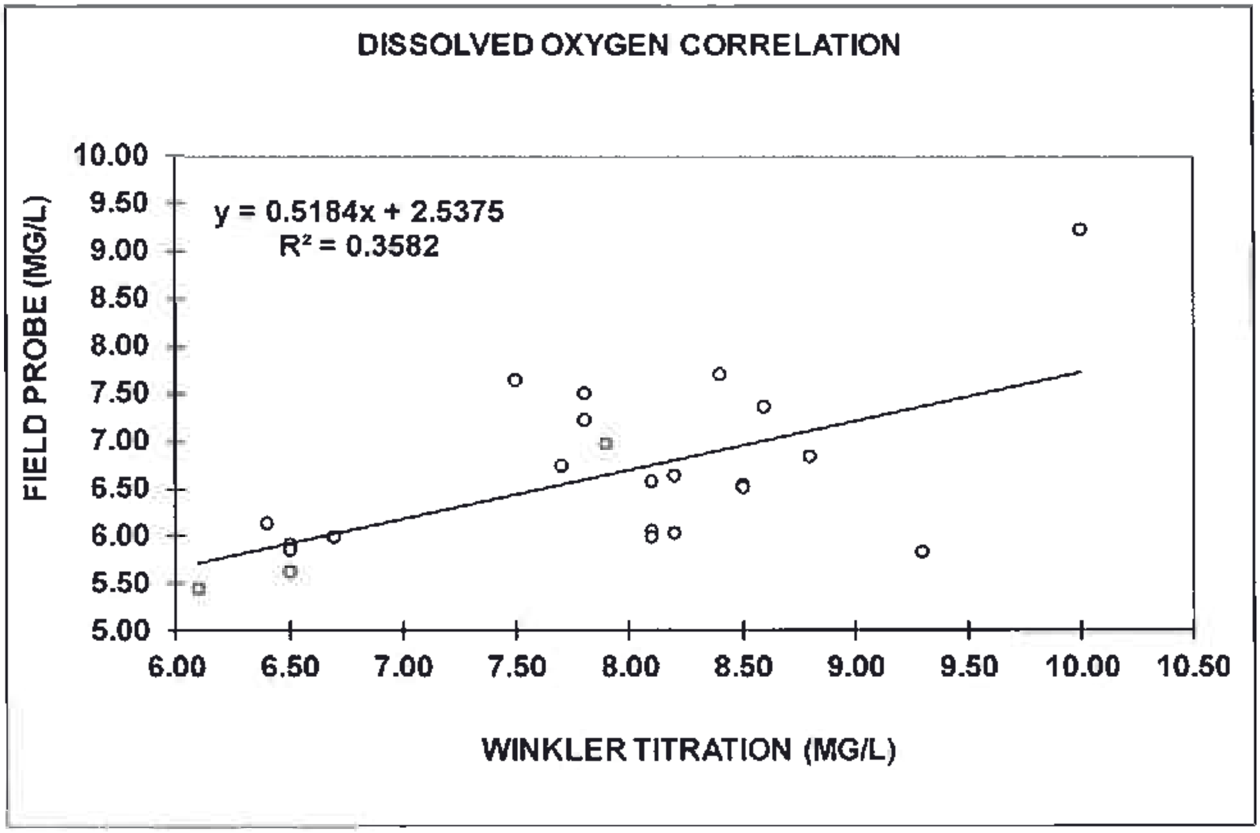

Figure 10-1. (continued)

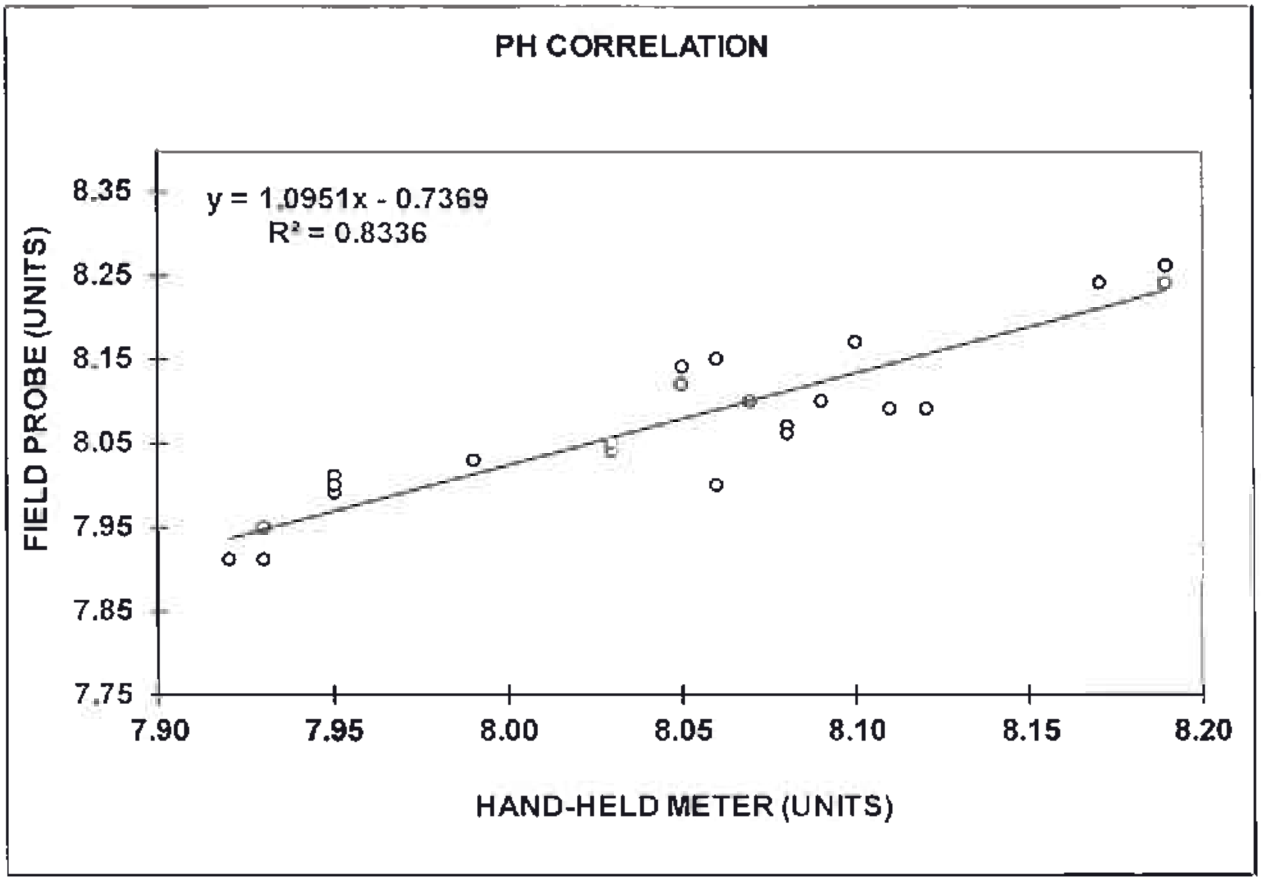

Figure 10-1. (continued)

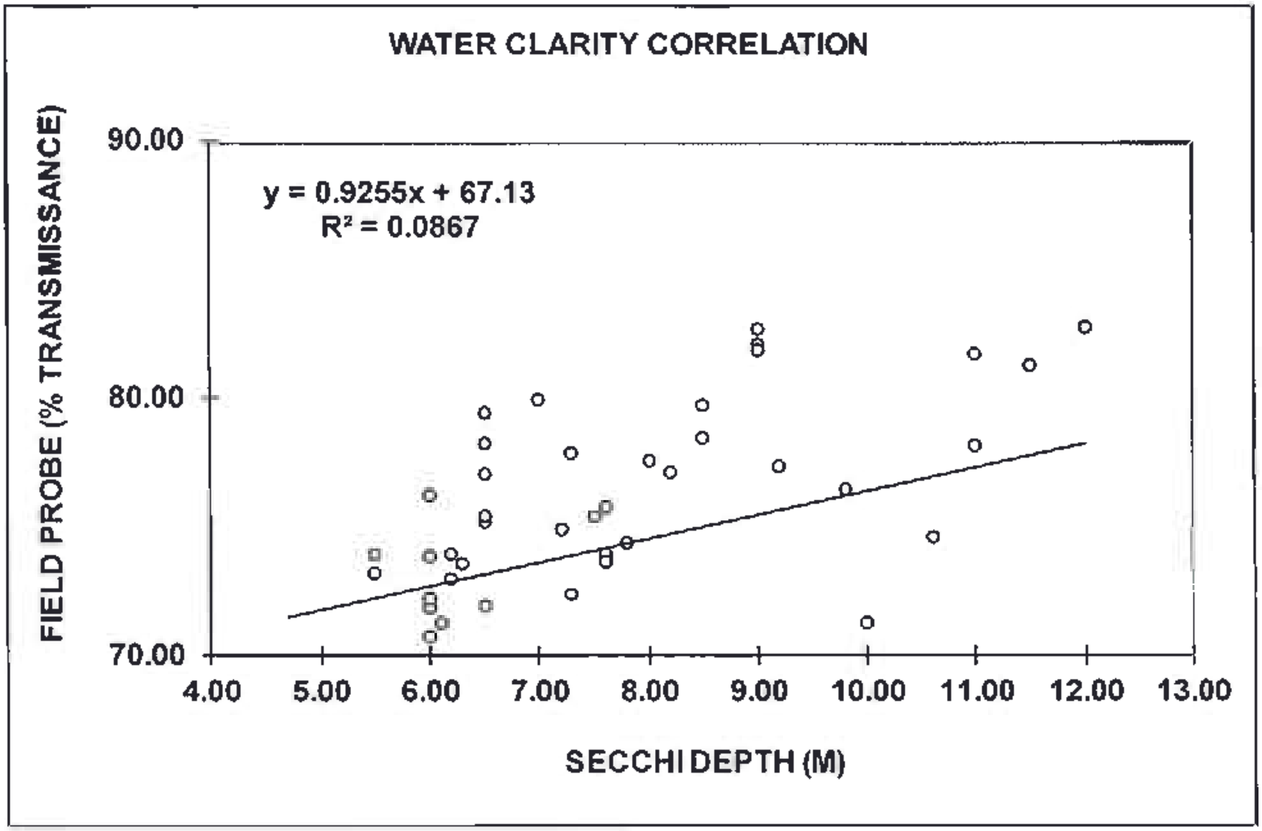

Figure 10-1. (continued)

10.3. Particle Size

Table 10-2. Particle sizes by channel sizes in phi and microns for each Goleta sediment station.

phi Size	<-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	>12
Microns	>2000	1410	1000	710	500	354	250	177	125	88.4	62.5	44.2	31.3	22.1	15.6	11.1	7.8	5.5	3.9	2.8	1.95	1.38	0.98	0.69	0.49	0.35	<0.24
Sample ID	coarse sand	coarse sand	med sand	med sand	med sand	med sand	fine sand	very fine sand	very fine sand	very fine sand	very fine sand	very fine sand	course silt	course silt	course silt	silt	fine silt	very fine silt	very fine silt	clay	clay	clay	clay	clay	clay	clay	clay
B1	0.00	0.00	0.00	0.06	0.82	3.52	9.41	14.61	15.24	11.15	7.25	5.06	4.31	4.23	4.36	4.58	4.05	3.19	2.18	1.62	1.22	0.80	0.79	0.75	0.50	0.14	0.00
B2	0.00	0.00	0.00	0.03	0.40	1.38	5.50	16.81	23.36	16.36	6.17	4.37	3.36	3.31	3.45	3.50	2.88	2.09	1.34	1.09	0.74	0.53	0.52	0.46	0.32	0.02	0.00
B3	0.00	0.00	0.00	0.03	0.47	2.04	9.32	26.03	28.68	12.88	5.03	2.47	1.95	2.00	2.15	2.24	1.90	1.42	0.93	0.76	0.52	0.38	0.38	0.34	0.08	0.00	0.00
B4	0.00	0.00	0.00	0.03	0.61	3.72	19.54	37.61	18.02	4.66	1.90	1.45	1.64	1.95	2.03	1.92	1.48	1.06	0.69	0.56	0.39	0.29	0.28	0.13	0.00	0.00	0.00
B5	0.00	0.00	0.00	0.04	0.59	2.99	12.81	25.34	19.37	9.28	4.75	3.30	3.22	3.46	3.48	3.26	2.48	1.72	1.09	0.87	0.59	0.43	0.40	0.35	0.19	0.00	0.00
B6	0.00	0.00	0.00	0.00	0.23	0.87	3.36	12.63	24.49	21.47	10.41	4.76	3.31	3.16	3.28	3.27	2.61	1.83	1.18	0.94	0.86	0.49	0.47	0.42	0.22	0.00	0.00

Table 10-3. Summary of particle sizes by fraction, percentiles, dispersion, sorting index and distribution.

	Summary (Percent)					Percentile (microns)					Percentile (phi)					Microns			phi			Dispersion or Sorting index	Distribution (phi)	
Sample ID	Gravel*	Sand	Silt	Clay	Silt-Clay	5%	16%	50%	84%	95%	5%	16%	50%	84%	95%	Mean	Median	Mode	Mean	Median	Mode		Skewness	Kurtosis
B1	0.00	62.04	31.94	6.02	37.96	2.29	8.15	72.54	167.93	244.37	8.78	6.85	3.78	2.57	2.02	89.18	72.54	109.34	3.48	3.78	3.19	2.19	-0.14	-2.54
B2	0.00	72.00	24.31	3.68	28.00	3.67	14.21	83.80	147.87	204.84	8.02	6.14	3.57	2.75	2.28	87.83	83.80	105.47	3.51	3.57	3.24	1.69	-0.04	-2.69
B3	0.00	82.47	15.07	2.46	17.53	5.69	35.71	106.81	167.46	228.18	7.46	4.81	3.22	2.57	2.12	109.34	106.81	114.49	3.19	3.22	3.12	1.12	-0.03	-3.39
B4	0.00	88.12	12.23	1.65	13.88	7.97	63.52	139.04	203.52	247.19	6.98	3.97	2.84	2.29	2.01	136.26	139.04	149.79	2.87	2.84	2.73	0.84	0.03	-3.95
B5	0.00	75.17	22.02	2.81	24.83	4.86	17.52	107.90	178.06	240.87	7.69	5.84	3.21	2.47	2.05	109.81	107.90	142.20	3.16	3.21	2.81	1.68	-0.02	-2.68
B6	0.00	73.44	23.36	3.18	26.56	4.42	16.78	77.14	128.74	174.31	7.83	5.90	3.69	2.95	2.51	80.84	77.14	98.75	3.63	3.69	3.34	1.47	-0.05	-2.80

*Percentage of the sample retained on a 2 mm sieve.

