GOLETA SANITARY DISTRICT

NPDES MONITORING PROGRAM

2012 ANNUAL REPORT

Submitted: March 2013

GOLETA SANITARY DISTRICT

A PUBLIC AGENCY
www.goletasanitary.org

February 12, 2013

California Regional Water Quality Control Board
Central Coast Region
Attn: Monitoring and Reporting Review Section
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401

Dear Mr. Harris:

Facility Name: Goleta Sanitary District

Address: One William Moffett Place
Goleta, CA 93117

Contact Person: Robert Hidalgo
Job Title: Operations Supervisor
Phone Number: (805) 967-4519

WDR/NPDES Order Number: **R3-2010-0012**
WDID Number: **3/420102001**

Type of Report (circle one): **Monthly** **Quarterly** **Semi-Annual** **(Annual)**

Month(s) (circle applicable months*): **(JAN)** **FEB** **MAR** **APR** **MAY** **JUN**
JUL **AUG** **SEP** **OCT** **NOV** **DEC**

***Annual Reports** (circle the first month of the reporting period)

Year: 2012

Violation(s) (Place an X by the appropriate choice): **X** **No** (there are no violations to report) ___ **Yes**

If Yes is marked (complete a-g):

a) Parameter(s) in Violation: _____

b) Section(s) of WDR/NPDES Violated: _____

_____

c) Reported Value(s) _____

d) WDR/NPDES Limit/Condition: _____

e) Dates of Violation(s)
(reference page of report/data sheet)**:** _____

f) Explanation of Cause(s):
(attach additional information as needed) _____

g) Corrective Action(s):
(attach additional information as needed) _____

Comment

In accordance with the Standard Provisions and Reporting Requirements, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision following a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my knowledge of the person(s) who manage the system, or those directly responsible for data gathering, 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.

If you have any questions or require additional information, please contact me at the number provided above.

Sincerely,

GOLETA SANITARY DISTRICT

Name: Kamil S. Azoury, P.E..
Title: General Manager/ District Engineer

GOLETA SANITARY DISTRICT

NPDES Monitoring and Reporting Program

2012 Annual Report

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

Submitted March 2013

AQUATIC BIOASSAY OCEANOGRAPHIC TEAM

MARINE BIOLOGISTS

T. Mikel, President
S. Johnson, Principal Scientist
D. Laur, Ph.D., Chief Biologist
Jim Mann, Biologist
Karin Wisenbaker, Biologist

MARINE CHEMISTS

R. Gossett (CRG Marine Laboratories)

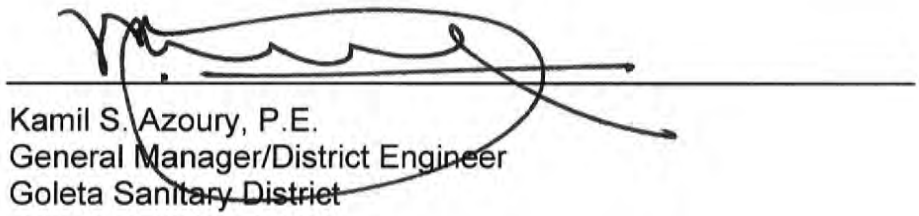
TAXONOMISTS

D. Laur, Ph.D., Miscellaneous
Phillips, Crustacean Taxonomist
S. Johnson, Mollusk Taxonomist

BOAT CREW

J. Gelsinger, Captain

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.



Kamil S. Azoury, P.E.
General Manager/District Engineer
Goleta Sanitary District

Date: 3/27/2013

CHAPTER 1

INTRODUCTION

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

As required by waste discharge requirements GSD submitted an NPDES permit renewal application to the RWQCB and the EPA in May 2009. At the time of the application submittal, the District was five years into the ten year conversion schedule described in the settlement agreement of 2004. Both the RWQCB and the EPA agreed to renew the 301(h) waiver permit for another five years while GSD continued to make progress to upgrade its treatment facility. The treatment plant is operating under WDR Order No. R3-2010-0012 and NPDES Permit No. CA0048160 which became effective September 2010.

As a condition of the NPDES permit, GSD is required to conduct an extensive monitoring and reporting program to assess compliance with limitations established by the California Ocean Plan and the federal Clean Water Act. For GSD, these limitations are met by blending primary and secondary treated effluent as allowed for ocean dischargers under Section 301(h) of the Clean Water Act. Under conditions set forth in the permit, GSD must monitor the influent, effluent, biosolids (sludge), the outfall and diffuser, receiving water, bottom sediment, and biology to demonstrate that the discharge of wastewater is not causing adverse impacts on the ocean environment.

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

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

WASTEWATER TREATMENT PROCESS

The following discussion focuses on the principal features of GSD's 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, 2003 to 2012, the plant has discharged about 3.9 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 a 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 facilities operate utilizing a split-stream process of physical and biological treatment. Biological treatment is provided by the trickling filter and solids contact process. The following sections describe the treatment process. A flow diagram summarizing the treatment process is presented in Figure 1-2.

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 a bar screen which removes large debris. Influent is then routed to aerated grit tanks where sand and grit are allowed to settle out. 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 odor reduction towers equipped with activated carbon.

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. The primary effluent flow is then

split with one portion of the effluent stream receiving additional secondary treatment and the remaining primary treated flow is discharged directly after being disinfected. On average 63% of the solids were removed in the primary treatment process during 2012.

Secondary Treatment

Secondary treatment involves three treatment elements: the biofilter, a solids contact channel, 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 a solids contact channel 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. Effluent from this secondary process is combined with primary effluent at the chlorine contact tank. A portion of the secondary process flow can be diverted to the reclamation facilities for tertiary treatment with gravity filters.

Chlorine Contact Tank

The primary and secondary effluent flows are combined at the head of the chlorine contact chamber where sodium hypochlorite is injected to kill bacteria in the effluent. According to the District's permit, a minimum of 5 mg/L total chlorine residual (calculated as a 7-day average) must be maintained at the end of the chlorine contact channel to ensure a sufficient bacterial kill. Prior to discharge into the ocean, sodium bisulfite is added for dechlorination, thus completing the disinfection process.

Sludge Treatment and Biosolids Disposal

On average throughout 2012, settleable solids and floatable materials from the primary clarifiers were treated in three heated anaerobic sludge digesters for approximately 41 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 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 compression through a belt filter press.

Because of the extensive construction taking place to upgrade the secondary portion of the treatment facilities, the sludge that would be air dried in the sludge drying beds and converted into Class A biosolids, for use by the local community has been temporarily discontinued. The belt pressed biosolids, identified as Class B, for the first three months of 2012 were transported by truck to Honey Bucket Farms in Kern County. This material was lime stabilized and applied to agricultural land as a soil amendment in Kern County. In April 2012 the district signed a three year contract with Western Express, Inc. to transport the class B biosolids to the Holloway Solid Waste Facility in Lost Hills, CA. The biosolids are used to reclaim the depleted gypsum mine pits.

A complete biosolids report describing the treatment and disposal process is prepared each year and submitted to the EPA.

Figure 1-1. Regional View of the Goleta Valley.

Figure 2-1. Treatment Process Flow Diagram

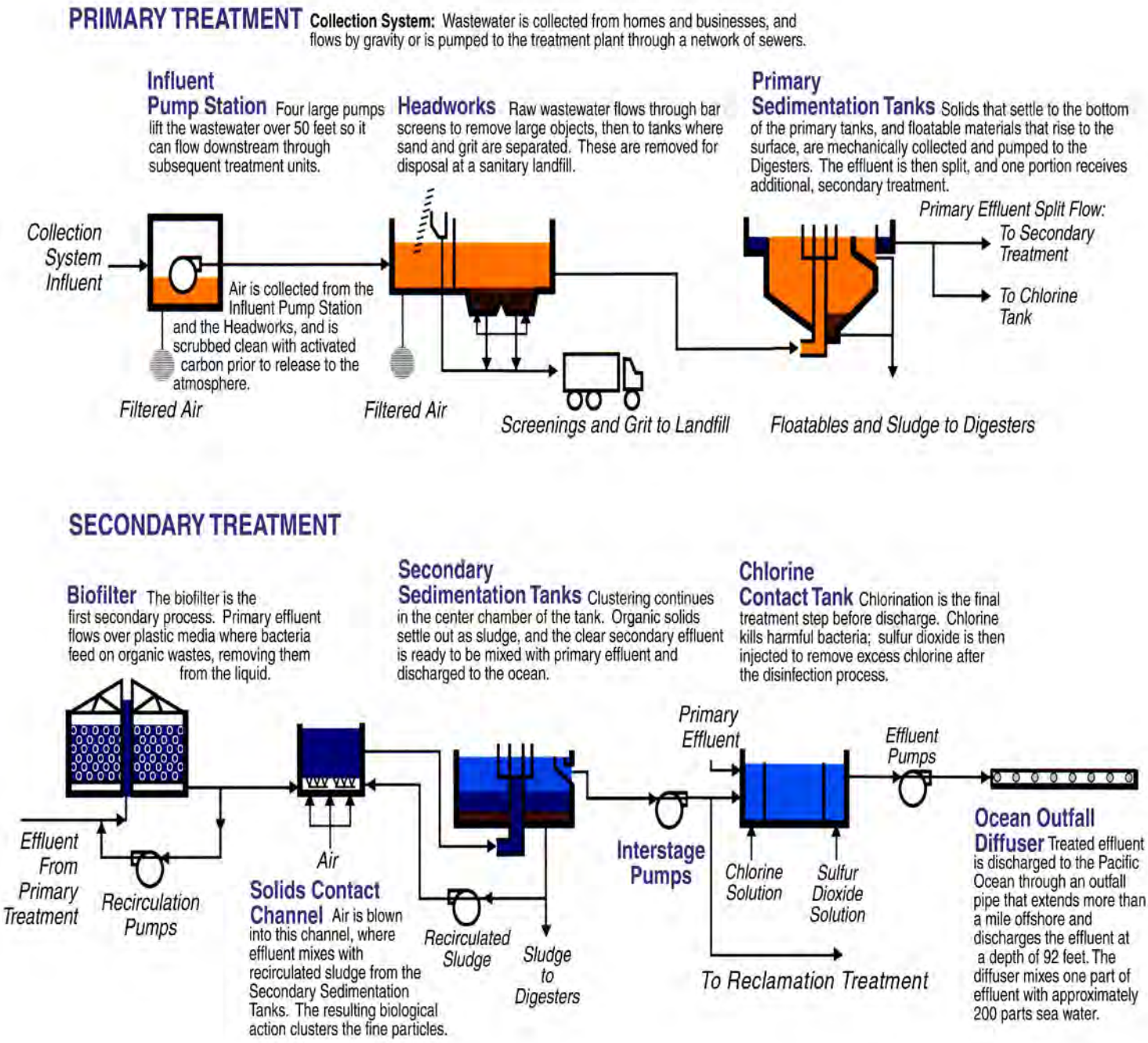
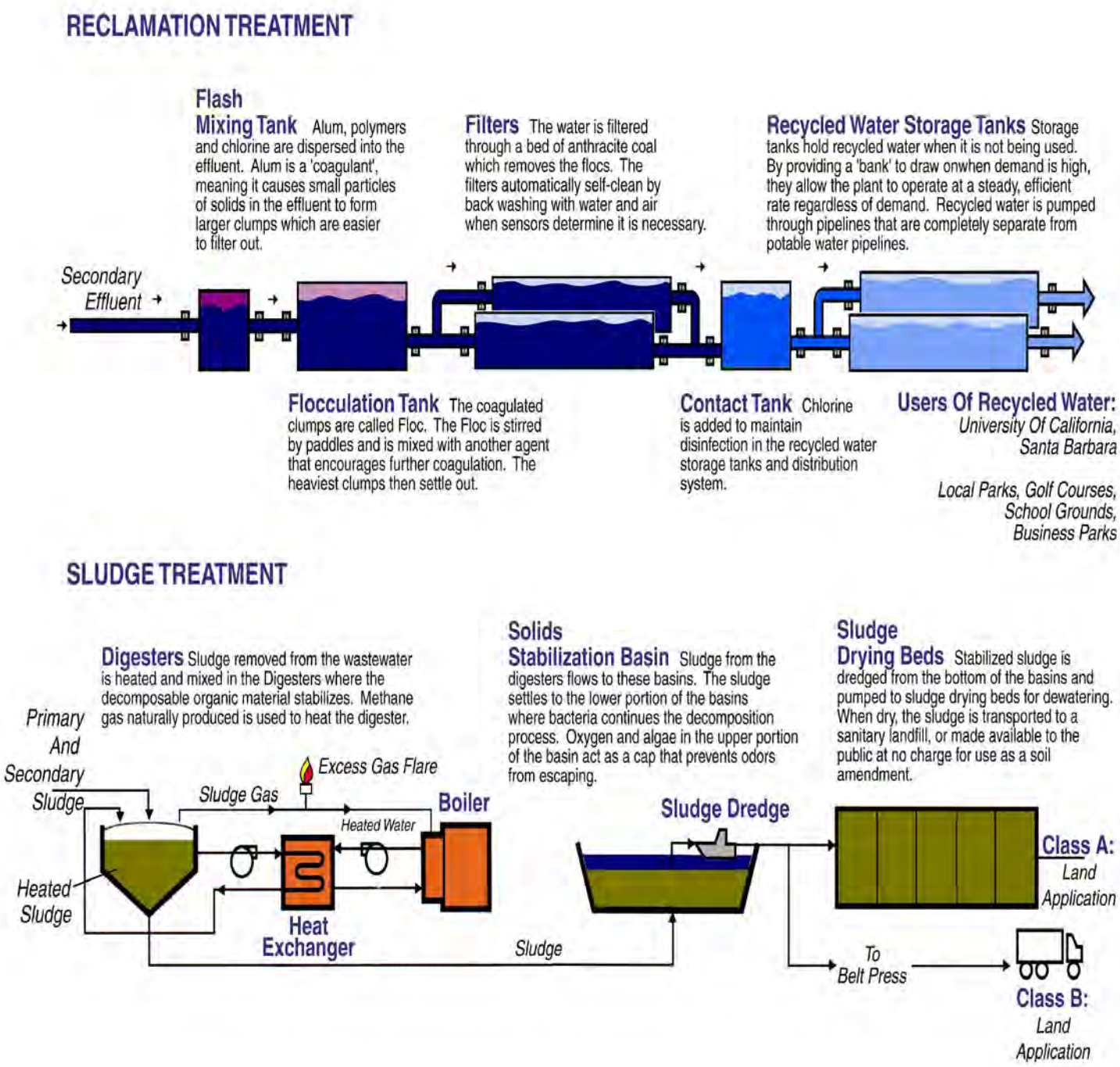


Figure 2-1. Treatment Process Flow Diagram (continued)



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 within 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 blended 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. Kamil Azoury, P.E., serves as GSD's General Manager and District Engineer. The General Manager is responsible for overall operation and performance of the treatment plant.

Eight state certified treatment plant operators operate the wastewater treatment plant under the direction of Mr. Jeffrey Salt, the District Operations Manager. Mr. Salt also supervises the treatment plant's industrial waste staff. Mr. Chuck Smolnnikar, supervises the maintenance staff and the laboratory is under the direction of Ms. Kathleen Werner, the technical services and laboratory supervisor. The grade and certification number of operations, maintenance, and laboratory personnel employed during the 2012 operational year are shown in Table 1-1.

Table 1-1. Goleta Sanitary District Operation Staff, 2012

Staff	Grade	California Certification No.
Operators		
Jeffrey Salt	V	4208
Paul Buckley	V	7728
Robert Hidalgo	IV	6905
Stephen Conklin	III	7065
Todd Frederick	IV	IV-27633
Ricardo Lopez	III	III-10756
Jose Sanchez	II	6400
Francisco M. Lemus	III	10893
Jes Hulbert	I	I-28266
Morgan Lee	I	I-28400
River Ferrara	I	I-28488
Lab Technologist		
Kathleen Werner	IV	070134001
Ray Giordano	III	070733003
Maintenance Technologist		
Charles Smolnikar		
Carl Easter	II	110662004
Mark Baumgartner	II	080722022
Mike Sullivan		
Jose Hernandez		

Monitoring and Reporting Program

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

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

The receiving water monitoring program consists of assessing water quality and ocean sediment chemistry, evaluating community structures of benthic biota, bottom fish, and epibenthic macroinvertebrates, and determining the bioaccumulation of pollutants in

various marine organisms. Table 1-2 summarizes the sampling schedule for various elements of the monitoring and reporting program conducted during 2012.

