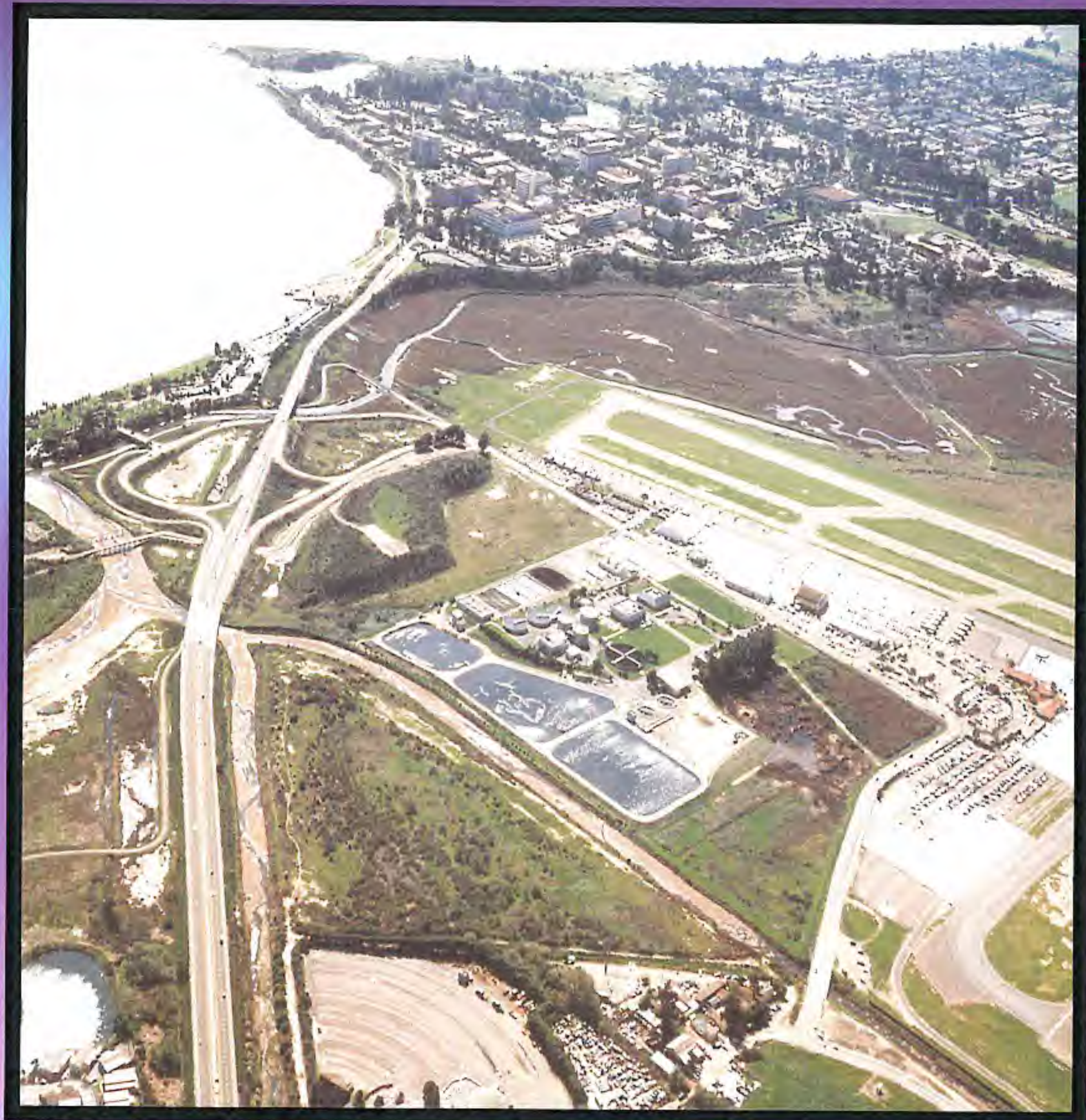


GOLETA SANITARY DISTRICT

NPDES MONITORING PROGRAM

2019 AMENDED ANNUAL REPORT

Submitted: February 27, 2020

GOLETA SANITARY DISTRICT

NPDES Monitoring and Reporting Program

2019 Amended Annual Report

Receiving Water Monitoring and Outfall Inspection
Conducted by
Aquatic Bioassay and Consulting Laboratories, Inc.
29 North Olive Street
Ventura, California 93001
(805) 643-5621

Amended Report Submitted February 27, 2020

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.

John Crisman
Operations Manager
Goleta Sanitary District

Date: 2/27/2020

CHAPTER 1

INTRODUCTION

The Goleta Sanitary District (GSD) treatment plant operated under WDR Order No. R3-2017-0021 and NPDES Permit No. CA0048160 which became effective November 10, 2017. January through December 2019 the plant was operating utilizing the full secondary process.

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, 2010 to 2019, the plant has discharged about 3.69 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.

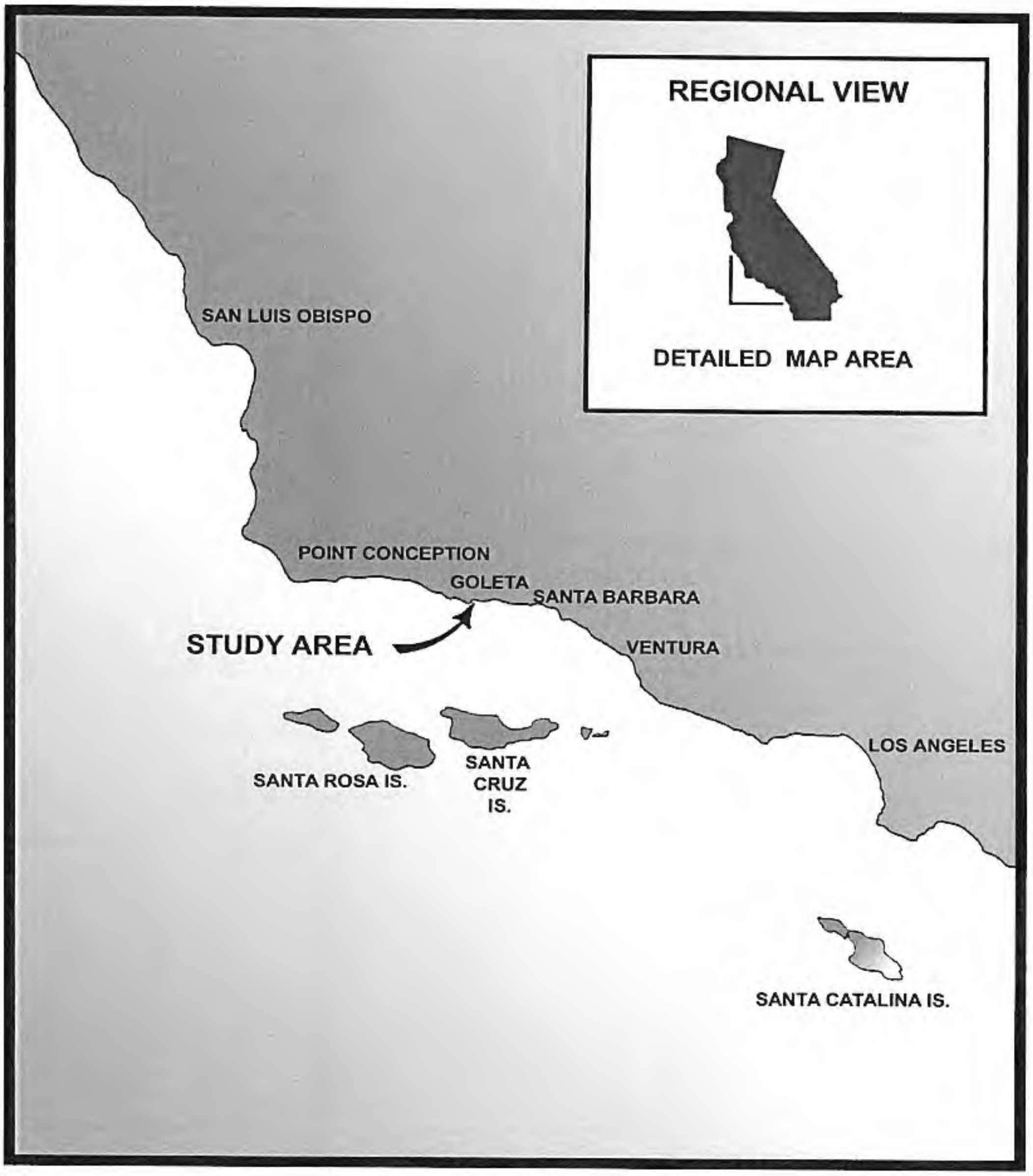
Sludge Treatment and Biosolids Disposal

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 to Liberty Composting Inc. located at 12421 Holloway Road, Lost Hills, CA 93249. Copies of the agreement with Liberty Composting 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.

Ten state certified treatment plant operators operated the wastewater treatment plant under the direction of the District Operations Manager, Mr. John Crisman. The Plant Operations Manager 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 and Technical Services Manager. The grade and certification number of operations, maintenance, industrial waste control, and laboratory personnel employed during the 2019 operational year are shown in Table 1-1.

Table 1-1. Goleta Sanitary District Operation Staff, 2019

Staff	Grade	California Certification No.
Operators		
Todd Frederick	V	27633
John Crisman	V	28857
Pete Regis	IV	28277
Stephen Conklin	III	7065
Ricardo Lopez	III	10756
Francisco M. Lemus	III	10893
Morgan Lea	III	28400
Jes Hulbert	I	28266
River Ferrara	I	28488
Justin Graves	I	43450
Lab Analysts		
Lena Cox	IV	90334003
Todd Frederick	I	60731013
Teresa Kistner	I	99076111
River Ferrara	I	1308214257
John Crisman	I	1308214787
Justin Graves	I	1308219530
Maintenance Technologist		
Carl Easter	III	1308213756
Alejandro Bautista	I	1308213795
Torrey Jones	I	1308217681
Electrical / Instrumentation		
Charles Smolnikar	II	60172004
Ramon Garza	I	1308216916
Dept. of Industrial Relations – Electrician		
Charles Smolnikar	NA	107709
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:

- 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 self-monitoring and reporting program consists of assessing water quality and compliance with effluent limits. Table 1-2 summarizes the sampling schedule for various elements of the monitoring and reporting program conducted during 2019.

Table 1-2. Schedule for NPDES Monitoring, Goleta Sanitary District, 2019

Monitoring Program Component	Frequency	Schedule
Standard Wastewater Parameters	Daily - Weekly	As Specified
Chronic Toxicity	Quarterly	Jan, April, July, and Oct
Effluent Metals	Annually	October
Effluent Priority Pollutants	Annually	October
Outfall Inspection	Annually	October
Benthic Monitoring	Once During Permit Term	2019

Influent, and effluent 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 2019 monitoring and reporting program, and analyzes this data to determine compliance with the discharge permit terms and conditions.

Chapter presentation is as follows:

Chapter 1	Introduction
Chapter 2	Treatment Plant Performance
Chapter 3	Collection System Summary
Chapter 4	Physical Characteristics of Benthic Sediments
Chapter 5	Chemical Characteristics of Benthic Sediments
Chapter 6	Biological Characteristics of Benthic Sediments
Chapter 7	Outfall Dive Survey
Chapter 8	Appendicies

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, 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 2019, influent, effluent, and biosolids (sludge) 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 Testing Laboratories (ATL) for acute and chronic toxicity, OEC Laboratory, McCampbell Analytical Laboratory and Ceres Analytical Laboratory. Treatment plant personnel monitored and analyzed wastewater for performance-evaluating parameters including wastewater flow, suspended solids, biochemical oxygen demand (BOD), pH, turbidity, settleable solids, oil and grease, temperature, residual chlorine, coliform and enterococcus bacteria. The previously mentioned environmental laboratories performed annual analysis of priority pollutants, metals and other parameters in final effluent and biosolids samples. Final effluent samples were also analyzed for radioactivity.

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, 22nd ed.* All methodologies employed during 2019 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, 22nd edition.*

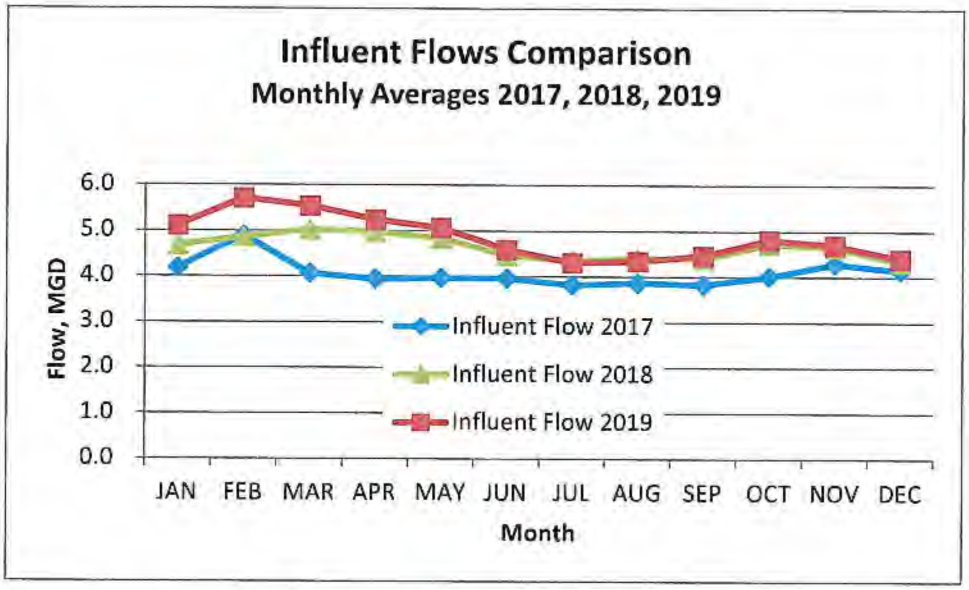
Results of the wastewater chemical analyses used to monitor proper operation of the treatment plant during 2019, and the respective discharge permit limitations, are presented in Tables 2-1 and Table 2-2. All monthly averaged data presented in these tables are calculated from daily values at the treatment 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 2019. Influent flow without the internal plant recirculated flow, averaged 4.9 million gallons per day (MGD) which is a 6% increase compared to the average of 4.6 MGD that was treated in 2018.

Overall, the average monthly influent flows for 2019 varied throughout the year, fluctuating from a low of 4.3 MGD in July to a high of 5.7 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 2017, 2018 and 2019



The highest flows into the plant during 2019 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 2019 and averaged 4.1 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 2019 Monthly Averages

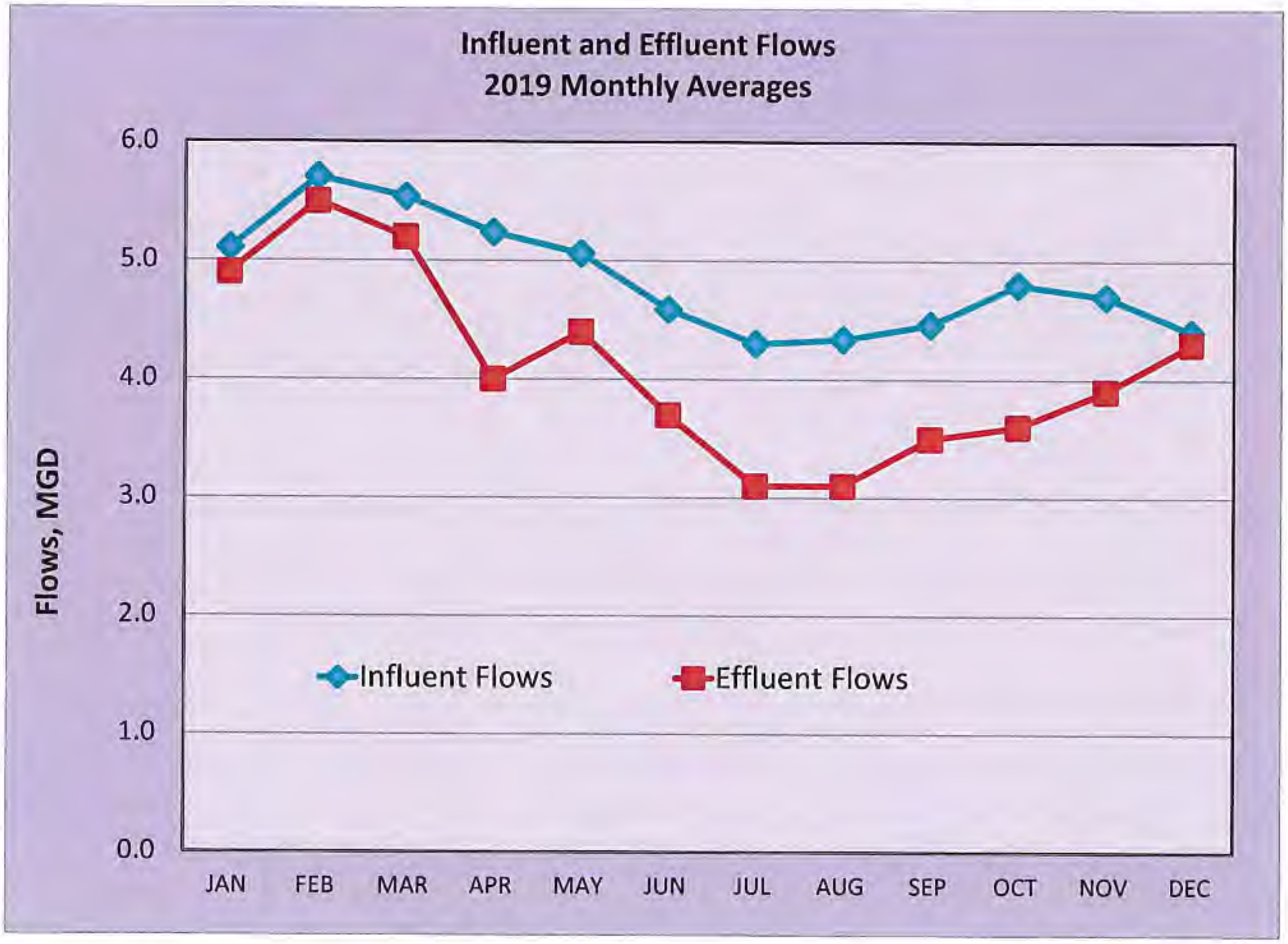


Figure 2-2 shows the monthly average influent and effluent flows for 2019. Higher wastewater effluent flow generally occurs during the winter months when influent flow is also the highest and recycling is minimal. The most important factor contributing to fluctuations in the effluent flow is the amount of wastewater that is processed into reclaimed water and used for irrigation. The lowest effluent flow occurred during July and August when the amount of flow discharged to the Pacific Ocean dropped to 3.1 MGD as depicted in Figure 2-2. The temporal variations in the monthly average effluent flow seen in 2019 fluctuated from a low of 3.08 MGD in July, when the daily production of reclaimed water was one of the highest production months of the year and averaged 1.2 MGD for the month to a high of 5.5 MGD during February when the reclaimed facility was on line for three days out of the month and a total of 3.2 million gallons were filtered. There was also significant rainfall during February with approximately 7.30 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, 2019.

	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	5.11	4.95	709	9.8	98.8	419	512	6.1	98.8	258
Feb	5.71	5.54	601	8.8	98.7	402	414	6.0	98.5	272
Mar	5.54	5.22	590	7.9	98.6	346	412	6.3	98.4	264
Apr	5.24	4.04	474	7.9	98.3	266	400	7.8	98.0	260
May	5.06	4.40	555	5.1	99.0	194	452	8.0	98.1	293
Jun	4.59	3.71	557	5.7	98.9	173	464	8.1	98.2	250
Jul	4.30	3.08	604	5.0	99.0	126	540	5.9	98.9	150
Aug	4.34	3.08	918	4.6	99.5	123	600	5.6	99.1	145
Sep	4.46	3.46	576	4.5	99.1	128	462	5.1	98.8	145
Oct	4.80	3.55	719	6.8	98.7	209	538	7.5	98.4	227
Nov	4.70	3.87	547	4.8	99.1	156	455	6.4	98.6	204
Dec	4.40	4.34	571	3.2	99.4	116	427	5.0	98.8	181
Average	4.85	4.10	618	6.2	98.9	221	473	6.5	98.6	221
Limit	NL	7.64	NL	30	85	1912	NL	30	85	1912

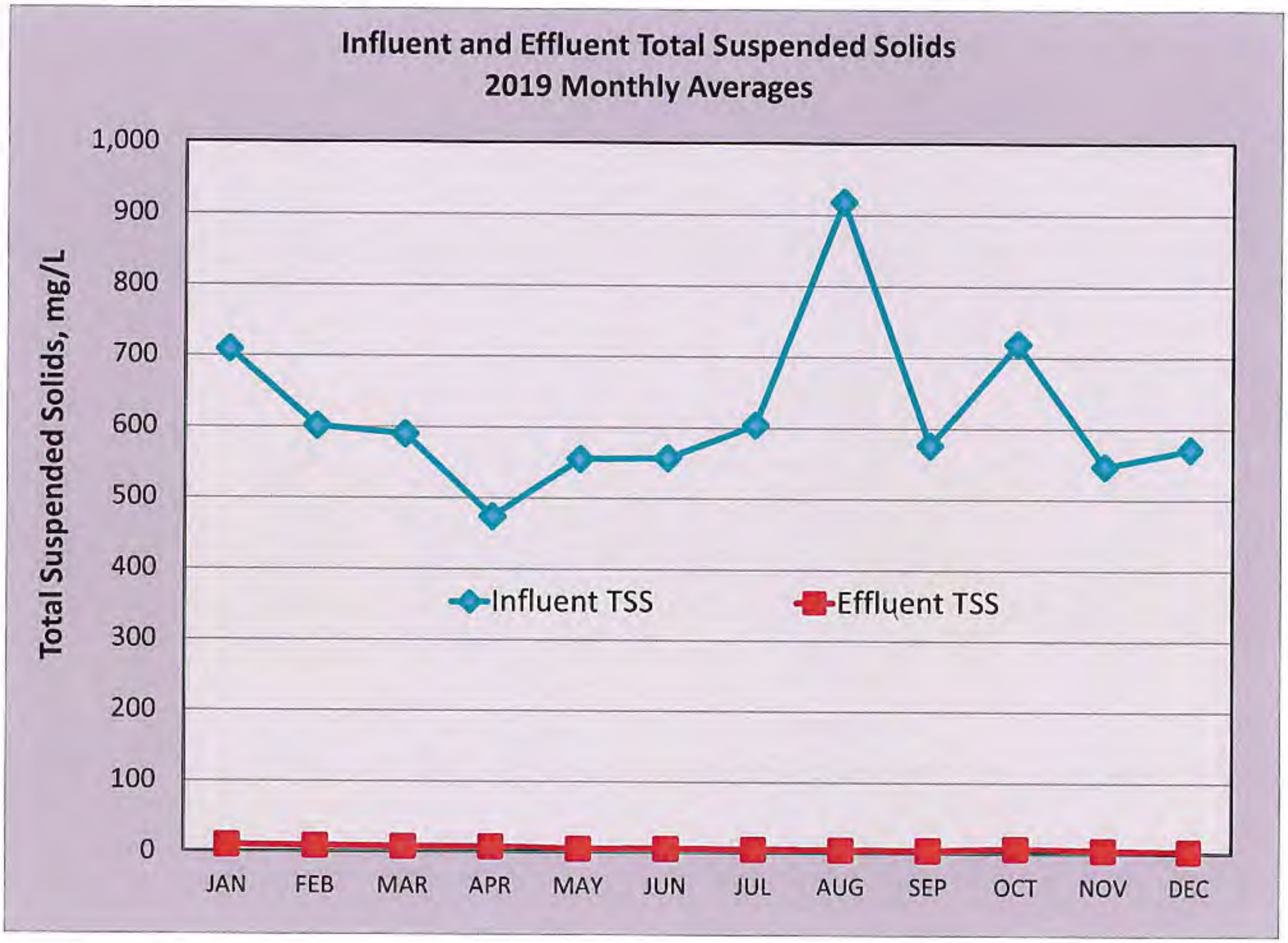
NL = No Limit

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 618 mg/L for the year an increase of about 26% from the 2018 annual average of 459 mg/L. Figure 2-3 shows a fluctuation in concentration of suspended solids that occurred during the year. The treatment process reduced the concentration of total suspended solids in the effluent to an annual average of 6.2 mg/L which is a slight increase from the 6.1 mg/L average of 2018.