10.4 Sediment Chemistry

10-4 Sediment contaminant concentrations normalized to % total organic carbon (TOC) in the Goleta survey area. Correlations by nonparametric Spearman's rho.

	Sediment Stations								Correlations	
Constituent	B1	B2	B3	B4	B5	B6	Mean	S D	Outfall	Fines
Undifferentiated Organics										
Oil and Grease	1716	1370	1373	742	1015	776	1165.3	385.0	0.32	-0.77
TKN	387	621	1208	1204	1328	696	908.7	386.5	-0.72	0.60
AVS	7.72	15.93	49.00	44.38	30.61	8.89	26.24	17.79	-0.78	0.20
Heavy Metals										
Aluminum	13579	13560	17075	18167	17385	19921	16264	2437	-0.03	0.94
Antimony	0.17	0.19	0.25	0.26	0.28	0.28	0.24	0.05	-0.38	0.94
Arsenic	5.80	6.49	10.33	10.77	11.77	10.08	9.37	2.19	-0.78	0.80
Cadmium	0.51	0.60	1.05	0.77	0.83	0.92	0.78	0.20	-0.12	0.66
Chromium	38.11	37.04	52.00	46.67	53.50	56.10	47.20	9.08	-0.03	0.94
Copper	7.43	7.52	8.98	10.02	10.49	8.71	8.52	1.54	-0.89	0.14
Iron	14421	14074	18550	17125	20000	18421	17099	2391	-0.41	0.88
Lead	5.47	6.38	7.73	7.98	8.82	6.71	6.95	1.38	-0.67	0.54
Mercury	0.022	0.023	0.041	0.042	0.048	0.040	0.036	0.0103	-0.81	0.66
Nickel	18.89	20.74	27.25	22.08	26.41	24.26	23.44	3.02	-0.38	0.60
Selenium	0.47	0.49	0.76	0.67	0.66	0.59	0.61	0.11	-0.64	0.43
Silver	0.221	0.173	0.275	0.229	0.231	0.184	0.219	0.037	-0.84	0.14
Tin	0.97	1.06	1.51	1.93	1.74	2.11	1.57	0.46	-0.12	0.94
Zinc	36.74	37.28	50.25	43.83	54.10	44.21	44.74	6.82	-0.72	0.60
Complex Organics										
DDTs	5.20	3.50	1.70	ND	0.00	0.00	2.09	2.20	0.40	-0.94
HCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlordane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Mirex	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
PCBs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aroclors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total PAHs	61.05	34.60	35.00	5.42	14.10	20.00	28.36	19.78	[illegible]	-0.71
1-Methylnaphthalene	1.58	ND	ND	ND	ND	ND	0.26	0.64	[illegible]	-0.65
1-Methylphenanthrene	3.58	2.50	3.25	ND	ND	2.89	2.05	1.62	[illegible]	-0.52
2,3,5-Trimethylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
2,6-Dimethylnaphthalene	2.53	ND	ND	ND	ND	ND	0.42	1.03	0.40	-0.65
2-Methylnaphthalene	2.32	ND	ND	ND	ND	ND	0.39	0.95	0.40	-0.65
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Benz[a]anthracene	11.37	5.66	4.50	ND	ND	ND	3.59	4.57	0.40	-0.84
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Benzo[e]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	0.00	0.00
Biphenyl	6.11	1.85	3.25	ND	ND	ND	1.87	2.46	0.34	-0.88
Fluoranthene	11.58	11.23	11.50	2.50	5.38	5.26	7.91	4.00	0.32	-0.77
Naphthalene	7.26	1.46	3.00	ND	ND	ND	1.95	2.86	0.34	-0.88
Perylene	55.37	34.32	24.00	8.76	12.82	10.53	24.30	16.05	0.30	-0.83

Bold = marginally significant (0.05 < p < 0.10)
Bold = significant (p < 0.05)

10-5. Sediment chemistry minimum detection limits (MDL) and reporting limits (RL) and methods.

Parameter	MDL	RL	Units	Method
General Chemistry				
Acid Volatile Sulfides	0.05	0.1	µg/g	Plumb, 1981 and TERL
Oil & Grease	100	200	µg/g	SM 5520 E
TKN	1.2	10	µg/g	EPA 351.2
Total Organic Carbon	100	200	µg/g	SM 5310 B
Trace Metals				
Aluminum	1	5	µg/g	EPA 6020
Antimony	0.025	0.05	µg/g	EPA 6020
Arsenic	0.025	0.05	µg/g	EPA 6020
Cadmium	0.0025	0.005	µg/g	EPA 6020
Chromium	0.0025	0.005	µg/g	EPA 6020
Copper	0.0025	0.005	µg/g	EPA 6020
Iron	1	5	µg/g	EPA 6020
Lead	0.0025	0.005	µg/g	EPA 6020
Mercury	0.00001	0.00002	µg/g	EPA 245.7
Nickel	0.01	0.02	µg/g	EPA 6020
Selenium	0.025	0.05	µg/g	EPA 6020
Silver	0.01	0.02	µg/g	EPA 6020
Tin	0.025	0.05	µg/g	EPA 6020
Zinc	0.025	0.05	µg/g	EPA 6020
Chlorinated Pesticides				
2,4'-DDD	1	5	ng/g	EPA 8270D
2,4'-DDE	1	5	ng/g	EPA 8270D
2,4'-DDT	1	5	ng/g	EPA 8270D
4,4'-DDD	1	5	ng/g	EPA 8270D
4,4'-DDE	1	5	ng/g	EPA 8270D
4,4'-DDT	1	5	ng/g	EPA 8270D
Aldrin	1	5	ng/g	EPA 8270D
BHC-alpha	1	5	ng/g	EPA 8270D
BHC-beta	1	5	ng/g	EPA 8270D
BHC-delta	1	5	ng/g	EPA 8270D
BHC-gamma	1	5	ng/g	EPA 8270D
Chlordane-alpha	1	5	ng/g	EPA 8270D
Chlordane-gamma	1	5	ng/g	EPA 8270D
cis-Nonachlor	1	5	ng/g	EPA 8270D
Dieldrin	1	5	ng/g	EPA 8270D
Endosulfan sulfate	1	5	ng/g	EPA 8270D
Endosulfan-I	1	5	ng/g	EPA 8270D
Endosulfan-II	1	5	ng/g	EPA 8270D
Endrin	1	5	ng/g	EPA 8270D
Endrin aldehyde	1	5	ng/g	EPA 8270D
Endrin ketone	1	5	ng/g	EPA 8270D
Heptachlor	1	5	ng/g	EPA 8270D
Heptachlor epoxide	1	5	ng/g	EPA 8270D
Methoxychlor	1	5	ng/g	EPA 8270D
Mirex	1	5	ng/g	EPA 8270D
Oxychlordane	1	5	ng/g	EPA 8270D
Perthane	5	10	ng/g	EPA 8270D
trans-Nonachlor	1	5	ng/g	EPA 8270D
Polynuclear Aromatic Hydrocarbons (PAHs)				EPA 8270D
1-Methylnaphthalene	1	5	ng/g	EPA 8270D
1-Methylphenanthrene	1	5	ng/g	EPA 8270D
2,3,5-Trimethylnaphthalene	1	5	ng/g	EPA 8270D
2,6-Dimethylnaphthalene	1	5	ng/g	EPA 8270D
2-Methylnaphthalene	1	5	ng/g	EPA 8270D
Acenaphthene	1	5	ng/g	EPA 8270D
Acenaphthylene	1	5	ng/g	EPA 8270D
Anthracene	1	5	ng/g	EPA 8270D
Benz[a]anthracene	1	5	ng/g	EPA 8270D
Benzo[a]pyrene	1	5	ng/g	EPA 8270D
Benzo[b]fluoranthene	1	5	ng/g	EPA 8270D
Benzo[e]pyrene	1	5	ng/g	EPA 8270D
Benzo[g,h,i]perylene	1	5	ng/g	EPA 8270D
Benzo[k]fluoranthene	1	5	ng/g	EPA 8270D
Biphenyl	1	5	ng/g	EPA 8270D
Chrysene	1	5	ng/g	EPA 8270D
Dibenz[a,h]anthracene	1	5	ng/g	EPA 8270D
Dibenzothiophene	1	5	ng/g	EPA 8270D
Fluoranthene	1	5	ng/g	EPA 8270D
Polynuclear Aromatic Hydrocarbons (Continued)				
Fluorene	1	5	ng/g	EPA 8270D
Indeno[1,2,3-c,d]pyrene	1	5	ng/g	EPA 8270D
Naphthalene	1	5	ng/g	EPA 8270D
Perylene	1	5	ng/g	EPA 8270D
Phenanthrene	1	5	ng/g	EPA 8270D
Pyrene	1	5	ng/g	EPA 8270D
Polychlorinated Biphenyls (PCB's)				
PCB003	1	5	ng/g	EPA 8270D
PCB008	1	5	ng/g	EPA 8270D
PCB018	1	5	ng/g	EPA 8270D
PCB028	1	5	ng/g	EPA 8270D
PCB031	1	5	ng/g	EPA 8270D
PCB033	1	5	ng/g	EPA 8270D
PCB037	1	5	ng/g	EPA 8270D
PCB044	1	5	ng/g	EPA 8270D
PCB049	1	5	ng/g	EPA 8270D
PCB052	1	5	ng/g	EPA 8270D
PCB056(060)	1	5	ng/g	EPA 8270D
PCB066	1	5	ng/g	EPA 8270D
PCB070	1	5	ng/g	EPA 8270D
PCB074	1	5	ng/g	EPA 8270D
PCB077	1	5	ng/g	EPA 8270D
PCB081	1	5	ng/g	EPA 8270D
PCB087	1	5	ng/g	EPA 8270D
PCB095	1	5	ng/g	EPA 8270D
PCB097	1	5	ng/g	EPA 8270D
PCB099	1	5	ng/g	EPA 8270D
PCB101	1	5	ng/g	EPA 8270D
PCB105	1	5	ng/g	EPA 8270D
PCB110	1	5	ng/g	EPA 8270D
PCB114	1	5	ng/g	EPA 8270D
PCB118	1	5	ng/g	EPA 8270D
PCB119	1	5	ng/g	EPA 8270D
PCB123	1	5	ng/g	EPA 8270D
PCB126	1	5	ng/g	EPA 8270D
PCB128	1	5	ng/g	EPA 8270D
PCB138	1	5	ng/g	EPA 8270D
PCB141	1	5	ng/g	EPA 8270D
PCB149	1	5	ng/g	EPA 8270D
PCB151	1	5	ng/g	EPA 8270D
PCB153	1	5	ng/g	EPA 8270D
PCB156	1	5	ng/g	EPA 8270D
PCB157	1	5	ng/g	EPA 8270D
PCB158	1	5	ng/g	EPA 8270D
PCB167	1	5	ng/g	EPA 8270D
PCB168/132	1	5	ng/g	EPA 8270D
PCB169	1	5	ng/g	EPA 8270D
PCB170	1	5	ng/g	EPA 8270D
PCB174	1	5	ng/g	EPA 8270D
PCB177	1	5	ng/g	EPA 8270D
PCB180	1	5	ng/g	EPA 8270D
PCB183	1	5	ng/g	EPA 8270D
PCB187	1	5	ng/g	EPA 8270D
PCB189	1	5	ng/g	EPA 8270D
PCB194	1	5	ng/g	EPA 8270D
PCB195	1	5	ng/g	EPA 8270D
PCB199(200)	1	5	ng/g	EPA 8270D
PCB201	1	5	ng/g	EPA 8270D
PCB206	1	5	ng/g	EPA 8270D
PCB209	1	5	ng/g	EPA 8270D
Aroclors				
Aroclor 1016	1	10	ng/g	EPA 8270D
Aroclor 1221	1	10	ng/g	EPA 8270D
Aroclor 1232	1	10	ng/g	EPA 8270D
Aroclor 1242	1	10	ng/g	EPA 8270D
Aroclor 1248	1	10	ng/g	EPA 8270D
Aroclor 1254	1	10	ng/g	EPA 8270D
Aroclor 1260	1	10	ng/g	EPA 8270D

10-6. Sediment chemistry complex organic derivatives.