Table 1-2. Schedule for NPDES Monitoring, Goleta Sanitary District, 2012

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

Influent, effluent, and receiving water monitoring is conducted in accordance with U.S. Environmental Protection Agency approved test procedures as stipulated under Title 40 of the Code of Federal Regulations, Section 136 (40 CFR 136): *Guidelines establishing test procedures for the analysis of pollutants*. Water quality analyses for compliance monitoring are performed by analytical laboratories certified by the California Department of Health Services. 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. In light of this change the District contacted all other interested parties to whom monitoring reports are sent and except for the Division of Water Quality, all agreed to accept their routine reports electronically. The first report submitted this way was the June 2008 monthly reclaimed water report.

WASTEWATER TREATMENT UPGRADING PROJECT

A condition of the November 2004 301(h) permit renewal included a provision to upgrade the current blended effluent treatment process to full secondary. Under a negotiated settlement agreement between the RWQCB and GSD the District agreed to follow a detailed conversion schedule to ensure that the treatment plant was discharging full secondary treated effluent by November 2014. The conversion schedule is shown below. The District is now eight years into the 10 year conversion timeline.

The District awarded the facility planning contract to HDR Engineering and the environmental review contract was awarded to Tetra Tech. A preliminary draft of the facilities plan was sent to the Regional Water Quality Control Board in December 2006 and was circulated for review to all treatment plant contract users and other interested parties. The final facilities planning document was completed in June 2008.

A separate contract was then awarded to HDR Engineering to initiate and complete the design of the new treatment plant. The treatment plant design process addressed concerns regarding cultural resources and construction costs and allowed GSD to retain the use of current structures while planning for future regulatory changes. The new secondary treatment structures include the construction of a second biofilter, identical to the existing, an aeration basin and two new secondary sedimentation tanks. Primary and secondary solids will be co-thickened in mechanical thickeners located in a newly constructed solids handling building. The solids treatment will continue with anaerobic digestion, lagoon stabilization and finally, conversion to biosolids with two new screw presses.

Other features of the proposed upgraded plant include:

- Conversion of stabilization basin #1 into a flow equalization basin
- Construction of a second biofilter with a total media depth of 6 feet to match the existing biofilter
- Construction of a three train aeration basin with stub outs to add a fourth train at a future date if needed
- Construction of two new secondary clarifiers, and
- Construction of a solids handling building that will house the mechanical thickeners, polymer tanks and screw presses.

The District has met all timelines specified in the conversion schedule except for C. 2. Environmental Review & Permitting, Certification of Final CEQA Document. The January 31, 2009 deadline to complete this milestone proved to be unattainable due to a flaw in the original negotiated agreement. The District requested and received, from the RWQCB, an extension for this task. The extension request was based on force majeure reasons caused by unforeseen cultural resource issues at the treatment plant site. The District conducted an extended phase 1 archaeology study in the areas of the new biofilter, proposed DAFTs and new pipeline corridors. Two inch geoprobes were drilled approximately every 10 meters and the contents of the geoprobe were examined by a geomorphologist, an archaeologist and a Native American representative. The results of this extensive archaeological investigation indicated that the location proposed for the DAFTs had the possibility of containing some Native American artifacts and the District was advised to relocate these structures. Eventually the design was modified and the DAFT structures were removed and replaced with mechanical thickeners that were located in the southern portion of the plant.

No indication of artifacts were found in the location proposed for the new biofilter and corresponding pipeline corridors. These structures did not need to be relocated, however

archaeologists and native American monitors were on site during the excavation of these areas.

CONVERSION SCHEDULE

Tasks	Date of Completion*
A. Preliminary Activities:	
1. Submittal of Detailed Conversion Plan and Timeline to Owners of Capacity in District's Plant	01/01/05
2. Coordination of Conversion concepts w/Owners of capacity in District's Plant (Education regarding participation in conversion)	06/30/05
3. Send Requests for Environmental & Consulting Engineering Contracts	12/31/05
4. Award of Environmental & Consulting Engineering Contracts	06/30/06
B. Facilities Planning:	
1. Complete Draft Facilities Plan	12/31/06
2. Complete Final Facilities Plan	06/30/08
C. Environmental Review & Permitting:	
1. Complete & Circulate Draft CEQA Document	06/30/08
2. Certify Final CEQA Document	~~**01/31/09**~~ **06/30/10**
3. Submit Applications for all Necessary Permits	01/31/09
4. Obtain all Necessary Permits	01/31/11
D. Financing:	
1. Complete Draft Plan for Project Design & Construction Financing	01/30/07
2. Complete Final Plan for Project Design & Construction Financing	03/31/08
3. Submit Proof that all Necessary Construction Financing has been Secured, Including Compliance with Proposition 218	12/31/10
E. Design & Construction:	
1. Initiate Design	06/30/08
2. 30% Design	12/31/08
3. 60% Design	11/30/09
4. 90% Design	03/31/10
5. 100% Design	09/30/10
6. Issue Notice to Proceed to Contractor	04/30/11
7. Construction Progress Reports	Quarterly (w/self monitoring reports)
8. Complete Construction & Commence Debugging and Startup	04/30/14
9. Full Compliance w/Secondary Requirements	11/01/14

*Any completion date falling on a Saturday, Sunday or State Holiday shall be extended until the next business day. The district shall submit proof of completion of each task within 30 days after the due date for completion.

By the end of December 2010, the District was successful in meeting all regulatory conditions and received all permits necessary to complete the project. For reference purposes, the following permits have been approved:

Permitting Agency	Type of Permit	Permit Number
Santa Barbara County	Government Code Consistency	09GOV-00000-00001
Santa Barbara County	Revised Development Plan	09RVP-00000-00001
Santa Barbara County	Grading Permit	09GRD-00000-00073
Santa Barbara County	Coastal Development Permit	09CDP-00000-00099
California Coastal Commission	Coastal Development Permit	4-09-011
Santa Barbara County	Land Use Permit	10LUP-00000-00235
Santa Barbara County	Land Use Permit	10LUP-00000-00360
Santa Barbara County Air Pollution Control District	Authority to Construct	13378
Santa Barbara County	Grading Permit	10GRD-00000-00075
Santa Barbara County	Building Permit	10BDP-00000-00553
Goleta Water District	Can & Will Serve Letter	

PCL Construction company was the low bidder and was awarded the construction contract. Their bid submittal was for $28.6 M. Mobilization took place in April 2011 and construction started in May 2011. A total of seven quarterly construction progress reports were prepared and submitted to the state and regional water quality control boards and several other interested parties. By the end of December 2012 all new structures have been built. The new biofilter, the aeration basin and one of the new secondary clarifiers have been put on line and are operational. However, as some of the existing structures have been taken off line for extensive renovations, the flow through the secondary system is still being limited to approximately 4.2 MGD. The stabilization basin has been modified and work is continuing on the shower and locker building. Overall it is estimated athat 96% of the work for this project was completed by the end of December 2012.

REPORT ORGANIZATION

This report summarizes data collected during the 2012 monitoring and reporting program, and analyzes this data to determine compliance with the discharge permit terms and conditions. Chapters in this report have been organized to parallel sections of the monitoring and reporting program. The chapter sequence also follows the flow of wastewater as it undergoes treatment in the plant, as it is discharged to the marine receiving waters, and as it encounters nearby sediments and resident biota. Chapter 9 presents a summary of the lift station and collection system overflows, the causes of the overflows, the corrective actions taken, and any corrective actions planned. Chapter presentation is as follows:

Chapter 1	Introduction
Chapter 2	Treatment Plant Performance
Chapter 3	Receiving Water Environment
Chapter 4	Physical Characteristics of Benthic Sediments

Chapter 5	Chemical Characteristics of Benthic Sediments
Chapter 6	Biological Characteristics of Benthic Sediments
Chapter 7	Fish Populations
Chapter 8	Chemical Characteristics of Fish and Mussel Tissue
Chapter 9	Collection System Summary
Chapter 10	Discussion and Conclusions

CHAPTER 2

TREATMENT PLANT PERFORMANCE

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

WASTEWATER CHARACTERIZATION

Goleta Sanitary District's NPDES monitoring program requires measurement of many parameters at frequencies ranging from continuous to once per year. During 2012, influent, effluent, biosolids (sludge), and surf zone samples were collected by treatment plant personnel, and analyzed by the Goleta Sanitary District wastewater treatment plant laboratory and various contract laboratories such as; FGL Environmental Laboratories, Aquatic Bioassay Laboratories, Pace Analytical Laboratories, ToxScan, Inc., and Aquatic Testing Laboratories (ATL). Treatment plant personnel monitored and analyzed wastewater for performance-evaluating parameters including wastewater flow, suspended solids, biochemical oxygen demand (BOD), pH, turbidity, settleable solids, ammonia, oil and grease, temperature, residual chlorine, coliform and enterococcus bacteria. Monthly analyses for influent and effluent metals were performed by FGL Environmental Laboratories of Santa Paula, CA. FGL Environmental Laboratories, ToxScan, and Pace Analytical Laboratories performed annual analysis of priority pollutants and other parameters in influent, effluent, and biosolids samples. Influent and effluent samples were also analyzed for radioactivity. Bioassay tests for acute and chronic toxicity concentration were performed quarterly by Aquatic Testing Laboratory.

Analytical methodologies used by Goleta Sanitary District Laboratory and other contract laboratories used by GSD are based on approved U.S. Environmental Protection Agency (EPA) methods (EPA 1983; Federal Register 1984) and other methods in *Standard Methods for the Examination of Water and Wastewater, 21st ed*. (Standard Methods 2005). All methodologies employed during 2012 were approved for NPDES monitoring programs. Quality assurance and quality control procedures followed those presented in *Standard Methods for the Examination of Water and Wastewater, 21st edition.*

Results of the wastewater chemical analyses used to monitor proper operation of the treatment plant during 2012, 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

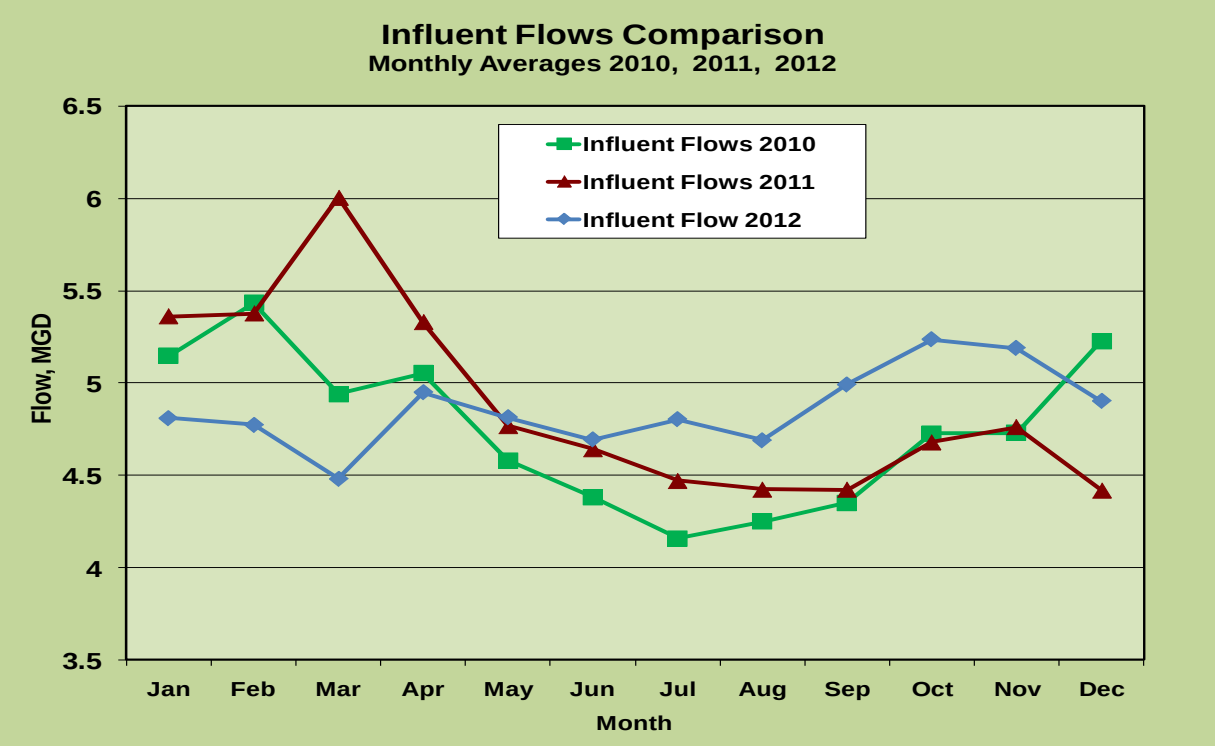
calculated from daily values at the treatment plant, with the exception of removal efficiencies, which are calculated from the monthly averages of the respective influent and effluent parameters.

Influent Flow

The daily influent flow into the treatment plant was monitored continuously throughout 2012. Influent flow without the internal plant recirculated flow, averaged 4.86 million gallons per day (MGD) an insignificant decrease from the 4.89 MGD treated during 2011.

Overall, the average monthly influent flows for 2012 were uncharacteristically stable throughout the year, fluctuating from a low of 4.5 MGD in March to a 5.2 MGD in October. This contrasts with a range of 1.6 MGD for 2011 and 1.2 MGD for 2010. No sharp spikes during the rainy winter months were observed as was seen in March of 2011 and no dramatic drops occurred during the dry summer months as reflected in the June through August flows of 2010. See Figure 2-1.

Figure 2-1. Influent Flows Monthly Average Comparison for 2010, 2011 and 2012



The highest flows into the plant during 2012 occurred in October, but were not associated with heavy rains, as is usually the case. The high flows may be due to the return of students to the University of California at Santa Barbara for the fall 2012 quarter.
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 2012 and averaged 3.9 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 2012 Monthly Averages

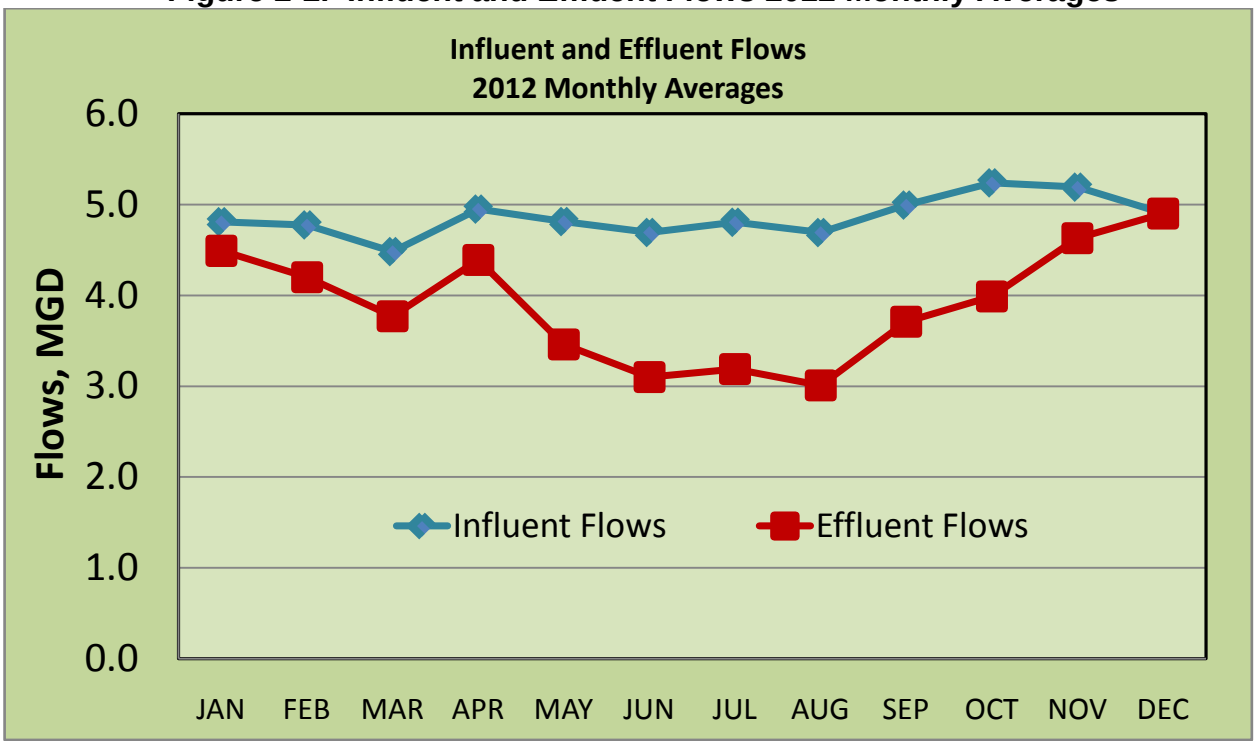


Figure 2-2 shows the monthly average influent and effluent flows for 2012. Higher wastewater effluent flow generally occurs during the winter months when influent flow is also the highest and recycling is minimal. The most important factor contributing to fluctuations in the effluent flow is the amount of wastewater that is processed into reclaimed water and used for irrigation. The lowest effluent flow occurred during August when the amount of flow discharged to the Pacific Ocean dropped to 3.0 MGD as depicted in Figure 2-2. The temporal variations in the monthly average effluent flow seen in 2012 fluctuated from a low of 3.0 MGD in August, when the daily production of reclaimed water was the highest of the year and averaged 1.7 MGD for the month to a high of 4.9 MGD during December when the reclaimed facility was off line for the entire month and the

influent and effluent flows were the same. 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, 2012.