All effluent 30-day monthly averages were well below the 30-mg/L monthly average limitation. Overall removal efficiency for the year was an average of 98.6 percent, see Table 2-1.

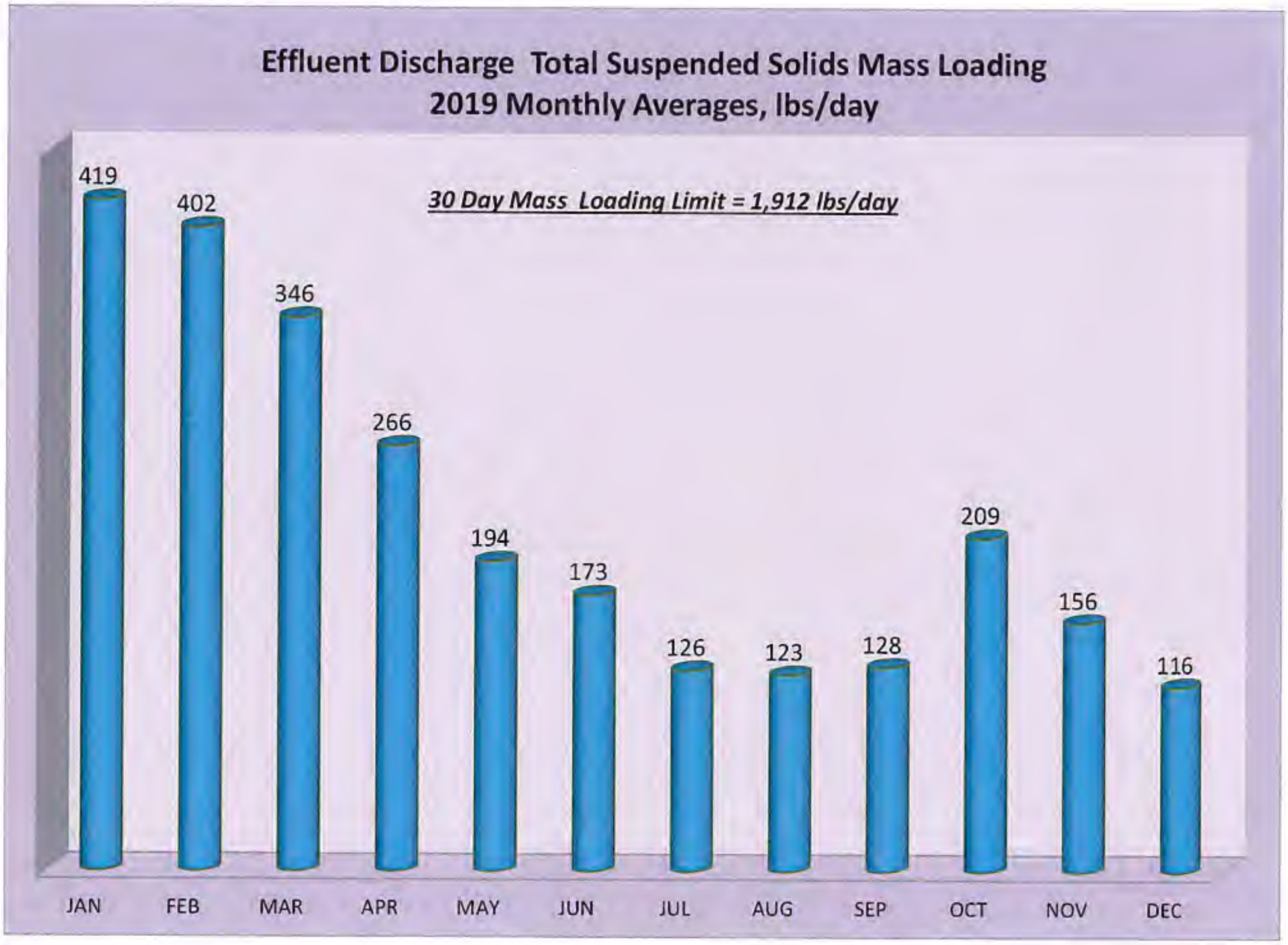
Figure 2-3. Influent and Effluent Total Suspended Solids 2019 Monthly Averages



Average monthly suspended solids mass loading rates for 2019 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 2019 occurred in January at a high of 419 lbs/day, which is approximately 22 percent of the permitted 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, 2019 Monthly Averages, lbs/day



Biochemical Oxygen Demand

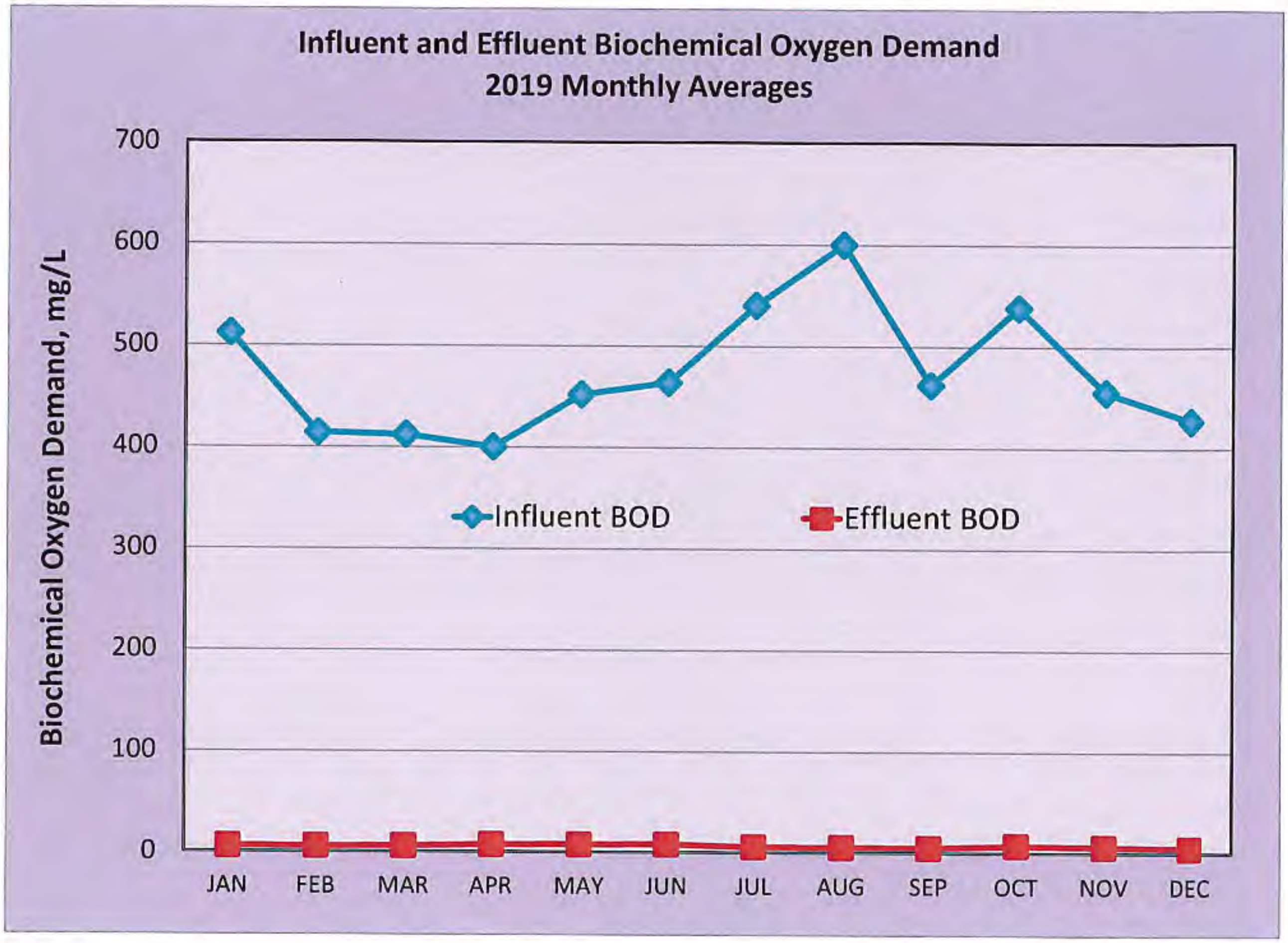
Biochemical oxygen demand (BOD) levels were measured on 24 hour composite samples of the influent and effluent, at least monthly and five days per week, respectively.

During 2019 influent BOD averaged 473 mg/L showing an increase of 11% from the annual influent average of 423 for 2018. The influent BOD varied throughout the year, ranging from a monthly average low of 400 mg/L in April to a high of 600 mg/L in August.

A small variation in the monthly average final effluent BOD concentration was observed throughout the year with the annual average of 6.5 mg/L and the range extending from a low of 5.0 in December to a high of 8.1 in June, (Table 2-1). The difference between influent and effluent BOD represents an overall removal rate of 98.6 percent.

The NPDES R3-2017-0021 permit limits are an 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 2019 Monthly Averages



In 2019, all effluent BOD mass emission values were below all limitations. The maximum monthly average mass emission was 293 lbs/day for May. The mass emission limit is based on average dry weather flow (ADWF) and is a limit that only applies to dry weather flows (DWF). There is no limit for mass emissions on wet weather flows. The mass emissions limits 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 2019.

Table 2-2. Monthly Averages of Effluent Parameters, Goleta Sanitary District, 2019

	pH		Turbidity	Settleable Solids	Oil and Grease		Toxicity Chronic
	Influent	Effluent	Effluent	Effluent	Effluent	Mass Emission	Effluent
Month	SU	SU	NTU	mL/L/hr	mg/L	lbs/day	TUc
January	7.8	6.9	2.6	0.32	3.7	158.4	3.1
February	7.6	6.9	2.2	0.15	3.7	166.3	
March	7.7	7.0	2.6	0.17	3.7	155.5	
April	7.8	6.9	2.5	0.19	3.2	112.9	10.0
May	7.7	7.1	1.5	0.13	3.7	135.0	
June	7.7	7.1	1.3	0.13	3.7	113.1	
July	7.6	6.9	1.1	0.12	3.7	100.4	10.0
August	7.5	7.2	1.0	0.10	3.7	93.2	
September	7.7	7.2	1.3	0.10	7.2	211.4	
October	7.7	7.2	2.0	0.10	3.7	112.4	
November	7.8	7.3	1.8	0.10	3.7	122.8	17.9
December	7.7	7.1	1.3	0.10	3.7	136.9	
Average	7.7	7.1	1.8	0.14	4.0	134.9	10.3
Limit	NL	6 to 9	75	1.0	25	1590	123

NR = Not-Required NL = No Limit

Hydrogen-Ion Concentration (pH)

Influent pH was monitored weekly 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 7.7 units for the year; effluent pH averaged 7.1 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 2019.

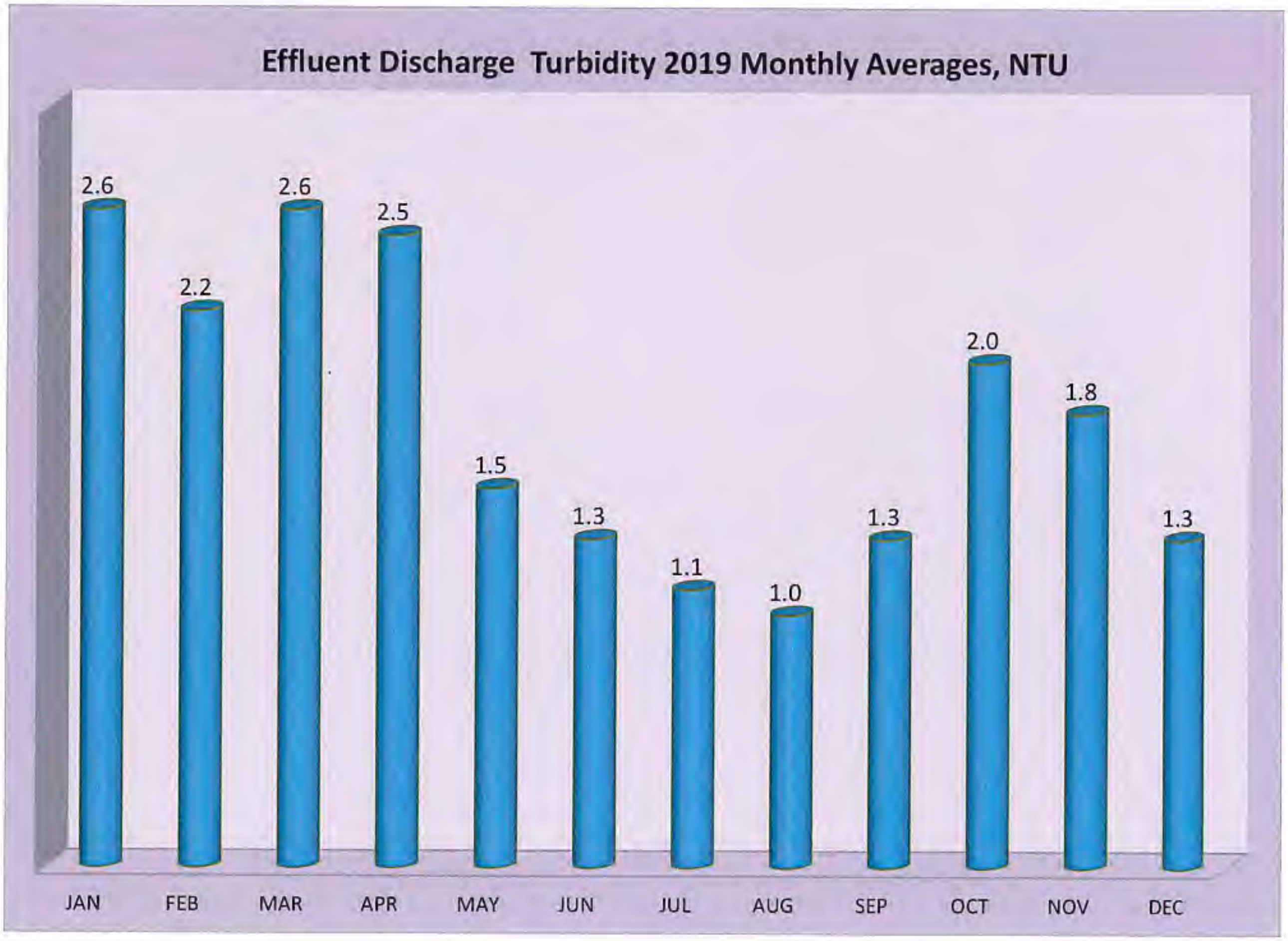
Ammonia

The effluent was monitored once during October by a certified commercial laboratory, to determine the concentration of ammonia. 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. However, the measured ammonia concentration of the effluent was 29 mg/L.

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, 4.8 NTU, occurred on January 7 which was still well below the effluent limits. Monthly averages ranged from a low of 1.0 NTU to a high of 2.6 NTU. All values were significantly below their respective permit limitations.

Figure 2-6. Effluent Discharge Turbidity 2019 Monthly Averages, NTU



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. See Table 2-2.

Settleable Solids

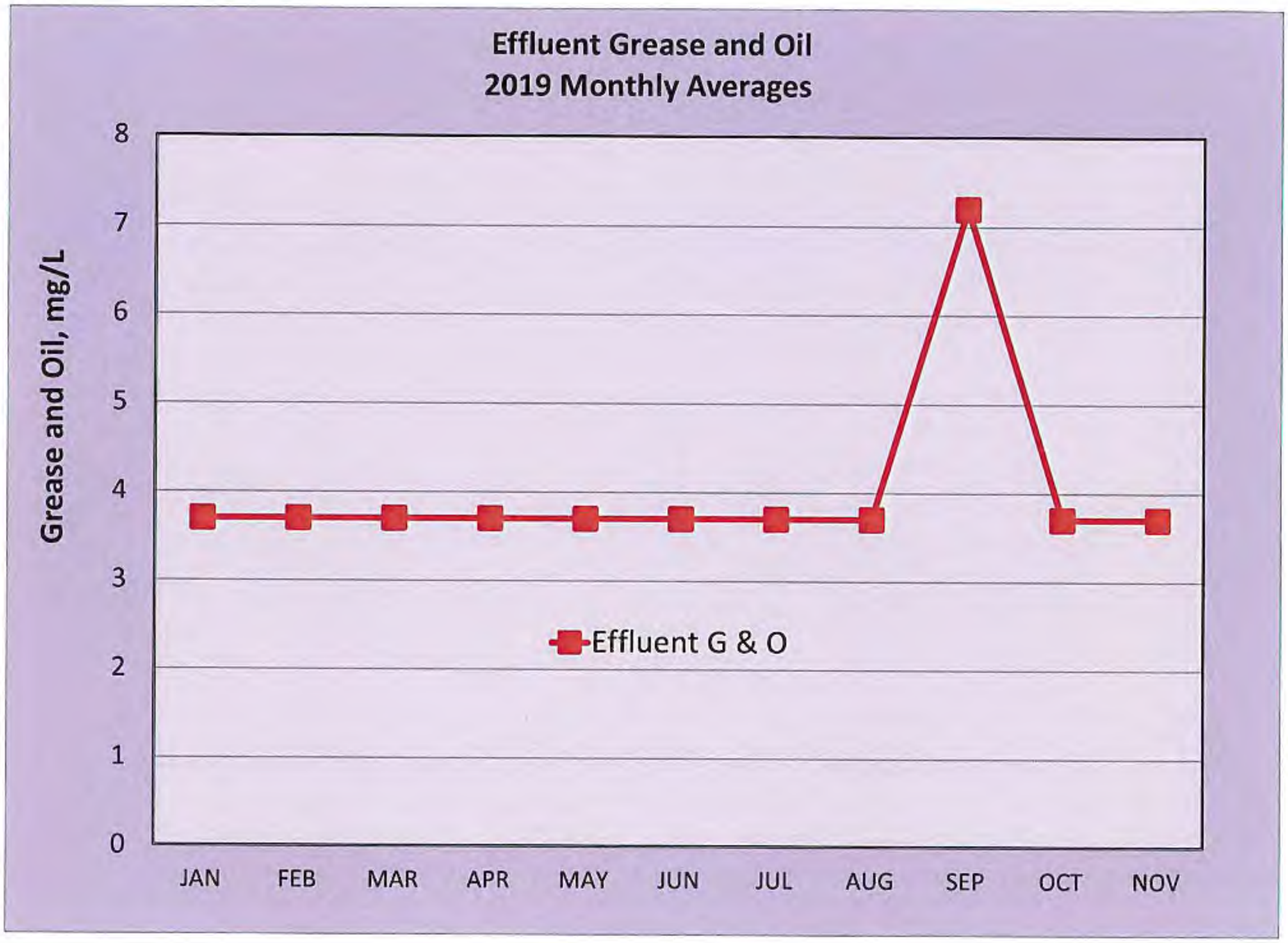
The effluent was monitored for settleable solids concentrations 5 days per week. The permit specifies that the monthly average, weekly average, and maximum at any time may not exceed 1.0 milliliters/liter/hour (ml/L/hr), 1.5 ml/L/hr, and 3.0 ml/L/hr, respectively. Monthly averages ranged from 0.10 ml/L/hr to 0.32 mL/L/hr. The maximum value at any time was 0.62 mL/L/hr which occurred on the 7th of January. All values were well below their respective permit limitations.

Oil and Grease

Effluent oil and grease were monitored weekly. 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.

Effluent grease and oil concentrations were very low and consistent during 2019. All monthly, weekly, and maximum permit limits were met. Mass emissions values ranged from a monthly average low of ≤ 93.2 lbs/day in August to a high of 211 lbs/day in September. Both are well below the permit limitation of 1,590 lbs/day. Monthly average oil and grease concentrations in the effluent ranged from 7.2 mg/L to <3.7 mg/L which is below the method detection limit. A sample was sent to a certified commercial laboratory due to an analysis equipment problem during April. The commercial laboratory method detection limit for the analysis is 1.4 mg/L which reduced the result average for the month. See Table 2-2 for a visual representation of the monthly average results. All permit limitations for effluent oil and grease were met during 2019.