Sediment Stations	B1	B2	B3	B4	B5	B6
DDTs (ng/g)						
2,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0
2,4'-DDE	0.0	0.0	0.0	0.0	0.0	0.0
2,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDE	5.0	3.5	1.7	0.0	0.0	0.0
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	5.0	3.5	1.7	0.0	0.0	0.0
Chlordane (ng/g)						
Chlordane alpha	0.0	0.0	0.0	0.0	0.0	0.0
Chlordane-gamma	0.0	0.0	0.0	0.0	0.0	0.0
cis-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0
trans-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0
None	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0
HCH (ng/g)						
HCH-alpha	0.0	0.0	0.0	0.0	0.0	0.0
HCH-beta	0.0	0.0	0.0	0.0	0.0	0.0
HCH-delta	0.0	0.0	0.0	0.0	0.0	0.0
HCH-gamma	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0
Polychlorinated Biphenyls (PCB's, ng/g)						
PCB003	0.0	0.0	0.0	0.0	0.0	0.0
PCB008	0.0	0.0	0.0	0.0	0.0	0.0
PCB018	0.0	0.0	0.0	0.0	0.0	0.0
PCB028	0.0	0.0	0.0	0.0	0.0	0.0
PCB031	0.0	0.0	0.0	0.0	0.0	0.0
PCB033	0.0	0.0	0.0	0.0	0.0	0.0
PCB037	0.0	0.0	0.0	0.0	0.0	0.0
PCB044	0.0	0.0	0.0	0.0	0.0	0.0
PCB049	0.0	0.0	0.0	0.0	0.0	0.0
PCB052	0.0	0.0	0.0	0.0	0.0	0.0
[illegible]	0.0	0.0	0.0	0.0	0.0	0.0
PCB066	0.0	0.0	0.0	0.0	0.0	0.0
PCB070	0.0	0.0	0.0	0.0	0.0	0.0
PCB074	0.0	0.0	0.0	0.0	0.0	0.0
PCB077	0.0	0.0	0.0	0.0	0.0	0.0
PCB081	0.0	0.0	0.0	0.0	0.0	0.0
PCB087	0.0	0.0	0.0	0.0	0.0	0.0
PCB095	0.0	0.0	0.0	0.0	0.0	0.0
PCB097	0.0	0.0	0.0	0.0	0.0	0.0
PCB099	0.0	0.0	0.0	0.0	0.0	0.0
PCB101	0.0	0.0	0.0	0.0	0.0	0.0
PCB105	0.0	0.0	0.0	0.0	0.0	0.0
PCB110	0.0	0.0	0.0	0.0	0.0	0.0
PCB114	0.0	0.0	0.0	0.0	0.0	0.0
PCB118	0.0	0.0	0.0	0.0	0.0	0.0
PCB119	0.0	0.0	0.0	0.0	0.0	0.0
PCB123	0.0	0.0	0.0	0.0	0.0	0.0
PCB126	0.0	0.0	0.0	0.0	0.0	0.0

Sediment Stations	B1	B2	B3	B4	B5	B6
Polychlorinated Biphenyls (PCB's, ng/g)						
PCB128	0.0	0.0	0.0	0.0	0.0	0.0
PCB138	0.0	0.0	0.0	0.0	0.0	0.0
PCB141	0.0	0.0	0.0	0.0	0.0	0.0
PCB149	0.0	0.0	0.0	0.0	0.0	0.0
PCB151	0.0	0.0	0.0	0.0	0.0	0.0
PCB153	0.0	0.0	0.0	0.0	0.0	0.0
PCB156	0.0	0.0	0.0	0.0	0.0	0.0
PCB157	0.0	0.0	0.0	0.0	0.0	0.0
PCB158	0.0	0.0	0.0	0.0	0.0	0.0
PCB167	0.0	0.0	0.0	0.0	0.0	0.0
PCB168/132	0.0	0.0	0.0	0.0	0.0	0.0
PCB169	0.0	0.0	0.0	0.0	0.0	0.0
PCB170	0.0	0.0	0.0	0.0	0.0	0.0
PCB174	0.0	0.0	0.0	0.0	0.0	0.0
PCB177	0.0	0.0	0.0	0.0	0.0	0.0
PCB180	0.0	0.0	0.0	0.0	0.0	0.0
PCB183	0.0	0.0	0.0	0.0	0.0	0.0
PCB187	0.0	0.0	0.0	0.0	0.0	0.0
PCB189	0.0	0.0	0.0	0.0	0.0	0.0
PCB194	0.0	0.0	0.0	0.0	0.0	0.0
PCB195	0.0	0.0	0.0	0.0	0.0	0.0
PCB199(200)	0.0	0.0	0.0	0.0	0.0	0.0
PCB201	0.0	0.0	0.0	0.0	0.0	0.0
PCB206	0.0	0.0	0.0	0.0	0.0	0.0
PCB209	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0
Aroclors						
Aroclor 1016	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1221	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1232	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1242	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1248	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1254	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1260	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0
Polynuclear Aromatic Hydrocarbons (PAH's, ng/g)						
Acenaphthylene	0.0	0.0	0.0	0.0	0.0	0.0
Anthracene	1.7	0.0	0.0	0.0	0.0	0.0
Benz[a]anthracene	10.8	4.6	1.8	0.0	0.0	0.0
Benzo[a]pyrene	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[b]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[g,h,i]perylene	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[k]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0
Chrysene	22.0	8.6	3.2	0.0	1.5	1.6
Dibenz[a,h]anthracene	0.0	0.0	0.0	0.0	0.0	0.0
Fluorene	1.3	0.0	0.0	0.0	0.0	0.0
Indeno[1,2,3-c,d]pyrene	0.0	0.0	0.0	0.0	0.0	0.0
Phenanthrene	10.1	5.0	4.0	2.6	2.3	3.5
Pyrene	12.1	9.9	5.0	0.0	1.7	2.5
Sum =	58.0	28.1	14.0	2.6	5.5	7.6

10.6. Benthic Infauna

10-8. Benthic infauna taxonomic abundances.

Phylum	Class	Species	Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Annelida	Oligochaeta	Oligochaete				1	2	2	3					2		3		19	19	5	6	12	11	22	5		7					1
	Polychaeta	Aglaophamus verrilli														1																
		Ampeana occidentalis			1																											
Total Annelids 6,025		Amage aculeata											1													1				1		
% of Population 50.48		Amphareta labrops		1				3	1				1	2				1	2	1		1								3		
		Amphicteis scaphobranchiata					1	1						1				1					1					6	10	4	9	7
		Amphisamytha bioculata														2																
		Ancistrosyllis groenlandica																							1				2			
		Ancistrosyllis hamata							1									1														
		Anobothrus gracilis																						1								
		Anotomastus gordiodes																											2	3	2	
		Aphelochaeta glandaria Cmplx		1														8	1			2		2								
		Aphelochaeta petersenae																5	3		1		1	1								
		Aphelochaeta sp HYP2		1		1		1																		1						
		Aphrodita sp												1					1				1	1						1		
		Arabella iricolor							1						1			1							1	1						
		Arcteobia cf anticostiensis		4	6	11	5																									
		Aricidea (Acmira) catherinae		3	5	5		8	12					9	1	3	4	10	10	9	6	12	3	12	7	1	3	1		1		1
		Aricidea (Acmira) horikoshii		1	1	1			2					2				4		1		2					1					
		Aricidea (Acmira) simplex																						1								
		Aricidea (Aricidea) wassi																3	1	5	2	6	2	2				1			1	
		Artacamella hancocki																								3						
		Axiothella sp																											3	3	2	
		Bipalponephtys cornuta		1	1			1	1					3		1			1	1	1	1	2	3	3		1	10			2	4
		Boccardia basilaria			3		1	1																		2						
		Brada pilosa																				1	1	1								
		Capitella capitata Cmplx			2	1		5					2		9			20	2		1	2		2								
		Carazziella sp A		2		1																										
		Chaetopterus variopedatus Cmplx																													1	
		Chaetozone acuta																						2	1						1	
		Chaetozone columbiana						5	5				1	13	1	8	2	35	21	31	27	28	10	5	10		5	3	1		2	1
		Chaetozone corona		2		1														1								2		1	1	1
		Chaetozone hedgpethi		1												1		2	2		2	2				1				1	1	
		Cirratulidae			1																											
		Cirrophorus furcatus																										1				
		Clymenella sp A		1	3	1	1																									
		Cossura sp A		4	7	19	6	18	59				3	21	2	4	16	1	1			2	31	54	6	14	5					
		Dialychone albocincta			3		2	1						2				14	9	12	10	2	2	2	2		6	2		3	2	5
		Dialychone veleronis						1	4				1	3			2								2	1	1	2		1		
		Diopatra ornata		1	3		1	4	1				2	2	2	2	1	19	21	8	15	5	1	2	2	2	2	2	1	2	1	1
		Diopatra sp				1				1				1																		
		Diopatra tridentata					1																									
		Dipolydora bidentata			7	10	13	5	2															3	3	11	1					
		Dipolydora socialis		1			1													1		1	1									
		Dorvillea (Schistomeringos) annulata					1																									
		Drilonereis falcata						1																						1		
		Drilonereis mexicana			1				1				1				1								2	2						
		Drilonereis sp		3	1	2	3							2						1	1					3	1		1			
		Drilonereis sp LA1						1																								
		Ephesiella brevicapitis		17	1	23	9	1											1													
		Eranno lagunae																2														
		Euchone hancocki							1															3	1							
		Euchone incolor		1	1									1		1								3	4	1						
		Euclymeninae		1	8	4	4	6	5				1	7	4	4	1	4	9	2	1	1		8	3	1	2		4			
		Euclymeninae sp A		2	5	2		9	2				3	1	1	1		6	14	10	2	9	11	8	22	5	4	2	4	4	5	2
		Eulalia californiensis		1																						1						
		Eumida longicornuta		1		1												5	2	1			2	1							2	

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Eupolymnia heterobranchia																				2							1	2	1	
		Eusyllis transecta																									2	2				
		Exogone dwisula																	1								1					
		Exogone lourei			1																											
		Exogone sp												1																		
		Glycera americana		1	2	5	2		2							1		1	1	1			1			5						
		Glycera macrobranchia																		1		1	8				1	1		1	1	
		Glycera nana		12	7	9	5	2	2						1			3	2		1	1		5		1	1			1		
		Glycinde armigera						1	2				2	2	2	1	1	2	2	2	1	5	2	2			3	4	8	7	9	5
		Goniada littorea																										1		2	2	
		Goniada maculata		8	6	7	3		3				4	1	2	3	4	1	6	1		3	2	3	3	5	8	6	1	3	1	1
		Gymnonereis crosslandi		2	4	3	1																									
		Halosydna brevisetosa																	1	1	1									1	1	
		Harmothoe hirsuta																	1													
		Hermundura fauveli			1	1		1	2					1			1	1	3	3	1	3	1	1	1		3		1			
		Hesperonoe laevis		1			2																									
		Heterospio catalinensis																				1				2	1					1
		Isocirrus longiceps																								1						
		Kirkegaardia cryptica		37	23	42	19	9	27				3	30		4	2	14	8	4	6	12	4	14	9	17	8	5		1		2
		Lanice conchilega				2	3																		1							
		Laonice cirrata		1			1						2			1				1	1	1	2	1	1			2	6	11	9	4
		Leitoscoloplos pugettensis			2	1	4	1	2				4	6	9	2	3	4	3	3	3	3	1	1	1	1	1					
		Leodice americana		1	1		2											1		8		1	2	3	3	2						
		Levinsenia gracilis						10	14					30	1	13	1	9	7	8	1	9	28	2	8		17	2				1
		Levinsenia multibranchiata												1																		
		Loimia sp A											1																			
		Lumbrineridae																						2	1							
		Lumbrineris cruzensis		2	2	2	3		1					1		1		1	2		1		1	1	3		1				1	
		Lumbrineris japonica																	3			1	1		2		1					
		Lumbrineris latreilli												2																		
		Lumbrineris ligulata		1	1	2	2	1	1					1	1		1							4								
		Lumbrineris limicola																		1	1											
		Lumbrineris sp		2	1	2			1				1	1	1	1								1			1					
		Lysippe sp A		3			3		1				1	3	2	1		3	2		1	1	5	5	4		1					
		Malmgreniella baschi		1		2	1																									
		Malmgreniella macginitiei																							1	4				2		
		Malmgreniella scriptoria																										1	1			
		Malmgreniella sp		1					1				1		1										2	4	1				1	1
		Malmgreniella sp A		1		1	2											1							1	1						
		Marphysa disjuncta		33	34	53	42	1						1				1	2	1				5	3	51	1					1
		Mediomastus acutus																												1		
		Mediomastus sp						19	32	1			5	69	1	22	6	110	67	40	91	80	38	109	59	21	24	6	4	8	1	8
		Mediomastus sp 6		17	12	30	9																									
		Megalomma pigmentum		2										1							1		2	1						1		2
		Melinna oculata				1		1	1				2	1	2	2	1			2			4		2	3						
		Metasychis disparidentatus		2	1	1	2	1	6				2	5		2			2			2	1	2	6	6	2					
		Microspio pigmentata																					1			1						
		Mooreonuphis nebulosa			1	1								1		1			1			2			1		1	1			1	
		Myriochele striolata												1																		
		Neosabellaria cementarium																			2											
		Nephtys caecoides		3	2	1		2	5				2	2	3	1	1	2	1	1		2	2	2	5	2	1	1		1		
		Nephtys ferruginea			3	2	1		1									2	3	1	1	1		1	2	3	1	1				
		Nereis latescens																			2											
		Nereis sp A		11	15	11	14		4				1	3		2		7	14	5	1	6	10	2	5	22	10	19	19	30	17	23
		Ninoe tridentata			1	1			1																							
		Notomastus hemipodus		3	1	11	3																		1	4						
		Notomastus magnus			1	1			3					1				1														

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Odontosyllis phosphorea					2	1	1				5	8	2			8	5	1	2	1	6	4	9	7	1	2	1	1	1	1
		Onuphidae											1																			
		Onuphis sp A																					1						3		1	
		Orbinia johnsoni																		1												
		Paleanotus bellis																4											1			1
		Paradialychone ecaudata																1														
		Paradialychone paramollis				1												1	1	2	9		1						1			
		Paranaitis sp SD1																						1								
		Paraprionospio alata			2	3		1	2					5	2	4		1	1	1	6		4	5	4	2	3	8	8	4	1	3
		Parexogone molesta																				2			1		1			1		
		Pectinaria californiensis						1	5									1		1		2		3	4							1
		Petaloclymene pacifica		1	4	4		5	9				4	7		3	2									1		1				
		Pherusa neopapillata					1	1						1	1		1		2			1	1	1		1	2			1		
		Pholoe glabra		3	7	9	4		1					5	1	4	1	1	1	1			1	1	1	3						
		Pholoides asperus																2	1	1		1		1	1							
		Phyllochaetopterus prolifica																1	3												1	
		Phyllodoce hartmanae			1		1		1								1	3	1	2			1	1	2		1		1	1	1	
		Phyllodoce longipes		3	1		1							2		1		2	3	3	2	1	3	7		1	7	1	2	2	3	2
		Phyllodoce medipapillata																1					1									
		Phyllodoce pettiboneae					1						1						1			2			1							
		Phyllodoce sp												1		1		4	1	1	2	1		1	1	1	1					
		Phylo felix				1																										
		Pilargis berkeleyae					1		1								1											1				
		Pilargis sp A																	1		1											
		Pilargis sp B																					1	1	2		2					
		Pista brevibranchiata		2	6				1										1	2	1											
		Pista estevanica												2																		
		Pista wui				1								1					1				1	2	1					1		
		Platynereis bicanaliculata					1	1	1									25	13	13	5	6	1	1	1	1	6	2	2	4	3	2
		Podarkeopsis glabrus		4	5	1	2		1									2		1	1	1	1		1	3			1			
		Poecilochaetus johnsoni																1	3		1	2	5	7	3	6	5		1			
		Poecilochaetus martini		1	4	5	2	10	23					5	1	4									1	1						
		Poecilochaetus sp		2		1		1	6				4	4	1	1	1															
		Polycirrus californicus			1	1	1																			1						
		Polycirrus sp																							1							
		Polycirrus sp A																			1										1	
		Polydora narica																			1						2					
		Polynoinae		1																												
		Praxillella pacifica		1	5	1			4					1	1			15	11	6	7	3	7	6	10	5	1	4	7	13	4	3
		Praxillura maculata																2							1							
		Prionospio jubata		15	5	5	3	2	11				14	30	1	12	5	16	19	21	18	12	21	30	8	9	14		1	5		
		Prionospio lighti				1	2	1	2				2	2		1		8	8	8	4	9		2			1	1				
		Prionospio pygmaeus				1		1						1	1	1		13	1	19	5	10	4	3	3		9	3	3	3	1	1
		Sabellaria gracilis				1													3		1											
		Sabellides manriquei				1			1					1							1					1						
		Salvatoria californiensis						2	4																							
		Scalibregma californicum		1	1	1	2	3	18				2	5			2	4	17	5	7	3	3	1	1	2	2	1	4		8	4
		Schistocomus sp A																	2			1										
		Scoletoma sp		1				1	2									1					4		1		2					
		Scoletoma sp A											1																			
		Scoletoma zonata														1	1													1	1	1
		Scoloplos armiger Cmplx							1																							
		Sigalion spinosus							1					2	2								1		2			3	6	8	1	2
		Sigambra sp CC1			1	1																										
		Sigambra tentaculata		6	5	1	1						1			1			1						1	1						
		Sige sp A		1	1	2	4																1			1	1					
		Sphaerosyllis californiensis																2	2	1	1						1					1