	Flow		Total Suspended Solids				Biochemical Oxygen Demand			
Month	Influent MGD	Effluen MGD	Influent mg/L	Effluent mg/L	Removal (%)	Mass Emission (lbs/day)	Influent mg/L	Effluent mg/L	Removal (%)	Mass Emission (lbs/day)
Jan	4.810	4.49	272	45	83	1685	279	65	76	2394
Feb	4.775	4.20	299	52	82	1787	297	66	77	2284
Mar	4.482	3.77	295	47	84	1467	288	76	73	2374
Apr	4.949	4.39	285	49	82	1770	272	70	74	2544
May	4.812	3.46	307	51	83	1465	296	91	69	2619
Jun	4.692	3.10	323	44	86	1105	286	89	68	2235
Jul	4.804	3.19	290	38	87	1017	271	74	72	2017
Aug	4.691	3.01	316	40	87	1020	264	74	71	1888
Sep	4.993	3.71	307	40	87	1245	279	74	74	2340
Oct	5.237	3.99	323	42	86	1390	296	74	74	2400
Nov	5.190	4.63	284	38	87	1459	283	78	72	3000
Dec	4.903	4.90	296	33	89	1347	267	45	83	1868
Average	4.86	3.90	300	43	85	1396	282	73	74	2330
Limit	NL	7.64	NL	63		4010	NL	98		6240

***NL = No Limit*

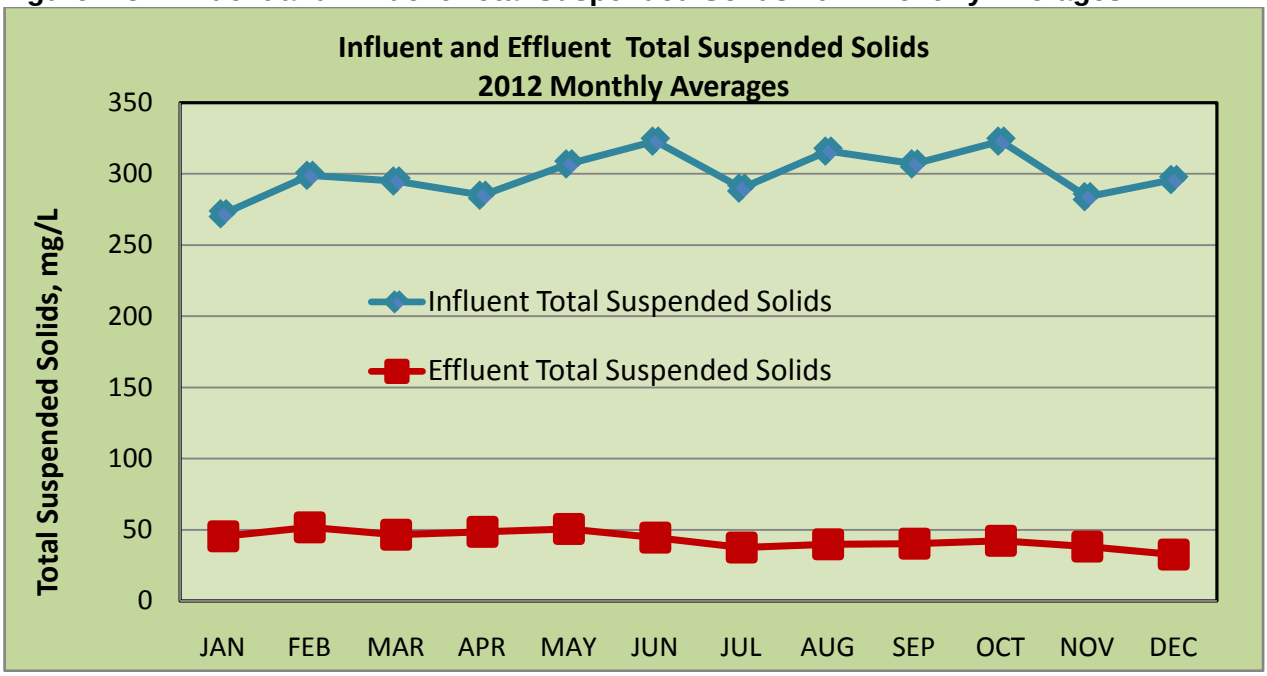
Suspended Solids

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 300 mg/L for the year an increase of about 5% from the 2011 annual average of 286 mg/L. Figure 2-3 below shows relatively consistent concentration of suspended solids in the influent TSS throughout the year.

The treatment process reduced the concentration of total suspended solids in the effluent to an annual average of 43 mg/L, representing an overall removal of 85 percent of the solids for the year; an efficiency similar to previous years.

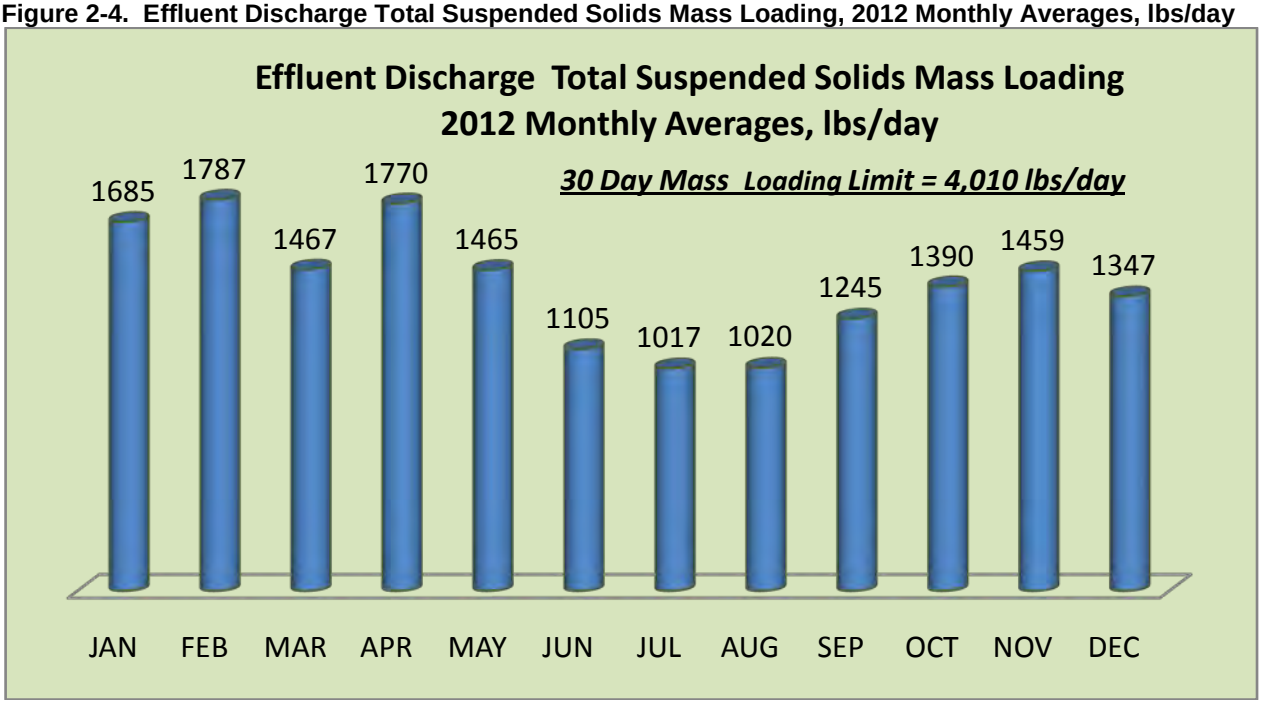
The monthly average suspended solids concentrations in the effluent ranged from 33 mg/L in December to 52 mg/L in February (Table 2-1), all 30-day monthly averages were well below the 63-mg/L monthly average limitation. The maximum daily value for 2012 was 76.5 mg/L, 23% below the 100 mg/L maximum at any time limitation and occurred on Saturday, October 6, 2012.

Figure 2-3. Influent and Effluent Total Suspended Solids 2012 Monthly Averages



Average monthly suspended solids mass loading rates for 2012 are represented graphically in Figure 2-4. Mass loading calculations factor in flow rates and as such they correspond very closely with total plant flows and rainfall. Loadings are the highest during the wet winter months and drop to the lowest values during the dry summer months. 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 2012 occurred in February at a high of 1,787 lbs/day, which is approximately half of the permitted monthly 30-day average limit of 4,010 lbs/day. The highest one-day maximum load for the year occurred on January 23, 2012 when 2,565 lbs of suspended solids were discharged. This maximum day discharge occurred at the end of a two day rainstorm and when the reclamation facility was off-line.

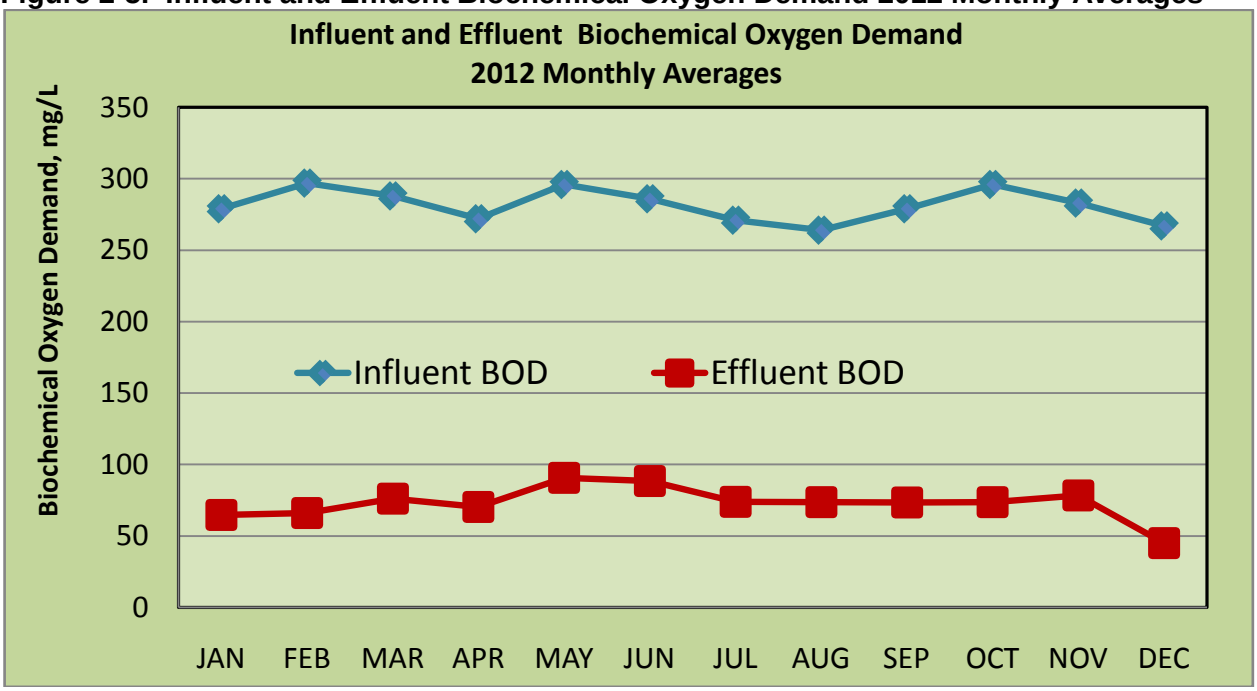
Figure 2-4. Effluent Discharge Total Suspended Solids Mass Loading, 2012 Monthly Averages, lbs/day



Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) levels were measured on 24 hour composite samples of the influent and effluent, at least three and five days per week, respectively. Fluctuations in the influent BOD concentration were somewhat larger than those observed for the effluent, but both were relatively stable throughout the year. (see Figure 2-5).

Figure 2-5. Influent and Effluent Biochemical Oxygen Demand 2012 Monthly Averages



During 2012 influent BOD averaged 282 mg/L showing no significant change from the annual influent average of 271 for 2011 and 273 mg/L for 2010. The influent BOD remained relatively stable throughout the year, ranging from a monthly average low of 264 mg/L in August to a high of 297 mg/L in February.

The monthly average final effluent BOD was very stable throughout the year with the annual average of 73 mg/l and the range extending from a low of 45 in December to a high of 91 in May, (Table 2-1). This difference between influent and effluent BOD represents an overall removal rate of 74 percent. Similar to observations in 2011 there seemed to be an increase in the number of individual daily BOD results that exceeded 100 mg/L. 2011's high samples were attributed to unexplained fluctuations in the laboratory BOD meter, although no clear quality control evidence existed to support this observation. The maximum effluent concentration for 2012 was measured on September 25, 2012 at a concentration of 149 mg/L, and occurred in conjunction with the return of the students at the University of California at Santa Barbara for the fall quarter. Several times throughout the year, effluent BOD measurements spiked up to unusually high values, on June 11, 2012 the BOD was 139 mg/L and on July 10, 2012 it reached 130 mg/L, both days saw increased volumes of secondary effluent diverted for tertiary treatment thereby increasing the primary / secondary ratio in the final effluent. The NPDES effluent BOD monthly average limitation and the maximum at any time limitation are 98 mg/L and 150 mg/L, respectively. All BOD NPDES limitations were achieved throughout the year.

Table 2-2. Monthly Averages of Influent and Effluent Parameters, Goleta Sanitary District, 2012

	pH		Turbidity	Settleable Solids	Ammonia	Oil and Grease			Toxicity	
			Effluent	Effluent	Effluent			Mass Emission	Effluent	Effluent
Month	Influent	Effluent	(NTU)	(mL/L/hr)	(mg/L)	Influent	Effluent	(lbs/day)	Acute (TUa)	Chronic (TUc)
Jan	7.6	7.3	45	0.2	45	34.2	6	241	2.73	17.9
Feb	7.6	7.3	46	0.2	48	41.4	7	241		
Mar	7.5	7.3	43	0.2	44	33.2	6	162		
Apr	7.5	7.3	45	0.2	48	46.8	6	194	3.25	17.9
May	7.4	7.3	51	0.3	47	30.7	8	217		
Jun	7.4	7.2	42	0.3	27	44.6	8	192		
Jul	7.4	7.3	35	0.2	59	40.8	5	132	3.36	17.9
Aug	7.3	7.2	37	0.3	51	37.1	5	135		
Sep	7.6	7.5	36	0.3	48	67.2	7	191		
Oct	7.6	7.4	37	0.3	43	42.5	8	279		
Nov	7.4	7.2	38	0.4	49	33.4	9	362	3.25	17.9
Dec	7.5	6.9	34	0.4	19	46.2	6	238		
Average	**7.5**	**7.3**	**41**	**0.3**	**44**	**41.5**	**7**	**215**	**3.15**	**17.9**
Limit	NL	6 to 9	75	1.0	74	NL	25	1590	4.0	123

**NL = No Limit

In 2012, all effluent BOD mass emission values were below all limitations. The maximum monthly average mass emission was 3,000 lbs/day for November. The maximum at any time mass emission was 4,375 lbs/day and occurred on March 10, 2011. The mass emission limit is based on average dry weather flow (ADWF) and is a limit, which is only applied to dry weather flows (DWF). There is no limit for mass emissions on wet weather flows. The mass emissions monthly average limitation of 6,240 lbs/day and the maximum at any time limitation of 9,560 lbs/day were never exceeded during 2012.

Hydrogen-Ion Concentration (pH)

Influent and effluent pH levels were monitored five days per week to ensure that the effluent remained within an acceptable range when discharged into the ocean. Influent pH averaged 7.5 units for the year; effluent pH averaged 7.3 units. Monthly averages of effluent pH were very stable ranging from 6.9 units to 7.5 units throughout 2012 (Table 2-2). 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 2012.