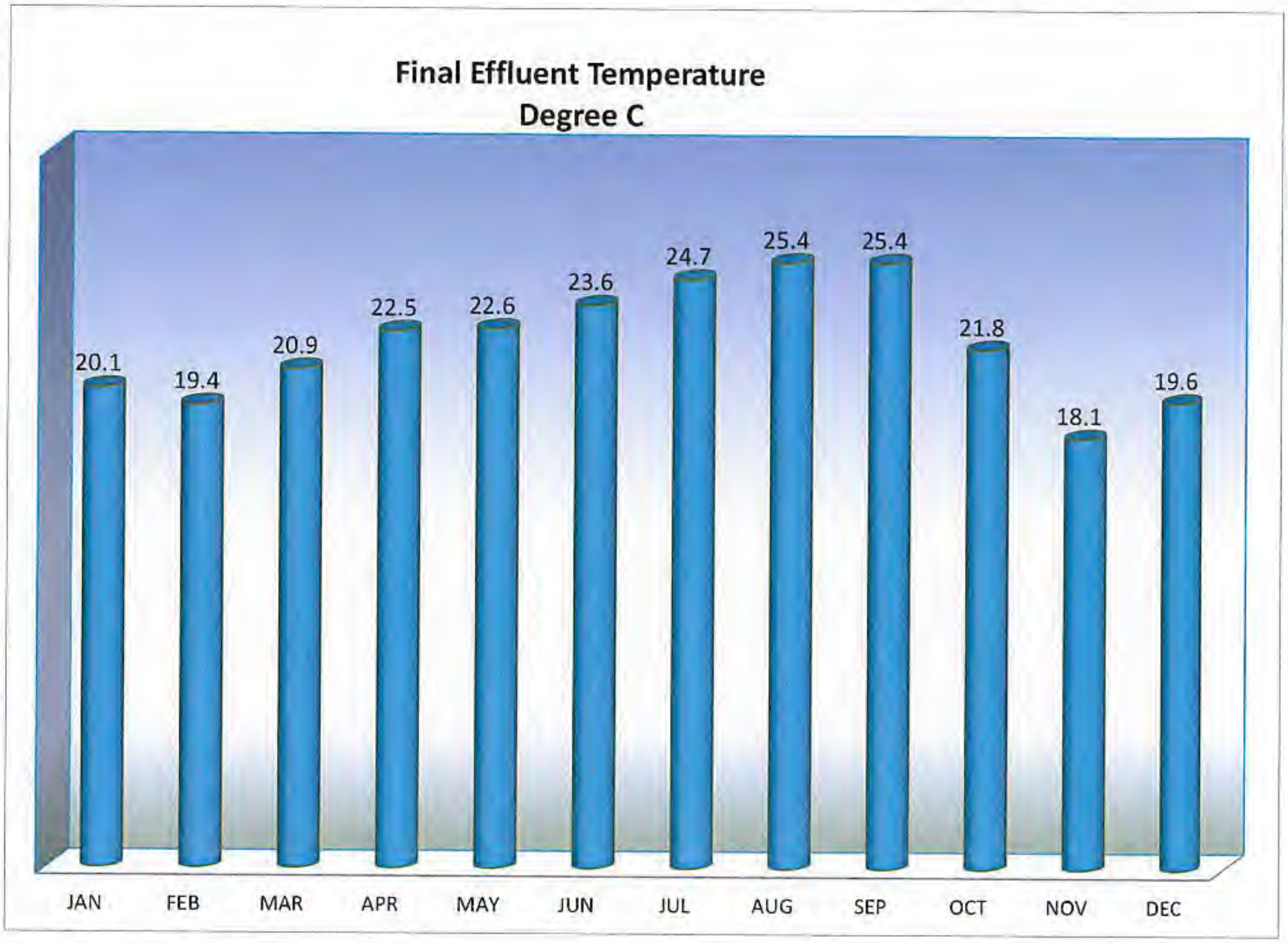
Figure 2-7. Effluent Grease and Oil 2019 Monthly Averages



Temperature

Effluent temperature was sampled five days per week throughout 2019. The data reflect a typical response to seasonal changes (Figure 2-8). The coolest temperatures occurred during November with average monthly temperatures of 18.1 ° C. A warming trend continued throughout the summer and fall months to reach a monthly averaged high of 25.4 ° C in August and September. As expected, the year ended with a cooling trend during November and December.

Figure 2-8. Effluent Discharge Temperature 2019 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 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 5.3 mg/L during 2019. The average monthly values are reported in Table 2-3.

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 the majority of the year. The monthly average values are shown in Table 2-3.

Effluent Bacteria

The effluent was analyzed five days a week for total coliforms, fecal coliforms and enterococcus bacteria. The permit specifies that effluent limits will apply if the Executive Officer concludes that the discharge consistently exceeds receiving water limitations. 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 13.0 to 6,162.1 MPN/100 mL for total coliform, from 1.8 to 46.8 MPN/100 mL for fecal coliform, and 1.1 to 813.9 MPN/100 mL for enterococcus. The monthly mean values presented below illustrate that the results were relatively low throughout the year, thereby demonstrating the effectiveness of the chlorination process.

Table 2-3. Chlorine and Bacteria Monthly Averages, 2019

Month	Chlorine at the end of the CCC	Chlorine after Dechlorination	Total Coliform	Fecal Coliform	Enterococcus
	mg/L	mg/L	MPN/100mL		
January	5.4	0.22	6,162.1	46.8	339.3
February	6.7	< 0.05	329.6	5.8	16.9
March	6.6	< 0.05	13.0	1.8	34.8
April	8.8	< 0.05	26.3	2.1	813.9
May	4.9	< 0.05	22.8	1.9	4.2
June	4.6	< 0.05	110.2	2.5	3.0
July	4.3	< 0.05	23.6	2.0	1.4
August	4.5	< 0.05	219.0	3.3	1.2
September	4.4	< 0.05	53.4	3.8	1.6
October	4.5	< 0.05	122.6	4.9	111.6
November	4.5	< 0.05	259.9	8.9	1.1
December	4.5	< 0.05	84.9	6.6	21.3

Priority Pollutants and Metals

The NPDES permit requires priority pollutant and metals analyses to be performed on the final effluent composite samples annually. Compounds detected in the final effluent samples are presented in Table 2-4; 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. Fifteen compounds were detected 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 2-4. Detected Priority Pollutants and Metals, Goleta Sanitary District, 2019

Parameter, units	Effluent, ug/L
Ammonia	29,000
Antimony	0.87
Arsenic	0.66
Bis (2-chloroethyl) Ether	0.12
Beryllium	< 0.056
Cadmium	< 0.60
Chromium	0.64
Chromium III	0.64
Copper	9.3
Diethyl Phthalate	74
Dimethyl Phthalate	0.76
Lead	< 0.32
Nickel	2.9
Mercury	< 0.14
Selenium	0.50
Silver	< 0.042
TCDD, equivalents, pg/L	0
Thallium	< 0.047
Zinc	37
Radioactivity, Gross Alpha pCi/L	0.839
Radioactivity, Gross Beta pCi/L	21.1
o-Xylene	0.15
ND = Not Detected	

DISCHARGE COMPLIANCE

Throughout 2019 the wastewater discharge from Goleta Sanitary District complied with all applicable permit effluent limitations. 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 2019. 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 7 of this report. Copies of the outfall dive on DVDs are available at the District for review.

CHAPTER 3

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 2019 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 2019 Spills

Lift Station Overflows

There were no lift station overflows that occurred within the Goleta Sanitary District service area during 2019.

Collection System Overflows

There was one (1) Collection System Overflow in 2019. On September 27, 2019, the CS crew responded to an SSO at 301 Mentor Drive in the City of Goleta. Construction debris had created a blockage in the sewer main line and resulted in a two hundred (200) gallon spill onto the public road. The sewer main line was cleaned and CCTV inspected to verify that the debris was removed. The spill area was cleaned and the sewer line was flagged for follow up periodic inspections.

Discussion

The Goleta Sanitary District's wastewater collection system management plan has been completed and complies with all of the requirements of MRP No. R3-2017-0021. 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.

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 physio-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 Project Field Operations Manual* (SCCWRP 2018).

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. If 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 was conducted on September 27th, 2019 under overcast skies, and calm to moderate conditions (Table 4-1). Wave height was two feet from the southwest and winds were five knots from the southwest.

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, except at B1 where they were composed of silt and clay. Surface color was brown, except at B1 where sediments were olive green. There was no odor detected in the sediments at any of the six stations.

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 station B5 which was characterized as fine sand and B1 which was characterized as coarse silt. Median particle sizes ranged from 51 to 133 µm.

4.3.2.3. Sorting Index & Percent Fines

Particle distributions ranged from very poorly sorted at station B1 to moderately well sorted at B6. Sorting indices ranged from 0.69 at B6 to 2.32 at B1 (Table 4-3). The percent fine sediments ranged from 8% at station B6 to 47% 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 47% at Goleta Point station B1 to 8% at station B6 furthest east of the outfall. These results were very similar to previous survey 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.

The gradient in particle sizes from Goleta Point at station B1 to reference station B6 is evidence 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
Date	27-Sep-19	27-Sep-19	27-Sep-19	27-Sep-19	27-Sep-19	27-Sep-19
Time	8:32	9:11	9:39	10:21	10:48	11:40
Research Vessel	*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
Dist. From Outfall (m)	1500	500	250	25	25	3000
Direc. From Outfall (°M)	270	270	270	270	90	90
Depth (m)	29.8	27.1	26.8	26.6	28.8	16.2
Latitude (N)	34.39924	34.40190	34.40196	34.40198	34.40219	34.40520
Longitude (W)	119.84107	119.83076	119.40197	119.82552	119.82464	119.78852
Weather	Overcast	Overcast	Overcast	Overcast	Overcast	Overcast
Tide	Incoming	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing
Swl. Ht. (ft)	2	2	2	2	2	2
Swl. Dir.	SW	SW	SW	SW	SW	SW
Wind Sp. (Kn)	5	5	5	5	5	5
Wind Dir.	SW	SW	SW	SW	SW	SW

Table 4-2. Sediment grab descriptions.

Station	Rep	Penetration (cm)	Surface Description	Surface Color	Odor	Analysis
B1	1	11.0	Silt/Clay	Olive Green	None	Biology
B1	2	10.5	Silt/Clay	Olive Green	None	Biology
B1	3	14.0	Silt/Clay	Olive Green	None	Biology
B1	4	10.0	Silt/Clay	Olive Green	None	Chemistry
B1	5	15.0	Silt/Clay	Olive Green	None	Biology
B1	6	11.5	Silt/Clay	Olive Green	None	Biology
B2	1	13.5	Fine Sand	Brown	None	Biology
B2	2	13.0	Fine Sand	Brown	None	Biology
B2	3	13.0	Fine Sand	Brown	None	Chemistry
B2	4	14.5	Fine Sand	Brown	None	Biology
B2	5	12.5	Fine Sand	Brown	None	Biology
B2	6	12.5	Fine Sand	Brown	None	Biology
B3	1	12.0	Fine Sand	Brown	None	Biology
B3	2	10.0	Fine Sand	Brown	None	Biology
B3	3	12.0	Fine Sand	Brown	None	Biology
B3	4	13.5	Fine Sand	Brown	None	Chemistry
B3	5	10.0	Fine Sand	Brown	None	Biology
B3	6	12.0	Fine Sand	Brown	None	Biology
B4	1	10.0	Fine Sand	Brown	None	Biology
B4	2	11.0	Fine Sand	Brown	None	Biology
B4	3	9.5	Fine Sand	Brown	None	Biology
B4	4	11.5	Fine Sand	Brown	None	Chemistry
B4	5	12.0	Fine Sand	Brown	None	Biology
B4	6	10.5	Fine Sand	Brown	None	Biology
B5	1	7.0	Fine Sand	Brown	None	Chemistry
B5	2	10.5	Fine Sand	Brown	None	Biology
B5	3	9.5	Fine Sand	Brown	None	Biology
B5	4	11.5	Fine Sand	Brown	None	Biology
B5	5	9.5	Fine Sand	Brown	None	Biology
B5	6	12.0	Fine Sand	Brown	None	Biology
B6	1	10.0	Fine Sand	Brown	None	Biology
B6	2	9.0	Fine Sand	Brown	None	Biology
B6	3	10.5	Fine Sand	Brown	None	Chemistry
B6	4	12.0	Fine Sand	Brown	None	Biology
B6	5	9.5	Fine Sand	Brown	None	Biology
B6	6	9.0	Fine Sand	Brown	None	Biology

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

Station	Median (microns)[1]	Category	Sorting Index[2]	Sorting	% Fines
B1	51	coarse silt	2.32	very poorly sorted	47
B2	71	very fine sand	1.95	poorly sorted	35
B3	95	very fine sand	1.72	poorly sorted	26
B4	115	very fine sand	1.89	poorly sorted	26
B5	133	fine sand	0.80	moderately sorted	12
B6	107	very fine sand	0.69	moderately well sorted	8

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.

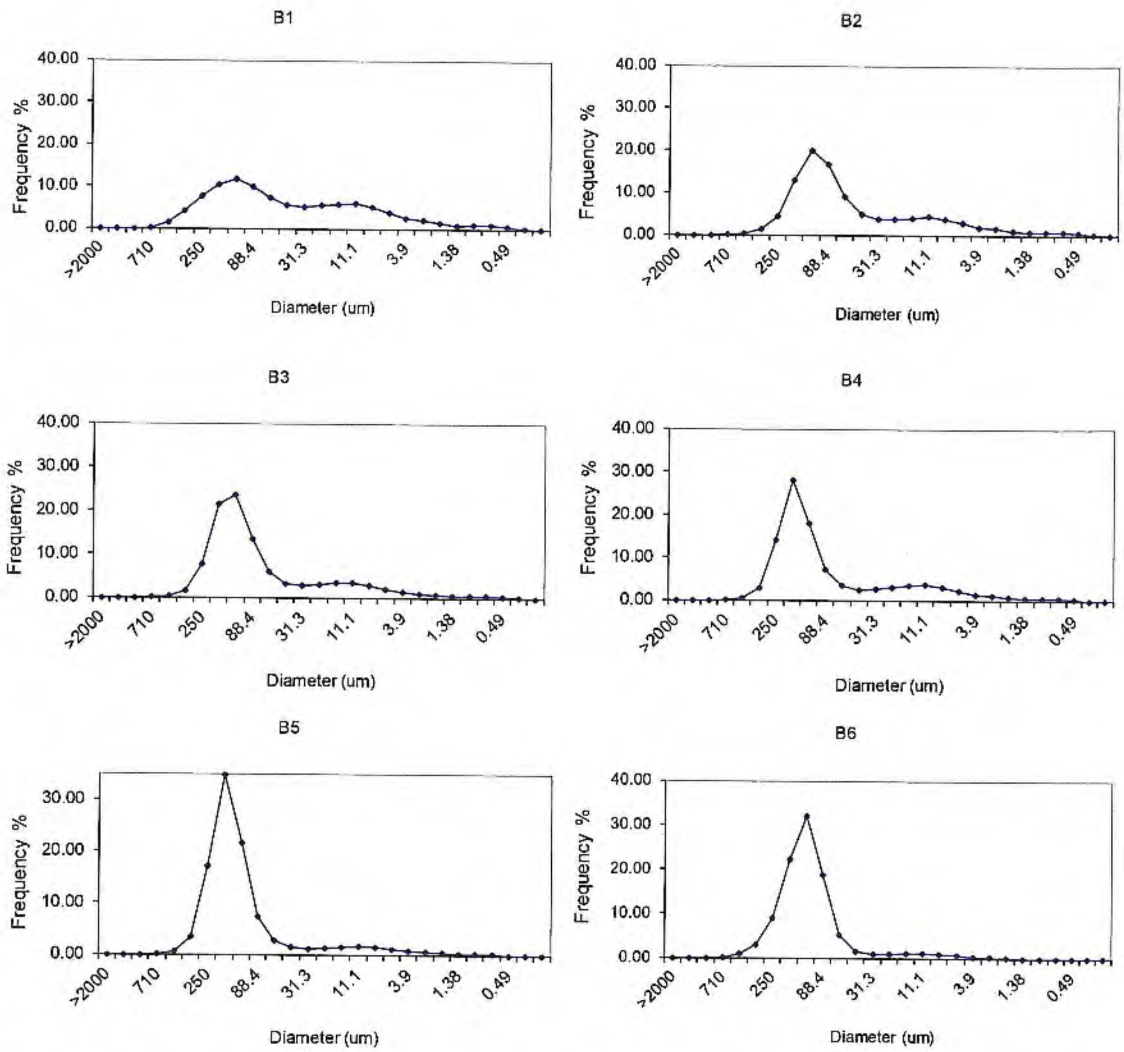


Figure 4-1. Particle size frequency (%) at each station in the Goleta survey area.

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 chemistry 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 ($0.05 < p \leq 0.10$) and expected (negative) or unexpected (positive). 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, 2019 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 2018). 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, 2008 and 2013. 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 10^{th} percentile and median (50^{th}) percentile were identified. The lower 10^{th} 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, and are presented in the appendices. 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 5-2 and 5-3 compare the Goleta sediment chemistry results with the 1998, 2003, 2008 and 2013 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 each constituent were greatest at Station B1 near Goleta Point and decreased toward Station B6. Oil and grease was greatest at Station B1 offshore Goleta Point (654 µg/g) and decreased toward the outfall with the lowest concentration measured at outfall station B5 (141 µg/g). Total Kjeldahl nitrogen (TKN) concentrations were greatest at B1 and B2, (571 and 563 ug/g, respectively) and was least at station B6 (220 ug/g). TOC concentrations were greatest at B2 (9,900 ug/g) and least at B6 (3,400 ug/g). Acid volatile sulfide (AVS) was greatest at B6 (20.8 ug/g) and least at B3 (2.93 ug/g).

Each of the undifferentiated organics correlated unexpectedly (increased) with distance from the outfall. Of these correlations with distance to the outfall, only oil and grease was significant ($p < 0.05$). All the undifferentiated organics correlated expectedly with distance to Goleta Point, except AVS. TKN and TOC were significant. Each constituent correlated unexpectedly with particle size and TKN 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 high in 2011, dropped to background levels in 2012 and remained low in 2019. Concentrations of TKN, TOC and acid volatile sulfides were variable in 2019, but within range of the past 20 years with no sustained increasing or decreasing trends evident. AVS concentrations increased from 2010 to 2017 but decreased in 2019.

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, 2008 and 2013 (Table 5-2 and 5-3). O&G, TKN and AVS were not measured during these surveys. Average TOC concentrations in the Goleta survey area were greater than several of the concentrations measured during the Bight 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 and concentrations were, for the most part, greatest at B1 and decreased toward B6. None of the 14 metals correlated significantly with distance from the outfall. Each of the fourteen metals correlated expectedly and significantly with distance to Goleta Point ($p < 0.05$), except arsenic, cadmium and chromium which were not significant. Each metal correlated unexpectedly and significantly with particle size.

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, 2008 and 2013 (Tables 5-2 and 5-3). Of the metals where comparisons could be made, several slightly exceeded concentrations measured in other surveys (aluminum, arsenic, cadmium, chromium, copper, nickel, selenium and zinc).

5.3.2.4 Heavy Metals Compared with NOAA Effects Range Thresholds

Metals concentrations measured at each station in the Goleta survey area during 2019 were compared to the ER-L and ER-M threshold values (Table 5-2). 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

Chlorinated 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 detected at each station and were greatest at Goleta Point (9.0 ng/g) and least at outfall station B5 (1.8 ng/g). Other chlorinated hydrocarbons were below detection, except chlordane which was measured in low concentrations at B1, B2 and B3 (range = 0.6 to 0.8 ng/g). Total PCBs were greatest near Goleta Point at B2 (12.02 ng/g) and were below detection at B5 near the outfall and B6. Aroclor was below detection at all sites except B2.

Similar to past years, total PAHs were above detection at each site in the survey area, with concentrations ranging from 128.51 ug/Kg at station B1 to 4.95 ug/Kg at station B6. Total PAHs correlated unexpectedly and insignificantly with the distance to the outfall; expectedly and significantly with distance from Goleta Point; and, unexpectedly and significantly with particle size.

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 2019 survey were compared to concentrations found during three southern California reference site surveys conducted in 1998, 2003, 2008 and 2013 (Table 5-2). Each of these groups of organic compounded exceeded concentrations measured during past Bight surveys and strata.

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 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 greatest near Goleta Point and decreased toward the outfall, similar to many previous surveys (Aquatic Bioassay 1997 to 2017). Of the fourteen metals measured, nearly all correlated unexpectedly and non-significantly with distance to the outfall. Most metals correlated expectedly and significantly with distance to Goleta Point and unexpectedly and significantly with particle size.

Of the complex organic compounds measured, total DDTs, PCBs and PAHs were above detection at most of the six stations. 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 2019 were within the ranges of past years. Metals and organic contaminants remained low in 2019. Total DDTs were within the range of past years.