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Spiochaetopterus costarum Cmplx		2		3	2	1					2	3		4		5	4	6		6	3	9	5	5	2		2		2	2
		Spiophanes berkeleyorum							3				1		1	1			4	1					1	1		1	3	1	5	1
		Spiophanes duplex		10	4	16	2	5	10				4	4		5	3	9	7	2	5	8	11	5	12	5	4		1	1	1	2
		Spiophanes norrisi				1		1						4	1		1	2				1	1	2	2		5	5	2	1	2	4
		Sternaspis affinis		1	4	4			9				3	3	1	4	2		1	1			2	7	1	1	1					
		Sthenelais tertiaglabra			1													4	3		4		1	1				1	1	1		
		Sthenelais verrucosa																												1		1
		Sthenelanella uniformis		20	22	9	2						1	1			1							1	3	2	1	1	1			
		Streblosoma crassibranchia		32	84	53	42	2					2	2	1	1							1		12	77						
		Streblosoma sp B																	1									1				
		Tenonia priops			1								1						2	1		1	2					1	2	1	1	
		Terebellides californica		1		1												2	2		1	1	1									
		Trochochaetella harrisae														1																
		Typosyllis farallonensis															1															
		Typosyllis heterochaeta		1	1		1		1													1			2	1						
		Typosyllis hyperioni		14	31	31	21		1					1											6	21						
		Ysideris hastata																								1						
		Kirkegaardia siblina		2	1	2	1		4				5	17	2	5		24	25	20	27	28	1	25	3	1	1	6	11	6	7	6
		Leitoscoloplos panamensis		1	1	2	1		1						1	2			3	1	2	1	9	8	7	4	3		1			
		Rhamphobrachium longisetosum			1																											
		Aphelochaeta sp CA?P1																	1													
		Sphaerodoridium sp A																		1												
Arthropoda	Malacostraca	Acidostoma hancocki																		5	1					1						
		Alienacanthomysis macropsis															1								2							
Total Arthropods 4,427		Americhelidium rectipalmum			1	1			2									4					1	3	1					1		2
% of Population 33.85		Americhelidium shoemakeri						1						3	1			5	6	10	1	2		1			1		1		2	1
		Americhelidium sp						1																								
		Americhelidium sp SD4			1	2	1		3				1	4		3	1		2	1			1		10	2	1					
		Ampelisca agassizi		1	1	1			1					6				2	1	1		1		1								
		Ampelisca brachycladus																				2								1		
		Ampelisca brevisimulata		11	1	7	2	1	10				3	10	9	10	8			4	3	7	15	11	16	5	9	9	5	3	12	4
		Ampelisca careyi		2	3			1																	1	1						
		Ampelisca cf brevisimulata		2		1																				1						
		Ampelisca cristata cristata												1			1							1								
		Ampelisca cristata microdentata				1		2	5				3	2	9	5	6	2	7	8	5	8	14	13	5	8	8	12	10	11	17	14
		Ampelisca hancocki		1			1																		1		1					
		Ampelisca indentata					2														1											
		Ampelisca lobata						1	5										1													
		Ampelisca milleri					1													2	1	1										
		Ampelisca pacifica		1		1																										
		Ampelisca pugetica		1	3	2			3				2	5	1	4	3	1		2			1	2	3	1	1			1		
		Ampelisca romigi																				1										
		Ampelisca sp		2	3	1	1	1						2			3		1	2		2		1	2		1			1		
		Ampeliscliphotis podophthalma		13	13	7		9	27				9	6	1	3	1	1	8		2	2	2	3	12	11	2	2		2		
		Amphideutopus oculatus		2	4	4		1	19				34	7	1	5	11	1	3	6	3	5	21	64	21	30	34		9	7	11	8
		Aoridae																	1													
		Aoroides columbiae																				1										
		Aoroides exilis																4	13		3	5							1			
		Aoroides inermis																3														2
		Aoroides intermedia																	9			1										
		Aoroides sp																	1													
		Apolochus barnardi																8														
		Argissa hamatipes							1				1			1		1									4	1				1
		Aruga oculata						1								1		2									1					
		Bemlos sp																1	3			1										
		Brachyura						1						1			1									1						
		Byblis millsi		1	4	1								2		1																

10-8. Continued.

Phylum	Class	Species	Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Caecognathia crenulatifrons		4	7	14	2		4				3	4	2	1		2	2	1			4	4	7	1	4				3	
		Campylaspis canaliculata						1																								
		Campylaspis hartae																		1		1										
		Campylaspis rubromaculata			1	1	2	3						1			3			1				7	1	2						1
		Caprella californica Cmplx						1										6	1	1	1											
		Caprella mendax			12		13											7	4		4	1										
		Caprella sp																2	2													
		Caridea											1										1		1							1
		Corophioidea																5	1	1												
		Cumacea		1																												
		Diastylis californica		1	2	1	2		1				1	3		1	2	4		1	1	3	5	1	3		3					
		Diastylopsis tenuis																										1				
		Edotia sp B		2		1			1				2	1	2	3		2			1		2	2			4				1	
		Epialtidae					2														1	2										
		Ericerodes hemphilli		1																												
		Ericthonius brasiliensis																	1													
		Foxiphalus golfensis							1							2																
		Foxiphalus obtusidens			1	6		5	24				21	19	25	24	23	19	65	50	30	40	31	52	58	14	50	7	22	17	11	13
		Gammaropsis thompsoni						17	10									6	6	3	2	16								1		3
		Gnathopleustes pugettensis					3		3									4	7													
		Haliophasma geminata		2	4	1	1		3					8			1	1	1	1	1		16	41	1	3	6					
		Hartmanodes hartmanae		1		1		1	2				3	2		6	4	1	2	3	1	5	2	6	2	1	1		2			
		Hemilamprops californicus																		1	1	2						2	1	1	2	2
		Heterophoxus ellisi		1			1																2			1						
		Heterophoxus oculatus		2	10	1	3	1	2					1		1																
		Heterophoxus sp				3	4	2																1								
		Hippolytidae																2			2											
		Hippomedon sp																1		1												
		Hippomedon zetesimus							2						1	1				2	1	4	2	3			3	1		3	1	
		Idarcturus allelomorphus		1			7		1												2											
		Idarcturus hedgpethi																5	1			1										
		Idarcturus sp																15	10						2		1	1				
		Ischyroceridae																				1										
		Ischyrocerus sp B																	1													
		Jassa slatteryi																									1	1	1			
		Latulambrus occidentalis															1	2	1											1		
		Leptochelia dubia Cmplx	1	13	28	14	4	15	29			1	7	21	4	8	2	11	19	16	7	18	18	35	15	7	28	6	8	13	4	6
		Listriella eriopisa																						1								
		Listriella goleta		4	4	2	1		3					2	2	5		8	12	6	9	6	2	4	6	1	7	2			2	1
		Listriella melanica					4							2					2	1			2	3		1		1		1		
		Listriella sp						1																								
		Lophopanopeus sp																	2	1												
		Majoidea																1														
		Metaphisana bola Cmplx											1																1			
		Mesocrangon munitella																1														
		Mesolamprops bispinosus																							1							
		Metamysidopsis elongata																			2	4							1			
		Metopa dawsoni					1																									
		Mysidae																	2													
		Neastacilla californica														1		6		4		3									1	2
		Nebalia daytoni				1								2			3			3		4		1	1			3				
		Nebalia pugettensis Cmplx												1		3		1	1	2		1		1	1							
		Neomysis kadiakensis																											1			
		Neotrypaea biffari																										1	1			
		Neotrypaea sp				1		2	1										1		1	1					1				1	
		Notopoma sp A			1											1					1	1		1						1		
		Orchomene anaquelus																		1			1	9	1	2					1	

10-8. Continued.

Phylum	Class	Species	Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Oxyurostylis pacifica																					1					1	3	3	6	
		Pachynus barnardi																	1													
		Paracanthomysis nephrophthalma				1																										
		Paguridae																1														
		Paranthura elegans					1																									
		Penaeoidea																									1					
		Pentidotea rufescens																1	1													
		Paramphithoe lindbergi																	7		3	2										
		Photis bifurcata																3	1		1	2						1				
		Photis brevipes			1		2	2										9	8	6	18	10			2		5	6		2	2	
		Photis californica			2		3							1				1	1		1	5			2	2		1				
		Photis lacia			1											2	2				4	3					1	1				
		Photis sp			2	2	1	1							2	1		7	1	6	11	5			1	1	1	4	1		1	1
		Photis sp A							7				1	3	3					3			9	44	9	1	3					
		Photis sp C																							1		2					
		Photis sp OC1																										6				
		Phoxocephalidae					1																									
		Pinnixa forficulimanus																												1		
		Pinnixa franciscana				1	1											5	6		3			1					1			
		Pinnixa longipes																													2	2
		Pinnixa minuscula																										2	1			
		Pinnixa occidentalis Cmplx		1																												
		Pinnixa sp					3	2	1							1		8	10	1	5	3					3	1			1	
		Pinnixa tomentosa				4																										
		Pleusymtes subglaber					4												2	2												
		Podocerus cristatus																2														
		Podocerus sp						1																								
		Pontogeneia rostrata																	1													
		Procampylaspis caenosa																								1						
		Rhepoxynius bicuspidatus					1	3	2					2		1	2		1		1			1		1	1					
		Rhepoxynius heterocuspidatus																2	2											2		
		Rhepoxynius menziesi						1	1					2	1			1				1					1		4	4	1	1
		Rhepoxynius sp																			2											
		Rhepoxynius stenodes				1		4	16				13	24	13	8	11	10	24	21	18	16	15	15	10	3	15	1	4	3	5	1
		Rhepoxynius variatus																										2	3	5	9	
		Romaleon jordani																			1											
		Rudilemboides stenopropodus			1		1		7				2	10		7		9	6	39	3	13	25	30	19	5	16		5	2	12	9
		Sphaeromatidae					2											4		1												
		Stenothoides bicoma			1																											
		Westwoodilla tone		1	3	1	1	3					3	2		7		20	20	22	5	4	9	3	2	4	2	1	2	1		2
		Talitridae		1																												
		Hourstonius vilordes						2																								
		Thorlaksonius platypus																6	1		2											
		Amphilochidae																	1													
		Iphimedia rickettsi																	1													
		Apolochus sp																				1										
		Exosphaeroma inornata																														1
	Maxillopoda	Hamatoscalpellum californicum																				1										
		Megabalanus californicus						1			1																					
	Ostracoda	Asteropella slatteryi																		2				1					1			1
		Cylindroleberididae														1																
		Euphilomedes carcharodonta		15	19	10	6	21	26	1	8	5	22	28	25	19	20	18	22	10	8	36	5	32	34	12	34		1	2	2	5
		Eusarsiella thomina				1																										
		Leuroleberis sharpei																		1												
		Rutiderma rostratum							1					1	1	2		1									1		2			1
		Xenoleberis californica		1					1										1	4		2	1	1	1		1					
	Pycnogonida	Anoplodactylus erectus												1						1												

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Echinodermata	Aphiuroidea	Amphioplus sp A							1							2	1						1			3						
	Asteroidea	Asteroidea				2	2	1																	1							
		Astropecten californicus		1			1							2	1					1		1		1			2					
	Echinoidea	Lovenia cordiformis																												1		
		Nacospatangus laevis																		2												
	Holothuroidea	Chiridota sp				4	3																									
		Leptosynapta sp				2	1															1	1	1	1	1						
		Pentamera populifera															1															
		Pentamera pseudopopulifera				1																										
	Ophiuroidea	Amphiodia digitata			1	4																				1						
		Amphiodia psara				1			2					2											1							
Total Echinodermata 243		Amphiodia sp			2			2	3		1	2		3	1					1	9		1			2						
% of Population 1.85		Amphiodia urtica		7	11	7	3		2											1					2	1						
		Amphioplus sp										1																				
		Amphipholis squamata						2	1			1		1		1		5	2			1	1	2		1						
		Amphiura arcystata		4	1	9	4										1		1					2								
		Amphiuridae					1	8	5		1	6		2	4	2	1	4	6	3	1	5	4	3	2	1	12		1	1	2	
		Ophiothrix spiculata																3	1		1											
		Ophiuroconis bispinosa																2	2				1				1					
Mollusca	Bivalvia	Axinopsida serricata					1																									
		Bivalvia		3	6	7	1																	1								
Total Mollusca 990		Cardiidae																					1									
% of Population 7.67		Compsomyax subdiaphana			2		3		1																							
		Cooperella subdiaphana		1				2	2					3	1		1		1		1				4		1					1
		Cyathodonta pedroana																			1											
		Ensis myrae						3						2		2	1				1		2	1								1
		Kurtiella coani		1																												1
		Kurtiella grippi																1	5	2		5			1							
		Kurtiella tumida		4	26	17	11	1	1						1			6	23	1	11	4	2		9	1	3	5	1		3	8
		Leptopecten latiauratus			2		2	1	5					1					1	1	1				1				2			
		Lucinisca nuttalli																			1									1		
		Lucinoma annulatum						1	1					1						1												
		Macoma yoldiformis		4	4	6	3	3	8				2	5	2	3	5	4	6	6	2	5	2	14	8	4	2	1	3	5	9	4
		Modiolatus neglectus		1		3		3	3					2							1				2		2		1			
		Neaeromya compressa				5	4																									
		Nuculana taphria		7	1	5	1	1	4				2	7	8	9	2							3	10	6	1		1			
		Nutricola tantilla																2			1	1					1					
		Panopea generosa		1																												
		Parvilucina tenuisculpta		2	12	2	4		1				2	1			4		2	5	3	8	2	3	2	5	2			1		
		Periploma discus			2															2												
		Solamen columbianum					1		1					1		2		1	1					1	2							
		Solen sicarius				1										1	1	1				2		2	4	1	1	1				
		Tellinidae																	1				1									
		Tellina modesta						2	7				8	6	6	6	7	4	7	4	3	2	4	3	2		3	11	17	16	7	5
		Tellina sp		2	8	2	2																									
		Tellina sp B		3	5	1	1	7	12				5	15	14	12	8	3	2	2	2	1	4	5	20	11	3					
		Thracia sp				1																										
		Thyasira flexuosa		1																												
		Trachycardium quadragenarium			1																											
		Kellia suborbicularis																			1											
	Caudofoveata	Chaetoderma pacificum		1	1											1	1			1				1								
		Falcidens longus							1																							
	Gastropoda	Aglaja ocelligera																	2													
		Alia tuberosa							1												1	1										
		Amphissa undata																														
		Armina californica																					1									
		Balcis oldroydae																														