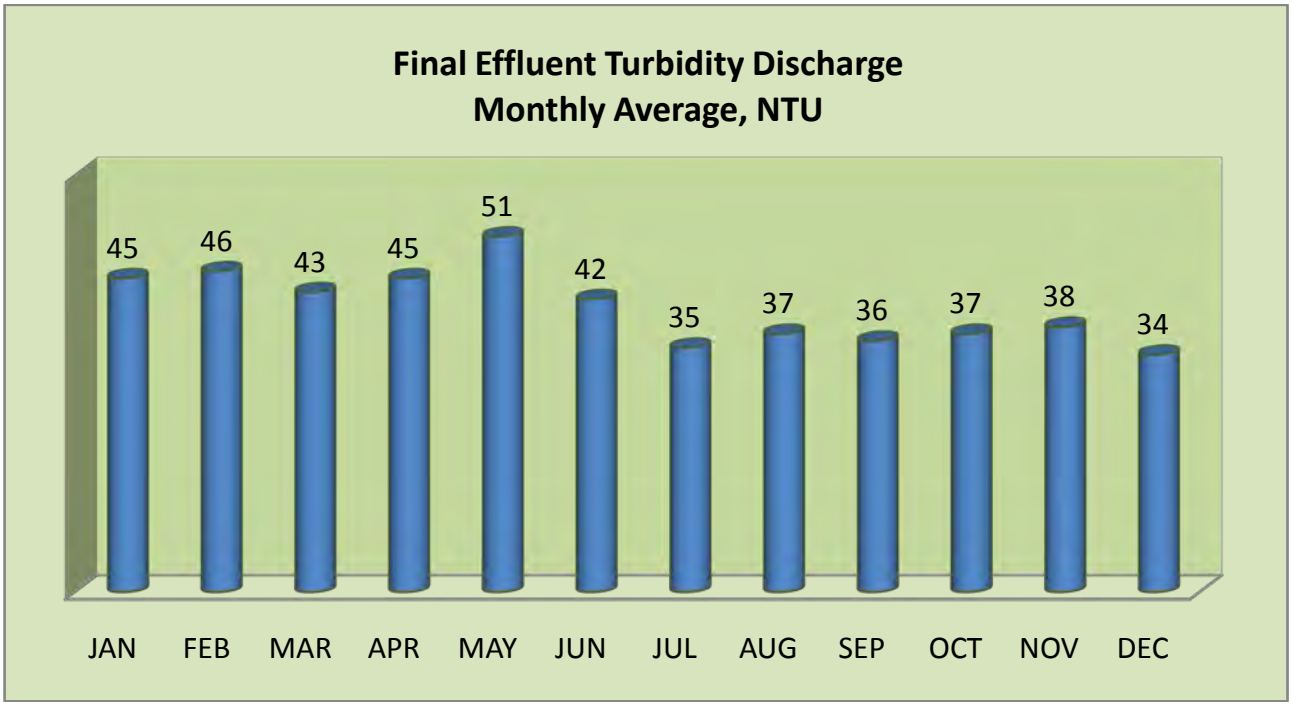
Ammonia

The effluent was monitored monthly to determine the concentration of ammonia. The permit specifies six-month median, daily maximum, and instantaneous maximum limitations of 74 mg/L, 300 mg/L, and 740 mg/L, respectively. The monthly average ammonia concentration ranged from 19 mg/L in December up to 59 mg/L in July (Table 2-2). The unusually low ammonia concentration measured in December was the first sample taken after the newly constructed aeration basin and one of the two new secondary clarifiers were placed on line at the end of November 2012. The increased aeration basin volume had a direct impact on decreasing the concentration of the ammonia in the secondary treated effluent, which was measured in the December monthly ammonia sample. The monthly average for the year was 44 mg/L. The values for ammonia were well below all their respective permit limitations.

Turbidity

Effluent turbidity was monitored five days per week. The permit limitations for effluent turbidity consists of a monthly average of 75 Nephelometric Turbidity Units (NTU), a weekly average of 100 NTU, and a maximum at any time limitation of 225 NTU. Effluent turbidity data are shown graphically in Figure 2-6. The maximum value at any time, 81 NTU, occurred on January 19th. Monthly averages ranged from a low of 34 NTU in December to a high of 51 NTU which occurred in May (Table 2-2). All values were significantly below their respective permit limitations.

Figure 2-6. Effluent Discharge Turbidity 2012 Monthly Averages, NTU



Acute Toxicity Concentration

All quarterly acute toxicity tests were performed on 24-hour composite effluent samples. The acute toxicity has a daily maximum limit of 4.0 acute toxicity units (TU_a). All four quarterly acute toxicity samples for 2012 were collected under the conditions of the new NPDES WDR Order No. R3-2010-0012 which requires the District to use Topsmelt as the acute toxicity test species, replacing fathead minnow larvae. The annual average acute toxicity value was 3.15 Tua. (See Table 2-2). All values were below the permit limitation of 4 Tua.

Chronic Toxicity Concentration

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

Settleable Solids

The effluent was monitored for settleable solids concentrations 5 days per week. The permit specifies that the monthly average, weekly average, and maximum at any time may not exceed 1.0 milliliters/liter/hour (ml/L/hr), 1.5 ml/L/hr, and 3.0 ml/L/hr, respectively. Monthly averages ranged from 0.17 ml/L/hr to 0.45 mL/L/hr. The maximum value at any

time was 0.8 mL/L/hr which occurred on November 10th, December 8th and December 30th, 2012. All values were well below their respective permit limitations.

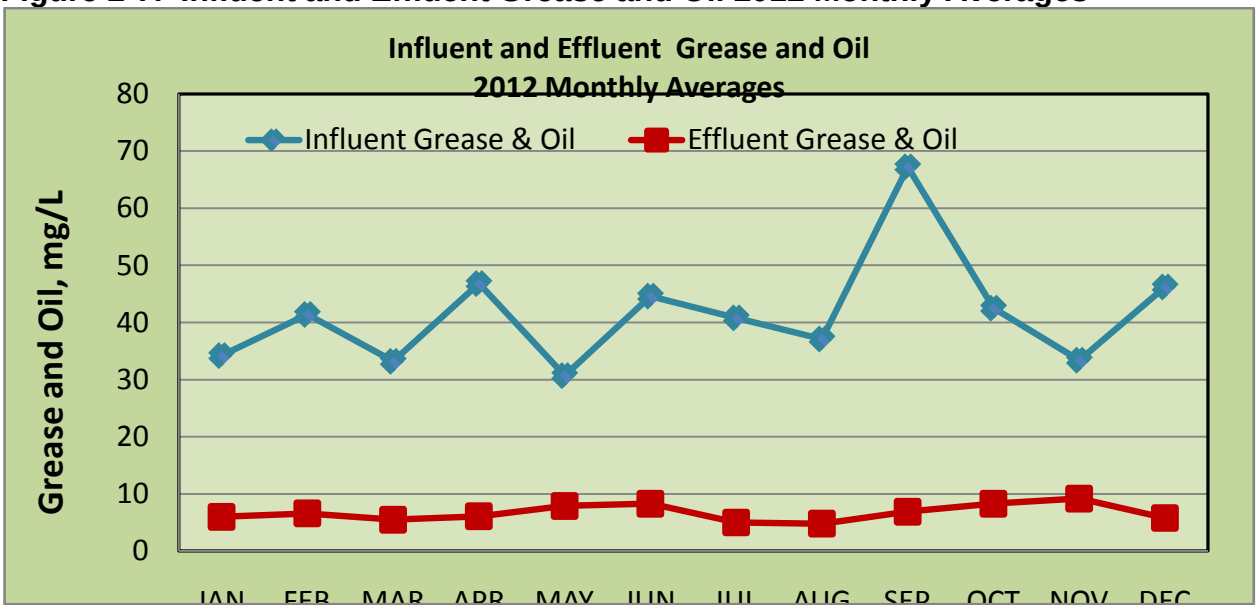
Oil and Grease

Influent and effluent oil and grease were monitored bi-weekly (once every two weeks) and weekly, respectively. 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.

Influent grease and oil results were very consistent throughout the year, except for September, when the highest one day influent grease and oil concentration was measured on September 22nd at 105 mg/L. This individual high value caused the monthly influent average to increase to 67 mg/L the highest monthly average of the year. The September 22nd sample collection date coincided with the beginning of the fall quarter for the University of California at Santa Barbara. The increase in student population and wastewater flows seems to have had an impact on the concentration of oils and greases entering the sewer system. The effluent sample collected on September 22nd was determined to have an oil and grease concentration of 7.6 mg/L showing that the treatment process was efficient in removing oils and greases.

The influent annual average value of 42 mg/L was reduced to an annual average of 7 mg/L in the final effluent resulting in an 83 percent annual average removal rate. All monthly, weekly, and maximum permit limits were met. Mass emissions values ranged from a monthly average low of 132 lbs/day in July to a high of 362 lbs/day in November, both are well below the permit limitation of 1,590 lbs/day. Monthly average oil and grease concentrations in the effluent ranged from 5 mg/L in July and August to 9 mg/L in November (Table 2-2). All permit limitations for effluent oil and grease were met during 2012.

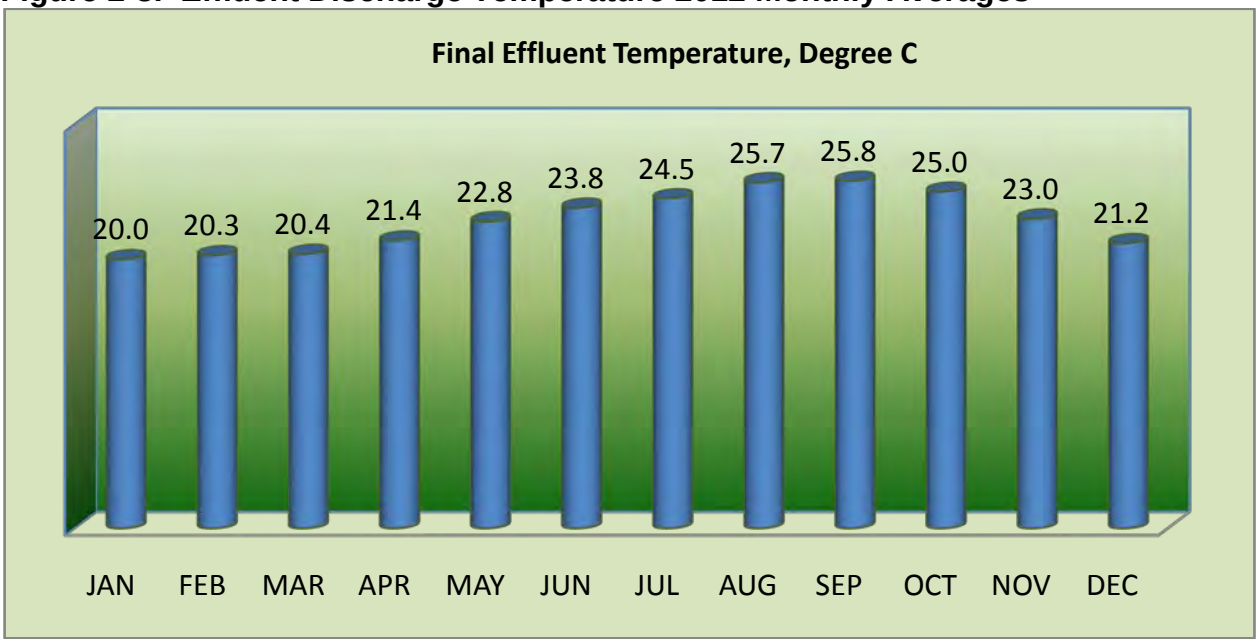
Figure 2-7. Influent and Effluent Grease and Oil 2012 Monthly Averages



Temperature

Effluent temperature was sampled five days per week throughout 2012. The data reflect a typical response to seasonal changes (Figure 2-8). The coolest temperatures occurred during January with an average monthly temperature of 20.0 ^{o}C. A warming trend continued throughout the spring and summer months to reach a monthly averaged high in September of 25.8 ^{o}C, a 1.3 ^{o}C increase from the high in August of 24.5 ^{o}C. As expected, the year ended with a cooling trend during the fall and winter months (October through December).

Figure 2-8. Effluent Discharge Temperature 2012 Monthly Averages



Wastewater Disinfection

Sodium hypochlorite is used to disinfect the treated wastewater at the Goleta Sanitary District. The sodium hypochlorite is flash mixed into the wastewater at the beginning of the chlorine contact channel. At an average effluent flow rate of 4 MGD, the chlorine is in contact with the wastewater for approximately 2½ hours (145 minutes). The NPDES permit specifies that the District must maintain a total chlorine residual of at least 5 mg/L at the end of the chlorine contact channel under total suspended solids peak loading conditions. The Goleta Sanitary District maintains its chlorine contact tank to provide maximum chlorination effectiveness at all times. The chlorine residual at the end of the chlorine contact channel averaged 9.1 mg/L during 2012. The average monthly values are reported in Table 2-3.

After the disinfection process is completed, 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; at or below the detection limit of 0.1 mg/L for all months. The monthly average values are shown in Table 2-3. No chlorine residual exceedences occurred during 2012.

Effluent Coliform Bacteria

The effluent was analyzed five days a week for coliform bacteria. The monthly average values for total coliform, fecal coliform, and enterococcus bacteria detected in the effluent are presented in Table 2-3. Monthly average values ranged from 21 to 45 MPN/100 mL for total coliform and from 11 to 25 MPN/100 mL for fecal coliform. The permit prohibits more than 10 percent of the final effluent samples, in any thirty-day period, to exceed a total coliform density of 2,400 MPN/100mL with no sample exceeding a total coliform concentration of 16,000 MPN/100mL. A total of 302 final effluent total coliform samples were analyzed throughout the year with no samples exceeding either the 30-day limitation or the 16,000 MPN/100mL limit. The maximum total coliform concentration was measured on July 23, 2012 at 300 MPN/100mL.

Effluent Enterococcus Bacteria

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

Table 2-3. Chlorine and Bacteria Monthly Averages, 2012

Month	Chlorine at the end of the CCC	Chlorine after Dechlorination	Total Coliform	Fecal Coliform	Enterococcus
	mg/L	mg/L	MPN/100mL		
January	9.5	0.1	39	20	2
February	9.7	< 0.1	23	20	2
March	9.1	0.1	21	19	2
April	9.0	< 0.1	31	19	2
May	9.1	< 0.1	21	19	2
June	9.9	0.1	24	19	2
July	8.8	< 0.1	37	22	2
August	8.2	0.1	27	25	3
September	9.0	< 0.1	21	11	2
October	8.5	< 0.1	21	13	2
November	9.7	0.1	33	23	2
December	8.9	< 0.1	45	15	2

SURF ZONE BACTERIA

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

Table 2-4. Bacteria Monitoring Program

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

Final effluent samples and weekly receiving water surf zone samples are collected and analyzed in-house by GSD personnel the results of which are discussed in this chapter. Zone of initial dilution, far shore and near shore bacteria samples are collected and

analyzed by ABC Laboratories of Ventura. Results of this testing is presented in chapter 3.

Approximately 900 samples are collected each year from the surf zone and each sample is analyzed for total coliform, fecal coliform and enterococcus for a total of approximately 2,700 bacteria tests conducted every year. These samples are collected and indicator organism concentrations are monitored in order to ensure that the beneficial uses of the Goleta Beach coastal area are protected. The following section discusses the 2012 bacterial trends found in the surf zone environment.

Surf-zone Stations.

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

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

Concentrations of bacteria at surf-zone stations in 2012 in general, were higher than that observed in the effluent, offshore and near shore ocean stations. This is consistent with the results of earlier years. Throughout the year, levels of bacteria at surf-zone monitoring stations ranged from < 2 to >=1,600 MPN/100mL for total coliform, <2 to 1,600 MPN/100mL for fecal coliform bacteria and <2 to 170 MPN/100mL for enterococcus bacteria. Several maximum one time exceedences occurred throughout the year and were reported in the corresponding monthly report. In each case the exceedence occurred in samples collected in the days immediately following a rainstorm. Although the range of bacteria concentrations was large the average values for the year were 110 for total coliform, 75 for fecal coliform and 10 for enterococcus.

As in previous years, the highest concentrations of bacteria at the surf zone stations were most often associated with storm events and the increased contamination from storm water runoff. No samples were collected from Station E on January 24th and December 14th, 20th and 26th because Station E was inaccessible due to high flows in the Goleta Slough and the Slough could not be crossed safely by District staff.