This year's results were compared to sediment contaminant concentrations measured during the 1998, 2003, 2008 and 2013 SCBRMP surveys on the inner shelf (depth < 30m) and near SPOTWs (SCBRMP 1998, 2003, 2008 and 2013). Of the metals where comparisons could be made, several slightly exceeded concentrations measured in other surveys (aluminum, arsenic, cadmium, chromium, copper, nickel). Concentrations of each group of organics were, on several occasions, greater 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 2019 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 2019 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 slightly greater than 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								Correlations		
	B1	B2	B3	B4	B5	B6	Mean	S.D.	Outfall	Point	Prt.Sz.
Undifferentiated Organics											
Oil and Grease (detention = 100 µg/g)[3]	654	302	208	266	141	329	317	179	**0.84**	-0.37	0.43
TKN (detection = 0.6 µg/g)[3]	571	563	402	418	282	220	409	143	0.03	**-0.94**	**1.00**
TOC (detection = 100 µg/g)[3]	9800	9900	6400	5100	3500	3400	6350	2929	0.06	**-0.94**	**0.89**
AVS (detection = 0.05 µg/g)[3]	20.80	7.45	2.93	11.50	18.50	18.20	13.23	7.10	0.20	0.03	0.09
Heavy Metals											
Aluminum (detection = 1.0 µg/g)[3]	13500	12600	10100	8790	6650	6100	9623	3035	0.12	**-1.00**	**0.94**
Antimony (detection = 0.025 µg/g)[3]	0.26	0.20	0.16	0.15	0.12	0.11	0.166	0.055	0.12	**-1.00**	**0.94**
Arsenic (detection = 0.025 µg/g)	6.76	6.49	6.12	5.94	4.22	3.88	5.57	1.21	-0.38	**-0.80**	**0.94**
Cadmium (detection = 0.0025 µg/g)	0.48	0.51	0.41	0.36	0.34	0.35	0.41	0.07	-0.08	-0.59	**0.87**
Chromium (detection = 0.0025 µg/g)	36.30	35.40	29.30	27.50	22.60	20.90	28.67	6.36	-0.23	-0.78	**0.97**
Copper (detection = 0.0025 µg/g)[3]	6.97	7.03	5.19	4.85	3.11	2.37	4.92	1.92	0.06	**-0.94**	**0.89**
Iron (detection = 1.0 µg/g)[3]	13000	12900	10400	9910	7300	6390	9983	2753	0.12	**-1.00**	**0.94**
Lead (detection = 0.0025 µg/g)[3]	5.44	5.28	4.43	4.47	3.27	2.61	4.25	1.11	0.03	**-0.94**	**1.00**
Mercury (detection = 0.00001 µg/g)	0.0255	0.0236	0.0217	0.0207	0.0150	0.0137	0.020	0.005	-0.31	**-0.82**	**0.97**
Nickel (detection = 0.01 µg/g)[3]	19.60	19.80	15.20	14.10	11.10	10.10	14.98	4.11	0.06	**-0.94**	**0.89**
Selenium (detection = 0.025 µg/g)[3]	0.50	0.38	0.40	0.36	0.30	0.21	0.36	0.10	0.06	**-0.94**	**0.83**
Silver (detection = 0.01 µg/g)[3]	0.23	0.12	0.10	0.09	0.07	0.05	0.11	0.06	0.12	**-1.00**	**0.94**
Tin (detection = 0.025 µg/g)	0.95	0.84	0.77	0.70	0.56	0.48	0.72	0.17	-0.27	**-0.86**	**0.99**
Zinc (detection = 0.025 µg/g)[3]	36.40	36.20	29.00	27.30	21.00	18.30	28.03	7.51	0.12	**-1.00**	**0.94**
Complex Organics (ng/g dry weight)[2]											
Chlorinated Pesticides											
DDTs[3]	9.0	2.6	3.9	2.0	1.8	2.4	3.58	2.73	0.58	**-0.77**	0.60
HCHs	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00
Chlordane[3]	0.8	0.5	0.6	0.0	0.0	0.0	0.32	0.36	0.34	**-0.88**	0.70
Aldrin (detection = 0.25 µg/Kg)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00
Dieldrin (detection = 0.1 µg/Kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.10	0.00	0.00	0.00	0.00
Heptachlor (detection = 0.25 µg/Kg)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00
Heptachlor epoxide (detection = 0.25 µg/Kg)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00
Mirex (detection = 0.25 µg/Kg)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00
Hexachlorobenzene (detection = 1.0 µg/Kg)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	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

Constituent[1]	Sediment Stations								Correlations		
	B1	B2	B3	B4	B5	B6	Mean	S.D.	Outfall	Point	Prt.Sz.
Polychlorinated Biphenyls											
PCBs[3]	3.06	12.02	0.86	0.95	0.00	0.00	2.81	4.64	0.10	**-0.87**	**0.93**
Aroclors[3]	0.00	14.00	0.00	0.00	0.00	0.00	2.33	5.72	0.13	-0.39	0.39
Polycyclic Aromatic Hydrocarbons											
PAHs[3]	128.510	79.260	51.808	21.302	38.952	4.949	54.13	44.49	0.12	**-0.94**	**0.83**
1-Methylnaphthalene (detection = 0.084 µg/Kg)[3]	1.980	1.470	1.040	0.577	0.481	0.248	0.97	0.66	0.12	**-1.00**	**0.94**
1-Methylphenanthrene (detection = 0.076 µg/Kg)[3]	3.920	1.040	1.020	0.076	0.651	0.076	1.13	1.43	0.25	**-0.90**	**0.75**
2,3,5-Trimethylnaphthalene (detection = 0.059 µg/Kg)[3]	2.370	1.630	1.780	0.871	1.030	0.157	1.31	0.78	0.06	**-0.89**	0.71
2,6-Dimethylnaphthalene (detection = 0.065 µg/Kg)[3]	5.630	2.620	2.270	1.400	0.871	0.363	2.19	1.86	0.12	**-1.00**	**0.94**
2-Methylnaphthalene (detection = 0.106 µg/Kg)[3]	3.020	1.990	2.000	0.885	0.757	0.521	1.53	0.97	0.06	**-0.94**	**0.83**
Acenaphthene (detection = 0.078 µg/Kg)[3]	0.773	0.429	0.078	0.078	0.078	0.078	0.25	0.29	0.45	**-0.85**	**0.85**
Benz[a]anthracene (detection = 0.107 µg/Kg)[3]	9.160	4.820	3.690	1.060	3.090	0.107	3.66	3.20	0.12	**-0.94**	**0.83**
Benzo[b]fluoranthene (detection = 0.063 µg/Kg)[3]	16.300	9.630	7.140	3.470	4.030	0.063	6.77	5.70	0.12	**-0.94**	**0.83**
Benzo[e]pyrene (detection = 0.098 µg/Kg)[3]	15.900	8.850	6.760	3.150	3.760	2.410	6.81	5.08	0.12	**-0.94**	**0.83**
Benzo[g,h,i]perylene (detection = 0.093 µg/Kg)[3]	10.700	7.040	5.210	2.510	2.770	0.093	4.72	3.78	0.12	**-0.94**	**0.83**
Biphenyl (detection = 0.092 µg/Kg)[3]	1.350	1.020	0.540	0.360	0.246	0.189	0.62	0.47	0.12	**-1.00**	**0.94**
Fluoranthene (detection = 0.035 µg/Kg)[3]	12.300	9.860	4.790	1.680	4.800	0.776	5.70	4.54	0.03	**-0.83**	**0.77**
Naphthalene (detection = 0.187 µg/Kg)[3]	2.460	2.190	1.020	0.439	0.444	0.663	1.20	0.90	0.64	**-0.77**	0.60
Perylene (detection = 0.114 µg/Kg)[3]	61.400	31.000	18.100	10.200	8.830	9.660	23.20	20.52	0.38	**-0.94**	**0.89**

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.

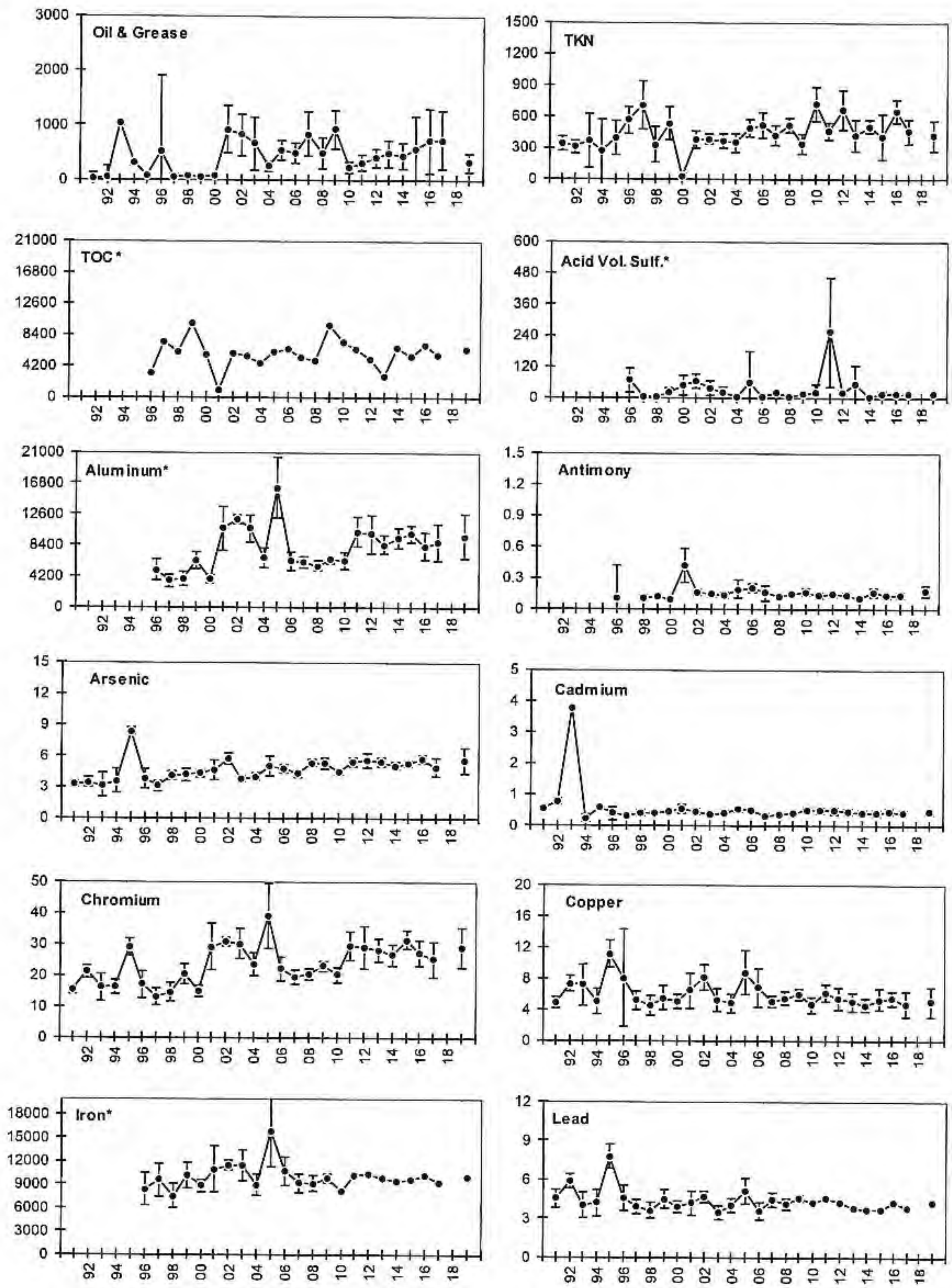


Figure 5-2. Average concentrations (±SD) of sediment contaminants measured between 1991 and 2019 in the Goleta survey area. TOC, acid volatile sulfide, aluminum, iron, selenium and tin were not measured from 1991 to 1995.

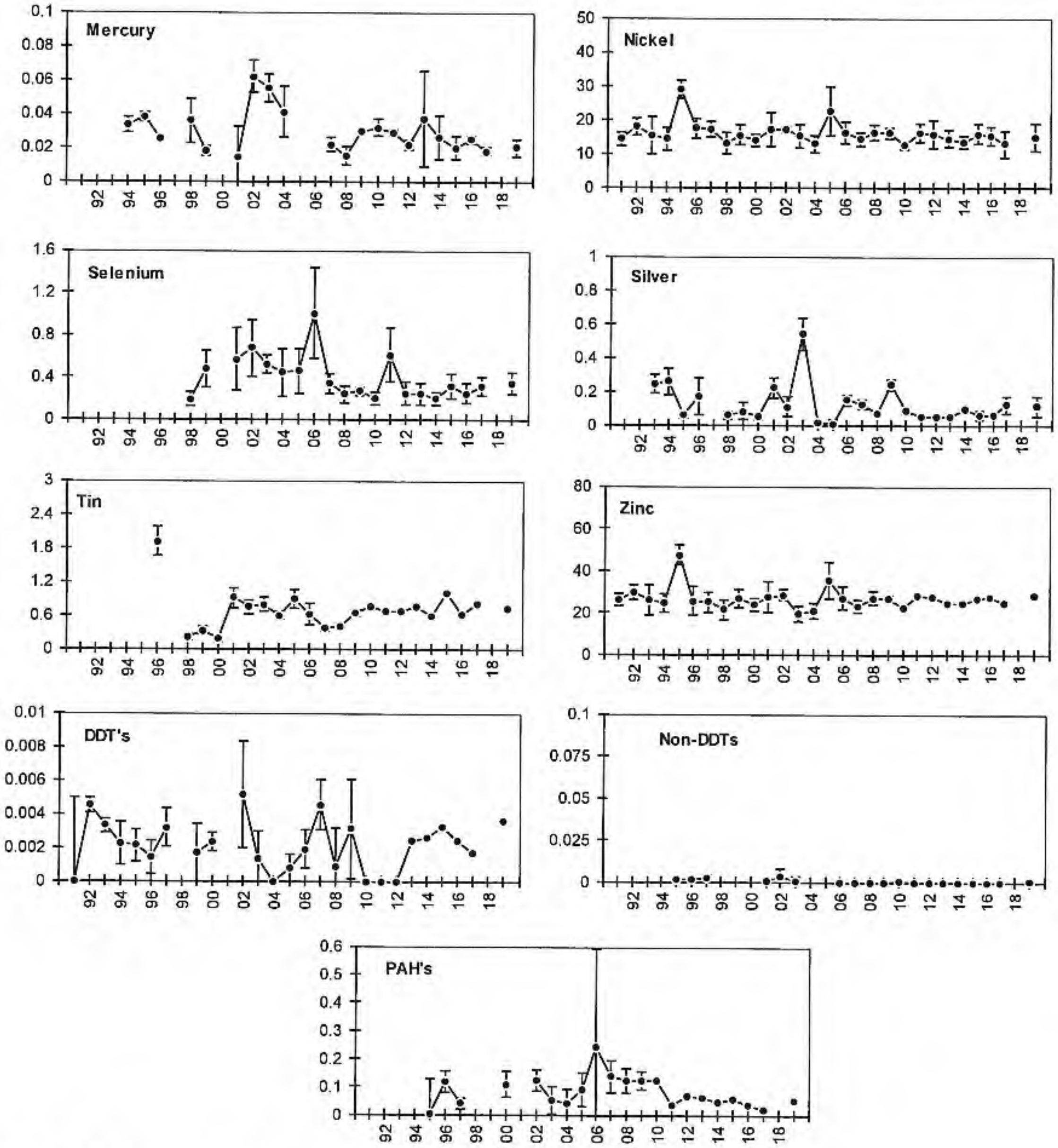


Figure 5-2. (continued)

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. Average concentrations in Goleta survey area exceeding reference concentrations are grayed.

Constituent	GOLETA S.D.		SCBRMP (2013)[1]				SCBRMP (2008)[2]				SCBRMP (2003)[3]				SCBRMP (1998)[4]		NOAA (1990)[5], Long,et.al. (1995)[6]	
			Inner Shelf		So Cal Bight		Inner Shelf		So Cal Bight		Inner Shelf		Small POTW		SPOTW	Shallow		
	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	317	141 - 654	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TKN	409	220 - 571	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOC	6350	3400 - 9900	2500	400	21000	3000	66000	4100	30000	100	2700	800.00	5400	1600	5500	4200	---	---
AVS	13.2	2.9 - 20.8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Heavy Metals																		
Aluminum	9623	6100 - 13500	7000	1000	20000	1594	5256	726	15372	1594	9212	2233	13244	3585	---	---	---	---
Antimony	0.17	0.11 - 0.26	0.43	0.11	0.90	0.15	0.12	0.02	0.28	0.04	0.14	0.04	0.15	0.02	1.09	1.59	2	25
Arsenic	5.57	3.88 - 6.76	2.4	0.3	4.00	0.50	4.3	1.2	6.70	1.20	4.2	1.4	4.6	0.67	7.67	4.39	8.2	70
Cadmium	0.41	0.34 - 0.51	0.66	0.11	1.30	0.30	0.23	0.03	0.86	0.12	0.20	0.06	0.22	0.05	0.28	0.36	1.2	9.6
Chromium	28.67	20.90 - 36.30	17	2.0	57.0	5.0	16	3.8	56.0	9.9	27	6.8	27	5.6	24.72	19.02	81	370
Copper	4.92	2.37 - 7.03	3.7	0.5	25.00	3.00	4.4	0.8	23.00	5.80	6.6	1.8	9.0	2.5	17.41	6.82	34	270
Iron	9983	6390 - 13000	11000	1000	25000	1100	10239	2233	26218	3125	12952	2784	16255	3655	---	---	---	---
Lead	4.25	2.61 - 5.44	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	0.020	0.014 - 0.026	0.04	0.02	0.089	0.020	0.02	0.01	1.600	2.800	0.03	0.01	0.05	0.03	0.050	0.036	0.15	0.71
Nickel	14.98	10.10 - 19.80	9.7	1.2	33.00	2.90	9	1.7	27.00	2.80	13	3.8	11	2.0	13.85	15.50	20.9	51.6
Selenium	0.36	0.21 - 0.50	0.07	0.02	1.30	0.40	0.44	0.11	3.50	2.60	0.69	0.22	0.55	0.12	0.97	0.47	---	---
Silver	0.11	0.05 - 0.23	0.22	0.31	0.41	0.11	0.12	0.06	0.91	0.40	0.13	0.06	0.14	0.06	0.12	0.19	1.0	3.7
Tin	0.72	0.48 - 0.95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Zinc	28.03	18.30 - 36.40	29	4.0	86.00	6.00	25	6.8	71.00	5.90	34	7.8	40	8.0	52.14	33.59	150	410
Complex Organics																		
DDTs	0.0036	0.0018 - 0.0090	0.0120	0.0150	0.1300	0.0680	0.0023	0.0004	0.1260	0.0970	0.0023	0.0004	0.0012	0.0002	0.020	0.036	0.00158	0.0461
HCHs	0.0000	0.0000 0.0000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Chlordane	0.0003	0.0000 - 0.0008	0.0000	0.0001	0.0002	0.0002	0.0005	0.0001	0.0016	0.0008	0.00001	0.00001	0.00000	0.00000	---	---	---	---
PCBs	0.0023	0.0000 - 0.0140	0.0006	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	0.0541	0.0049 - 0.1285	0.0240	0.0060	0.1200	0.0290	0.0512	0.0449	0.2860	0.0390	0.0512	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 Surveys?								Exceeds	
			2013 Inner Shelf	20013 So Cal Bight	2008 Inner Shelf	2008 So Cal Bight	2003 Inner Shelf	2003 SPOTW	1998 SPOTW	1998 Shallow	ER-L?	ER-M?
Oil and Grease	No	No	---	---	---	---	---	---	---	---	---	---
TKN	No	No	---	---	---	---	---	---	---	---	---	---
TOC	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	---	---
AVS	No	No	---	---	---	---	---	---	---	---	---	---
Aluminum	No	No	Yes	No	Yes	No	Yes	No	---	---	---	---
Antimony	No	No	No	No	Yes	No	Yes	Yes	No	No	No	No
Arsenic	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
Cadmium	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No	No
Chromium	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	No
Copper	No	No	Yes	No	Yes	No	No	No	No	No	No	No
Iron	No	No	No	No	No	No	No	No	---	---	---	---
Lead	No	No	No	No	No	No	No	No	No	No	No	No
Mercury	Yes	No	No	No	No	No	No	No	No	No	No	No
Nickel	No	No	Yes	No	Yes	No	Yes	Yes	Yes	No	No	No
Selenium	No	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	Yes	No	---	---	---	---	---	---	---	---	---	---
Zinc	No	No	No	No	Yes	No	No	No	No	No	No	No
DDTs	No	No	No	No	Yes	No	Yes	Yes	No	No	Yes	No
HCHs	No	No	---	---	---	---	---	---	---	---	---	---
Chlordane	No	No	Yes	Yes	No	No	Yes	Yes	---	---	No	No
PCB'S	No	No	Yes	No	Yes	No	No	Yes	No	No	No	No
PAH'S	No	No	Yes	No	Yes	No	Yes	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). 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*, 2018. 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 8.6. 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.

<u>Analysis of Variance (ANOVA).</u> 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.

<u>Cluster Analysis.</u> 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:

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

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 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 the six sediment stations.

Spatial infauna abundance patterns. Infauna abundances at the six sediment sampling stations are listed in Table 6-1. Individual abundances were significantly greatest by ANOVA at Goleta Point station B1 (average = 624), followed by outfall stations B4 (average = 600) and B5 (average = 600), and were least at station B6 (average = 403), furthest from the outfall to the east. Numbers of individuals correlated unexpectedly and non-significantly with distance from the outfall, unexpectedly and significantly with distance from Goleta Point, and unexpectedly and non-significantly with particle size.

Infauna abundance patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past thirty 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. In 2019 abundances were similar to 2017.

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, 2008 and 2013. Average numbers of individuals collected in the Goleta survey area (average = 525) were greater and well within the ranges measured at inner shelf reference sites 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 significantly ($p < 0.05$) greatest at station B1 near Goleta Point (average = 156) and decreased toward the east with lowest numbers of taxa found at station B6 (average = 96). Numbers of species correlated unexpectedly and significantly with distance from the outfall, unexpectedly and significantly with Goleta Point, and unexpectedly and 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 thirty 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 steadily increased to a high from 2006 to 2010 when it reached a historic high. Since 2011 the average number of species steadily declined thru 2014 (average = 101), before increasing through 2016. In 2017 the numbers of species declined before increasing again in 2019.

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, 2008 and 2013. The average for Goleta species counts in 2019 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 and Margalef's indices were uniformly elevated in the survey area and were significantly greatest at station B1 and decreasing gradually to lowest at station B6. Both Shannon's and Margalef's Diversity correlated significantly with distance to the outfall, but only Margalef's was significant. Both indices correlated expectedly and significantly with distance to Goleta Point and particle size. There was little change in Simpson Diversity across sites (range = 0.97 to 0.98).

Infauna diversity patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past thirty 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 2019. 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 2019, diversity declined to pre-2016 levels, but rebounded in 2019.

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, 2008 and 2013. Shannon Diversity measured in the Goleta survey area was greater in 2019 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 significantly greatest at B1 near the outfall (average = 47) and decreased toward station B2 (average = 29). Dominance correlated unexpectedly and non-significantly with distance from the outfall, unexpectedly and 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 thirty 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, before increasing again in 2019.