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Californiconus californicus						3				1	1	1				1		1												
		Calyptraeidae																		1												
		Crepidula glottidiarum				1		3																				2				
		Cylichna diegensis							1				1			1			2				1		1	1				1		
		Epitonium bellastriatum																								1			1			
		Epitonium hindsii																					1									
		Eulima raymondi																							1							
		Eulimidae					1																									
		Kurtzia arteaga						2																								
		Kurtziella plumbea																												1		
		Melanella rosa				1							2																			
		Naticidae							1																							
		Odostomia sp HYP1												1		1									1							
		Ophiodermella inermis				1			1	1				1	1															2		
		Philine auriformis		1					2																				2			
		Polygireulima rutila											1	1																		
		Turbonilla chocolata																											1			
		Turbonilla laminata																												2		1
		Turbonilla santarosana																1														
		Volvulella cylindrica														1																
		Volvulella panamica		1	1	4	1		1																							
		Turbonilla tridentata							1																							
		Turbonilla sp 5												1																		
		Turbonilla sp OC1																							1							
	Scaphopoda	Gadila aberrans		4	5	7	4	10	8				5	10	3	2	8	1	1			1	11		7	4	1					
	Terebridae	Terebra pedroana								1														1					1			
Total Misc. Phyla 780 % of Population 4.46																																
Brachiopoda	Lingulata	Glottidia albida		1	2	6		2	1							1	1			1			1	1		1		1				
Chordata	Enteropneusta	Balanoglossus sp																					1					2	3	3		
		Saccoglossus sp															1					1										
		Schizocardium sp			1	3	4		1									4	5	1	1	2				1						1
		Stereobalanus sp		5	2	2	4											2	3			1				1						
Cnidaria	Anthozoa	Actiniaria			1			1																								
		Arachnanthus sp A		2		1			2					1		1						1	1		2	3	1					
		Ceriantharia							1				2						1				2									
		Cladumene sp																3	2											1		
		Edwardsia juliae											1						3		1								1		1	
		Halcampa decemtentaculata																					1									
		Halianthella sp A							1																							
		Limnactiniidae sp A				2	1																			1						
		Pentactinia californica		2	4	2	1																									
		Scolanthus triangulus		1																								1			1	1
		Virgularia californica																											1			
	Hydrozoa	Corymorpha sp					1																									
Echiura	Echiurida	Arhynchite californicus																							1							
		Listriolobus pelodes		5	3	1	4	1					1										1									
Nematoda		Nematoda		1	3	6	1	1															4	4	1		1	16	4	12	4	13
Nemertea		Nemertea																4	5		1											
	Anopla	Carinoma mutabilis			3	1	1										1		1				1					6	5		3	4
		Cerebratulus californiensis			3	2	1	2	2					3	3	1	1		3	8		4	3	2	4	3	3		1	1	2	
		Cerebratulus marginatus		1			1																1	1	1		1					
		Cerebratulus sp																1	1													
		Heteronemertea sp HYP1		1																												
		Lineidae		1	1	4		1						2		1		3	1	1					1				2			

10-8. Continued.

			Station & Replicate																													
			B1					B2					B3					B4					B5					B6				
Phylum	Class	Species	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Lineus bilineatus		2	1	1			1									1		1		2				2	1					[illegible]
		Tubulanidae		2	5	5	2	2	1					9				10	2	1	2	2	1	3	1	1	1	2	1			[illegible]
		Tubulanidae sp B				1														1					1							
		Tubulanidae sp D			1																											
		Tubulanidae sp E		2										[illegible]					2						1			1	1	1	1	2
		Tubulanus cingulatus																	1							2	1					
		Tubulanus polymorphus		7	6	8	4	4	2					4		3	2	3	4		2	1	7	2	1	4	1	1				2
		Tubulanus sp A		1	3	1			3					[illegible]				1					1			1						
	Enopla	Amphiporus californicus														1		1	1			1	1			1	1				2	
		Amphiporus cruentatus				2							2	1		1	1			2			1	3	1		1	1	1	2	2	1
		Amphiporus sp					1																1	2	2		2				1	
		Cryptonemertes actinophila																		2			1		2							
		Hoplonemertea																										1				
		Oerstedia dorsalis Cmplx		1			1		1									1			2	1									1	
		Paranemertes californica		1		4	1	2						3		1		1	3	4	3	1	3	2	3	2	2	2				
		Tetrastemma albidum												1					1	1		1										
		Tetrastemma candidum						1	1									2		1	1				1		[illegible]					
Phorona	None	Phoronis sp		19	8	18	13	5						1	2	4	1	2	2	2	5	6	3	5	5	4	2		3		1	
Platyhelminthes	Turbellaria	Stylochus exiguus			1	2								1		1									1							[illegible]
Sipuncula	Phascolosomatidea	Apionsoma misakianum		2	2	2	2									[illegible]		4	11	11	2	2	1	4	2	1						
	Sipunculidea	Sipunculus nudus																											1			
		Thysanocardia nigra			4	3	2	1								1							1			[illegible]						

10.7. Fish and Invertebrate Abundance and Biomass

10-9. Fish abundance by size class (cm) for each replicate trawl.

Scientific Name	Common Name	Size Class (cm)	Abundance			
			TB3		TB8	
			1	2	1	2
Citharichthys sordidus	Pacific sanddab	7		1		
		10	1	1		
		11	2	1		1
		12	1			
		15		1		
Citharichthys stigmaeus	speckled sanddab	4	1		1	
		5	5		4	
		6	18	3	17	2
		7	30	4	16	7
		8	10	3	22	
		9	2		7	
		10	2	1	2	1
Citharichthys xanthostigma	longfin sanddab	9		1		
		11				1
		13	1		1	1
		14	1			
Cymatogaster aggregata	shiner perch	10				1
		11				1
Genyonemus lineatus	white croaker	12				1
		15				3
		16				3
		17				1
Heterostichus rostratus	giant kelpfish	8	2	1	1	
		9	1	1		
		10			1	
Icelinus quadriseriatus	yellowchin sculpin	4			1	1
		5	3	1		3
		6		2		
Myliobatis californica	bat ray	64			1	
Paralabrax clathratus	kelp bass	5	1			1
		6		1		
Paralichthys californicus	California halibut	38			1	
Phanerodon furcatus	white seaperch	10	1			
Pleuronichthys decurrens	curlfin sole	13	1	1		
Pleuronichthys ritteri	spotted turbot	[illegible]			1	
Pleuronichthys verticalis	hornyhead turbot	3	1			
		4		2		
		5		2	1	
		6	4			
		7		1	1	
		8	1		1	
		9	2	2		
		10	1		1	
		12		1		
		14				1
		20	1			
Porichthys myriaster	specklefin midshipman	16	2			
		17			1	
Porichthys notatus	plainfin midshipman	3	1			
		6		1		
		14				[illegible]
Raja inornata	California skate	28	1			
Sebastes caurinus	copper rockfish	6	2	1		
		7	5	1	2	1
		8		1	1	1
		9	1			
Squatina californica	Pacific angel shark	27	1			
		110			1	
Symphurus atricaudus	California tonguefish	[illegible]			1	
Synodus lucioceps	California lizardfish	10		1	1	
		11	2		1	
		12			2	2
		13	1		3	
		16	2			
		18				1
		19				1
		20	1		1	4
		21			2	1
		23				1
		24				1
		25				1
		39	1			
Xystreurys liolepis	fantail sole	5			1	
		6	1		3	
		7	1		1	
		13				2
		14	1			
		15	1			
		16			1	
Zaniolepis latipinnis	longspine combfish	13	1		4	3
		14			3	
		15	1	1	1	1

10-10. Fish biomass (Kg) by replicate.

Scientific Name	Common Name	Weight (kg)			
		T3		T6	
		1	2	1	2
Citharichthys sordidus	Pacific sanddab	0.1	0.13		<0.1
Citharichthys stigmaeus	speckled sanddab	0.32	0.1	0.43	0.11
Citharichthys xanthostigma	longfin sanddab	0.13	<0.1	<0.1	<0.1
Cymatogaster aggregata	shiner perch				<0.1
Genyonemus lineatus	white croaker				0.52
Heterostichus rostratus	giant kelpfish	<0.1	<0.1	<0.1	
Icelinus quadriseriatus	yellowchin sculpin	<0.1	<0.1	<0.1	<0.1
Myliobatis californica	bat ray			0.9	
Paralabrax clathratus	kelp bass	<0.1	<0.1		<0.1
Paralichthys californicus	California halibut			0.78	
Phanerodon furcatus	white seaperch	<0.1			
Pleuronichthys decurrens	curlfin sole	<0.1	0.1		
Pleuronichthys ritteri	spotted turbot			0.3	
Pleuronichthys verticalis	hornyhead turbot	0.26	0.11	<0.1	<0.1
Porichthys myriaster	specklefin midshipman	0.11		<0.1	
Porichthys notatus	plainfin midshipman	<0.1	<0.1		<0.1
Raja inornata	California skate	0.15			
Sebastes caurinus	copper rockfish	0.12	<0.1	<0.1	<0.1
Squatina californica	Pacific angel shark	0.43		16	
Symphurus atricaudus	California tonguefish			<0.1	
Synodus lucioceps	California lizardfish	0.62	<0.1	0.33	0.43
Xystreurys liolepis	fantail sole	0.17		0.11	<0.1
Zaniolepis latipinnis	longspine combfish	<0.1	<0.1	0.25	0.1
	composite	0.26	0.15	0.3	0.35
	Sum	**2.67**	**0.59**	**19.40**	**1.51**

10-11. Invertebrate abundances by replicate.

Scientific Name	Common Name	Abundance			
		TB3		TB6	
		1	2	1	2
Aplysia californica	purple sea hare				1
Astropecten californicus	California sand star				4
Crangon nigromaculata	blackspotted bay shrimp	7	1	2	
Lytechinus pictus	white sea urchin		1		
Octopus rubescens	red octopus	1	6	2	
Ophiothrix spiculata	Pacific spiny brittlestar	1			
Sicyonia penicillata	peanut rock shrimp	14	8	5	
	Sum	**23**	**16**	**9**	**5**

10-12. Invertebrate biomass (Kg) by replicate.

Scientific Name	Common Name	Weight (kg)			
		TB3		TB6	
		1	2	1	2
Aplysia californica	purple sea hare				0.19
Astropecten californicus	California sand star				<0.1
Crangon nigromaculata	blackspotted bay shrimp	<0.1	<0.1	<0.1	
Lytechinus pictus	white sea urchin		<0.1		
Octopus rubescens	red octopus	<0.1	0.14	<0.1	
Ophiothrix spiculata	Pacific spiny brittlestar	<0.1			
Sicyonia penicillata	peanut rock shrimp	<0.1	<0.1	<0.1	
	Composite	<0.1	<0.1	<0.1	
	Sum	**0**	**0.14**	**0**	**0.19**

10.8. Fish and Bivalve Bioaccumulation Data

10-13. Whole weight, tissue weight and standard length of fish.

STATION TB3				STATION TB6			
Standard Length (mm)	Total Weight (g)	Muscle Weight (g)	Liver Weight (g)	Standard Length (mm)	Total Weight (g)	Muscle Weight (g)	Liver Weight (g)
86	13	1.1	0.34	79	7	1.3	0.15
89	14	2.2	0.49	78	8	1.5	0.22
88	12	1.7	0.33	79	8	1.4	0.16
84	11	2.0	0.29	75	8	1.2	0.14
75	8	1.3	0.24	71	7	1.1	0.22
76	9	1.6	0.26	75	8	1.5	0.20
76	8	0.9	0.23	75	7	1.2	0.16
69	7	1.2	0.08	74	7	1.2	0.15
68	6	1.2	0.10	70	6	1.1	0.07
66	5	1.0	0.10	71	6	0.9	0.12
69	5	0.9	0.10	75	6	0.9	0.13
78	10	2.1	0.29	88	15	3.0	0.26
68	5	1.0	0.05	66	5	0.9	0.07
70	6	1.2	0.14	72	6	0.9	0.17
68	5	0.8	0.13	70	6	0.8	0.14
70	5	1.0	0.10	70	6	0.9	0.06
68	5	0.6	0.10	68	5	0.9	0.10
66	5	1.0	0.08	70	6	0.8	0.14
65	4	0.6	0.09	67	6	1.1	0.07
65	6	0.7	0.10	69	6	1.1	0.10
64	4	0.7	0.09	67	5	0.6	0.04
63	3	0.8	0.09	68	6	1.1	0.09
88	14	2.0	0.48	92	14	2.4	0.40
65	4	0.8	0.07	68	5	0.9	0.06
66	4	0.8	0.09	66	5	0.8	0.13
69	4	0.8	0.08	74	7	1.3	0.19
65	5	0.8	0.10	71	6	1.1	0.17
64	4	0.7	0.04	77	6	1.0	0.11
64	4	0.4	0.08	65	5	0.7	0.10
67	5	0.8	0.10	64	5	0.9	0.14
63	4	0.8	0.08	65	5	0.9	0.06
65	4	0.6	0.11	67	5	1.0	0.13
88	12	1.7	0.35	62	5	0.7	0.13
75	8	1.1	0.23	85	11	1.8	0.38
72	8	1.3	0.23	58	4	0.5	0.12
75	7	1.1	0.24	62	4	0.5	0.07
99	17	2.8	0.43	82	9	1.2	0.30
90	14	2.7	0.48	95	16	2.6	0.41
				97	18	3.0	0.42
				80	10	1.7	0.22
				75	8	1.3	0.18
Count = 38 Total = 2766.0 Average = 72.79	Count = 38 Total = 274.3 Average = 7.22	Count = 38 Total = 44.7 Average = 1.18	Count = 38 Total = 7.0 Average = 0.18	Count= 41 Total= 3002.0 Average = 73.22	Count = 41 Total = 296.8 Average = 7.24	Count = 41 Total = 49.5 Average = 1.21	Count = 41 Total = 6.7 Average = 0.16

10-14. Whole weight, tissue weight and total weight of caged bivalves.