Figure 2-9. Surf Zone Annual Average Bacteria Concentrations 2012

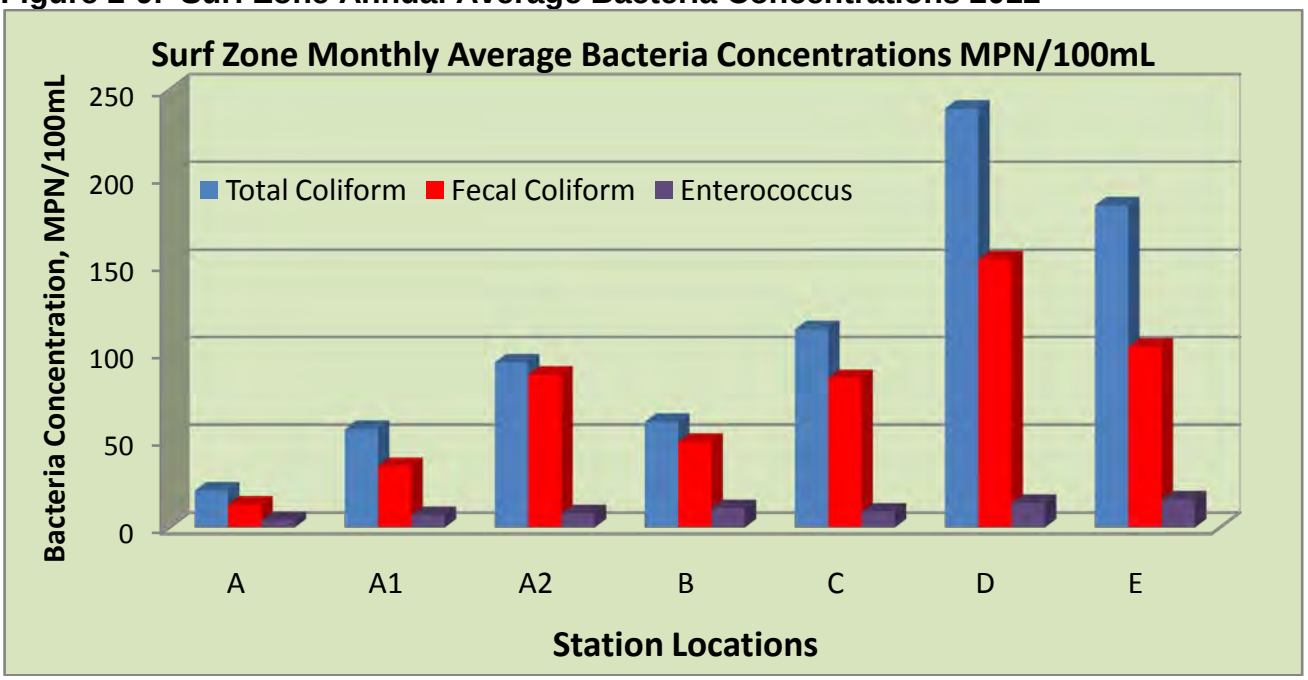


Figure 2-9 shows the impact of the Goleta Slough discharge on the surf zone samples. Goleta Slough empties between station location D and E which show the highest overall annual average bacteria concentrations for all three indicator organisms measured weekly. The further the station is from the slough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

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

The impact of Goleta Slough on bacteria water quality in the surf zone of the study area has been documented for the past 21 years. This historical data has shown, year after year that the highest concentration of indicator organisms are found in and adjacent to the Goleta Slough mouth.

Metals

Twenty four-hour composite samples of influent and effluent were collected monthly and analyzed for metals (Table 2-7). In all instances, the concentrations of metals in the effluent for 2012 (Table 2-7) were low or undetected and were well below all permit limitations.

Table 2-7. Influent and Effluent Metals (ug/L), Goleta Sanitary District, 2012.

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Influent (ug/L)									
January	< 2	< 0.2	5	116	1.9	0.13	9	1	110
February	2	< 0.2	2	97	1.5	0.08	5	< 1	150
March	< 2	0.2	2	127	1.8	0.09	6	< 1	130
April	< 2	0.3	5	131	2.2	0.23	7	< 1	200
May	2	0.3	6	95	3.9	0.17	8	< 1	190
June	< 2	< 0.2	4	67	1.8	0.21	6	< 1	120
July	< 2	0.3	2	78	1.5	0.07	5	< 1	130
August	< 2	0.3	5	91	2.1	0.13	7	< 1	170
September	< 2	0.2	3	94	1.9	0.06	5	2	140
October	< 2	< 0.2	3	94	2.6	0.10	11	< 1	140
November	3	0.2	6	124	2.4	0.39	15	< 1	160
December	< 2	< 0.2	3	74	1.4	0.08	6	1	90
Effluent (ug/L)									
January	< 2	< 0.2	2	31	0.5	0.02	6	< 1	30
February	< 2	< 0.2	1	36	0.5	0.02	4	< 1	70
March	< 2	< 0.2	2	42	1.8	< 0.02	5	< 1	50
April	< 2	< 0.2	2	33	0.5	< 0.02	5	< 1	80
May	< 2	< 0.2	2	25	0.7	< 0.02	5	< 1	40
June	< 2	< 0.2	2	25	0.5	0.03	5	< 1	50
July	< 2	0.3	1	24	0.7	0.02	5	1	50
August	< 2	< 0.2	2	26	0.9	0.03	7	< 1	80
September	< 2	< 0.2	2	23	0.7	0.03	5	< 1	40
October	< 2	< 0.2	1	25	0.4	0.03	7	< 1	40
November	2	< 0.2	2	25	0.4	0.08	7	< 1	30
December	< 2	< 0.2	1	18	0.4	< 0.02	7	< 1	40
Effluent Limits (ug/L)									
6-month median	620	120	250	120	250	4.9	620	67	1,500

Priority Pollutants

Table 2-8. Detected Priority Pollutants, Goleta Sanitary District, 2012

Parameter, units	Influent, ug/L	Effluent, ug/L
Acetone	1,350	708
Antimony	ND	1
Bis(2-Ethylhexyl)phthalate	13	7
Bromodichloromethane	1.6	0.5
Chloroform	9	7
Chloromethane	ND	1.0
Dibromochloromethane	0.5	ND
Diethylphthalate	3	1
TCDD, equivalents, pg/L	0.23	ND
Phenol	20	ND
Radioactivity, gross Alpha pCi/L	6.59 +/- 2.57	10.1 +/-3.15
Radioactivity, gross Beta pCi/L	15.7 +/-2.90	16.3 +/-3.00
ND = Not Detected		

The NPDES permit requires priority pollutant analyses to be performed on influent and effluent composite samples annually. Compounds detected in the influent and/or effluent samples are presented in Table 2-8; 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. Ten compounds were detected in the influent and nine in the effluent. Dibromochloromethane, phenol, and TCDD equivalents were detected in the influent but not in the effluent. Whereas a small amount of antimony and chloromethane were detected in the effluent but not in the influent. Acetone was detected in both the influent and effluent. It has been one of the most consistently detected chemicals in the wastewater stream. The most likely source of acetone entering the treatment plant is probably the University of California at Santa Barbara where acetone is used extensively in many of the research laboratories. Concentrations of detected chemicals are all reported as parts per billion.

Results of influent and effluent radioactivity determinations for 2012 are also presented in Table 2-8. Limits for radioactivity are defined in Title 17 of the California Code of Regulations section 30269, which state limitations of $3x10^{-8}$ µCi/mL (or 30 pCi/L) for alpha emission and $3x10^{-6}$ µCi/mL (or 3000 pCi/L) for beta emission. Samples collected during 2012 were below these limitations.

BIOSOLIDS CHARACTERIZATION

As required, samples of wastewater biosolids (sludge) were collected quarterly in January, April, July, and October. All samples were collected from the belt press. Constituents detected in biosolids samples (Table 2-9) are expressed in dry weight units of mg/Kg. The complete list of laboratory analytical results is available at the Goleta Sanitary District's laboratory for review.

In September of 2010 the Goleta Sanitary District's new NPDES permit became effective. Prior to September the district operated under NPDES Permit No. CA0048160 and Waste Discharge Requirements (WDR) Order No. R3-2004-*0129. The new WDR order is identified as No. R3-2010-0012. The permit specifies that the character of the sludge demonstrate compliance with appropriate disposal/reuse requirements. Therefore analytical results are compared to the federal sewage sludge regulations defined in Title 40 of the Code of Federal Regulations, 40 CFR 503.13(b)(3) (Table 2-9). Using these guidelines for comparison, the concentrations of metals were within the limits specified for unrestricted land application. As required, a complete biosolids annual report for the year 2012 was prepared and submitted to Lauren Fondahl of the EPA prior to the February 19, 2012 deadline.

Biosolids Use and Disposal

Safety concerns for the general public on-site during the construction to upgrade the treatment plant has caused the Goleta Sanitary District to temporarily stop offering Class A air-dried wastewater biosolids as a soil amendment for residential use. All biosolids were treated by a belt press and transported, under contract with Honey Bucket Farms to Tule Ranch which has disposal sites in Kern County, California.

In April 2012 a new agreement between the Goleta Sanitary District and Western Express Inc. was approved by the GSD governing board. The new three year agreement allows Western Express Inc., to remove, transport and dispose of the District's Class B biosolids at the Holloway Solid Waste Facility located at 13850 Holloway Road, Lost Hills in Kern County. The Holloway Solid Waste Facility is permitted by the California Regional Water Quality Control Board – Central Valley Region under Order No. R5-2010-0123. The Holloway Solid Waste Facility has four depleted gypsum mine pits that are specifically designated for waste disposal. The mine pits are being reclaimed and are permitted to accept Class A and Class B municipal biosolids.

From January 2012 to December 2012, the Goleta Sanitary District distributed a total of 564 dry metric tons of biosolids. According to *40 CFR 503.8(b)(4)* and *Table E-12 Amount of Biosolids and Frequency of Analysis* this amount of biosolids is required to be monitored quarterly. No biosolids were taken to the Tajiguas landfill for disposal

TABLE 2-9. PRIORITY POLLUTANTS BIOSOLIDS 2012, mg/dry Kg

POLLUTANT	POLLUTANT LIMITS Part 503 Table 3, Sec 503.13	January 2012 Belt Press	April 2012 Belt Press	July 2012 Belt Press	October 2012 Belt Press
Antimony	NL	NA	NA	NA	< 1.3
Arsenic	41	2.94	4.64	< 2.3	< 2.6
Beryllium	NL	NA	NA	NA	< 0.78
Cadmium	39	1.97	3.19	1.97	< 0.78
Chromium	* (1)	32.2	37.7	39.7	13.3
Copper	1,500	658	822	734	265
Lead	300	20.6	28.1	20.1	6.55
Mercury	17	0.25	1.32	1.68	0.480
Molybdenum*(2)	75	10.3	16.7	12.9	4.32
Nickel	420	34.5	34.7	31.9	9.12
Phosphorus	NL	25,100	38,300	32,100	10,500
Selenium	100	7.64	9.28	5.71	3.06
Silver	NL	NA	NA	NA	2.61
Thallium	NL	NA	NA	NA	< 1.3
Zinc	2,800	925	1,110	865	326
pH	NL	NA	NA	NA	7.1
Oil & Grease	NL	NA	NA	NA	1,200
% Moisture	NL	79.4	82.1	77.9	61.6
Nitrate	NL	< 19	< 22	< 18	< 10
Organic Nitrogen	NL	31,820	13,620	8,500	10,220
Kjeldahl Nitrogen	NL	36,800	17,400	11,000	13,500
Ammonia	NL	4,980	3,780	2,500	3,280

NL = No Limit. NA = Not Analyzed.

*(1) On October 25, 1995 the EPA amended Part 503 to delete chromium standards from Tables 1 through 4 of Subpart B, Land Application.

*(2) The EPA amended Part 503 on February 25, 1994 to delete temporarily the Table 3 molybdenum limits. However, the ceiling limit of 75 mg/Kg from Table 1 has been retained and must be met.

Trace Metals

The results of the trace metal priority pollutants are tabulated above in TABLE 2-9. Not all metals were analyzed for all samples. An analysis that was not performed on a specific sample is denoted by the letters “NA”. Samples listed as NA – not analyzed - are analyzed, in October, on an annual basis only. All laboratory results indicate that the District's biosolids meet all of the metal pollutant limits found in TABLE 3 of 503.13 for the "Exceptional Quality" and “Pollutant Concentration” designations.

All results in Table 2-9 are reported in mg/dry Kg. Percent moisture at the time of sampling is also recorded. Complete copies of all laboratory reports can be found at the Goleta Sanitary District where they are available for review.

The annual priority pollutant analysis conducted on a sample of biosolids collected in October of 2012 detected low concentrations of three pollutants, summarized in Table 2-10.

Table 2-10. Detected Parameters, Biosolids, October 2012

Parameter, concentration unit	Concentration
Cyanide, Total, mg/Kg	0.308
bis(2-Ethylhexyl)phthlate, mg/Kg	6.21
TCDD equivalents, pg/g	5.908

All detected chemicals are relatively common in our society.

The October 2012 biosolids sample was analyzed for all dioxin isomers using EPA Method HR EPA 8290 Full List. Six of eleven dioxin isomers were detected by this method. Three of the isomer results were flagged to indicate the result was reported as an estimated value because the result was less than the reporting limit but greater than or equal to the method detection limit. All flagged results even those reported as estimates were used in the final calculation for TCDD equivalents. The resulting TCDD equivalence is 5.908 pg/g. The full laboratory results are available at the Goleta Sanitary District laboratory for review.

DISCHARGE COMPLIANCE

Throughout 2012 the wastewater discharge from Goleta Sanitary District complied with all applicable permit effluent limitations. All 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. on October 25, 2012. A report

was prepared and videotape was made 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 an appendix to this report. Copies of the outfall dive on DVDs are available at the District for review.

CHAPTER 3

Receiving Water Environment

3.1. Scope and Period of Performance

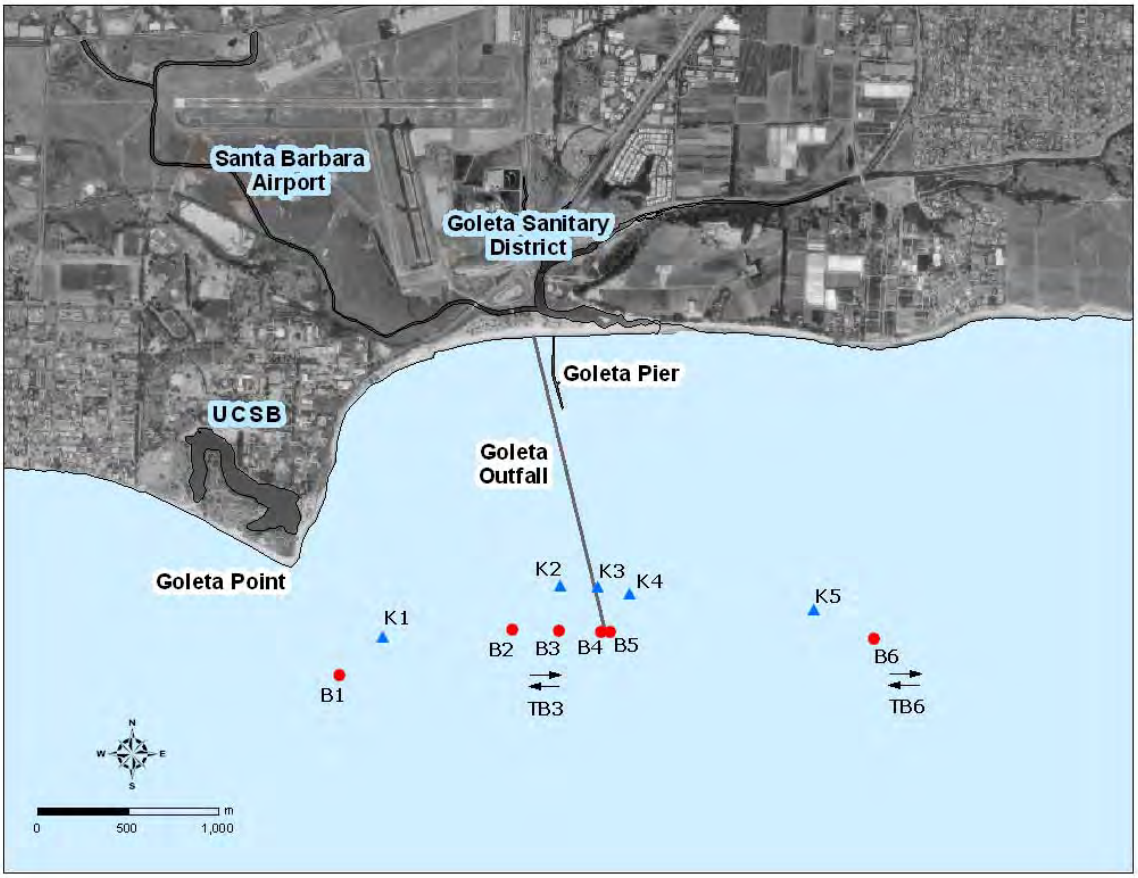
This report covers the period of field and laboratory studies conducted from January 1, 2012 through December 31, 2012. The Aquatic Bioassay consulting team conducted water quality surveys in the vicinity of the of the Goleta Sanitary Districts outfall on January 30rd, April 17th, July 23rd, and October 22nd, 2012. The team evaluated the local effect of the discharge within the immediate vicinity of the outfall terminus, and compared conditions there with those at control sites up-coast and down-coast of the outfall. During each field survey, the team recorded general observations of weather, etc., sampled for bacteria and water column variables (temperature, salinity, pH, transmissance and dissolved oxygen). On July 23rd, the team deployed a series of caged mussel arrays for bioaccumulation analysis and on October 22nd, the team retrieved the mussels. On October 23rd, the team collected epibenthic fish and macroinvertebrates by otter trawl, and collected benthic sediments for physical, chemical, and infaunal analysis using a Van Veen Grab.