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, these 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 scores were similar across sites, ranging from 81 at B3 to 85 at outfall station B4. ITI values correlated expectedly and non-significantly with distance from the outfall, expectedly and non-significantly with distance from Goleta Point, and expectedly 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).

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 thirty years. Average ITI values have remained stable across years and were similar in 2019 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 unexpectedly (increased) and significantly with distance to the outfall, unexpectedly and significantly with distance to Goleta Point, and significantly with particle size (Table 6-1). Average BRI scores were significantly greatest by ANOVA at B1 near Goleta Point and were lower at the outfall stations and B1. Scores were below 31 at all six stations 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 2019 survey, rare species were excluded from the analysis so that 255 species that occurred at > three sites were retained for analysis (97% of the total number of individuals collected).

Stations clustered into four groups (Figure 6-2). The greatest Bray-Curtis distance between any two station nodes was approximately 60%, which indicates moderate differences in species abundances and composition between sites. Station group 1 included station B1, group 2 included stations B2 and B3, group 3 included outfall stations B4 and B5, and group four included only B6.

Of the twenty relatively abundant species collected in each cluster group, seven 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 4 (B6) had lower abundances, taxa richness, BRI and Shannon Diversity (Table 6-4). Station B6 is the site furthest away from the Goleta outfall and is considered the reference site by design. 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 impact 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 2019 survey showed they were greatest near Goleta Point and graded to least at station B6, the station furthest east from the outfall. This was in keeping with past surveys, when increased abundance, taxa and diversity were measured near Goleta Point. This may have may have been due to the increased availability of organic material emanating from the oil seeps that are present there (Pearson and Rosenberg 1978). 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 2019 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 (81) at station B3, to greatest at outfall station B4 (85). 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 Benthic Response Index (BRI) scores across all six sites were well 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 2019 survey were compared to results of past surveys at the same sampling locations established in 1990. Each of the metrics measured in 2019 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 60% different from one another based on infauna abundances and taxa composition. Of the top twenty most abundant species in the survey area, seven 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 2019 (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 (19%) 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, 2008 and 2013.

Although there are no specific numerical limitations regarding infauna animals, the California Ocean Plan (SWRCB 2012) 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	717	463	500	564	799	328
Repl. 2	556	383	387	506	368	455
Repl. 3	635	510	577	480	470	356
Repl. 4	626	307	554	628	673	425
Repl. 5	584	397	536	820	704	453
Mean =	624	412	511	600	603	403
Std. Dev. =	61	78	75	136	178	58
Lower Conf. Int. =	570	344	445	481	447	352
Upper Conf. Int. =	677	480	576	719	759	454
Overall Mean = 625		r (outfall)= **-0.32**		r (point) = **-0.46**		r (prt.sz.) = 0.21
Overall S.D. = 134		H^1 = **15.6**		Comp. of means = B1 > B4, B5 > B2, B6		
SPECIES [1]						
Repl. 1	163	133	132	120	144	83
Repl. 2	151	110	131	114	113	104
Repl. 3	154	136	128	117	127	92
Repl. 4	171	114	130	140	144	98
Repl. 5	139	130	138	157	147	103
Mean =	156	125	132	130	135	96
Std. Dev. =	12	12	4	18	15	9
Lower Conf. Int. =	145	114	128	113	122	88
Upper Conf. Int. =	166	135	135	146	148	104
Overall Mean = 128.8		r (outfall) = **-0.44**		r (point) = **-0.82**		r (prt.sz.) = **0.62**
Overall S.D. = 21.2		H^1 = **18.9**		Comp. of means = B1 > B2, B3, B4, B5 > B6		
SHANNON DIVERSITY						
Repl. 1	4.43	4.16	4.02	4.15	4.09	3.88
Repl. 2	4.30	4.00	4.23	3.88	4.08	4.04
Repl. 3	4.33	4.31	4.06	3.95	4.13	3.88
Repl. 4	4.44	4.19	4.14	4.14	4.12	3.95
Repl. 5	4.24	4.35	4.26	4.33	4.19	4.04
Mean =	4.35	4.20	4.14	4.09	4.12	3.96
Std. Dev. =	0.09	0.14	0.10	0.18	0.04	0.08
Lower Conf. Int. =	4.27	4.08	4.05	3.93	4.08	3.89
Upper Conf. Int. =	4.42	4.32	4.23	4.25	4.16	4.03
Overall Mean = 4.14		r (outfall) = -0.22		r (point) = **-0.71**		r (prt.sz.) = **0.69**
Overall S.D. = 0.16		H^1 = **16.0**		Comp. of means = B1 > B3, B4, B5, B6		
MARGALEF RICHNESS						
Repl. 1	24.64	21.51	21.08	18.78	21.40	14.16
Repl. 2	23.73	18.33	21.82	18.15	18.96	16.83
Repl. 3	23.71	21.65	19.98	18.79	20.48	15.49
Repl. 4	26.40	19.73	20.42	21.58	21.96	16.03
Repl. 5	21.66	21.56	21.80	23.25	22.27	16.68
Mean =	24.03	20.56	21.02	20.11	21.01	15.84
Std. Dev. =	1.72	1.48	0.82	2.20	1.33	1.08
Lower Conf. Int. =	22.52	19.26	20.30	18.18	19.84	14.89
Upper Conf. Int. =	25.53	21.85	21.74	22.04	22.18	16.78
Overall Mean = 20.43		r (outfall) = **-0.46**		r (point) = **-0.86**		r (prt.sz.) = **0.69**
Overall S.D. = 2.81		H^1 = **19.2**		Comp. of means = B1 > B2, B3, B4, B5 > 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).

Table 6-1. continued

Constituent	Offshore Stations					
	B1	B2	B3	B4	B5	B6
SIMPSON DIVERSITY						
Repl. 1	0.98	0.97	0.95	0.97	0.97	0.97
Repl. 2	0.98	0.97	0.98	0.96	0.97	0.97
Repl. 3	0.98	0.98	0.96	0.96	0.97	0.97
Repl. 4	0.98	0.98	0.97	0.97	0.97	0.97
Repl. 5	0.98	0.98	0.98	0.98	0.97	0.97
Mean =	0.98	0.98	0.97	0.97	0.97	0.97
Std. Dev. =	0.00	0.01	0.01	0.01	0.00	0.00
Lower Conf. Int. =	19.20	22.03	20.29	19.88	24.65	21.34
Upper Conf. Int. =	26.20	24.95	25.23	21.70	27.68	22.39
Overall Mean = 0.972		r (outfall) = 0.14		r (point) = **-0.33**		r (prt.sz.) = **0.45**
Overall S.D. = 0.006		H[1] = **12.41**		Comp. of means = B1 > B3, B4, B5, B6		
SCHWARTZ DOMINANCE						
Repl. 1	51	40	39	36	34	29
Repl. 2	44	31	43	29	35	30
Repl. 3	47	44	36	31	38	27
Repl. 4	53	42	37	37	34	28
Repl. 5	42	44	44	42	40	31
Mean =	47	40	40	35	36	29
Std. Dev. =	5	5	4	5	3	2
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 37.93		r (outfall) = -0.26		r (point) = **-0.78**		r (prt.sz.) = **0.76**
Overall S.D. = 6.81		H = **11.4**		Comp. of means = B1 > B2, B3, B4, B5 > B6		
INFAUNAL INDEX						
Repl. 1	83	82	81	87	82	82
Repl. 2	83	81	77	81	87	84
Repl. 3	83	84	81	85	85	84
Repl. 4	83	84	82	87	82	85
Repl. 5	83	85	82	84	81	86
Mean =	83	83	81	85	84	84
Std. Dev. =	0	2	2	2	2	1
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 83.14		r (outfall) = 0.14		r (point) = 0.17		r (prt.sz.) = -0.14
Overall S.D. = 2.11		H[1] = 9.6		Comp. of means = N/A		
BENTHIC RESPONSE INDEX						
Repl. 1	26	25	26	23	24	19
Repl. 2	26	28	22	23	25	21
Repl. 3	28	25	24	23	24	18
Repl. 4	27	25	24	24	22	21
Repl. 5	28	26	25	24	26	20
Mean =	27	26	24	24	24	20
Std. Dev. =	1.1	1.4	1.3	0.6	1.3	1.4
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 24.15		r (outfall) = **-0.47**		r (point) = **-0.86**		r (prt.sz.) = **0.77**
Overall S.D. = 2.57		H = **19.97**		Comp. of means = B1 > B3, B5, B2 > 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.

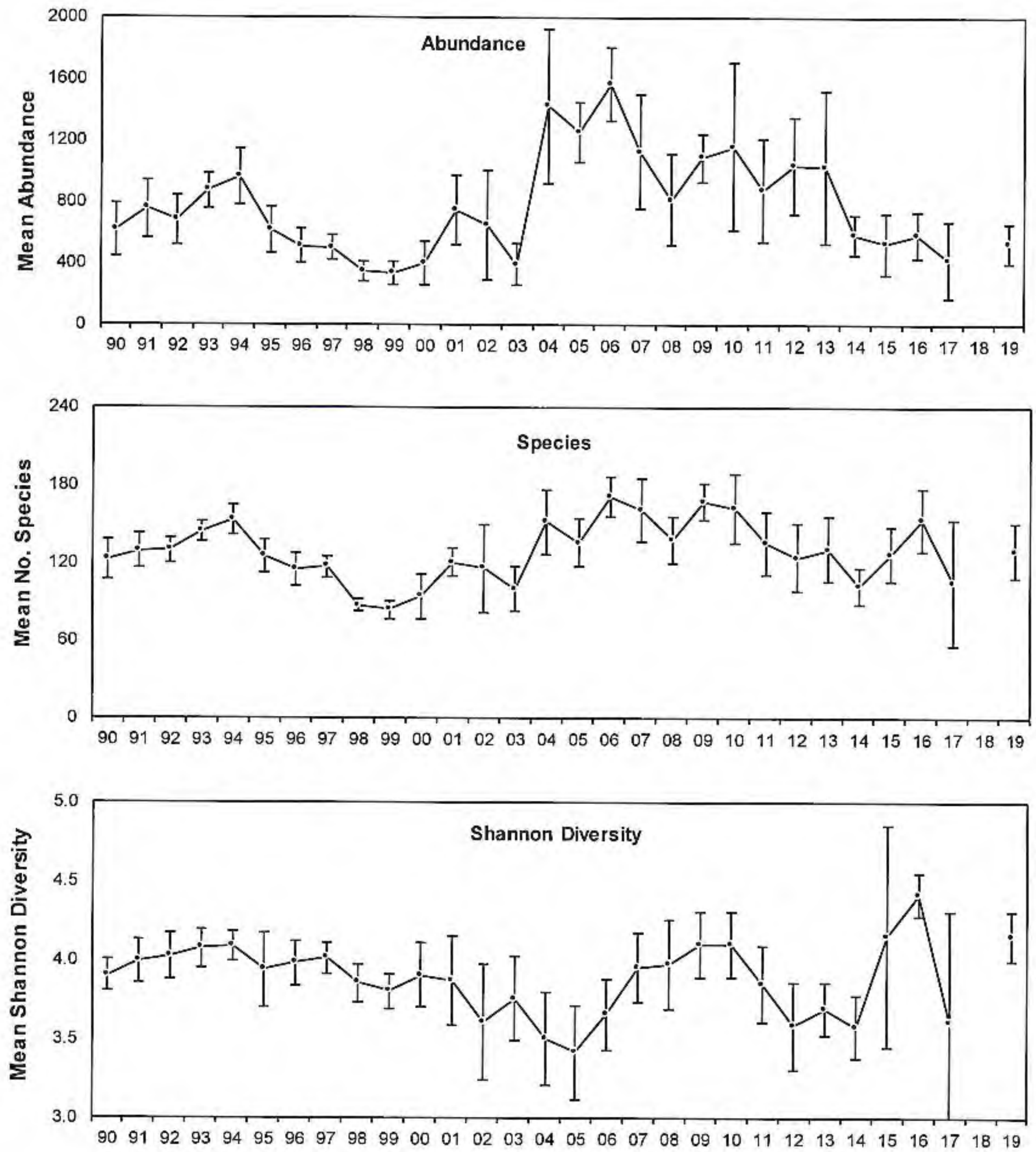


Figure 6-1. (continued).

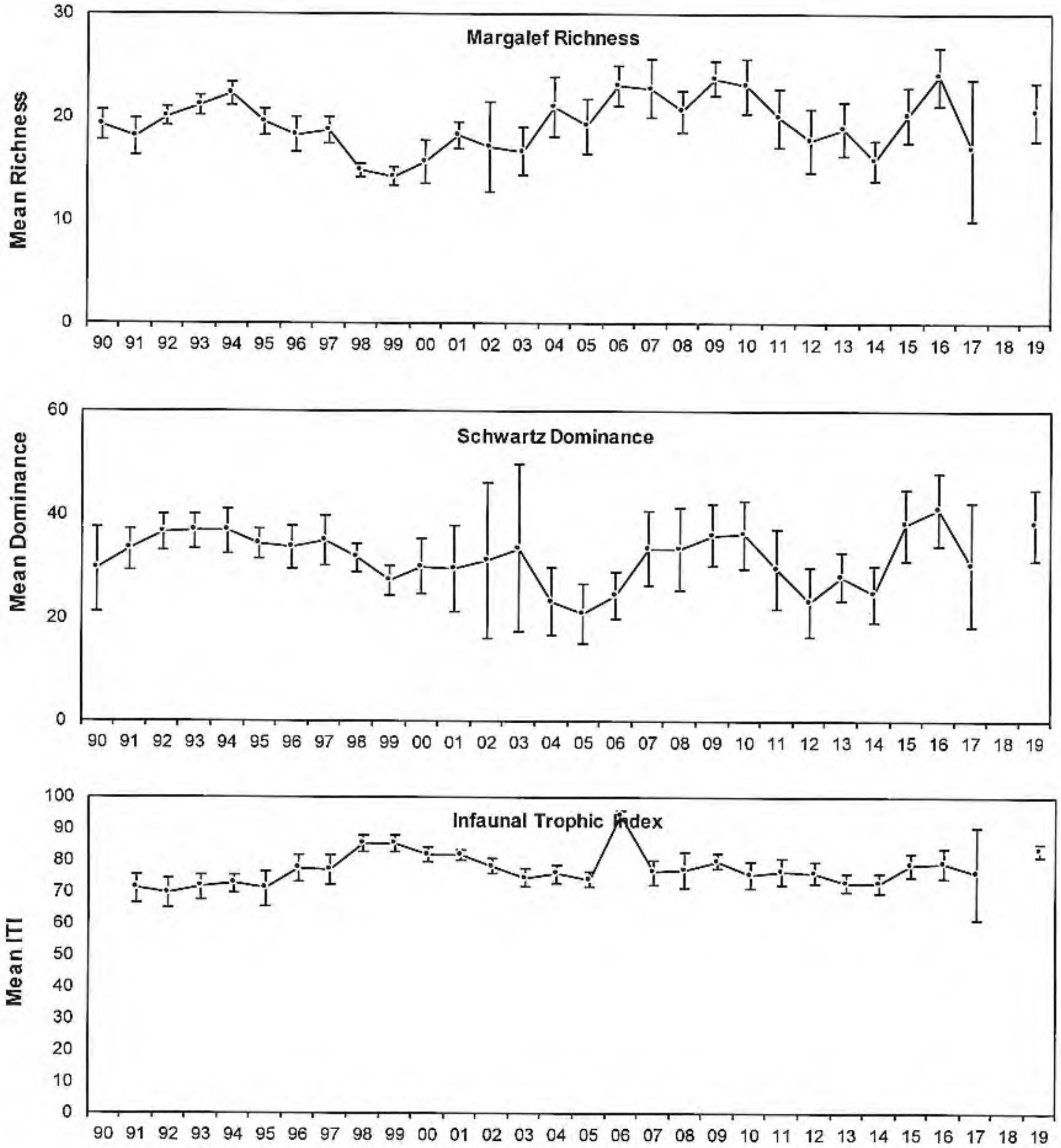


Table 6-2. Comparison of Goleta infauna variables with results from other studies (per 0.1 m^2).

Variable	Goleta 2019		SCBRMP 1998		SCBRMP 2003 Inner Shelf		SCBRMP 2008 Inner Shelf		SCBRMP 2013 Inner Shelf	
	Mean	Range	Mean	Range	Mean	±95% CI	Mean	SE	Mean	Range
Number of Individuals	525	307 - 820	385	35 - 1696	283	30	346	22	420	90 - 2191
Number of Species	129	83 - 171	85	18 - 162	62	5	85	4	80	27 - 164
Shannon Diversity Index	4.1	3.9 - 4.4	3.60	2.00 - 4.40	3.48	0.09	3.63	0.06	3.50	2.5 - 4.3

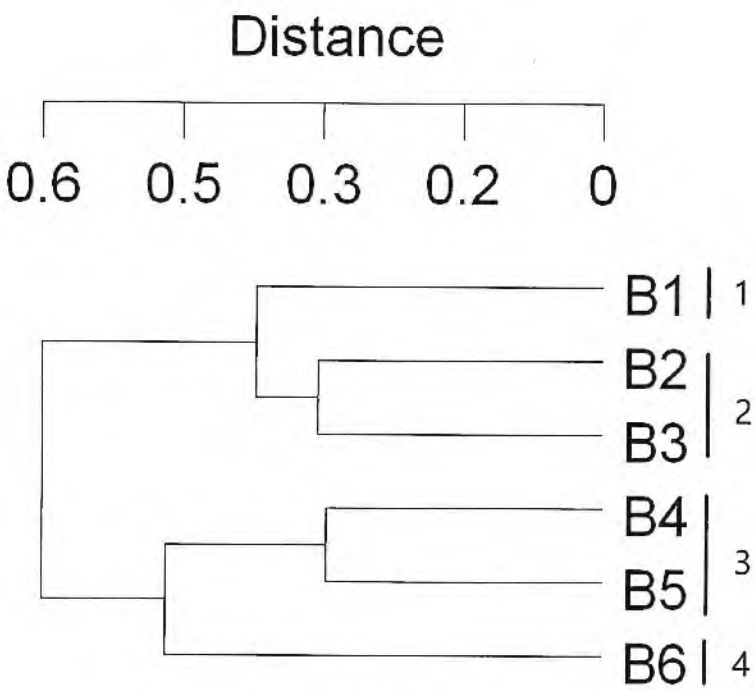


Figure 6-2. Station dendrogram based on cluster analysis (UPGMA, Sneath and Sokal 1973). The Bray-Curtis dissimilarity index was used to calculate the distances among stations and species (Gauch 1982, Jongman et. al. 1995).

Table 6-3. Average abundances of the top twenty species for each cluster group in 2019.

Species	Cluster Group			
	1	2	3	4
Kirkegaardia cryptica	36	16		
Streblosoma crassibranchia	32	18		
Marphysa disjuncta	26			
Spiophanes duplex	25	52	55	11
Pista brevibranchiata	21			
Dipolydora bidentata	20			
Edwardsia juliae	16	13		
Dialychone albocincta	15	17	84	20
Amphideutopus oculatus	14	34	51	17
Gadila aberrans	13	12	16	
Phoronis sp	12			
Tellina sp B	11	21		
Metasychis disparidentatus	10	23		
Ampelisca brevisimulata	9	25	18	15
Scalibregma californicum	9			
Kirkegaardia siblina	8	79	47	25
Chondrochelia dubia Cmplx	8	21	15	8
Euclymeninae sp A	8	13	32	9
Parvilucina tenuisculpta	8			
Spiochaetopterus costarum Cmplx	8			
Paraprionospio alata		23	21	
Petaloclymene pacifica		22	37	
Poecilochaetus martini		17		
Foxiphalus obtusidens		15	38	22
Euphilomedes carcharodonta		15	24	12
Caecognathia crenulatifrons		12		
Diopatra ornata		11	31	6
Prionospio jubata			67	15
Mediomastus sp			30	
Levinsenia gracilis			21	
Glycinde armigera			18	9
Ampelisca cristata microdentata			16	17
Mooreonuphis nebulosa			16	
Praxillella pacifica			16	8
Kurtiella tumida				7
Nematoda				6
Nereis sp A				6
Rhepoxynius menziesi				6
Rhepoxynius stenodes				12
Rudilemboides stenopropodus				8
Tellina modesta				13

Table 6-4. Biological metrics for each station in 2019 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	267	649	27	83	0.81	41.07	59	4.53	0.98
B2	2	225	435	26	83	0.82	36.87	52	4.42	0.98
B3	2	238	531	24	81	0.80	37.77	53	4.39	0.97
	average	232	483	25	82	0.81	37.32	53	4.41	0.98
B4	3	255	612	23	85	0.80	39.58	50	4.45	0.98
B5	3	259	618	25	83	0.79	40.14	47	4.38	0.98
	average	257	615	24	84	0.80	39.86	49	4.42	0.98
B6	4	190	409	21	84	0.81	31.43	36	4.26	0.98

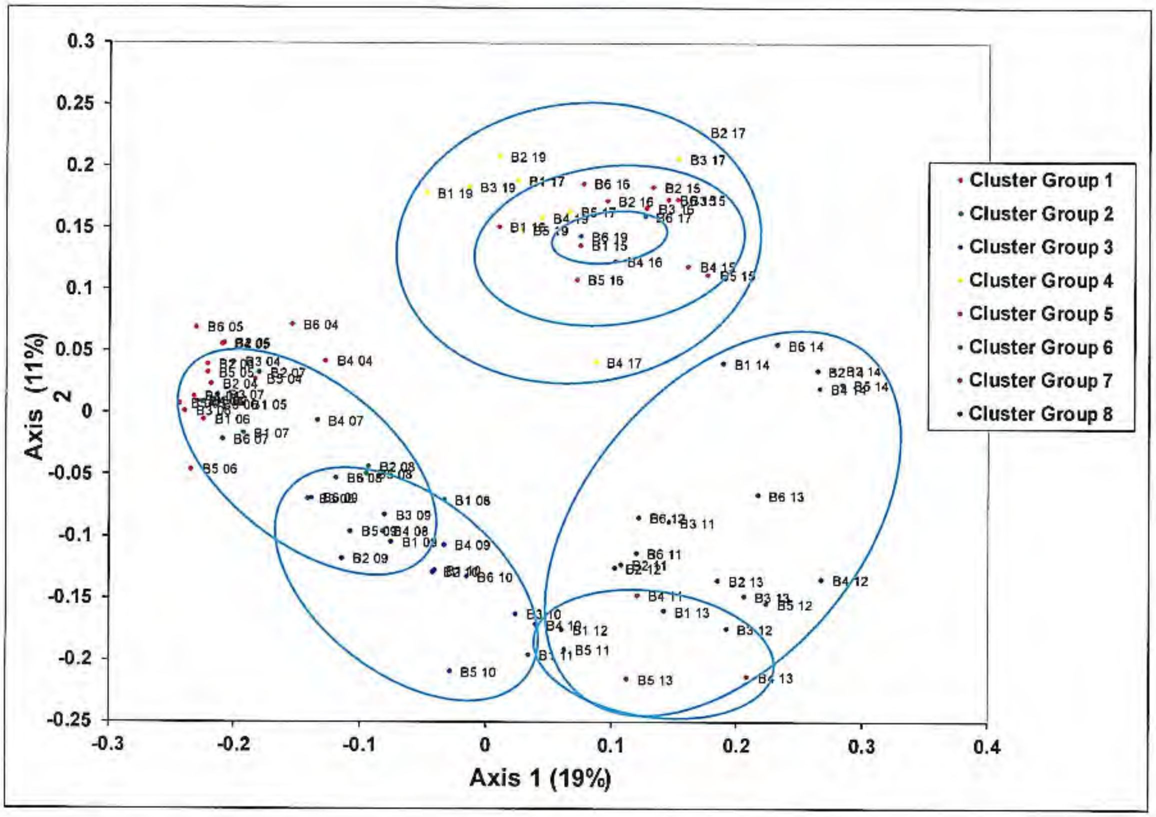


Figure 6-3. Plot of ordination scores for infauna communities at stations measured from 2004 to 2019.