Control, Rep 1			Control, Rep 2			Control, Rep 3		
Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)
64	[illegible]	[illegible]	71	24.5	7.5	[illegible]	23.7	11.0
70	27.1	8.4	57	14.4	4.3	56	14.4	4.0
71	24.6	9.5	67	24.5	8.3	65	19.7	6.6
60	19.1	6.5	62	21.6	6.6	60	13.7	3.6
60	17.9	5.7	60	15.7	5.8	62	21.4	6.0
56	16.1	4.4	64	20.7	7.0	60	17.8	6.2
58	17.0	5.5	52	10.8	3.7	71	26.5	8.4
53	12.8	4.7	58	14.3	4.6	60	17.0	4.3
55	13.0	3.4	60	18.7	5.6	[illegible]	13.9	3.9
65	13.5	4.1	53	13.0	4.6	[illegible]	17.5	4.1
[illegible]	11.5	3.0	55	14.7	4.9	[illegible]	19.9	4.6
71	21.8	7.3	72	20.9	4.1	71	25.4	7.3
61	10.5	3.7	[illegible]	17.4	6.9	[illegible]	11.3	4.3
63	10.2	6.2	77	20.4	4.1	[illegible]	16.1	6.8
57	13.8	3.8	66	21.0	6.2	[illegible]	13.4	4.7
72	31.0	9.8	69	32.6	10.4	70	27.7	9.4
53	12.2	3.4	54	12.3	4.5	64	18.4	6.5
72	22.0	6.8	65	20.0	4.1	[illegible]	23.5	6.7
61	20.4	6.8	58	18.8	4.8	56	14.6	4.5
63	24.0	10.5	63	20.6	7.4	62	21.6	7.8
Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =
20	20	20	20	20	20	20	20	20
Total =	Total =	Total =	81.0	Total =	Total =	Total	Total =	Total =
1242.8	380.5	118.5	1240.0	383.5	127.1	1272.7	379.8	121.7
Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =
62.1	19.5	5.9	62.0	19.2	6.4	63.6	19.0	6.1

B3, Rep 1			B3, Rep 2			B3, Rep 3		
Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)
70	34.8	10.9	64	27.8	11.1	61	24.2	9.1
74	31.7	11.2	58	20.4	8.2	64	20.8	8.9
66	27.5	10.4	60	23.3	11.4	64	20.0	8.5
[illegible]	24.7	9.1	[illegible]	22.3	8.5	60	18.1	7.1
70	33.3	10.8	58	22.6	9.2	58	19.3	6.2
73	40.8	14.1	56	14.8	6.5	56	17.7	6.6
67	30.0	10.5	[illegible]	18.4	7.2	65	22.7	6.2
[illegible]	37.4	11.9	62	28.1	9.8	59	17.5	7.1
71	33.5	11.3	61	23.3	10.4	59	22.0	7.8
73	39.1	10.8	62	28.2	9.7	65	24.5	8.2
76	38.6	13.5	59	19.3	8.1	54	18.6	7.8
67	30.3	10.1	61	24.1	8.3	59	21.6	8.0
76	40.6	17.5	63	24.8	8.6	58	23.9	7.8
67	28.6	8.8	55	17.5	8.8	[illegible]	26.3	11.5
70	34.4	13.8	59	18.5	7.7	62	22.9	8.4
68	33.1	11.6	58	18.4	8.2	63	22.3	8.4
71	33.2	11.9	65	24.0	10.6	58	19.0	6.8
66	28.6	8.8				54	19.5	6.6
65	25.5	8.2				57	20.2	6.4
						62	24.0	6.4
Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =
19	19	19	17	17	17	20	20	20
Total =	Total =	Total =	81.0	Total =	Total =	81.0	Total =	Total =
1322.9	624.2	221.1	1034.0	363.0	149.6	1201.5	446.6	149.2
Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =
69.7	32.8	11.6	60.8	21.3	8.8	60.1	22.3	7.4

B4, Rep 1			B4, Rep 2			B4, Rep 3		
Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)
64	37.6	13.4	[illegible]	23.6	6.6	56	24.7	8.4
64	35.5	11.3	64	20.8	7.0	51	18.6	8.2
66	30.5	13.3	56	24.0	9.5	62	21.6	8.8
74	45.7	16.9	63	21.0	[illegible]	61	21.2	8.8
68	32.6	13.3	61	23.2	[illegible]	61	20.8	8.8
66	27.4	14.7	51	19.6	8.9	66	26.4	9.2
65	28.5	11.4	52	14.1	8.8	60	29.8	9.2
66	29.5	12.2	60	18.2	8.7	[illegible]	31.6	10.8
[illegible]	34.2	11.8	60	23.8	10.2	64	26.4	10.6
79	40.2	10.7	53	14.7	6.8	55	18.6	7.9
75	42.3	18.9	[illegible]	27.6	12.3	62	25.7	10.9
74	37.3	16.9	64	27.8	11.7	66	28.5	8.3
72	33.1	11.8	[illegible]	21.7	7.6	64	30.7	13.5
63	23.9	4.3	58	18.1	7.2	63	25.8	8.4
74	38.3	10.2	66	33.3	8.6	66	28.5	6.5
71	42.0	10.0	65	30.4	8.1	[illegible]	18.1	7.6
73	38.8	17.4	66	33.6	11.3	40	23.8	7.1
[illegible]	38.2	14.6	63	33.3	8.4	62	23.0	6.5
						55	20.3	7.4
						63	27.5	4.8
Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =
18	18	18	18	18	[illegible]	20	20	20
Total =	Total =	Total =	Total =	Total =	Total =	Total =	Total =	Total =
1254.4	600.3	238.6	1076.4	383.6	158.2	1223.3	482.9	168.2
Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =
69.5	33.4	13.3	59.8	21.4	8.8	61.2	24.1	8.4

B6, Rep 1			B6, Rep 2			B6, Rep 3		
Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)	Total Length (mm)	Total Weight (g)	Tissue Weight (g)
74	37.1	12.9	[illegible]	13.0	4.7	63	17.9	6.1
69	33.6	16.5	49	10.5	7.3	58	17.9	7.3
68	36.1	15.9	50	16.6	6.7	60	25.1	11.4
65	29.6	12.6	56	16.7	6.4	58	19.8	7.2
73	36.7	14.7	57	21.2	7.8	60	20.4	6.3
79	45.1	17.6	57	18.4	6.3	58	17.8	7.7
66	25.4	10.2	59	22.8	6.3	62	19.3	6.3
75	34.6	15.4	[illegible]	13.5	6.3	54	20.0	7.2
77	41.9	16.4	72	28.3	11.8	58	19.6	5.4
66	30.1	14.5	73	28.8	17.8	[illegible]	23.8	9.3
79	37.8	18.3	63	30.2	6.1	70	31.9	12.6
78	39.2	11.8	58	14.4	5.6	[illegible]	14.4	7.3
68	36.5	11.3	59	17.7	4.6	[illegible]	21.8	8.8
78	42.1	18.5	[illegible]	19.7	5.6	[illegible]	22.8	10.8
69	38.0	11.8	59	24.0	4.6	62	20.8	8.7
76	39.5	17.5	54	20.3	4.3	64	27.6	10.6
71	39.3	17.9	[illegible]	22.4	10.3	65	26.6	9.1
73	34.0	15.1	61	20.8	4.1	66	20.9	7.6
72	39.1	12.2	64	21.3	9.3	65	26.6	11.5
73	34.8	15.8				56	17.4	7.6
Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =	Count =
20	20	20	19	19	19	20	20	20
Total =	Total =	Total =	Total =	Total =	Total =	Total =	Total =	Total =
1433.3	688.2	288.6	1140.5	387.4	158.2	1230.0	427.3	173.8
Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =	Average =
71.8	34.4	14.5	60.0	20.4	8.8	61.5	21.4	8.7

10-15. Fish and bivalve tissue concentrations by replicate for all constituents measured.

		Fish Muscle		Fish Liver		Bivalve			
Constituent	Replicate	TB3	TB6	TB3	TB6	Control	B3	B4	B6
General Chemistry (µg/dry g)									
	#1	4.38	2.34	60.90	70.90	8.26	9.15	8.23	6.42
% Lipids (detection limit = 0.01)	#2	4.41	2.63	62.10	73.10	8.35	8.45	8.43	7.04
	#3	4.38	2.84	64.00	72.90	8.74	8.51	6.17	6.24
	Mean =	4.39	2.60	62.33	72.30	8.45	8.70	7.61	6.57
	S.D. =	0.02	0.25	1.56	1.22	0.26	0.39	1.25	0.42
	Mean for each Tissue =	3.497		67.317		7.833			
% Moisture (detection limit = 0.1)	#1	85.9	79.1	62.7	55.9	82.7	77.6	77.1	79.5
	#2	NS	NS	NS	NS	83.3	76.7	77.1	78.2
	#3	NS	NS	NS	NS	83.2	76.6	78.1	77.5
	Mean =	85.9	79.1	62.7	55.9	83.1	77.0	77.4	78.4
	S.D. =	—	—	NA	NA	0.3	0.6	0.6	1.0
	Mean for each Tissue =	82.5		59.3		79.0			
Metals (µg/dry g)									
	#1	9.610	6.250	8.180	5.070	10.600	10.400	10.100	10.100
	#2	9.530	6.240	8.300	6.290	10.000	10.700	10.200	9.810
Arsenic	#3	9.350	6.340	9.790	5.800	10.800	9.600	8.840	9.670
(detection limit = 0.025 µg/dry g)	Mean =	9.497	6.277	8.757	5.720	10.467	10.233	9.713	9.860
	S.D. =	0.133	0.055	0.897	0.614	0.416	0.569	0.758	0.219
	Mean for each Tissue =	7.887		7.238		10.068			
Cadmium	#1	0.03	0.02	3.66	2.76	3.01	2.18	1.86	2.31
(detection limit = 0.01 µg/dry g)	#2	0.03	0.03	3.22	2.74	2.88	2.05	1.97	2.32
	#3	0.04	0.03	3.66	3.22	3.11	1.98	1.95	2.28
	Mean =	0.03	0.03	3.51	2.91	3.00	2.07	1.93	2.30
	S.D. =	0.01	0.01	0.25	0.27	0.12	0.10	0.05	0.02
	Mean for each Tissue =	0.03		3.21		2.33			
Chromium	#1	0.46	0.37	0.67	0.39	0.76	0.93	0.98	0.94
(detection limit = 0.01 µg/dry g)	#2	0.48	0.38	0.68	0.65	0.69	0.90	0.92	0.81
	#3	0.64	0.37	0.96	0.50	0.68	0.85	0.80	0.77
	Mean =	0.53	0.37	0.77	0.51	0.71	0.89	0.90	0.84
	S.D. =	0.10	0.01	0.16	0.13	0.04	0.04	0.09	0.09
	Mean for each Tissue =	0.45		0.64		0.84			
Copper	#1	2.04	1.30	10.60	11.00	6.65	5.79	5.32	5.14
(detection limit = 0.01 µg/dry g)	#2	2.09	1.21	10.50	11.90	6.54	5.76	5.87	5.15
	#3	2.00	1.27	11.20	11.50	6.81	5.31	4.83	4.95
	Mean =	2.04	1.26	10.77	11.47	6.67	5.63	5.34	5.08
	S.D. =	0.05	0.05	0.38	0.45	0.14	0.27	0.52	0.11
	Mean for each Tissue =	1.65		11.12		5.68			
Lead	#1	0.04	0.03	0.36	0.28	1.04	0.85	0.71	0.80
(detection limit = 0.01 µg/dry g)	#2	0.04	0.03	0.29	0.29	1.01	0.81	0.75	0.78
	#3	0.04	0.02	0.36	0.34	1.09	0.84	0.76	0.78
	Mean =	0.04	0.03	0.34	0.30	1.05	0.83	0.74	0.79
	S.D. =	0.00	0.01	0.04	0.03	0.04	0.02	0.03	0.01
	Mean for each Tissue =	0.03		0.32		0.65			
Mercury	#1	0.1040	0.0639	0.0329	0.0215	0.0388	0.0188	0.0196	0.0169
(det. Limit = 0.00001 µg/dry g)	#2	0.1010	0.0664	0.0267	0.0238	0.0377	0.0194	0.0186	0.0188
	#3	0.1040	0.0707	0.0239	0.0225	0.0388	0.0173	0.0180	0.0193
	Mean =	0.1030	0.0670	0.0278	0.0226	0.0384	0.0185	0.0187	0.0183
	S.D. =	0.0017	0.0034	0.0046	0.0012	0.0006	0.0011	0.0008	0.0013
	Mean for each Tissue =	0.0850		0.0252		0.023			
Nickel	#1	0.16	0.04	0.02	0.02	0.50	0.49	0.46	0.56
(detection limit = 0.02 µg/dry g)	#2	0.16	0.04	0.02	0.02	0.57	0.46	0.42	0.50
	#3	0.15	0.06	0.02	0.02	0.47	0.38	0.41	0.51
	Mean =	0.16	0.05	0.02	0.02	0.51	0.44	0.43	0.52
	S.D. =	0.01	0.01	0.00	0.00	0.05	0.07	0.03	0.03
	Mean for each Tissue =	0.10		0.02		0.48			

NS=not enough tissue for replicate analysis

10-15. continued.