3.2. Station Locations and Descriptions

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

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

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



3.3. Navigation and Positioning

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

3.4. Statistical Analysis

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

chance in ten or less (but more than one chance in 20) is said to be "marginally significant". That is, the probability is less than 10% but greater than 5% of being random ($0.05 < p < 0.10$).

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

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

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

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

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

3.5.2. T-tests. This statistic is used to compare variables when there are only two. Unlike correlation coefficients, the trend with distance is not evaluated. For most variables, the mean of values near the outfall and the mean of values farther away will be different. The t-test

determines whether or not that difference is statistically significant. Note that trend with distance or sign of the statistic is not of importance for this test. The question asked is only if they are different beyond what might be expected of random chance.

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

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

3.5. General Observations

General water observations for the four quarterly water column surveys have been described in quarterly reports submitted previously (Aquatic Bioassay 2012 a, b, c, d and e). Observations for the annual survey are summarized in Table 3-1. Weather and water conditions were moderate on October 23rd for grab and trawl sampling. Weather was clear throughout the day. Air visibility was 15 km. Wind speeds were moderate to gusty (5 to 25 knots) from the west. The swell was from the southwest at 4-6 feet. The tide was incoming during sample collections at Stations B1 to B6 and outgoing during the trawls. Water turbidity was moderate and the color was green at all stations. No odors, discoloration, or suspended material were observed during the survey.

Table 3-1. General ocean state observations for benthic sediment and trawl sampling.

Sampling Stations	BI	B2	B3	B4	B5	B6	TB3	TB6
Date	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12
Time	11:00	10:23	9:57	9:27	8:53	8:02	12:07	13:59
Research Vessel	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*
Survey Program	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Trawl, Bioaccum.	Trawl, Bioaccum.
Dist. From Outfall (m)	1500	500	250	25	25	3000	250	3000
Direc. From Outfall (°M)	270	270	270	270	90	90	270	90
Depth (m)	25.9	26.5	26.5	26.5	26.5	26.2	22.8	25.9
Latitude (N)	34.58261	34.40192	34.40192	34.40192	34.40197	34.40283	34.40247	34.40063
Longitude (W)	119.84103	119.83069	119.82792	119.82547	119.82492	119.79269	119.83282	119.78075
Weather	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Air Vis. (km)	15	15	15	15	15	15	15	15
Tide	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Incoming	Incoming
Swl. Ht. (ft)	6	6	5-6	5	5	4-5	4-6	6
Swl. Dir.	SW	SW	SW	SW	SW	SW	SW	SW
Wind Sp. (Kn)	15	5-10	5	10	5	5	20	25
Wind Dir.	W	W	W	W	W	W	W	W
Water Turbidity	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Color	Green	Green	Green	Green	Green	Green	Green	Green

3.6. General Oceanographic Conditions

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

Superimposed upon annual trends are the sporadic occurrences of the El Nino Southern Oscillation (ENSO) that can be described as an oceanographic anomaly whereby particularly warm, nutrient-poor water moves northward from the tropics and overwhelms the typical upwelling of colder nutrient-rich water. The El Nino Watch (http://coastwatch.pfel.noaa.gov/elnino.html) program continuously monitors global sea surface temperatures. These temperature data are compared to the long-term sea surface temperatures generated from data collected from 1950 to 2012. Comparison of the monthly sea temperature with this long term average creates a temperature anomaly so that the average monthly temperature falls either above or below the average. This anomaly allows us to determine how a given month or time period deviates from the long term ocean temperature trend. The water temperatures offshore Goleta was at or up to one and one half degree below the long term trend from January through May, were greatest in August, September and October (+ 1 degree) (Figure 3-2).

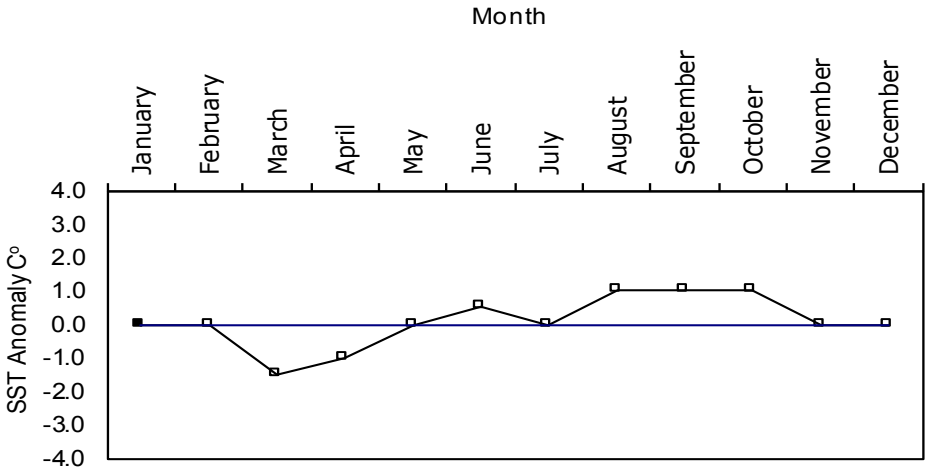


Figure 3-2. Sea surface anomaly temperatures for 2012 compared with long term trends.

3.7. Anthropogenic Inputs

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

3.8. Rainfall

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

The rainfall reported in this document is for Santa Barbara Airport obtained from the Western Regional Climate Center in Reno, Nevada. Data is summarized in Table 3-2 and Figure 3-3, where periods of precipitation and water column survey days are highlighted. The rainfall for this period (12.77 inches) was 5.39 inches below the average yearly rainfall since 1981 (18.96 inches). The wettest month was December (4.00 in), followed by March (2.28 in), April (2.24) and January (2.09). No rain fell in May and July. Rain in all other months ranged from 0.01 to 1.93 inches. Each of the water quality surveys occurred following periods of no rain, except in April when rain fell before, during and after the sampling event.

Figure 3-3. Santa Barbara rainfall for 2012.

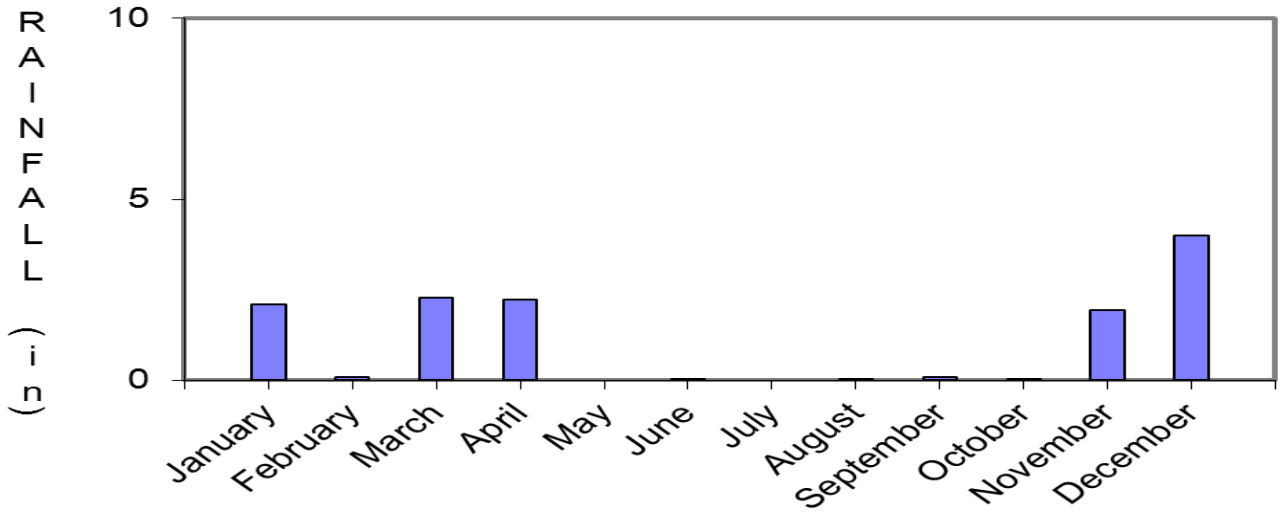


Table 3-2. Daily 2012 Santa Barbara Airport rainfall (inches) with dates of water column surveys bordered and rain days in gray.

Day/Month	January	February	March	April	May	June	July	August	September	October	November	December
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
7	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
13	0.00	0.01	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
15	0.00	T	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02
16	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.10
17	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.23
18	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T	0.05
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
21	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.19
23	0.68	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59
25	0.00	0.00	0.99	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
26	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
27	0.00	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00
29	0.00	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.31
30	0.00		0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00
31	0.00		0.35		0.00		0.00	0.00		0.00		0.00
Monthly Total	**2.09**	**0.08**	**2.28**	**2.24**	**0.00**	**0.01**	**0.00**	**0.02**	**0.08**	**0.04**	**1.93**	**4.00**
Annual Total	**12.77**											

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

3.9. Water Quality Materials and Methods

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

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

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

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

3.10. Results

3.10.1. Physical and Chemical Water Quality

3.10.1.1. Temperature

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

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

Spatial temperature patterns. Examination of 3D contours for each quarterly survey showed that the water column was cool and isothermal during January and April. In July temperatures warmed and a steep thermal gradient was established. Finally, in October the water column warmed and became thermally stratified (Figure 3-6 and Table 3-3). In January, water temperatures essentially the same through the water column (13.9 $^{\circ}$C). The April survey occurred during an upwelling event when water temperatures declined with depth, ranging from 12.4 $^{\circ}$C near the surface to 9.9 $^{\circ}$C at the bottom. Thermal stratification was strongest in July when water temperatures were ranged from 12.3 to 17.0 $^{\circ}$C, representing a 4.7 $^{\circ}$C decrease from surface to bottom. In October the water column had the highest temperatures of the year, but the thermal stratification was weaker than in July with temperatures ranging from 19.1 $^{\circ}$C at the surface to 16.0 $^{\circ}$C near the bottom.

Influences of the outfall were not evident in the temperature profiles during any survey. Temperatures correlated with distance from the outfall in January, but the differences from near field to far field stations were exceedingly small, with the average water column temperature at the plume stations (13.9 $^{\circ}$C) and station B6 where temperatures were coolest (13.5 $^{\circ}$C) only 0.4 $^{\circ}$C difference. There were no significant temperature differences by t-test between near outfall and far field station groups during the four quarterly surveys.

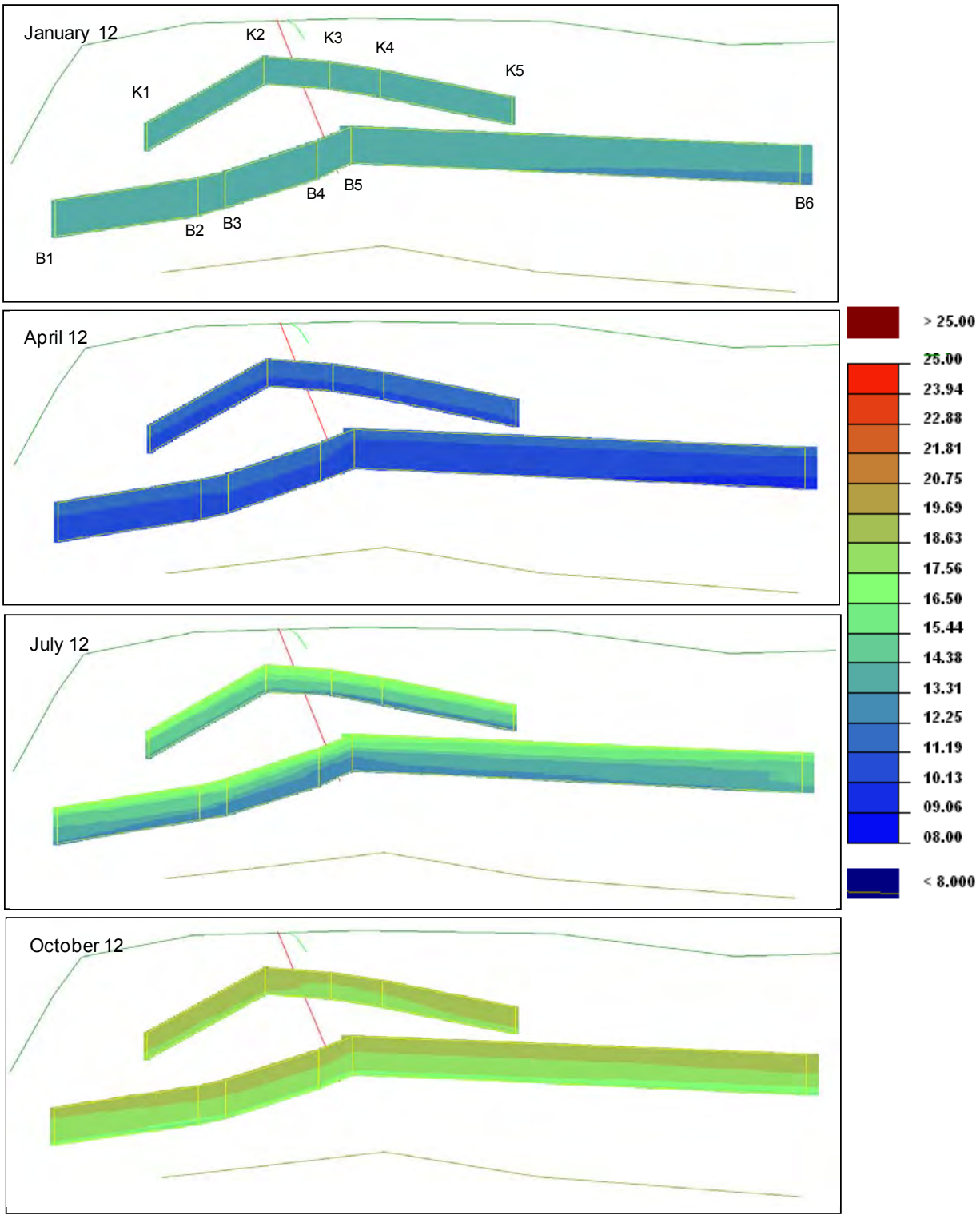


Figure 3-6. Temperature contours for the K Station (depth = 18 m) and B Station (depth = 28 m) water quality transects. The Goleta Sanitary District outfall is depicted as a red line. The color legend is presented to the right.

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

Parameter	Month	Average	Range	Expected & Significant Correlation w/ Outfall?	Significant t-test w/ Outfall?
Temperature	January	13.9	13.0 - 14.2	Yes	No
	April	11.2	9.9 - 12.4	No	No
	July	15.0	12.3 - 17.0	No	No
	October	18.5	16.0 - 19.1	No	No
Salinity	January	33.3	33.2 - 33.4	No	No
	April	33.8	33.7 - 34.0	No	Yes
	July	33.6	33.5 - 33.7	No	No
	October	33.5	33.4 - 33.6	No	No
pH	January	8.2	8.1 - 8.3	No	No
	April	8.0	7.7 - 8.2	No	No
	July	8.2	8.0 - 8.3	No	No
	October	8.3	8.2 - 8.3	No	No
DO	January	8.6	6.2 - 9.6	No	No
	April	5.6	2.1 - 8.6	No	No
	July	7.4	4.9 - 9.7	No	No
	October	7.5	7.0 - 7.8	No	No
Transmissance	January	80.2	75.5 - 82.1	No	No
	April	84.5	73.6 - 87.4	No	No
	July	76.2	65.4 - 81.6	Yes	Yes
	October	77.1	67.9 - 79.1	No	No
Transparency	January	7.4	6.9 - 8.6	No	No
	April	15.4	14.0 - 19.1	No	No
	July	6.5	6.0 - 7.1	No	No
	October	6.2	5.8 - 6.5	No	No

3.10.1.2. Salinity

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

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

Spatial salinity patterns. Salinity in the survey area was similar across the four surveys ranging from 33.2 ppt in January to 34.0 ppt in April, a difference of 0.8 ppt. However, salinity provided the best opportunity to detect the effluent plume which is evident in each of the monthly contours. In January, lower salinity water is seen as a surface and subsurface lens of slightly fresher water both to the north and south of the outfall. In April, a small patch of fresher water can be seen as a subsurface layer at station B5 and extending north and south. Finally, in July and October fresher water can be seen near the bottom at station B4. The depth of the plume in July and October are presumably due to the presence of a thermal gradient which held the buoyant freshwater plume beneath it.