Table 6-5. Biological metrics for each station for each year individually from 2004 thru 2019 and averaged by cluster group.

Staton/Year	Cluster Group	BRI	ITI	Number of Species	Total Abundance	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B1 04		32	73	369	2159	0.61	47.93	22	3.62	0.92
B1 05		29	78	315	1246	0.68	44.05	39	3.92	0.96
B1 06		29	74	302	1386	0.67	41.61	32	3.80	0.95
B2 04		29	77	330	1616	0.67	44.53	29	3.88	0.94
B2 05		31	72	246	1302	0.57	34.16	15	3.12	0.88
B2 06		30	73	300	1580	0.60	40.60	21	3.43	0.90
B3 04		29	74	247	1430	0.60	33.86	20	3.31	0.88
B3 05		29	74	284	1499	0.63	38.70	25	3.54	0.90
B3 06		29	74	299	1775	0.64	39.83	25	3.66	0.92
B4 04	1	29	72	238	1132	0.55	33.70	18	2.99	0.81
B4 05		30	71	261	1112	0.58	37.07	20	3.25	0.85
B4 06		31	72	291	1580	0.61	39.37	22	3.48	0.89
B5 04		26	75	257	1220	0.63	36.02	31	3.47	0.89
B5 05		28	74	300	1221	0.62	42.07	29	3.53	0.88
B5 06		28	72	312	1804	0.64	41.48	28	3.65	0.92
B6 04		25	79	258	945	0.68	37.51	34	3.80	0.92
B6 05		29	75	265	1124	0.62	37.58	27	3.43	0.88
B6 06		29	74	290	1270	0.64	40.44	26	3.61	0.89
	average	29	74	287	1411	0.62	39.47	26	3.53	0.90
B1 07		30	76	317	1022	0.75	45.60	51	4.33	0.97
B1 08		26	81	252	582	0.82	39.42	54	4.53	0.98
B2 07		30	80	248	729	0.77	37.48	44	4.25	0.97
B2 08		30	81	224	677	0.80	34.21	41	4.35	0.98
B3 07		31	73	261	1400	0.67	35.89	27	3.72	0.94
B3 08		29	77	261	1093	0.73	37.16	33	4.06	0.96
B4 07	2	31	71	247	1023	0.70	35.50	30	3.84	0.95
B4 08		31	63	237	854	0.72	34.96	31	3.95	0.95
B5 07		30	75	278	1220	0.70	38.98	36	3.95	0.95
B5 08		28	77	247	741	0.74	37.23	36	4.08	0.96
B6 07		29	78	315	1349	0.68	43.57	39	3.93	0.96
B6 08		27	76	258	910	0.72	37.72	36	4.01	0.95
	average	29	76	262	967	0.73	38.14	38	4.08	0.96
B1 09		27	78	311	1203	0.73	43.71	42	4.17	0.96
B1 10		27	75	299	1210	0.75	41.98	42	4.26	0.97
B2 09		29	76	287	1024	0.76	41.26	44	4.31	0.97
B2 10		27	75	291	920	0.78	42.50	47	4.42	0.98
B3 09		28	80	275	1124	0.72	39.01	35	4.05	0.96
B3 10		28	75	275	985	0.77	39.75	44	4.35	0.98
B4 09	3	26	81	247	950	0.72	35.88	33	3.98	0.96
B4 10		30	72	268	995	0.74	38.68	36	4.13	0.97
B5 09		27	81	290	1154	0.71	40.99	36	4.00	0.95
B5 10		28	80	349	1973	0.69	45.87	38	4.05	0.96
B6 09		26	81	265	1037	0.78	38.02	45	4.36	0.98
B6 10		25	79	265	855	0.76	39.11	45	4.26	0.97
	average	27	78	285	1119	0.74	40.56	41	4.20	0.97
B1 17		30	80	241	476	0.81	38.93	52	4.46	0.98
B1 19		27	83	267	649	0.81	41.07	59	4.53	0.98
B2 17		29	77	187	207	0.84	34.89	47	4.38	0.98
B2 19		26	83	225	435	0.82	36.87	52	4.42	0.98
B3 17		25	80	192	337	0.81	32.81	43	4.24	0.97
B3 19	4	24	81	238	531	0.80	37.77	53	4.39	0.97
B4 17		26	74	274	683	0.78	41.83	48	4.39	0.98
B4 19		23	85	255	612	0.80	39.58	50	4.45	0.98
B5 17		25	77	256	645	0.79	39.42	45	4.39	0.98
B5 19		25	83	259	618	0.79	40.14	47	4.38	0.98
	average	26	80	239	519	0.81	38.33	50	4.40	0.98

Table 6-5. continued.

Staton/Year	Cluster Group	BRI	ITI	Number of Species	Total Abundance	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B1 15		27	74	255	785	0.81	38.10	56	4.46	0.98
B1 16		27	78	275	758	0.81	41.32	60	4.53	0.99
B2 15		26	77	218	650	0.81	33.50	44	4.35	0.98
B2 16		27	78	254	549	0.83	40.11	59	4.59	0.99
B3 15		25	81	217	425	0.83	35.69	50	4.48	0.98
B3 16	5	24	75	243	405	0.86	40.30	61	4.70	0.99
B4 15		25	81	240	419	0.85	39.58	62	4.64	0.98
B4 16		25	82	282	682	0.82	43.07	70	4.60	0.99
B5 15		26	76	245	427	0.85	40.29	63	4.66	0.98
B5 16		25	79	282	782	0.79	42.18	62	4.43	0.98
B6 15		25	81	229	498	0.81	36.71	46	4.40	0.98
B6 16		25	81	264	584	0.82	41.28	56	4.58	0.99
	average	26	79	**250**	580	**0.82**	**39.35**	**57**	**4.54**	**0.98**
B6 17	6	20	78	196	268	0.83	34.88	42	4.36	0.98
B6 19		21	84	190	409	0.81	31.43	36	4.26	0.98
	average	**20**	81	**193**	**339**	**0.82**	**33.16**	**39**	**4.31**	**0.98**
B4 11		28	73	241	735	0.75	36.37	41	4.12	0.96
B4 13	7	28	74	266	1047	0.75	38.11	36	4.20	0.97
B5 11		31	75	242	738	0.76	36.49	38	4.15	0.97
B5 13		31	73	300	1796	0.68	39.90	33	3.85	0.96
	average	30	74	**262**	**1079**	**0.73**	**37.72**	37	**4.08**	**0.97**
B1 11		28	73	324	1343	0.73	44.84	45	4.22	0.97
B1 12		28	73	332	1457	0.75	45.44	44	4.34	0.97
B1 13		28	71	277	956	0.77	40.22	43	4.30	0.97
B1 14		28	69	231	603	0.78	35.93	46	4.22	0.97
B2 11		28	77	241	973	0.72	34.88	31	3.94	0.95
B2 12		28	74	261	1179	0.73	36.76	33	4.04	0.96
B2 13		28	69	250	936	0.71	36.40	32	3.93	0.95
B2 14		27	70	199	557	0.71	31.32	24	3.74	0.95
B3 11		26	82	228	816	0.70	33.86	25	3.81	0.95
B3 12	8	27	75	257	1114	0.71	36.49	28	3.94	0.96
B3 13		27	72	244	844	0.74	36.07	35	4.09	0.96
B3 14		27	75	182	550	0.72	28.68	26	3.74	0.95
B4 12		25	81	214	773	0.69	32.03	21	3.70	0.94
B4 14		26	74	214	536	0.73	33.89	32	3.92	0.96
B5 12		23	79	222	830	0.68	32.88	19	3.65	0.94
B5 14		26	73	207	527	0.74	32.87	32	3.93	0.96
B6 11		26	77	244	617	0.78	37.83	44	4.29	0.97
B6 12		28	74	228	842	0.68	33.70	28	3.68	0.91
B6 13		25	74	203	572	0.75	31.82	32	3.99	0.96
B6 14		27	73	211	695	0.69	32.09	25	3.69	0.95
	average	27	74	**238**	836	**0.72**	**35.40**	**32**	**3.96**	**0.95**

7.0 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 26th, 2019. 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.

7.1 Materials and Methods

Two divers, using GoPRo 5 Hero enclosed in underwater housings, 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 three dives were completed for the video: diffuser, west and east ports (100 ft. to 60 ft.); deep and middle outfall (60 ft. to 40 ft) and shallow outfall (40 ft. to surf zone).

The footage was downloaded to computer files, edited using *Adobe Premiere* software. The footage was 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).

7.2 Results

Outfall dive surveys were conducted between approximately 0800 and 1100 hours on October 26th, 2019 aboard the *Hey Jude*. Weather conditions were fair with a 3 knot wind and 2 ft. swell from the southwest (245 °). There was a thermocline at approximately 20 meters. Water color was green with moderate turbidity. Visibility at the terminus of the diffuser (100 feet) and throughout the dive was 0 to 3 meters.

7.2.1 Diffuser Section (Depth: 100 TO 60 ft)

7.2.1.1 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 moderate to poor, ranging from 3 to 0 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, however there was little or no flow from both the upper and lower terminal ports.

The terminus and then the lateral ports were observed and videotaped, starting on the east and west side of the pipe, and moving shoreward until the most shoreward 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.

7.2.1.2 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*), bat star (*Patiria miniate*), red urchin (*Strongylocentrotus franciscanus*), giant sea start (*Pisaster gigantis*) and Kellet's whelk (Kelletia kelleti) and various species of colonial hydroids and bryozoans dominated. Tube worms and especially the strawberry anemones were commonly observed surrounding the diffuser ports. Sheepshead (*Semicossyphus* pulcher), barred sandbass (*Paralabrax* nebulifer), sargo (*Anisotremus davidsonii*), rockfish (*Sebastes* sp) and kelp bass (*Paralabrax clathratus)* were observed either on the pipe, or in its immediate vicinity.

7.2.2 Deep and Middle Outfall Section (Depth: 60 TO 40 ft)

7.2.2.1 Physical Description

Throughout the dive survey, the outfall was completely covered by approximately one-meter layer of armor rock. 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.

7.2.2.2 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, tunicates, purple urchin (*Strongylocentrotus purpuratus*), red urchin (*Strongylocentrotus franciscanus*), giant sea start (*Pisaster gigantis*), California spiny lobster (*Panulirus interruptus*) and the giant keyhole limpets (*Megathura crenulata*). Several fish species were observed including sheepshead (*Semicossyphus pulcher*), barred sandbass (*Paralabrax nebulifer*), kelpbass (*Paralabrax clathratus*), garibaldi (*Hypsypops rubicundus*), rock wrasse (*Halichoeres* semicinctus), opaleye (*Girella nigricans*), rockfish (*Sebastes* sp) and blacksmith (*Chromis punctipinnis*).

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

7.2.3.1 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.

7.2.3.2 Biological Description

Dominant algae in this pipe section included foliose red algae (*Gigartina sp.*) and crustose coralline algae and several species of brown algae. Among the macroinvertebrates, purple urchin (*Strongylocentrotus purpuratus*), giant keyhole limpets (*Megathura crenulata*), bat star (*Patiria miniate*), giant green anemone (*Anthopleura xanthogrammica*), and red gorgonian (*Lophogorgia chilensis*) were most dominant. Fish species observed at this depth included sheepshead (*Semicossyphus* pulcher), opaleye (*Girella nigricans*), Garibaldi (*Hypsypops rubicundus*), kelp bass (*Paralabrax clathratus),* and blacksmith (*Chromis punctipinnis*.

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.

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8.3. Particle Size

Table 8-2. Particle sizes by channel sizes in phi and microns for each Goleta sediment station.

Sample ID	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
	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	0.07	1.39	4.35	7.78	10.45	11.65	10.09	7.41	5.65	5.26	5.56	5.90	6.09	5.15	3.85	2.51	2.04	1.33	0.85	0.90	0.89	0.63	0.18	0.00
B2	0.00	0.00	0.00	0.03	0.44	1.34	4.51	13.03	20.07	16.63	9.08	4.88	3.74	3.77	4.11	4.39	3.83	2.91	1.92	1.56	1.02	0.66	0.71	0.72	0.50	0.15	0.00
B3	0.00	0.00	0.00	0.03	0.38	1.63	7.67	21.48	23.64	13.42	6.06	3.30	2.79	3.04	3.39	3.53	2.90	2.06	1.30	1.02	0.66	0.45	0.46	0.44	0.32	0.02	0.00
B4	0.00	0.00	0.00	0.03	0.52	2.90	14.17	28.00	17.86	7.18	3.53	2.56	2.64	3.09	3.49	3.69	3.13	2.29	1.45	1.11	0.70	0.46	0.47	0.48	0.25	0.00	0.00
B5	0.00	0.00	0.00	0.03	0.59	3.41	17.13	34.70	21.54	7.42	2.75	1.45	1.23	1.36	1.54	1.67	1.47	1.11	0.74	0.59	0.40	0.29	0.30	0.25	0.00	0.00	0.00
B6	0.00	0.00	0.00	0.06	0.97	3.11	9.08	22.35	31.96	18.78	5.39	1.54	0.95	0.98	1.13	1.18	0.93	0.63	0.40	0.34	0.20	0.00	0.00	0.00	0.00	0.00	0.00

Table 8-3. 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	53.21	39.97	6.82	46.79	2.03	6.66	51.35	163.41	266.80	8.96	7.24	4.28	2.61	1.90	81.35	51.35	105.68	3.62	4.28	3.24	2.32	-0.29	-2.52
B2	0.00	65.13	29.55	5.32	34.87	2.60	9.17	70.91	136.68	195.77	8.60	6.77	3.81	2.87	2.35	78.08	70.91	101.90	3.68	3.81	3.29	1.95	-0.07	-2.60
B3	0.00	74.30	22.31	3.39	25.70	4.11	14.75	94.88	159.85	218.77	7.93	6.09	3.39	2.64	2.18	96.37	94.88	111.52	3.37	3.39	3.16	1.72	-0.01	-2.67
B4	0.00	74.19	22.34	3.47	25.81	3.95	13.45	114.84	184.16	240.78	7.99	6.22	3.12	2.43	2.05	111.88	114.84	145.37	3.15	3.12	2.78	1.89	0.02	-2.57
B5	0.00	87.59	10.57	1.84	12.41	7.52	64.98	132.58	196.45	245.21	7.06	3.94	2.91	2.34	2.02	131.79	132.58	145.50	2.92	2.91	2.77	0.80	0.01	-4.15
B6	0.00	91.70	7.76	0.54	8.30	16.61	65.22	106.90	169.52	241.98	5.91	3.94	3.22	2.55	2.04	117.82	106.90	107.17	3.08	3.22	3.22	0.69	-0.20	-3.80

8.4 Sediment Chemistry

8-4 Sediment contaminant concentrations normalized to % total organic carbon (TOC) in the Goleta survey area. Correlations by nonparametric Spearman's rho.

Constituent	Sediment Stations B1	B2	B3	B4	B5	B6	Mean	S.D.	Correlations Outfall	Point
Undifferentiated Organics										
Oil and Grease	667	305	325	522	403	968	531.6	252.7	0.46	**0.37**
TKN	583	569	628	820	806	647	675.3	110.3	-0.58	0.71
AVS	21.22	7.53	4.58	22.55	52.86	53.53	27.04	21.48	0.12	**0.77**
Heavy Metals										
Aluminum	13776	12727	15781	17235	19000	17941	16077	2448	-0.32	**0.89**
Antimony	0.26	0.20	0.25	0.29	0.35	0.32	0.28	0.05	-0.20	**0.77**
Arsenic	6.90	6.56	9.56	11.65	12.06	11.41	9.69	2.45	-0.58	**0.77**
Cadmium	0.49	0.52	0.64	0.75	0.96	1.04	0.73	0.23	-0.12	**1.00**
Chromium	37.04	35.76	45.78	53.92	64.57	61.47	49.76	12.23	-0.32	**0.89**
Copper	7.11	7.10	8.11	9.51	6.89	6.97	7.95	1.07	**-0.93**	0.03
Iron	13265	13030	16250	19431	20857	18794	16938	3294	-0.58	**0.77**
Lead	5.55	5.33	6.92	8.76	9.34	7.68	7.27	1.64	-0.58	0.77
Mercury	0.026	0.024	0.034	0.041	0.043	0.040	0.035	0.0081	-0.58	**0.77**
Nickel	20.00	20.00	23.75	27.65	31.71	29.71	25.47	4.99	-0.35	**0.93**
Selenium	0.51	0.38	0.63	0.71	0.86	0.62	0.62	0.17	**-0.75**	0.60
Silver	0.232	0.122	0.163	0.175	0.193	0.154	0.173	0.037	-0.29	-0.20
Tin	0.97	0.85	1.20	1.36	1.61	1.42	1.24	0.29	-0.32	**0.89**
Zinc	37.14	36.57	45.31	53.53	60.00	53.82	47.73	9.63	-0.32	**0.89**
Complex Organics										
DDTs	9.13	2.59	3.87	ND	1.75	2.35	3.94	3.00	0.58	-0.03
HCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlordane	0.78	0.51	0.99	0.00	0.00	0.00	0.38	0.44	0.22	**-0.76**
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	3.12	12.14	1.34	1.86	0.00	0.00	3.08	4.59	0.10	**-0.87**
Aroclors	0.00	14.14	0.00	0.00	0.00	0.00	2.36	5.77	0.13	-0.39
Total PAHs	131.13	80.06	80.95	41.77	111.29	14.56	76.63	43.06	-0.17	-0.60
1-Methylnaphthalene	2.02	1.48	1.63	1.13	1.37	0.73	1.39	0.44	0.06	**-0.89**
1-Methylphenanthrene	4.00	1.05	1.59	0.15	1.86	0.22	1.48	1.42	0.09	-0.49
2,3,5-Trimethylnaphthalene	2.42	1.65	2.78	1.71	2.94	0.46	1.99	0.92	-0.64	-0.14
2,6-Dimethylnaphthalene	5.74	2.65	3.55	2.75	2.49	1.07	3.04	1.55	-0.09	**-0.83**
2-Methylnaphthalene	3.08	2.01	3.13	1.74	2.16	1.53	2.27	0.68	-0.20	-0.60
Acenaphthene	0.79	0.43	0.12	0.15	0.22	0.23	0.32	0.25	0.64	-0.43
Benz[a]anthracene	9.35	4.87	5.77	2.12	8.83	0.31	5.21	3.58	-0.17	-0.60
Benzo[b]fluoranthene	16.63	9.73	11.16	6.60	11.51	0.19	9.34	5.51	-0.17	-0.60
Benzo[e]pyrene	16.22	8.94	10.56	6.18	10.74	7.09	9.96	3.57	0.09	-0.49
Benzo[g,h,i]perylene	10.92	7.11	8.14	4.92	7.91	0.27	6.55	3.63	-0.09	-0.71
Biphenyl	1.38	1.03	0.84	0.71	0.70	0.56	0.87	2.46	0.12	**-1.00**
Fluoranthene	12.55	9.96	7.48	3.29	13.71	2.28	8.21	4.00	-0.32	-0.43
Naphthalene	2.51	2.21	1.59	0.86	1.27	1.95	1.73	2.66	**0.81**	-0.60
Perylene	62.65	31.31	28.28	20.00	25.23	26.41	32.65	15.19	**0.81**	-0.60