		Fish Muscle		Fish Liver		Bivalve			
Constituent	Replicate	TB3	TB6	TB3	TB6	Control	B3	B4	B6
Metals (µg/dry g)									
Selenium	#1	1.660	1.120	4.750	3.400	2.180	2.420	2.460	2.580
(detection limit = 0.025 µg/dry g)	#2	1.600	1.190	3.670	2.890	1.910	2.870	2.520	2.980
	#3	1.860	1.340	4.030	3.040	2.320	2.500	2.340	2.660
	Mean =	1.707	1.217	4,160	3.110	2.137	2.697	2.440	2.740
	S.D. =	0.138	0.112	0.550	0.262	0.208	0.240	0.092	0.212
	Mean for each Tissue =	1.46		3 63		2 478			
Silver	#1	0.04	0.02	0.14	0.14	0.17	0.13	0.13	0.14
(detection limit = 0.02 µg/dry g)	#2	0.03	0.02	0.13	0.14	0.16	0.12	0.13	0.14
	#3	0.02	0.02	0.16	0.14	0.15	0.12	0.12	0.13
	Mean =	0.03	0.02	0.14	0.14	0.16	0.12	0.13	0.14
	S.D. =	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.01
	Mean for each Tissue =	0 03		0 14		0 14			
Zinc	#1	24.90	17.20	60.10	45.80	107.00	109.00	102.00	104.00
(detection limit = 0.025 µg/dry g)	#2	23.00	17.20	54.80	44.60	99.10	107.00	105.00	104.00
	#3	24.10	17.400	60.800	45.500	111.00	113.00	94.80	105.00
	Mean =	24.000	17.267	58.567	45.300	105.700	109.667	100.600	104.333
	S.D. =	0.954	0.115	3.281	0.624	6.056	3.055	5.242	0.577
	Mean for each Tissue =	20.63		51.93		105 075			
Complex Organics (ng/dry Kg)									
Total DDT[1]	#1	12.6	8.2	579.0	648.0	35.4	12.6	13.1	11.7
	#2	12.5	7.2	562.0	673.0	37.7	13.9	15.0	12.7
	#3	11.4	7.3	581.0	644.0	43.0	13.0	14.3	14.1
	Mean =	12.1	7.6	574.0	655.0	38.7	13.2	14.1	12.8
	S.D. =	0.6	0.6	10.4	15.7	3.9	0.7	1.0	1.2
	Mean for each Tissue =	9.85		614.50		19.7			
Total Chlordane[1]	#1	0.0	0.0	59.5	40.5	5.5	2.6	0.0	2.4
	#2	0.0	0.0	59.7	52.3	4.9	2.5	1.6	1.6
	#3	0.0	0.0	67.0	57.4	6.2	0.0	3.9	1.7
	Mean =	0.0	0.0	62.1	50.1	5.5	1.7	1.8	1.9
	S.D. =	0.0	0.0	4.3	8.7	0.7	1.5	2.0	0.4
	Mean for each Tissue =	0.00		56 07		2.7			
Total HCHs[1]	#1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	#2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	#3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	0.0		0.0		0.0			
Aldrin	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(detection limit = 1.0 ng/g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.0		1.0		1.0			
Dieldrin	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(detection limit = 1.0 ng/g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.0		1.0		1.0			
Heptachlor	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(detection limit = 1.0 ng/g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.0		1.0		1.0			

[1] Complex organic derivatives are listed in Table 10-16.

10-15. continued.

Constituent	Replicate	Fish Muscle		Fish Liver		Bivalve			
		TB3	TB6	TB3	TB6	Control	B3	B4	B6
Complex Organics (ng/dry Kg)									
Hexachlorobenzene	#1	1.0	1.0	5.2	5.5	1.0	1.0	1.0	1.0
(detection limit = 1.0 ng/g)	#2	1.0	1.0	3.8	4.8	1.0	1.0	1.0	1.0
	#3	1.0	1.0	4.5	4.7	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	4.5	5.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.0		4.8		1.0			
Mirex	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(detection limit = 1.0 ng/g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.0		1.0		1.0			
Polychlorinated Biphenyls (PCBs)[1]	#1	4.2	1.3	121.4	137.0	14.8	1.0	0.0	1.6
	#2	2.1	1.6	126.5	140.1	11.6	1.1	0.0	0.0
	#3	4.1	1.1	122.3	126.9	13.0	0.0	1.4	0.0
	Mean =	3.5	1.3	123.4	134.7	13.1	0.7	0.5	0.5
	S.D. =	1.2	0.3	2.7	6.9	1.6	0.6	0.8	0.9
	Mean for each Tissue =	2.40		129.03		3.7			
Arochlors[1]	#1	0.0	0.0	149.0	170.0	18.3	0.0	0.0	0.0
	#2	0.0	0.0	168.0	174.0	14.3	0.0	0.0	0.0
	#3	0.0	0.0	163.0	158.0	16.0	0.0	0.0	0.0
	Mean =	0.0	0.0	160.0	167.3	16.2	0.0	0.0	0.0
	S.D. =	0.0	0.0	9.8	8.3	2.0	0.0	0.0	0.0
	Mean for each Tissue =	0.00		163.67		4.1			
Polynuclear Aromatic Hydrocarbons (PAHs)[1]	#1	55.4	31.6	1032.3	1240.7	157.2	198.4	260.8	218.3
	#2	56.8	31.2	1058.5	1212.9	147.0	244.3	241.3	232.7
	#3	42.1	30.6	1120.6	1102.5	157.0	257.0	178.3	196.3
	Mean =	51.4	31.1	1070.5	1185.4	153.7	233.2	226.8	215.8
	S.D. =	8.1	0.5	45.4	73.1	5.8	30.8	43.1	18.3
	Mean for each Tissue =	41.28		1127.92		207.38			
1-Methylnaphthalene	#1	1.0	1.0	5.8	14.8	3.3	1.9	1.6	1.3
(det. Limit = 1 ng/dry g)	#2	1.0	1.0	7.7	11.3	1.5	2.5	1.0	1.1
	#3	1.0	1.0	10.1	14.6	1.0	1.7	1.6	1.6
	Mean =	1.0	1.0	7.8	13.6	1.9	2.0	1.4	1.3
	S.D. =	0.0	0.0	2.3	2.0	1.2	0.4	0.3	0.3
	Mean for each Tissue =	1.00		10.68		1.68			
1-Methylphenanthrene	#1	3.8	3.3	1.0	1.0	4.4	1.0	1.0	1.0
(det. Limit = 1 ng/dry g)	#2	5.4	2.8	1.0	1.0	4.5	1.0	1.0	1.0
	#3	3.3	3.4	1.0	1.0	4.5	1.0	1.0	1.0
	Mean =	4.2	3.2	1.0	1.0	4.5	1.0	1.0	1.0
	S.D. =	1.1	0.3	0.0	0.0	0.1	0.0	0.0	0.0
	Mean for each Tissue =	3.67		1.00		1.87			
2-Methylnaphthalene	#1	3.3	1.9	12.6	29.1	8.0	4.3	4.0	3.8
(det. Limit = 1 ng/dry g)	#2	2.5	1.9	13.3	26.4	4.6	6.9	3.3	4.6
	#3	1.3	1.3	19.8	37.3	5.1	5.4	4.9	4.9
	Mean =	2.4	1.7	15.2	30.9	5.9	5.5	4.1	4.4
	S.D. =	1.0	0.3	4.0	5.7	1.8	1.3	0.8	0.6
	Mean for each Tissue =	2.03		23.08		4.98			
2,3,5-Trimethylnaphthalene	#1	1.3	1.0	8.0	1.0	1.0	2.0	2.4	3.8
(det. Limit = 1 ng/dry g)	#2	1.6	1.0	6.6	1.0	1.0	2.1	2.5	3.7
	#3	1.0	1.0	7.2	1.0	1.0	1.8	2.4	5.2
	Mean =	1.3	1.0	7.3	1.0	1.0	2.0	2.4	4.2
	S.D. =	0.3	0.0	0.7	0.0	0.0	0.2	0.1	0.8
	Mean for each Tissue =	1.15		4.13		2.41			

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1. Complex organic derivatives are listed in Table 10-16.

10-15. continued.

		Fish Muscle		Fish Liver		Bivalve			
Constituent	Replicate	TB3	TB6	TB3	TB6	Control	B3	B4	B6
2,6-Dimethylnaphthalene	#1	1.6	1.0	3.9	9.9	1.4	1.4	1.3	1.3
(det. Limit = 1 ng/dry g)	#2	1.5	1.0	3.9	6.7	1.0	1.6	1.0	1.0
	#3	1.6	1.6	4.9	9.3	1.0	1.2	1.2	1.9
	Mean =	1.6	1.2	4.2	8.6	1.1	1.4	1.2	1.4
	S.D. =	0.2	0.3	0.6	1.7	0.2	0.2	0.2	0.5
	Mean for each Tissue =	1.42		6.43		1.28			
Acenaphthene	#1	1.8	1.0	1.0	25.3	3.8	1.7	2.2	1.0
(det. Limit = 1 ng/dry g)	#2	1.0	1.1	1.0	23.5	1.3	2.7	1.0	1.7
	#3	1.0	1.0	1.0	29.5	1.0	1.1	1.2	1.0
	Mean =	1.3	1.0	1.0	26.1	2.0	1.8	1.5	1.2
	S.D. =	0.5	0.1	0.0	3.1	1.5	0.8	0.8	0.4
	Mean for each Tissue =	1.15		13.55		1.64			
Biphenyl	#1	19.6	9.1	1.0	117.0	40.1	14.7	17.4	3.3
(det. Limit = 1 ng/dry g)	#2	7.8	12.7	1.0	1.0	3.6	30.2	1.0	6.9
	#3	1.6	1.0	49.0	82.8	1.0	5.7	11.0	1.0
	Mean =	9.7	7.6	17.0	66.9	14.9	16.9	9.8	3.7
	S.D. =	9.1	6.0	27.7	59.6	21.9	12.4	8.3	3.0
	Mean for each Tissue =	8.63		41.97		11.33			
Benz[a]anthracene	#1	29.6	14.5	900.0	1040.0	118.0	169.0	232.0	180.0
(det. Limit = 1 ng/dry g)	#2	28.9	14.3	918.0	1030.0	112.0	213.0	215.0	197.0
	#3	20.9	13.6	981.0	927.0	119.0	224.0	152.0	160.0
	Mean =	26.5	14.1	933.0	999.0	116.3	202.0	199.7	179.0
	S.D. =	4.8	0.5	42.5	62.6	3.8	29.1	42.1	18.5
	Mean for each Tissue =	20.30		966.00		174.25			
Benzo[b]fluoranthene	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(det. Limit = 1 ng/dry g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.00		1.00		1.00			
Benzo[e]pyrene	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(det. Limit = 1 ng/dry g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.00		1.00		1.00			
Benzo[g,h,i]perylene	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(det. Limit = 1 ng/dry g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.00		1.00		1.00			
Fluoranthene	#1	6.0	5.6	18.7	12.6	11.7	5.3	6.6	11.7
(det. Limit = 1 ng/dry g)	#2	10.5	5.9	25.3	19.6	11.9	6.2	6.5	9.2
	#3	7.7	5.8	20.6	18.8	12.5	7.2	5.4	8.6
	Mean =	8.1	5.7	21.5	17.0	12.0	5.9	6.2	9.8
	S.D. =	2.3	0.2	3.4	3.6	0.4	1.1	0.7	1.6
	Mean for each Tissue =	6.88		19.23		8.48			
Napthalene	#1	22.6	10.7	1.0	168.0	64.8	17.8	23.7	2.1
(det. Limit = 1 ng/dry g)	#2	9.9	18.6	1.0	1.0	10.8	41.4	1.0	9.6
	#3	7.2	1.0	72.5	143.0	1.0	6.9	14.5	1.0
	Mean =	13.2	10.1	24.8	104.0	25.5	22.0	13.1	4.2
	S.D. =	8.2	8.8	41.3	90.1	34.4	17.6	11.4	4.7
	Mean for each Tissue =	11.67		64.42		16.20			
Perylene	#1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(det. Limit = 1 ng/dry g)	#2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	#3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mean =	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	S.D. =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean for each Tissue =	1.00		1.00		1.00			

1. Complex organic derivatives are listed in Table 10-16.

10-16. Complex organics (ng/dry g) in fish muscle and liver tissues.

Tissue[1]	Fish Muscle						Fish Liver					
Station	Trawl Station TB3			Trawl Station TB6			Trawl Station TB3			Trawl Station TB6		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3
DDT												
2,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4'-DDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDE	12.5	12.5	11.4	8.2	7.2	7.3	579.0	562.0	581.0	648.0	673.0	644.0
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	12.6	12.5	11.4	8.2	7.2	7.3	579.0	562.0	581.0	648.0	673.0	644.0
Chlordane												
Chlordane-alpha	0.0	0.0	0.0	0.0	0.0	0.0	17.4	17.0	17.9	13.1	16.8	16.6
Chlordane-gamma	0.0	0.0	0.0	0.0	0.0	0.0	7.7	7.6	9.1	0.0	6.9	9.7
cis-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0	10.6	10.8	11.8	8.1	8.5	8.9
Oxychlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trans-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0	23.8	24.4	28.2	19.3	20.1	22.2
Sum =	0.0	0.0	0.0	0.0	0.0	0.0	59.5	59.7	67.0	40.5	52.3	57.4
Hexachlorocyclohexane (HCH)												
BHC-alpha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-beta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-delta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-gamma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polynuclear Aromatic Hydrocarbons (PAH's)												
PCB003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB028	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB044	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB049	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB052	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB056(060)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB066	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB070	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB074	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB077	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB081	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB087	2.0	2.1	1.8	1.3	1.6	1.1	6.7	6.7	6.3	6.9	6.7	6.1
PCB095	0.0	0.0	0.0	0.0	0.0	0.0	5.3	5.9	6.5	6.3	6.9	5.9
PCB097	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB099	0.0	0.0	0.0	0.0	0.0	0.0	7.4	8.2	8.0	11.6	10.5	10.7
PCB101	0.0	0.0	0.0	0.0	0.0	0.0	12.6	12.3	11.9	11.0	9.3	10.8
PCB105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB110	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.6	5.8	7.4	7.0	6.8
PCB114	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB118	0.0	0.0	0.0	0.0	0.0	0.0	11.7	11.0	10.9	12.4	14.7	11.6
PCB119	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB123	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1. Minimum detection limits, reporting limits and methods are listed in table 10-18.