Salinity ranges and outfall effects. Table 3-3 shows the range of salinities for the 11 water column stations over the four quarterly sampling surveys. Salinities did not correlate with distance from the outfall and there were no significant salinity differences by t-test between near outfall and far field station groups, except for the April survey, when a 0.07 ppt difference occurred between the plume stations (33.81 ppt) and station B6 (33.88 ppt).

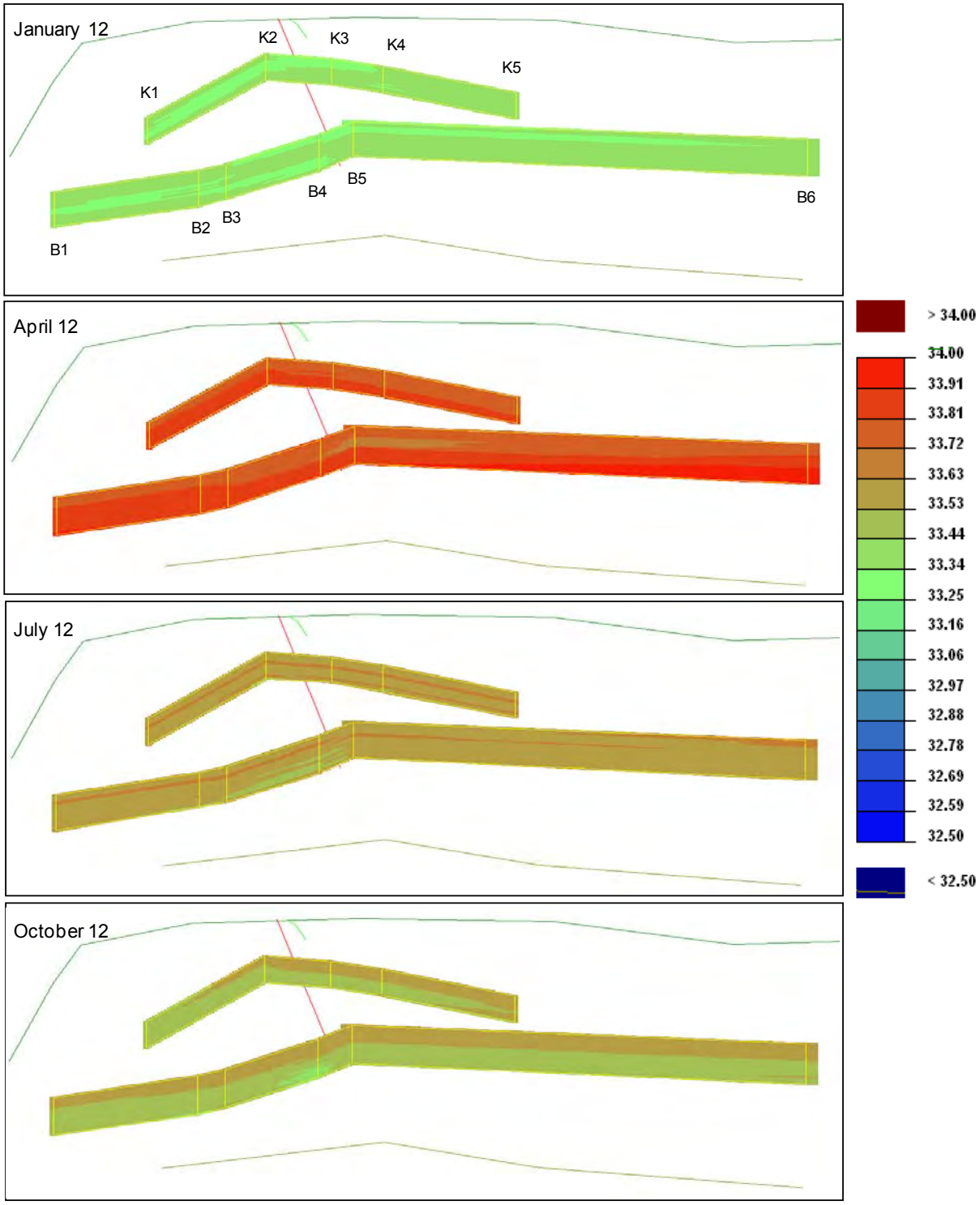


Figure 3-7. Salinity (ppt) contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.3. Hydrogen Ion Concentration (pH)

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

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

Spatial pH patterns. Average pH across the four quarterly surveys ranged from 8.0 to 8.3 (Figure 3-8 and Table 3-3). In January, July and October pH was similar through the water column and was only slightly greater near the surface (maximum = 8.3) compared to the bottom (minimum = 8.0). In April, upwelling was evident as a layer of depressed pH near the bottom (pH = 7.7). There was no clear evidence of the effluent plume from the contours during any of the four surveys.

pH ranges and outfall effects. Table 3-3 shows the range of pH values for 11 water column stations for each of the four quarterly sampling surveys. There were no expected and significant correlations with distance to the outfall for any survey. Also, there were no significant differences in pH among station groups located near and far from the outfall by t-test for any survey. Analysis of each quarterly data set showed that all pH differences between stations near and away from the outfall were very low and well within the 0.2 pH unit limit specified in the California Ocean Plan (2009).

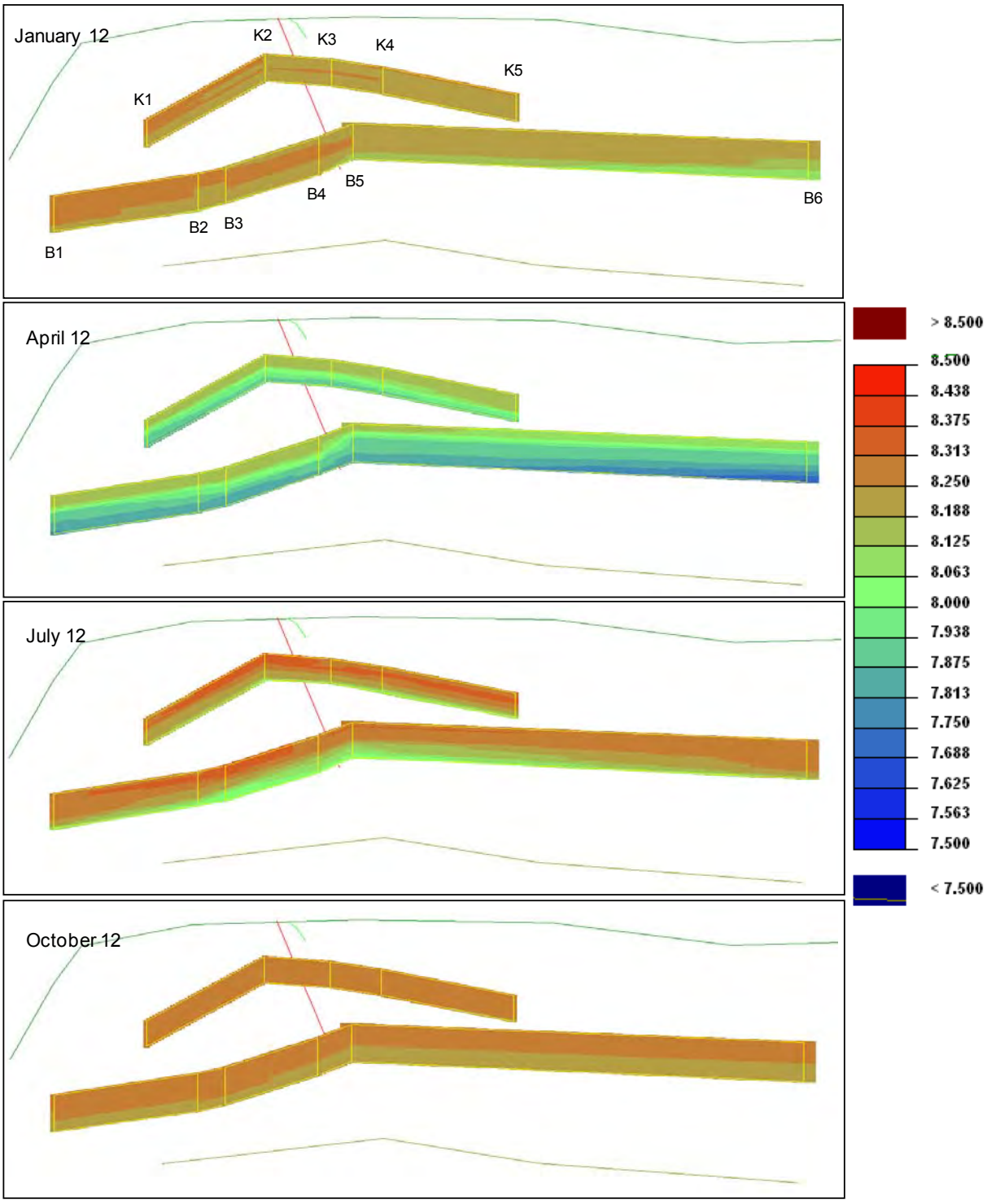


Figure 3-8. pH contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitation District outfall is depicted as a red line.

3.10.1.4. Dissolved Oxygen

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

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

Spatial oxygen patterns. During the January survey, dissolved oxygen concentrations ranged from 6.2 to 9.6 mg/L and were similar from surface to bottom (Figure 3-9 and Table 3-3). In April the water column was stratified for oxygen and ranged from 2.1 mg/L near the bottom to 8.6 mg/L near the surface. This was clearly the result of upwelled, oxygen depleted deep water coming onshore and supports the decreases in temperature, pH and salinity discussed in previous sections. In July dissolved oxygen decreased with depth (range = 4.9 to 9.7 mg/L), but not as steeply in April and was consistent with summer conditions when photosynthesis increases in surface water layer.

Oxygen ranges and outfall effects. Table 3-3 shows the range of oxygen concentrations for the 11 water column stations over the four quarterly sampling surveys. Dissolved oxygen did not correlate significantly with distance to the outfall for any of the four surveys and there were no significant differences by t-test among sites located near the outfall and those further away. This indicates that dissolved oxygen was not influenced by the outfall diffuser. Dissolved oxygen concentrations between stations located near and away from the outfall remained within the Ocean Plan standards (2009) throughout the year, except in April during the upwelling event when dissolved oxygen was depleted between the plume stations (5.29 mg/L) and sites on the K transect located closer to shore (range = 5.97 to 6.33 mg/L). These differences represented an 11% to 16% reduction in dissolved oxygen. It is most likely that the depressed oxygen offshore was due to upwelling since the plume sites were similar to the other B transect offshore stations (range = 4.10 to 5.75 mg/L). This water mass did not push into nearshore water on the K transect.

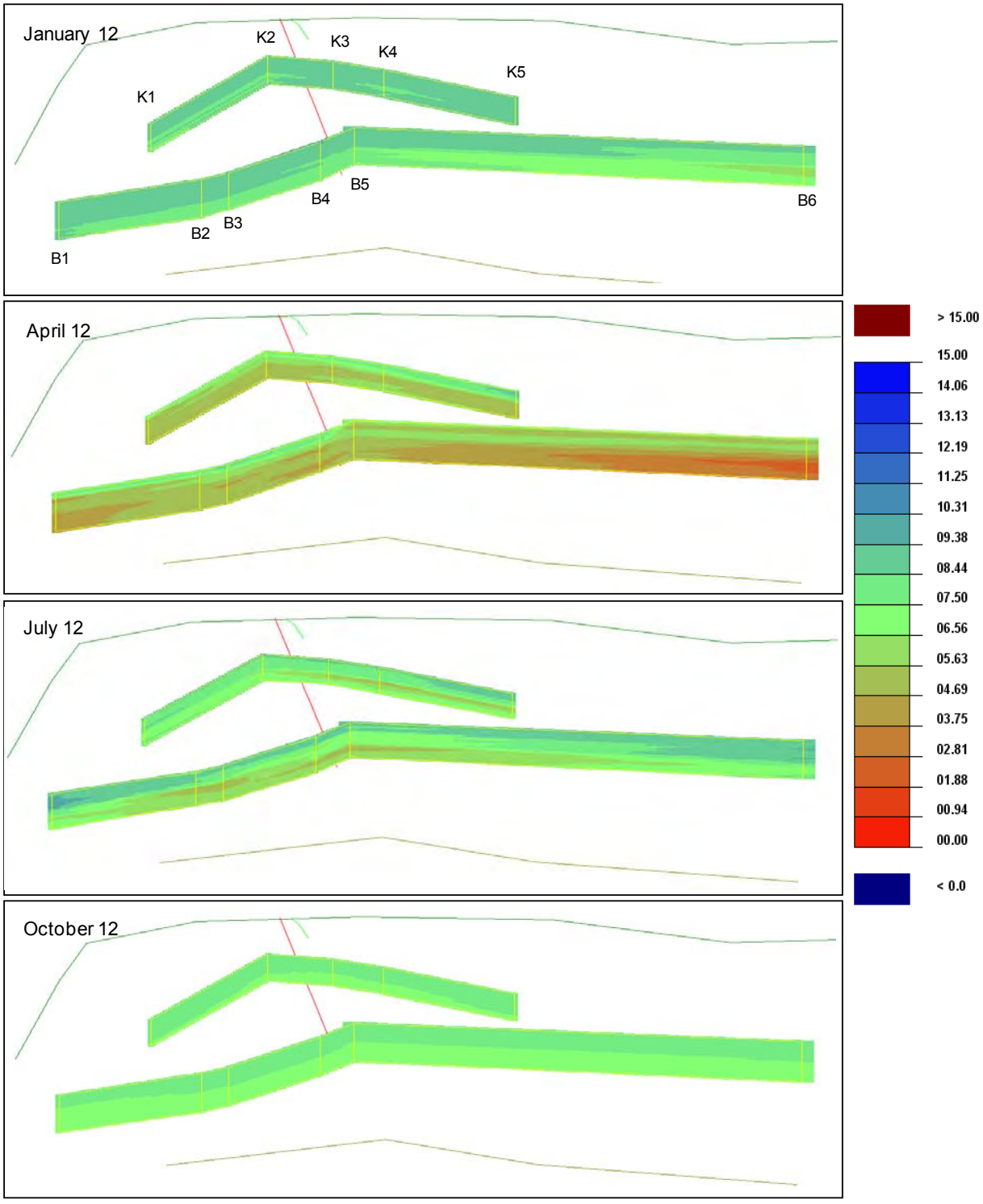


Figure 3-9. Dissolved oxygen contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.5. Light Transmissance

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

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

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

Spatial transmissance patterns. Water clarity was good throughout the water column during each of the four quarterly surveys (Figure 3-10). Average transmissance across the four surveys ranged from 77.1% in October to 84.5% in April (Table 3-3). In addition, clarity was similar with depth in each survey (range = 65.4% to 87.4%). The lowest transmissance occurred in July near the bottom at the outfall stations. Good water clarity might be due to lack of phytoplankton blooms as evidenced by lower than normal dissolved oxygen, especially in the summer months.

Transmissance ranges and outfall effects. Table 3-3 shows the range of transmissance for the 11 water column stations over the four sampling surveys. Comparisons among stations showed there was a significant correlation with distance to the outfall and a significant difference among near and far field station by t-test during July. In all cases, there was never a reduction in transmissance between near and far field stations that exceeded the Ocean Plan (2009) standard of 10%.