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

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

8-5. 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	0.6	5	µg/g	EPA 351.3
Total Organic Carbon	100	100	µg/g	EPA 9060
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	0.267	0.5	ng/g	EPA 8270D
2,4'-DDE	0.2	0.5	ng/g	EPA 8270D
2,4'-DDT	0.194	0.5	ng/g	EPA 8270D
4,4'-DDD	0.198	0.5	ng/g	EPA 8270D
4,4'-DDE	0.193	0.5	ng/g	EPA 8270D
4,4'-DDT	0.128	0.5	ng/g	EPA 8270D
Aldrin	0.25	0.5	ng/g	EPA 8270D
BHC-alpha	0.25	0.5	ng/g	EPA 8270D
BHC-beta	0.25	0.5	ng/g	EPA 8270D
BHC-delta	0.25	0.5	ng/g	EPA 8270D
BHC-gamma	0.25	0.5	ng/g	EPA 8270D
Chlordane-alpha	0.187	0.5	ng/g	EPA 8270D
Chlordane-gamma	0.179	0.5	ng/g	EPA 8270D
cis-Nonachlor	0.192	0.5	ng/g	EPA 8270D
Dieldrin	0.1	0.2	ng/g	EPA 8270D
Endosulfan sulfate	0.25	0.5	ng/g	EPA 8270D
Endosulfan-I	0.25	0.5	ng/g	EPA 8270D
Endosulfan-II	0.25	0.5	ng/g	EPA 8270D
Endrin	0.25	0.5	ng/g	EPA 8270D
Endrin aldehyde	0.25	0.5	ng/g	EPA 8270D
Endrin ketone	0.25	0.5	ng/g	EPA 8270D
Heptachlor	0.25	0.5	ng/g	EPA 8270D
Heptachlor epoxide	0.25	0.5	ng/g	EPA 8270D
Methoxychlor	0.25	0.5	ng/g	EPA 8270D
Mirex	0.25	0.5	ng/g	EPA 8270D
Oxychlordane	0.25	0.5	ng/g	EPA 8270D
Perthane	5	10	ng/g	EPA 8270D
trans-Nonachlor	0.166	0.5	ng/g	EPA 8270D
Base/Neutral Extractable Compounds				EPA 8270D
Hexachlorobenzene	0.25	0.5	ng/g	EPA 8270D
Polynuclear Aromatic Hydrocarbons (PAHs)				EPA 8270D
1-Methylnaphthalene	0.084	0.5	ng/g	EPA 8270D
1-Methylphenanthrene	0.076	0.5	ng/g	EPA 8270D
2,3,5-Trimethylnaphthalene	0.059	0.5	ng/g	EPA 8270D
2,6-Dimethylnaphthalene	0.065	0.5	ng/g	EPA 8270D
2-Methylnaphthalene	0.106	0.5	ng/g	EPA 8270D
Acenaphthene	0.078	0.5	ng/g	EPA 8270D
Acenaphthylene	0.058	0.5	ng/g	EPA 8270D
Anthracene	0.046	0.5	ng/g	EPA 8270D
Benz[a]anthracene	0.107	0.5	ng/g	EPA 8270D
Benzo[a]pyrene	0.106	0.5	ng/g	EPA 8270D
Benzo[b]fluoranthene	0.063	0.5	ng/g	EPA 8270D
Benzo[e]pyrene	0.098	0.5	ng/g	EPA 8270D
Benzo[g,h,i]perylene	0.093	0.5	ng/g	EPA 8270D
Benzo[k]fluoranthene	0.111	0.5	ng/g	EPA 8270D
Biphenyl	0.092	0.5	ng/g	EPA 8270D
Chrysene	0.067	0.5	ng/g	EPA 8270D
Dibenz[a,h]anthracene	0.106	0.5	ng/g	EPA 8270D
Dibenzothiophene	0.2	0.5	ng/g	EPA 8270D

Parameter	MDL	RL	Units	Method
Polynuclear Aromatic Hydrocarbons (Continued)				
Fluoranthene	0.035	0.5	ng/g	EPA 8270D
Fluorene	0.068	0.5	ng/g	EPA 8270D
Indeno[1,2,3-c,d]pyrene	0.087	0.5	ng/g	EPA 8270D
Naphthalene	0.167	0.5	ng/g	EPA 8270D
Perylene	0.114	0.5	ng/g	EPA 8270D
Phenanthrene	0.074	0.5	ng/g	EPA 8270D
Pyrene	0.048	0.5	ng/g	EPA 8270D
Polychlorinated Biphenyls (PCB's)				
PCB003	0.1	0.2	ng/g	EPA 8270D
PCB008	0.017	0.2	ng/g	EPA 8270D
PCB018	0.029	0.2	ng/g	EPA 8270D
PCB028	0.023	0.2	ng/g	EPA 8270D
PCB031	0.1	0.2	ng/g	EPA 8270D
PCB033	0.1	0.2	ng/g	EPA 8270D
PCB037	0.06	0.2	ng/g	EPA 8270D
PCB044	0.028	0.2	ng/g	EPA 8270D
PCB049	0.036	0.2	ng/g	EPA 8270D
PCB052	0.012	0.2	ng/g	EPA 8270D
PCB056(060)	0.1	0.2	ng/g	EPA 8270D
PCB066	0.027	0.2	ng/g	EPA 8270D
PCB070	0.023	0.2	ng/g	EPA 8270D
PCB074	0.021	0.2	ng/g	EPA 8270D
PCB077	0.018	0.2	ng/g	EPA 8270D
PCB081	0.084	0.2	ng/g	EPA 8270D
PCB087	0.081	0.2	ng/g	EPA 8270D
PCB095	0.1	0.2	ng/g	EPA 8270D
PCB097	0.1	0.2	ng/g	EPA 8270D
PCB099	0.026	0.2	ng/g	EPA 8270D
PCB101	0.027	0.2	ng/g	EPA 8270D
PCB105	0.047	0.2	ng/g	EPA 8270D
PCB110	0.074	0.2	ng/g	EPA 8270D
PCB114	0.072	0.2	ng/g	EPA 8270D
PCB118	0.069	0.2	ng/g	EPA 8270D
PCB119	0.071	0.2	ng/g	EPA 8270D
PCB123	0.018	0.2	ng/g	EPA 8270D
PCB126	0.066	0.2	ng/g	EPA 8270D
PCB128	0.061	0.2	ng/g	EPA 8270D
PCB138	0.057	0.2	ng/g	EPA 8270D
PCB141	0.1	0.2	ng/g	EPA 8270D
PCB149	0.092	0.2	ng/g	EPA 8270D
PCB151	0.073	0.2	ng/g	EPA 8270D
PCB153	0.065	0.2	ng/g	EPA 8270D
PCB156	0.089	0.2	ng/g	EPA 8270D
PCB157	0.103	0.2	ng/g	EPA 8270D
PCB158	0.074	0.2	ng/g	EPA 8270D
PCB167	0.049	0.2	ng/g	EPA 8270D
PCB168/132	0.094	0.2	ng/g	EPA 8270D
PCB169	0.116	0.2	ng/g	EPA 8270D
PCB170	0.118	0.25	ng/g	EPA 8270D
PCB174	0.12	0.25	ng/g	EPA 8270D
PCB177	0.085	0.25	ng/g	EPA 8270D
PCB180	0.154	0.25	ng/g	EPA 8270D
PCB183	0.056	0.25	ng/g	EPA 8270D
PCB187	0.168	0.25	ng/g	EPA 8270D
PCB189	0.109	0.25	ng/g	EPA 8270D
PCB194	0.164	0.25	ng/g	EPA 8270D
PCB195	0.093	0.25	ng/g	EPA 8270D
PCB199(200)	0.12	0.25	ng/g	EPA 8270D
PCB201	0.104	0.25	ng/g	EPA 8270D
PCB206	0.155	0.25	ng/g	EPA 8270D
PCB209	0.12	0.25	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

8-6. 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	3.9	0.0	1.7	0.7	0.7	1.3
4,4'-DDE	5.1	2.6	2.2	1.3	1.0	1.0
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0
Sum =	9.0	2.6	3.9	2.0	1.8	2.4
Chlordane (ng/g)						
Chlordane-alpha	0.2	0.0	0.3	0.0	0.0	0.0
Chlordane-gamma	0.3	0.3	0.3	0.0	0.0	0.0
cis-Nonachlor	0.0	0.0	0.0	0.0	0.0	0.0
trans-Nonachlor	0.2	0.2	0.0	0.0	0.0	0.0
Sum =	0.8	0.5	0.6	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
PCB056(060)	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	0.6	0.0	0.0	0.0	0.0
PCB095	0.2	0.9	0.0	0.1	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	1.1	0.0	0.3	0.0	0.0
PCB105	0.0	0.0	0.0	0.0	0.0	0.0
PCB110	0.0	1.0	0.0	0.0	0.0	0.0
PCB114	0.0	0.0	0.0	0.0	0.0	0.0
PCB118	0.0	0.8	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
PCB128	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)						
PCB138	1.4	1.9	0.0	0.0	0.0	0.0
PCB141	0.0	0.0	0.0	0.0	0.0	0.0
PCB149	0.0	1.1	0.0	0.0	0.0	0.0
PCB151	0.0	0.4	0.0	0.0	0.0	0.0
PCB153	1.5	1.6	0.9	0.6	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	0.7	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	0.6	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	0.7	0.0	0.0	0.0	0.0
PCB183	0.0	0.0	0.0	0.0	0.0	0.0
PCB187	0.0	0.4	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 =	3.1	12.0	0.9	1.0	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	3.1	1.1	0.6	0.2	0.5	0.0
Benz[a]anthracene	9.2	4.8	3.7	1.1	3.1	0.0
Benzo[a]pyrene	14.8	8.4	6.7	2.3	4.2	1.6
Benzo[b]fluoranthene	16.3	9.6	7.1	3.5	4.0	0.0
Benzo[g,h,i]perylene	10.7	7.0	5.2	2.5	2.8	0.0
Benzo[k]fluoranthene	4.6	4.2	2.6	1.2	1.7	0.0
Chrysene	14.0	8.2	4.8	2.3	3.8	1.2
Dibenz[a,h]anthracene	3.6	2.4	1.8	0.7	1.2	0.0
Fluorene	12.3	9.9	4.8	1.7	4.8	0.8
Indeno[1,2,3-c,d]pyrene	7.5	6.0	4.0	1.6	3.0	0.0
Phenanthrene	12.7	6.5	4.1	2.1	4.3	0.4
Pyrene	19.8	11.1	6.3	2.2	5.7	1.0
Sum =	128.5	79.3	51.8	21.3	39.0	4.9

8.6. Benthic Infauna

8-8. Benthic infauna taxonomic abundances.

			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
Annelida	Oligochaeta	Oligochaeta	1			2		1							1	1	1	1	1		4	7	6			6	4					
	Polychaeta	Acromegalomma pigmentum				1					1							1	1			1	2	4		1			1		3	2
		Aglaophamus verrilli										1																				
Total Annelids 10,096		Amaeana occidentalis	2		1	1		1	1	2			4	4	1	1	2	5	1	2	1	1		1			2			1	2	3
% of Population 59..85		Amage scutata	2	2	1	2	1	5	1	2	2	3	1	2	2	2	1			1		2	2	1		7		1				
		Ampharete finmarchica	1			1							1				1					3			1							
		Ampharete labrops																5				2				1	4	2	1	1	1	
		Amphicteis scaphobranchiata	3			1	1	1						1	1	1			1		1	2	4	2	2	1	3		6	1	3	
		Amphisamytha bioculata	1	1	1	1		1	1				1			1	1					1		1								
		Ancistrosyllis groenlandica											1											1					1	2	1	2
		Anobothrus gracilis	1	1									1		1		2		1				1	1		1						
		Anotomastus gordiodes																											1	1	5	2
		Aphelochaeta glandaria Cmplx	3	2	3	2	4	1	1	2	1	3	2	5	16	4	10	1	1	2	1	1	2		2	1	3					
		Aphelochaeta petersenae																4	3		1				2				1			1
		Aphelochaeta sp	2	2	2	2	1		2				3	1	2	1	1	1	1	2	1	5				2	1					
		Aphelochaeta sp HYP2	1		1	1	1							1																	1	
		Aphrodita japonica						1									2					2		1								
		Aphrodita sp	2				2							1	1																	
		Arabella iricolor Cmplx						1			1			1			1			1				1			1					
		Arabella protomutans								1																						
		Aricidea (Acmira) catherinae	2	1	3	1	4	4	1	2		3	5	1	9	1	5	2	1	1	3	16	13	1	2	5	13				1	
		Aricidea (Acmira) horikoshii	1					1					1						4			1					1			1		1
		Aricidea (Allia) antennata													1											1						
		Aricidea (Aricidea) wassi	1										2		2			3	2		1	3	3	2		4	1		1	1		
		Aricidea (Strelzovia) hartleyi			1								1	1																1	1	1
		Armandia brevis																	1			2	1			1						
		Artacamella hancocki				1			1	1					1																	
		Asabellides lineata						1																								
		Bipalponephtys cornuta	1										1					1			1	1				1			1	4		3
		Boccardia basilaria	2	5	2	1	2		3	1		1				1								1								
		Brada pilosa									1				1	1		1		2	1		1			1						
		Capitella capitata Cmplx												20				1			1	3	4	1			3					
		Carazziella sp A																						1	1							
		Chaetopterus variopedatus Cmplx																				1										
		Chaetozone columbiana			1				1				1					2			2		5		1	1			1		2	5
		Chaetozone corona			1				1							1													1		2	2
		Chaetozone hedgpethi		1	1	3	5	2	1	1		4	7	3	5	1	1	2	3	3		3	2	2		4	1		2			
		Chaetozone sp SD3																							2							
		Cirriformia sp GOL1									1																					
		Cirrophorus furcatus																									1					
		Clymenella complanata		1		1	2																									
		Clymenella sp A						1																								
		Clymenura columbiana								1		1				1	1					1	2	4								
		Cossura candida								1		1																				
		Cossura sp A	4	2	9	3	4	4	4	3	1	9	8	1	5	1	5			1		13	13	1	1		10					
		Dialychone albocincta	16	21	18	13	8	5	5	13	1	4	11	9	16	11	9	44	38	27	39	39	54	34	48	43	55	20	15	20	23	24
		Dialychone veleronis	3	3		1							2		1	1	2		2			6	2	3	2	2	2	1	1	1	1	
		Diopatra ornata	3	7	3	9	1	7	8	4	2	5	8	4	3	3	13	19	9	7	55	7	8	7	9	20	12	2	10	4	9	3
		Diopatra sp	2	4	2	1	1	4	2	3	2	2	1	1		1	1	2	1	1	3	3		6		2						
		Dipolydora bidentata	41	31	4	11	15	4	9		5	4		1			2	4			2				1							
		Dipolydora socialis						1									2		1			1	2	1		2						
		Drilonereis falcata			1			1							1					3												
		Drilonereis mexicana	3	2	2	2	1	2		4	2	2	3	1										1	1							
		Drilonereis sp					2			1																						
		Epheslella brevicapitis	5		8	1				7												7										
		Epigamia-Myrianida Cmplx	1																													
		Eteone californica	1																													

8-8. 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
		Eteone dilatae														1																
		Euchone incolor		1	3	8	1						2		10	3	2		1	7		24	2	2	2	3						
		Euchone sp A													2																	
		Euclymene campanula																											5		3	1
		Euclymeninae	4	11	3	3	3	1	3	10	1	8	7	1	11	8	3	1	2	2	2	11	7	4	1	1	4					
		Euclymeninae sp A	9	10	8	4	7	5	5	4	5	2	11	4	12	12	6	17	7	5	24	16	38	6	12	13	23	2	17	1	9	14
		Eulalia californiensis	2	1	1	3	2					1																				
		Eumida longicornuta	2	4	2	1	2	1		1	2	2		2		5		3			3			1			6	1	1			1
		Eunicidae			1	1							1																			
		Eupolymnia heterobranchia																	1		2	1				1	1		5		3	2
		Eusyllis transecta																							1	2						
		Exogone dwisula	1											3	2					1			1			1						
		Exogone lourei			1																										1	1
		Glycera americana	1	1	4	3	2	1	3	1		2	1	1	1									1	1							
		Glycera macrobranchia													1							1	1		1	1		1			1	
		Glycera nana	3	1	1	2	1			2			3			1	4					1	1		1		1	1		1		1
		Glycinde armigera			1	1		1	2	1	1	4	10	1	5	6	3	8	13	7	4	9	9	13	8	13	5	3	11	8	12	9
		Goniada maculata	4		2	5	6	1		2	4		2	2	4		3			1	1	1	2		1	3	5					1
		Gymnonereis crosslandi		1		2	2			1																						
		Gyptis sp				1																										
		Halosydna brevisetosa																	1		1							2				
		Hermundura fauveli	4	3	2	1	2		3	1		1	1	1		2	1	1	1	1	3	1			1							
		Heterospio catalinensis																	1									4	2	4		3
		Hyalopomatus biformis		1																												
		Kirkegaardia cryptica	36	17	57	39	33	8	8	14	2	6	1	4	11	11	13	1	1	3	9	11	8	1	3	3	2	2		1	2	2
		Kirkegaardia serratiseta		1																		2	1			2		1				
		Kirkegaardia siblina	7	6	7	10	8	44	34	15	2	11	92	12	84	46	55	10	12	23	16	37	45	11	16	41	22	21	29	25	19	30
		Lanice conchilega				1																										
		Laonice cirrata					2							1		1		3			2	3	1	1	2	3	2	4	2	4	8	5
		Leitoscoloplos pugettensis	7	1	2	1	6	4	4	5		2	1	2	4	5	4	1	1	1	1	3	2		2	7	4		4	3	7	1
		Leodice americana	9	5	4	9	6	2	3	1		2		1	2	2	3	3	1		1	14	7	5	5	1	6					
		Lepidasthenia berkeleyae							1			1													1							
		Levinsenia gracilis								2			8	1	13	1	5				7	34	35	1	6	9	14					
		Levinsenia multibranchiata															1				1			1								
		Lumbrineris cruzensis	1														2			3	1				1							
		Lumbrineris japonica	1	2		1			1			1													1							
		Lumbrineris ligulata								2		1		1	1	1	1									1						
		Lumbrineris sp	3	2	4	1	1	3	2		1	5	3	1	3	2	1					5	1	1	1	2	2	1	2		2	
		Lysippe sp A	4	1	2	2	7	1		2	2	2	1	3	4	4	2	3	1	2			2		2	2	5					
		Magelona berkeleyi			1						1																					
		Malmgreniella baschi	1	1	5															1		1										
		Malmgreniella macginitiei				2	1		1	3			1	1	1		1														2	
		Malmgreniella scriptoria		1				2																								
		Malmgreniella sp	3	1	5	5	1		1	1		3		1											1							
		Malmgreniella sp A	2	1	6	2	1	1									1					1										
		Marphysa disjuncta	26	21	28	36	20	1		2	3	1			2	2						2	2									
		Mediomastus sp	4	2	12	4	1	5	2	2	2	1	5	2	12	3	9	15	9	3	13	13	26	3	7	14	47	1	8	3	5	8
		Melinna oculata	1	3	3	2	1		2	2		2	9	1	2	2	2	2		1	1	4	2	4	12	7	6	2	2		3	5
		Metasychis disparidentatus	9	10	9	11	9	10	10	12	4	8	10	4	18	12	25		1	8	2	9	13	3	10	6	4		2	1		1
		Microspio pigmentata						1																	1							
		Mooreonuphis nebulosa	7	5	6	6	5		1	4	3	3	3	2	4	1	4	20	5	9	1	12	17	4	8	3	2	2	2		1	6
		Neosabellaria cementarium	1																													
		Nephtys caecoides	2	1	1			3	4	3	5	1		1	1	1		6	2	2	2	1	1	2	1	1	1		2	3	1	2
		Nephtys ferruginea	5		1	1			1	1				1		1	1			1	1				1							
		Nereis sp A		1	5	2	3	5	3	1		1			1		1	2	1		6	1	3				8	6	8	3	6	7
		Notomastus hemipodus	4	1	2	1	5	2			1		2				1	1				1	1			1			1			1
		Notomastus magnus							1			2																		1		

8-8. 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	4	2	4	2	5	1		2	1	1	5	1	3		2	3	1	1	2	1	4	4	3		5		1		1	1
		Onuphis sp A	1			1						1		1	1	1		2			1	1	1			1	2			3		3
		Ophelina acuminata								1																						
		Orbinia johnsoni		1	2		1														2	2										
		Owenia collaris						2													1											
		Paradialychone ecaudata																			1											
		Paradialychone harrisae	3			2	1						1				3									1						
		Paradialychone paramollis	1	3	3	1																										
		Paradiopatra parva				1								1	2	1		1			1	1										
		Paradoneis spinifera	1																													
		Paranaitis polynoides		1																												
		Paranaitis sp SD1																									1					
		Paraprionospio alata	3	5	5	6	8	8	20	17	7	16	6	11	11	12	9	5	7	15	3	6	14	17	10	18	10	5	6	1	9	2
		Parexogone molesta	1		1																											
		Pectinaria californiensis	1	1			4	1					1	4	1	3				1		5										
		Petaloclymene pacifica	8	8	6	8	4	23	8	16	2	13	6	3	17	11	9	15	3	20	40	26	26	18	2	19	18		11	2	4	5
		Pherusa neopapillata	1	2		3	1	1	1	2		1	1	1	4	2	3		1	2	2	4	2				1	1	1			
		Phisidia sanctaemariae										1				2	3			1			2									
		Pholoe glabra	2				1	2	3	1	1	3	2				1					1	1			1						
		Pholoe sp B																				1										
		Pholoides asperus	1											1				5			3	3										
		Phyllochaetopterus limicolus	4		2	3												1			3					1	1					
		Phyllodoce cuspidata														1																
		Phyllodoce groenlandica											1			1																
		Phyllodoce hartmanae	2	2	3	1	2	3	1	4	4	1	3	5	3	7	7	6	3	2	1	7	7	2	1	4	6		1	2		2
		Phyllodoce longipes								1			1		3	2	1	3	1		1	1		1		1	1	1	1		1	1
		Phyllodoce medipapillata																			2											
		Phyllodoce pettiboneae			1	1	2			1	1					1	1	1	1	2	4		1		1	4		1		1		
		Phyllodoce sp	2	3	1	4	1	1	1	1	1	1	2	1	1	2	2	2	2	3	2	3	2	2	3	3	4		2			1
		Phyllodocidae																									1					
		Pilargis berkeleyae	1																			2	2	1	1	2	1		1			
		Pilargis sp A					1	1						1																		
		Pilargis sp B																				1					1					
		Pista brevibranchiata	19	17	19	25	27						4	4	5	8	13	3		5	3	6	2		9	3	4					
		Pista estevanica			1			3					2	3	4	2	2					1		1	4							
		Pista moorei							1						1																	
		Pista sp												1																		
		Pista wui															1				1		1		1	1	1		2	1	1	
		Platynereis bicanaliculata												7				13	4		10	1				4	15		8	1	1	1
		Podarkeopsis glabrus			2	1		1	2	1	1	1		1	1			1				1						1				
		Poecilochaetus johnsoni				2							3	2	4	1	3		1	3	2	7	11	4	3	18	15		3	1	5	2
		Poecilochaetus martini	1	1	1	1	4	22	26	15	5	11			2	1	4					1										
		Poecilochaetus sp	2	1	1	1	1	3	3	2	1	2	1	3	3	1	1															
		Polycirrus californicus	2	2	8	2	6	8	3	7	5	7	3	7	9	2	5			1	1	5	3	2	3	2	2					
		Polycirrus sp	3	3	2	3	3	3	2	2	1	1	2	2	1	4	1					1	1	2	1	1	1					
		Polycirrus sp A	3				1	3		2		8	3	1	4	8	1				1	7	2			2	5					
		Polycirrus sp OC1	1		2			1		1		1		1								1	3		1	1	1					
		Polydora narica																							1							
		Polynoinae																							1							
		Praxillella pacifica	9	9	2	7	1	8	2	7	4	8	6	1	9	5	6	2	2	6	3	16	24	4	8	9	6	2	11	5	13	10
		Praxillura maculata		1		1																										
		Prionospio jubata	8	3	7	5	4	3	2	4	1	1	12	1	7	5	8	40	42	20	30	39	35	14	24	37	54	22	13	16	12	12
		Prionospio lighti				1															2	1					1				2	
		Prionospio pygmaeus																										3	1	4		1
		Pseudopotamilla sp 1																			1											
		Sabellaria gracilis													1			1			7						4					
		Sabellides manriquei	1	3	1		1					1				1	1	2	1	2	3	3	2	1		1	1					