10-16. continued.

Tissue[1]	Fish Muscle						Fish Liver					
Station	Trawl Station TB3			Trawl Station TB5			Trawl Station TB3			Trawl Station TB5		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3
PCB126	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB128	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB138	1.1	0.0	1.1	0.0	0.0	0.0	21.7	21.8	20.3	27.8	28.6	25.3
PCB141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB149	0.0	0.0	0.0	0.0	0.0	0.0	7.4	7.4	7.0	6.6	7.2	7.2
PCB151	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.6	3.1	3.0	2.5	2.7
PCB153	0.0	0.0	0.0	0.0	0.0	0.0	25.9	28.2	28.3	28.4	31.5	31.4
PCB156	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB157	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB158	1.1	0.0	1.2	0.0	0.0	0.0	5.5	5.0	5.1	4.7	6.3	0.0
PCB167	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB168/132	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB174	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB183	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB187	0.0	0.0	0.0	0.0	0.0	0.0	8.4	9.3	9.1	10.9	8.9	9.4
PCB189	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB194	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB195	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB199(200)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB201	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB206	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB209	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	4.2	2.1	4.1	1.3	1.6	1.1	121.4	126.5	122.3	137.0	140.1	126.9
Aroclors												
Aroclor 1016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1232	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1254	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1260	0.0	0.0	0.0	0.0	0.0	0.0	149.0	168.0	163.0	170.0	174.0	158.0
sum=	0.0	0.0	0.0	0.0	0.0	0.0	149.0	168.0	163.0	170.0	174.0	158.0
Polychlorinated Biphenyls (PCB's)												
Acenaphthylene	1.8	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	25.3	23.5	29.5
Anthracene	1.4	1.3	0.0	0.0	0.0	0.0	21.4	23.4	22.4	25.4	24.4	21.4
Benz[a]anthracene	29.6	28.9	20.9	14.5	14.3	13.6	900.0	918.0	981.0	1040.0	1030.0	927.0
Benzo[a]pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[b]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[g,h,i]perylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[k]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysene	2.9	2.7	2.7	3.0	1.5	1.2	36.7	40.9	48.7	79.1	69.2	63.7
Dibenz[a,h]anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluorene	0.0	1.1	0.0	0.0	0.0	0.0	9.3	9.1	11.1	15.5	11.3	13.1
Indeno[1,2,3-c,d]pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenanthrene	15.1	16.0	13.7	10.3	11.0	11.4	55.5	56.2	49.4	50.4	49.5	43.0
Pyrene	4.6	7.8	4.8	3.8	3.3	4.4	9.4	10.9	8.0	5.0	5.0	4.8
Sum =	55.4	56.8	42.1	31.6	31.2	30.6	1032.3	1058.5	1120.6	1240.7	1212.9	1102.5

1. Minimum detection limits, reporting limits and methods are listed in table 10-18.

10-17. Complex organics (ng/dry g) in caged bivalve tissues.

Tissue[1]	Mussel Tissue											
Station	Control			Station B3			Station B4			Station B6		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3
DDT & Derivatives												
2,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4'-DDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0
2,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDE	35.4	37.7	43.0	12.6	13.9	13.0	13.1	15.0	14.3	11.7	12.7	14.1
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	35.4	37.7	43.0	12.6	13.9	13.0	13.1	15.0	14.3	19.1	12.7	14.1
Chlordane												
Chlordane-alpha	1.6	1.6	2.3	1.5	1.1	0.0	0.0	1.6	1.4	1.2	0.0	0.0
Chlordane-gamma	2.2	1.8	2.4	1.1	1.4	0.0	0.0	0.0	1.4	1.2	1.8	1.7
cis-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oxychlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trans-Nonachlor	1.7	1.5	1.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
Sum =	5.5	4.9	6.2	2.6	2.5	0.0	0.0	1.6	3.9	2.4	1.8	1.7
Hexachlorocyclohexane (HCH)												
BHC-alpha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-beta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-delta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BHC-gamma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biphenyls (PCB's)												
PCB003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB028	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB044	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB049	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB052	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB056(060)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB066	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB070	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB074	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB077	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB081	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB087	3.1	1.8	1.3	0.0	0.0	0.0	0.0	0.0	1.4	1.6	0.0	0.0
PCB095	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB097	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB099	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB101	1.7	1.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB114	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB118	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB119	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB123	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB126	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1. Minimum detection limits, reporting limits and methods are listed in table 10-18.

10-17. continued.

Tissue[1]	Mussel Tissue											
Station	Control			Station B3			Station B4			Station B6		
Replicate	1	2	3	1	2	3	1	2	3	1	2	3
PCB128	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB138	3.5	2.1	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB149	2.1	1.8	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB151	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB153	3.0	3.4	3.5	1.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB156	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB157	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB158	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB167	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB168/132	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB169	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB174	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB183	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB187	1.4	1.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB189	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB194	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB195	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB199(200)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB201	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB206	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB209	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	14.8	11.6	13.0	1.0	1.1	0.0	0.0	0.0	1.4	1.6	0.0	0.0
Aroclors												
Aroclor 1016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1232	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1254	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aroclor 1260	18.3	14.3	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	18.3	14.3	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polynuclear Aromatic Hydrocarbons (PAH's)												
Acenaphthylene	3.8	1.3	0.0	1.7	2.7	1.1	2.2	0.0	1.2	0.0	1.7	0.0
Anthracene	1.3	1.0	1.5	1.5	1.0	1.3	1.3	1.2	0.0	2.1	1.6	2.1
Benz[a]anthracene	118.0	112.0	119.0	169.0	213.0	224.0	232.0	215.0	152.0	180.0	197.0	160.0
Benzo[a]pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[b]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[g,h,i]perylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo[k]fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysene	7.4	5.9	10.1	6.9	6.7	11.1	6.6	7.2	5.9	6.4	7.0	4.9
Dibenz[a,h]anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluorene	2.2	2.0	1.5	2.1	1.6	2.3	1.2	2.3	2.9	3.1	2.9	3.3
Indeno[1,2,3-c,d]pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenanthrene	19.2	18.4	19.3	14.1	13.7	13.4	13.9	12.8	13.6	21.5	18.0	21.8
Pyrene	5.3	6.4	5.6	3.1	3.6	3.8	3.6	2.8	2.7	6.2	4.5	4.2
Sum =	157.2	147.0	157.0	198.4	244.3	257.0	260.8	241.3	178.3	218.3	232.7	196.3

10-18 Tissue chemistry detection limits and methods

Parameter	MDL	RL	Units (dry wt.)	Method
General Chemistry				
Percent Lipids	0.01	0.05	%	Gravimetric
Percent Solids	0.1	0.1	%	SM 2540B
Trace Metals				
Arsenic	0.025	0.05	µg/g	EPA 6020
Cadmium	0.01	0.01	µg/g	EPA 6020
Chromium	0.01	0.01	µg/g	EPA 6020
Copper	0.01	0.01	µg/g	EPA 6020
Lead	0.01	0.01	µg/g	EPA 6020
Mercury	0.00001	0.00002	µg/g	EPA 245.7
Nickel	0.02	0.02	µg/g	EPA 6020
Selenium	0.025	0.05	µg/g	EPA 6020
Silver	0.02	0.02	µg/g	EPA 6020
Zinc	0.025	0.05	µg/g	EPA 6020
Chlorinated Pesticides				
2,4'-DDD	1	5	ng/g	EPA 8270D
2,4'-DDE	1	5	ng/g	EPA 8270D
2,4'-DDT	1	5	ng/g	EPA 8270D
4,4'-DDD	1	5	ng/g	EPA 8270D
4,4'-DDE	1	5	ng/g	EPA 8270D
4,4'-DDT	1	5	ng/g	EPA 8270D
Aldrin	1	5	ng/g	EPA 8270D
BHC-alpha	1	5	ng/g	EPA 8270D
BHC-beta	1	5	ng/g	EPA 8270D
BHC-delta	1	5	ng/g	EPA 8270D
BHC-gamma	1	5	ng/g	EPA 8270D
Chlordane-alpha	1	5	ng/g	EPA 8270D
Chlordane-gamma	1	5	ng/g	EPA 8270D
cis-Nonachlor	1	5	ng/g	EPA 8270D
Dieldrin	1	5	ng/g	EPA 8270D
Endosulfan sulfate	1	5	ng/g	EPA 8270D
Endosulfan-I	1	5	ng/g	EPA 8270D
Endosulfan-II	1	5	ng/g	EPA 8270D
Endrin	1	5	ng/g	EPA 8270D
Endrin aldehyde	1	5	ng/g	EPA 8270D
Endrin ketone	1	5	ng/g	EPA 8270D
Heptachlor	1	5	ng/g	EPA 8270D
Heptachlor epoxide	1	5	ng/g	EPA 8270D
Hexachlorobenzene	1	5	ng/g	EPA 8270D
Methoxychlor	1	5	ng/g	EPA 8270D
Mirex	1	5	ng/g	EPA 8270D
Oxychlordane	1	5	ng/g	EPA 8270D
Perthane	5	10	ng/g	EPA 8270D
trans-Nonachlor	1	5	ng/g	EPA 8270D
Polynuclear Aromatic Hydrocarbons (PAHs)				
1-Methylnaphthalene	1	5	ng/g	EPA 8270D
1-Methylphenanthrene	1	5	ng/g	EPA 8270D
2,3,5-Trimethylnaphthalene	1	5	ng/g	EPA 8270D
2,6-Dimethylnaphthalene	1	5	ng/g	EPA 8270D
2-Methylnaphthalene	1	5	ng/g	EPA 8270D
Acenaphthene	1	5	ng/g	EPA 8270D
Acenaphthylene	1	5	ng/g	EPA 8270D
Anthracene	1	5	ng/g	EPA 8270D
Benz[a]anthracene	1	5	ng/g	EPA 8270D
Benzo[a]pyrene	1	5	ng/g	EPA 8270D
Benzo[b]fluoranthene	1	5	ng/g	EPA 8270D
Benzo[e]pyrene	1	5	ng/g	EPA 8270D
Benzo[g,h,i]perylene	1	5	ng/g	EPA 8270D
Benzo[k]fluoranthene	1	5	ng/g	EPA 8270D
Biphenyl	1	5	ng/g	EPA 8270D
Chrysene	1	5	ng/g	EPA 8270D
Dibenz[a,h]anthracene	1	5	ng/g	EPA 8270D
Dibenzothiophene	1	5	ng/g	EPA 8270D
Fluoranthene	1	5	ng/g	EPA 8270D
Fluorene	1	5	ng/g	EPA 8270D
Indeno[1,2,3-c,d]pyrene	1	5	ng/g	EPA 8270D
Naphthalene	1	5	ng/g	EPA 8270D
Polynuclear Aromatic Hydrocarbons (Continued)				
Perylene	1	5	ng/g	EPA 8270D
Phenanthrene	1	5	ng/g	EPA 8270D
Pyrene	1	5	ng/g	EPA 8270D
Aroclors				
Aroclor 1016	10	20	ng/g	EPA 8270D
Aroclor 1221	10	20	ng/g	EPA 8270D
Aroclor 1232	10	20	ng/g	EPA 8270D
Aroclor 1242	10	20	ng/g	EPA 8270D
Aroclor 1248	10	20	ng/g	EPA 8270D
Aroclor 1254	10	20	ng/g	EPA 8270D
Aroclor 1260	10	20	ng/g	EPA 8270D
Polychlorinated Biphenyls (PCB's)				
PCB003	1	5	ng/g	EPA 8270D
PCB008	1	5	ng/g	EPA 8270D
PCB018	1	5	ng/g	EPA 8270D
PCB028	1	5	ng/g	EPA 8270D
PCB031	1	5	ng/g	EPA 8270D
PCB033	1	5	ng/g	EPA 8270D
PCB037	1	5	ng/g	EPA 8270D
PCB044	1	5	ng/g	EPA 8270D
PCB049	1	5	ng/g	EPA 8270D
PCB052	1	5	ng/g	EPA 8270D
PCB056(060)	1	5	ng/g	EPA 8270D
PCB066	1	5	ng/g	EPA 8270D
PCB070	1	5	ng/g	EPA 8270D
PCB074	1	5	ng/g	EPA 8270D
PCB077	1	5	ng/g	EPA 8270D
PCB081	1	5	ng/g	EPA 8270D
PCB087	1	5	ng/g	EPA 8270D
PCB095	1	5	ng/g	EPA 8270D
PCB097	1	5	ng/g	EPA 8270D
PCB099	1	5	ng/g	EPA 8270D
PCB101	1	5	ng/g	EPA 8270D
PCB105	1	5	ng/g	EPA 8270D
PCB110	1	5	ng/g	EPA 8270D
PCB114	1	5	ng/g	EPA 8270D
PCB118	1	5	ng/g	EPA 8270D
PCB119	1	5	ng/g	EPA 8270D
PCB123	1	5	ng/g	EPA 8270D
PCB126	1	5	ng/g	EPA 8270D
PCB128	1	5	ng/g	EPA 8270D
PCB138	1	5	ng/g	EPA 8270D
PCB141	1	5	ng/g	EPA 8270D
PCB149	1	5	ng/g	EPA 8270D
PCB151	1	5	ng/g	EPA 8270D
PCB153	1	5	ng/g	EPA 8270D
PCB156	1	5	ng/g	EPA 8270D
PCB157	1	5	ng/g	EPA 8270D
PCB158	1	5	ng/g	EPA 8270D
PCB167	1	5	ng/g	EPA 8270D
PCB168/132	1	5	ng/g	EPA 8270D
PCB169	1	5	ng/g	EPA 8270D
PCB170	1	5	ng/g	EPA 8270D
PCB174	1	5	ng/g	EPA 8270D
PCB177	1	5	ng/g	EPA 8270D
PCB180	1	5	ng/g	EPA 8270D
PCB183	1	5	ng/g	EPA 8270D
PCB187	1	5	ng/g	EPA 8270D
PCB189	1	5	ng/g	EPA 8270D
PCB194	1	5	ng/g	EPA 8270D
PCB195	1	5	ng/g	EPA 8270D
PCB199(200)	1	5	ng/g	EPA 8270D
PCB201	1	5	ng/g	EPA 8270D
PCB206	1	5	ng/g	EPA 8270D
PCB209	1	5	ng/g	EPA 8270D