8-8. 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
		Salvatoria californiensis																2			1						1					1
		Scalibregma californicum	11	7	3	10	13	5	3	5	4	4	2	3		5	3	9	1	2	7	8	3	1	2	4	6	1	2		7	1
		Schistocomus sp A	1							1								2			1			2			2			4		
		Scolelepis (Parascolelepis) texana										1	1				3			1								1				
		Scolelepis (Scolelepis) occidentalis																													1	
		Scolelepis (Scolelepis) squamata																											1			
		Scoletoma sp			1	1																										
		Scoletoma zonata	1				4	2	1	2	3		3		1		2			1	2		4		1		1	1	1			
		Scoloplos acmeceps		1	3	1														1	1	2			1		1				1	
		Scoloplos armiger Cmplx												1																		
		Sigalion spinosus							1					1				1	1									3	2	6		3
		Sigambra tentaculata	1	1	7	4	2	1	1	1		1																				
		Sige sp A	5	2	5	6	4		1	3		3					1					2				1						
		Sphaerephesia similisetis																									5					
		Sphaerodoropsis biserialis										1																				
		Sphaerosyllis californiensis																									1					
		Spiochaetopterus costarum Cmplx	9	9	10	7	6	3	3	5	4	1	8	3	1	9	6	3	4	3	15	4	6	5	6	5	4	1	1	1		2
		Spionidae						2	2	1	3	1	1			1																
		Spiophanes berkeleyorum	1	3	2	2	1		1	6		1	1		2		3	1	2		4	1	6	6	3	8	4	3	3	2	1	1
		Spiophanes duplex	21	37	28	23	18	27	18	26	29	14	29	24	34	37	23	6	17	26	14	21	68	21	29	43	29	14	26	5	6	6
		Spiophanes norrisi	3	1				2		2		1	2	1	1	3	4		4	2	3	1	4	1	3	11	2	3	2	2	1	4
		Spiophanes sp											1		2	2	1															
		Sternaspis affinis	4	3	9	3	8	1	3	3	6	5	3	2	3	4	2			1		1	3	1	1		2		1			
		Sthenelais tertiaglabra	1	1	1	3	1		2	3	1	1		1	1	4	3	1	1		3		1			1			1	1		1
		Sthenelanella uniformis	8	3	7	5	5	3	7	4	7	7	3		3	7	1		2	2		1		1	2	6	2	1				1
		Streblosoma crassibranchia	47	28	32	34	21	10	22	20	17	7	4		2	4	4		1	2		8	1	1	3	2	1					
		Streblosoma sp B								1																					2	2
		Streblosoma sp C						1																								
		Syllides mikeli		1																												
		Syllis heterochaeta	6					3	1	1		2	11	2	7	4	3					3	1			1						
		Syllis hyperioni	9	8	9	6	6	2	7	7	3	2		1			1					3										
		Tenonia priops											1				1				3									1	1	
		Terebellides californica						1	1	3	2	1		1	1	6	5	5	4	1	3	3	2	5	3	2	4	1	2			
		Trophoniella harrisae		1																												
Arthropoda	Malacostraca	Acidostoma hancocki				2																										
		Acuminodeutopus heteruropus																														1
Total Arthoropods 4,340		Americhelidium rectipalmum				1				1						2								1						1		
% of Population 25.73		Americhelidium shoemakeri														1									1							
		Americhelidium sp SD4	2	1	2			1							1		1	1	2	1		5	1				1					
		Ampelisca agassizi	1		2		1	1		1	1	1		1		2				1		2	1									
		Ampelisca brachycladus										1			1			1					1					1		1	2	1
		Ampelisca brevisimulata	11	11	10	5	10	21	14	10	8	11		20	13	16	14	3	16	19		13	7	8	10	11	4	7	15	16	16	21
		Ampelisca careyi			1		1				1		1						1			2	2		1	1						
		Ampelisca cf brevisimulata									2		7							1		1										
		Ampelisca cristata microdentata							1	1		3	2	4	2	1		11	7	2	4	6	7	2	6	24	9	13	18	10	21	21
		Ampelisca hancocki						1																								
		Ampelisca indentata	4				6				1											1										
		Ampelisca lobata							2					1							2											
		Ampelisca milleri	5		1	1		1			1			1	1				1			1	1		1	1						
		Ampelisca pacifica			1		1		1																							
		Ampelisca pugetica		1	4	4	2	2	4	2	3	4	4	7	6	4	2	1	3	2	2	2	1	1	3	2	3	2	2	1		
		Ampelisca sp			1			2	1			2	1	2										2	2		1			1	3	2
		Ampeliscphotis podophthalma	3	3		1		2	1	6	4	2		2	6	6		2	6	5	6	4	8	3	2	1		2	2		2	3
		Amphideutopus oculatus	21	11	10	13	14	14	1	19	13	13	10	31	15	40	16	2	61	61		45	28		19	37	2	12	2	26	26	17
		Aoroides exilis																7			2											
		Aoroides inermis																4			10						1					
		Aoroides sp																			2											

8-8. 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
		Argissa hamatipes															1						1	2	2	2						1
		Aruga holmesi												1																		
		Aruga oculata			1									3						1		1										
		Byblis millsi				1	1	1								1				1		1										
		Caecognathia crenulatifrons	12	4		1		1	6	5	12	5	3	3	1	10	14		8	4		22	7		5	4		3	4	2	6	5
		Campylaspis canaliculata						1					1							1										1	1	
		Campylaspis rubromaculata	2		2	1							1	1		1	1		3				1		1	1						
		Cancridae																											1		1	
		Caprella californica Cmplx			2					2				1				11			1						11	4	4			
		Caprella mendax																29	1		20											
		Caprella sp																								1	3					
		Caridea				1				1		1									1											
		Chondrochelia dubia Cmplx	14	4	12	2	6	7	11	13	5	14	3	6	17	11	17	9	4	3	15	20	2	6	4	7	6	5	14	1	14	5
		Columbiaemysis ignota																	1				1									
		Cumella californica																							1							
		Cyclaspis sp C																														1
		Diastylis californica	2		1	1			1	1		1	1	3		1		2	1		3	6	2	1	2							
		Edotia sp B		2	2	3	1			3								1			4			1		2	1			1		
		Ericerodes hemphillii																								1						
		Ericthonius brasiliensis						1																			3				1	
		Foxiphalus golfensis		3		1	1					2	1																		1	
		Foxiphalus obtusidens	3	2	1	4		3	4	10	4	9	12	7	10	9	6	23	15	12	27	22	19	15	21	22	15	20	11	22	27	31
		Gammaropsis thompsoni	1															5	1		3					2	10	2	9			1
		Gnathopleustes pugettensis																									1		1			
		Haliophasma geminata		2	2	3		3	2	5	2	2	2		3	4	4		4	5	1			4		2			1		1	2
		Hartmanodes hartmanae	1					1		1					1			1	1	2		1		1		2	3	3		1		2
		Hemilamprops californicus																										10		7	3	5
		Hemiproto sp A																	1													
		Heptacarpus stimpsoni																									1					
		Heterophoxus oculatus	6	2	6	4	2				2	1					1															
		Heterophoxus sp	1		1	1		1		2																						
		Hippomedon sp																3														
		Hippomedon zetesimus						1						6								1	1			2	1	5		2		
		Idarcturus allelomorphus	1							3								7			11	1					5					
		Idarcturus sp								8	1	1														1						
		Ischyrocerus anguipes																		1												
		Ischyrocerus pelagops																									1					
		Joeropsis dubia																			1											
		Laticorophium baconi																			2								1			
		Latulambrus occidentalis																			2								2			
		Listriella eriopisa				1													2													
		Listriella goleta			2	2	3		1	4	1	2	5	1	2		4	2	3	2		1	1	3	1	2	2					1
		Listriella melanica											2	1			1				2	4	1	2	2	2	1	1	3	1		
		Listriella sp SD1			1	1																										
		Mayerella banksia											1																			2
		Mesolamprops bispinosus																										2				
		Mysidae																					1									
		Neastacilla californica	1							2							1	4	2	1				3	2				1			5
		Nebalia daytoni	2			2		3		3	2			5	5	4	2	7	8	2	1		3		4	4		1		1	1	
		Nebalia pugettensis Cmplx					2	1	1			1	1	4				1		1	5	2			3	1						1
		Neotrypaea sp																								1						
		Notopoma sp A																1			1								1		2	
		Orchomene anaquelus																						1	1							1
		Orchomene limodes															2															
		Pachynus barnardi	1															1														
		Pacifacanthomysis nephrophthalma		1								1																				
		Parametaphoxus sp 1				1																										

8-8. 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
		Pentidotea rufescens									1							1														
		Photis bifurcata		1												2															2	
		Photis brevipes	10	2		4		8	1					2		17		4	4		2			3			6	3	8	4	6	4
		Photis lacia			1								1	1																		
		Photis sp	3		1											1									1	1	1				1	
		Photis sp B	5	1			2	1		5	3				5		1	1	10	5		12	1	2	3	2				1		
		Photis sp C	1			1																										
		Photis sp OC1																														2
		Phoxocephalidae									1																					
		Pinnixa franciscana		2	3						1	2				1		1	1	4	1	1		3	2	1		1				
		Pinnixa hiatus				1		1																								
		Pinnixa occidentalis Cmplx			1																											
		Pinnixa sp		1	1															1												
		Pinnixa weymouthi																										3		5		2
		Pinnotheres pugettensis					1																									
		Platymera gaudichaudii																					1									
		Pleustidae																			1											
		Pleusymtes subglaber								1																						
		Randallia bulligera																								1						
		Rhepoxynius bicuspidatus			1			2	1	5	1	2	2		1		2					1				1						
		Rhepoxynius daboius																							1				1			
		Rhepoxynius menziesi				1					1		3		1		2	4		1		1	2	1	1			6	4	4	2	13
		Rhepoxynius sp																						1								
		Rhepoxynius stenodes	3	1		1		2		2	1			4	5	3	4	7	9	4	7	5	7	9	4	2	8	17	16	13	5	8
		Rhepoxynius variatus																											3	7		3
		Rudilemboides stenopropodus												1	2			1	5			5	5		2	7	2	3	3	19	5	11
		Sphaeromatidae																1														
		Stenothoides bicorna																								1	1					
		Stomatopoda									1																					
		Sunamphitoe plea																1														
		Westwoodilla tone	2		5					3		2	4	1		7		11	6	1	3	2	3	1	2	8	8	1		1	1	5
	Maxillopoda	Hamatoscalpellum californicum	4		1																											
	Ostracoda	Asteropella slatteryi		1														1		1	1											
		Euphilomedes carcharodonta		2	2	3	1	6	6	8	1	8	9	6	12	11	6	12	32	14	12	14	6	10	9	6	5	8	20	6	12	13
		Eusarsiella thominx	3	4	2		1			1	1						2															
		Leuroleberis sharpei																										2	1	1		1
		Rutiderma rostratum									1								1													
		Vargula tsujii																	1													
		Xenoleberis californica		1				1			1					1			1			2					1					
		Westwoodilla tone		1	2	1	1	3					3	2		7		20	20	22	5	4	9	3	2	4	2	1	2	1		2
		Talitroidea		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 slatteryl																		2				1					1			1
		Cylindroleberididae														1																
		Euphilomedes carcharodonta		15	19	10	6	21	29	1	8	5	22	28	25	19	20	18	22	10	8	26	5	32	34	12	24		1	2	2	5
		Eusarsiella thominx				1																										
		Leuroleberis sharpel																		1												
		Rutiderma rostratum							1					1	1	2		1									1		2			1
		Xenoleberis californica		1					1										1	4		2	1	1	1		1					

8-8. 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						2			2		1	1			3		1	1		1				1	1					
	Asteroidea	Asteroidea																									1					
		Astropecten californicus	2	4	4	2	3	1			3		2	2		1							4	1					1			
	Echinoidea	Echinoidea																		1												
		Lovenia cordiformis																											1			
	Holothuroidea	Chiridota sp	1	1	3	1	1										1															
		Leptosynapta sp	3	2	2	1	2			1												1				1						
		Pentamera populifera										1																				
		Pentamera pseudopopulifera				4																			1							
		Pseudocnus lubricus																			1											
	Ophiuroidea	Amphiodia digitata						1																								
	Total Echinodermata 164	Amphiodia psara											1																			
	% of Population 0.97	Amphiodia sp				1							1							1		1					1					
		Amphiodia urtica	2	2	2		1	1	1	1	4								1			2					1					
		Amphipholis squamata	6	2						2					1			1				3			1		2					1
		Amphiura arcystata		1	6	2		1		1																					1	
		Amphiuridae		1		2	2	1	1		1	1	1		1	1	1			2	1		3							1	1	
		Ophiothrix spiculata		1		2	1												1													
		Ophiuroconis bispinosa																1		1					1		1	2		1		
Mollusca	Bivalvia	Axinopsida serricata	3	2			1	2	1	1			1																			
		Compsomyax subdiaphana	2	3	1	1	4				1						1						1	1	1			1				
	Total Mollusca 1,273	Cooperella subdiaphana	2	1		2	1	1		1		2		1	1	2			2				1						2			
	% of Population 7.55	Cyathodonta pedroana				1									1													1				
		Ennucula tenuis									1																					
		Ensis myrae				1																		1		1		2			1	
		Gari fucata															1															
		Kurtiella coani											1					2														1
		Kurtiella grippi				1		1			1	2	1	1	1		1									1						
		Kurtiella tumida	4	2	7	5	1	1	4		4	1	2			1		3	11	1	5	2	2	1	1	1	6	8	1	12	8	8
		Leptopecten latiauratus	2			2															1		1	1			1		2			
		Leukoma laciniata																					1		1							
		Lucinisca nuttalli														2								1								
		Lucinoma annulatum				1																										
		Lyonsia californica					1									1				2										1		
		Macoma yoldiformis	8	11	4	7	6	6	9	5	8	10	1	1	2	8	2	1	7	7		1	7	2	5	3	1		1	1	1	
		Mactromeris hemphillii																														1
		Modiolatus neglectus					1							1		1	1	2		1					1							
		Modiolinae								1																	2	1				1
		Neaeromya compressa			1																											
		Nuculana taphria	6	7	3	3	6	2	5	8	5	3	1	3	2	1	1						3		3	1	2				1	
		Panopea generosa																		1												
		Parvilucina tenuisculpta	9	11	3	13	5	2	1	1	1	7	3		4	1	2	6	1	3	1	5	3	1	3	1	2					
		Pectinidae																												1		
		Periploma discus	3	3	3	3	4	1			2	1	1			3				2			1							1		
		Pitar newcombianus																			1											
		Raeta undulata										1											1									
		Saxicavella nybakkeni															2							1								
		Solamen columbianum	6	6	2	3	2	2	3		1	1				5	1			2			2									
		Solen sicarius			1	1	2		1	1	1		2		2			2			1		1									
		Sphenia fragilis																					1									
		Tellina idae															1	1	1													
		Tellina modesta						2		5			3	3	1		1	11	4	1	7	4	3	4	2	1	2	7	19	8	16	13
		Tellina sp B	7	12	8	14	16	16	6	28	4	14	5	14	9	5	6	9	3	11	8	11	7	3	3	2	3					
		Thracia trapezoides										1	1																			
		Thyasira flexuosa		3	1	1																										
		Trachycardium quadragenarium				1			2		2	1								1		1										
	Caudofoveata	Chaetoderma pacificum			3																				1							

8-8. Continued.

Phylum	Class	Species	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
		Falcidens longus	1			1																										
	Gastropoda	Aglaja ocelligera																					1									1
		Amphissa undata																1														
		Ancula sp																	1													
		Armina californica					1																									
		Balcis sp										1																				
		Callianax pycna							1																					2		
		Calyptraea fastigiata																			1											
		Columbellidae																			1											
		Crepidula glottidiarum																									1					
		Cylichna diegensis		1		2	2	4	1		2	1				5																
		Epitonium sawinae		1	2																											
		Eulima raymondi											1							1			1									
		Kurtziella plumbea																									1		2			
		Lirobittium sp		1																												
		Odostomia astricta																			1											
		Odostomia sp																									1					
		Odostomia sp HYP1		1													1										1					
		Ophiodermella inermis																								1						
		Philine auriformis	2	2	1	1	1	3	1	3	1	1			1		2			1	1	3	1		1		2	1	1			
		Polygireulima rutila																		1					1							
		Rictaxis punctocaelatus																												2		
		Sulcoretusa xystrum																													1	
		Terebra hemphilli																					2									
		Turbonilla chocolata														1																
		Turbonilla santarosana													2	1				1			1								1	
		Turbonilla sp OC1		1																												
		Volvulella cylindrica					1				1																					
		Volvulella panamica		2	2	4	1		1																							
	Scaphopoda	Gadila aberrans	16	21	3	14	9						16	5	3	19	17	4	3	11	5	6	11	9	8	11	12	5	9	2	3	5
Total Misc. Phyla 997 % of Population 5.91																																
Brachiopoda	Lingulata	Glottidia albida		3		3	3	1			1					2	2			2		2	2		1		1					
Chordata	Enteropneusta	Balanoglossus sp																													1	
		Enteropneusta			1																							1			2	
		Saccoglossus sp				1																										
		Schizocardium sp	1	3	4	7	4											1		1	1			1				1				
		Stereobalanus sp	6	1	3	2	1		1		1	1														1						
Cnidaria	Anthozoa	Acanthoptilum sp			1																											
		Arachnanthus sp A	1				2	1		2	2		1			2				2												
		Ceriantharia		2		1		1				2			1				1					1		1						
		Edwardsia juliae	3	1	12	13	52	12	8	4	9	8	3	4	3	11	3			2		1	2			2				2		
		Edwardsiidae		1			1																									
		Halcampa decemtentaculata			2					1					1											1						1
		Halianthella sp A					1																									
		Pentactinia californica			1	1																										
		Scolanthus triangulus	2	1		4	7																									
		Virgularia californica																											1			
		Virgularia sp				1																										
	Hydrozoa	Corymorpha bigelowi																								1						
		Corymorpha palma												1	1																	
		Leuckartiara octona			1																•											
		Symplectoscyphus pedrensis	1																			1										
Echiura	Echiurida	Arhynchite californicus		1																												
		Listriolobus pelodes									1		2		1		1			1				1					1			

8-8. 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
Nematoda		Nematoda										1									2		2		3		18	5	6	1	10	9
Nemertea	Anopla	Carinoma mutabilis	2								1		1			1		2	2		4						1	3	3	2	3	3
		Cerebratulus californiensis	3	1	4	4	2	1	2	2	3	3	2	2	1	2	6	1			2	2	1			4	2	2	2	1	1	2
		Cerebratulus marginatus										2	3	1	4		1					2	1	2			1					
		Cerebratulus sp			1		1	2		1																						
		Lineidae	1	1				3				1	1	2			2				2		1			1	1					
		Lineus bilineatus	1	2	1				1	1		2	1	2	1	1	3	1	1		1	2	1	1	1	2	2					
		Lineus sp SD1																					1									1
		Tubulanidae				2	3		1	1		1									1		1			1					1	
		Tubulanidae sp A																			1											
		Tubulanidae sp E	5	2	1	1	2		1		1	2	1	2		1	2		1		4	1	5		1	2	5		2		1	
		Tubulanidae sp GOL1												1					1		2											
		Tubulanus cingulatus			1					1	1	1	1				2									2	2	1				
		Tubulanus polymorphus	7	4	14	3	10	7	6	5	1	6	6	5	4	2	6	2		4	8	3	3		1	2	5	1	1			
		Tubulanus sp	1			3	1																									
		Tubulanus sp A																								1	2					
		Zygeupolia rubens																									1					
	Enopla	Amphiporus californicus	2	1					1	1	1			2	1		1					3		2			1		1	1	2	2
		Amphiporus cruentatus				1												1	1	1			2		1	2	1			1	1	1
		Amphiporus flavescens	1	1		3	1	1		2	2	1		1	3	1			2			4	3	3	2	1	3				1	
		Amphiporus imparispinosus		1											1									1								
		Amphiporus sp	1	2						1					1	1																
		Cryptonemertes actinophila																										1				
		Oerstedia dorsalis Cmplx	1	1															1			1		1		1				1		2
		Paranemertes californica												1			2		1	1	2	4	1	1	1					2	2	1
		Quasitetrastemma nigrifrons																											1			
		Tetrastemma albidum																									1		2			
		Tetrastemma candidum											1	1								1				2						
Phorona	None	Phoronis sp	11	11	18	7	15	3	2	8	2	3	2	3	3	4		3	4	5	5	2	5	1		3	2	4	4	2	2	2
Platyhelminthes	Turbellaria	Cryptocelis occidentalis					1														1		1							1	1	
		Leptoplanidae																			1											
		Stylochus exiguus																									1		1		3	
		Stylochus franciscanus				1																										
Sipuncula	Phascolosomatide.	Apionsoma misakianum	1	3	3	6	1							1				2			3	1										
	Sipunculidea	Siphonosoma ingens											1																			
		Thysanocardia nigra	2	1	1	4	2																									