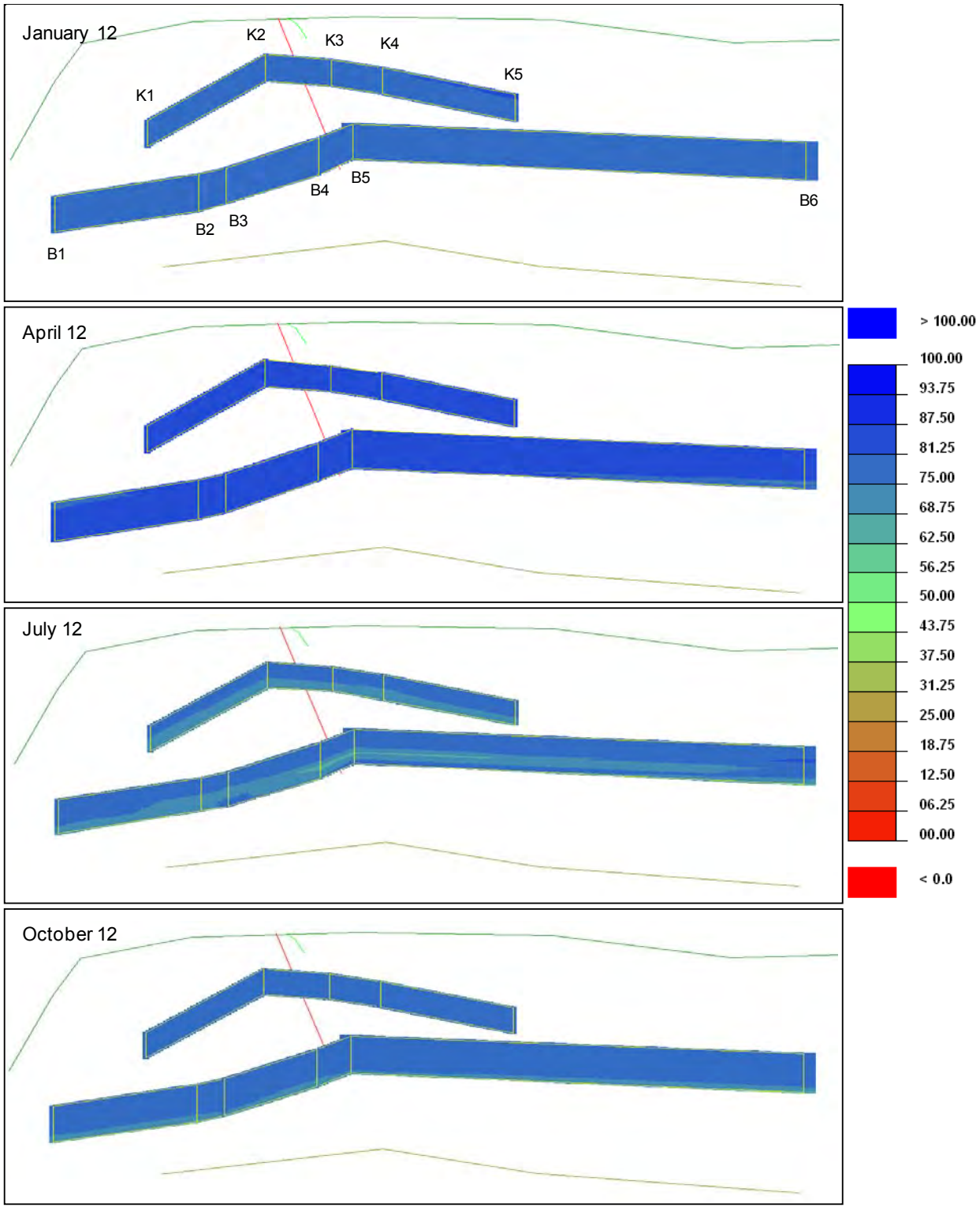


Figure 3-10. Transmissance (%) contours for the K Station (depth = 18 m) and B Station (depth = 28 m) transects. The Goleta Sanitary District outfall is depicted as a red line.

3.10.1.6. Surface Transparency

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

Transparency patterns and outfall effects. Figure 3-11 shows the range of transparency measurements for the 11 water column stations over the four sampling surveys. Average surface transparency was similar in January, July and October (range = 5.8 to 8.6 m). In April average transparency doubled to 15.4 m and ranged from 14.0 to 19.1 m. This was due to the strong upwelling event that occurred during this survey. Transparency did not correlate with distance from the outfall nor was it significantly different by t-test among stations located near to the outfall compared to stations further away.

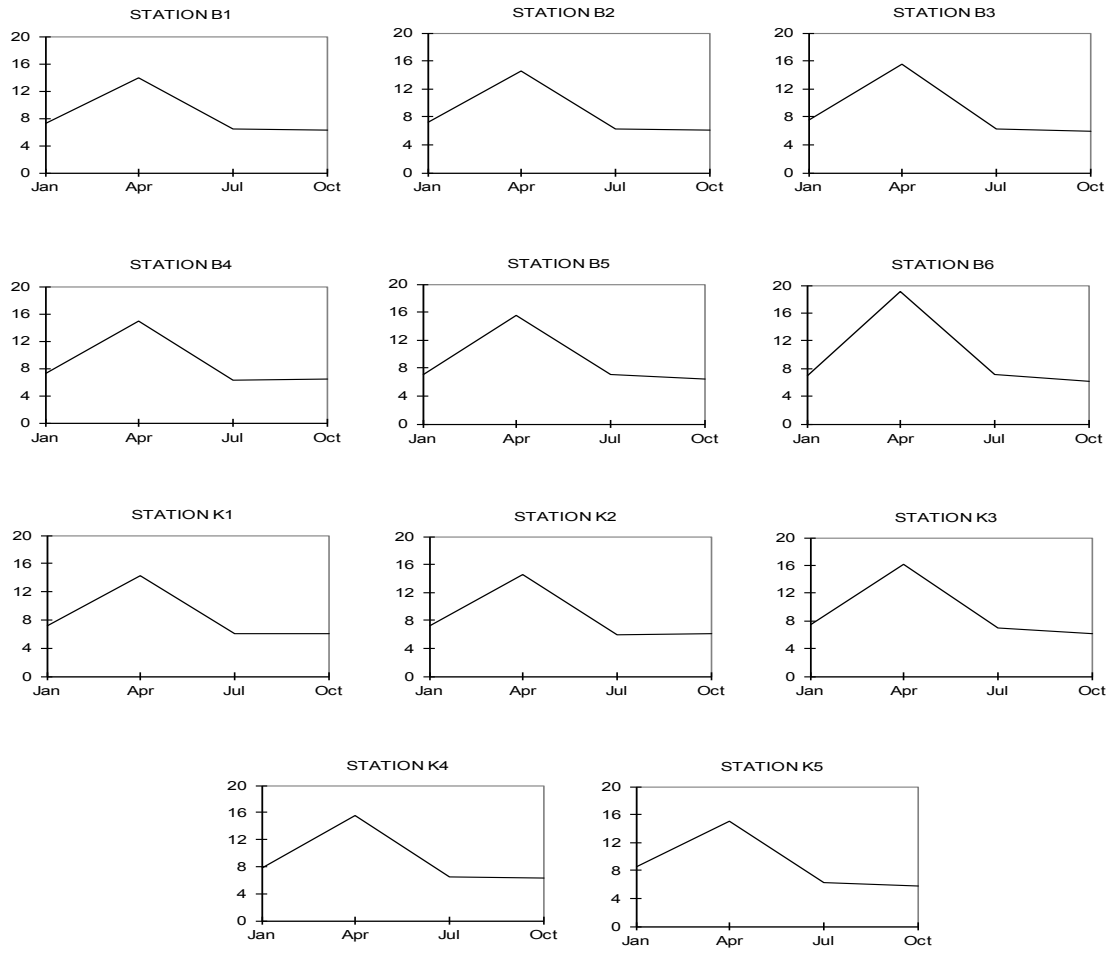


Figure 3-11. Average transparency vs. season for each of the 11 water quality stations.

3.10.2. Bacterial Water Quality

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

3.10.2.1. Total Coliforms

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

Total coliform patterns over the year. Total coliform counts were very low during the year, ranging from <2 to 20 MPN/100 mL for all surveys (Table 3-4). In general values were very low throughout the year at all stations and depths with most samples below detection (<2 MPN/100 mL). These total coliform concentrations were far below either the single sample Ocean Plan standard (2009) of 10,000 MPN/100 mL or the monthly average total coliform standard of 1,000 MPN/100mL (Table 3-5).

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

Sampling Station	Season	Offshore						Plume		Nearshore				
		BI	B2	B3	B4	B5	B6	WCZID	WC100	K1	K2	K3	K4	K5
SURFACE														
Total Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Fecal Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
MIDDLE														
Total Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Fecal Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
BOTTOM														
Total Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	20	<2	<2	<2
Fecal Coliform	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	<2	<2	<2	<2	20	<2	<2	<2
Enterococcus	Winter	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Spring	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Summer	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Fall	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2

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

Parameter	Month	Average	Range	Water Quality Standard	Standard Exceedances
Total Coliform	January	2	<2 - 2	10,000	0
	April	2	<2 - 2	10,000	0
	July	3	<2 - 20	10,000	0
	October	3	<2 - 20	10,000	0
Fecal Coliform	January	2	<2 - 2	400	0
	April	2	<2 - 2	400	0
	July	3	<2 - 20	400	0
	October	3	<2 - 20	400	0
Enterococcus	January	2	<2 - 2	104	0
	April	2	<2 - 2	104	0
	July	2	<2 - 2	104	0
	October	2	<2 - 2	104	0

3.10.2.2. Fecal Coliforms

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

Fecal coliform patterns over the year. Fecal coliform counts were very low during the year, ranging from <2 to 20 MPN/100 mL for all surveys (Table 3-4). In general values were very low throughout the year at all stations and depths with most samples below detection (<2 MPN/100 mL). These fecal coliform concentrations were far below either the single sample Ocean Plan standard (2009) of 400 MPN/100 mL or the monthly average fecal coliform standard of 200 MPN/100mL (Table 3-5).

3.10.2.3. Enterococcus

Enterococcus bacteria include species that are found in human wastes and are related to the Streptococcus bacteria. At one time they were believed to be exclusive to humans, but other Streptococcus species occur in feces of cows, horses, chickens, and other birds. Enterococci die off rapidly in the environment, making them

indicators of fresh contamination, but not exclusively from humans. The California Ocean Plan (SWRCB 2009) limitations within 1000 feet of shore are a 30 day average of 34 MPN/100 mL and a single sample limit of 104 MPN/100 mL.

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

3.11. Discussion

Quarterly water quality surveys were conducted offshore Goleta in January, April, July and October 2012. Measurements for temperature, salinity, pH, dissolved oxygen and water clarity showed that oceanographic conditions during the year were typical of nearshore areas in southern California. Rainfall for this period (12.77 inches) was 5.39 inches less than the average yearly rainfall since 1981 (18.96 inches). This lack of rainfall meant less nearshore surface runoff and may have led to the good water clarity and low bacteria counts throughout the year.

Salinity provided the best opportunity to detect the effluent plume which was evident in each of the monthly contours. In January, lower salinity water was seen as a surface and subsurface lens of slightly fresher water both to the north and south of the outfall. In April, a small patch of fresher water can be seen as a subsurface layer at station B5 and extending north and south. Finally, in July and October fresher water can be seen near the bottom at station B4. The depth of the plume in July and October are presumably due to the presence of a thermal gradient which held the buoyant freshwater plume beneath it. None of the other parameters showed evidence of the effluent plume.

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

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

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

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

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

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

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

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

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

The water quality parameters measured during the four quarterly surveys indicated that the outfall plume was not altering the condition of the water mass in the vicinity of the Goleta outfall. None of the above restrictions were exceeded outside the zone of initial dilution. Water color throughout the area was green, discharge related oil or floating particulates were never observed in the survey area. Water quality measurements taken near to and far from the outfall terminus did not correlate expectedly and significantly with distance from the outfall, except for temperature in January, salinity in April and transmissance in July. While statistically significant, these differences were small and not ecologically significant:

1. In January temperature differences from near field to far field stations were exceedingly small, with the average difference in water column temperature at the plume stations (13.9 ^{o}C) and the station with the coolest temperature (far field station B6, 13.5 ^{o}C) a 0.4 ^{o}C difference.
2. In April the average salinity difference between the plume stations (33.81 ppt) and station B6 (33.88 ppt) was only 0.07 ppt.
3. Finally, average transmissance in July was 76.40% at the plume stations and 77.50% at station B6, a 1.1% difference.

Dissolved oxygen, pH and transmissance were within Ocean Plan (2009) standards during each of the four quarterly surveys. The only exception to this was for oxygen in April during a large upwelling event. Dissolved oxygen was lower between the plume stations (5.29 mg/L) and sites on the K transect located close to shore (range = 5.97 to 6.33 mg/L). These differences represented an 11% to 16% reduction in dissolved oxygen; the Ocean Plan limits reductions in dissolved oxygen between sites near the ZID and those further away to 10%. It is most likely that the depressed oxygen offshore was due to upwelling since dissolved oxygen at the plume sites were similar to the other B transect offshore stations (range = 4.10 to 5.75 mg/L). Therefore, the upwelled water mass did not push into nearshore water on the K transect.

Bacteriological standards are addressed in the Ocean Plan and NPDES discharge permit, however these standards relate primarily to shoreline waters used for recreation or shellfish harvesting (REC-1 bathing water standards). Total coliforms, fecal coliforms and enterococcus indicator bacteria concentrations were very low throughout the year in the Goleta survey area. A total of 156 samples were collected and analyzed for each indicator. None of these exceeded the single sample Ocean Plan standard (2009) during the year and over 95% of the measurements were below detection limits.

In conclusion, evidence from the four quarterly water column monitoring surveys conducted in 2012 indicate that the Goleta Sanitary District Wastewater Treatment Plant was in compliance with all water quality standards, and that the treatment plant was operating effectively.

CHAPTER 4

Physical Characteristics of the Benthic Sediments

4.1. Background

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

4.2. Materials and Methods

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

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

Sediments to be analyzed for physical properties were removed from the top 2 cm of the surface and placed in clean plastic Whirl-Pacs. These were analyzed for particle size distribution using a Horiba LA920 Particle Size Analyzer and in accordance with Standard Methods 2560 D (APHA, 1998). Sub-samples from each sediment sample were re-suspended in de-ionized water, and then injected into the analyzer. The analyzer is capable of measuring particle sizes ranging from silt and clay (<2 µm) up to course sand (2,000 µm). Results were recorded as the percentage each size distribution represented of the whole. When the LA920 detected particles in a sample that neared its upper detection limit (2,000 µm), a portion of the sample was dried at 105 °C, weighed, then sieved through a 2,000 µm mesh screen. Particles not passing through the screen were weighed and expressed as the percentage of particles in the sample >2,000 µm (gravel).

Data for each station were reduced to the median particle size (µm), percent fines and, the sorting index. The sorting index values range between sediments that have a very narrow distribution (very well sorted) to those which have a very wide distribution (extremely poorly sorted). This index is simply calculated as the 84^{th} percentile minus the 16^{th} percentile divided

by two (Gray 1981). Well sorted sediments are homogeneous and are typical of high wave and current activity (high energy areas), whereas poorly sorted sediments are heterogeneous and are typical of low wave and current activity (low energy areas).

4.3. Results

4.3.1. Station Event and Sea State Conditions

Sediment sampling, trawling and mussel retrieval was conducted on October 23rd, 2012 under clear skies, 15 Km visibility, and calm to moderate conditions (Table 4-1). Wave height was 4 to six feet from the southwest and winds were 5 to 25 knots from the west. Water turbidity was moderate and the color was green.

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 μ are defined as sand, sediments ranging from 63 to 4 μ are defined as silt, and sediments that are 4 μ 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 4-2). 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 described by the sampling crew as fine sand at all stations, except station B2 where they were described as mixed. Surface sediment color ranged from brown at B1, B2 and B5 to olive green at B3 and B4 to gray at B6. Subsurface color was gray at B2, B3, B4 and B6, black at B1 and brown at B5. The smell of hydrogen sulfide was not detected at any station, except in the first two replicates at station B1.

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 B5 which was fine sand. Median particle sizes ranged from 65 to 130 μm. While there was no clear, stations B4 and B5 had the greatest median particle sizes of all sites (123 and 130, respectively).

4.3.2.3. Sorting Index & Percent Fines

Particles at all stations were poorly sorted, except at B1 which was very poorly sorted. Sorting indexes ranged from 1.16 at station B5 to 2.06 at B1 (Table 4-3). The percent fine sediments ranged from 16% at station B4 to 34% at station B1 near Goleta Point.

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 very fine and fine sand. The percentage of fine sediments (silt and clay) ranged from 16% to 34% at each of the stations, which was in keeping with results from previous years. In 2012 the smell of hydrogen sulfide was present in two replicates at station B1. Hydrogen sulfide gas is a byproduct of bacterial decomposition of organic material under anoxic conditions. It is difficult to determine the source of the organic material that caused the smell of hydrogen sulfide at these sites. Some sources might include decaying macro algae or oil from seeps that are present near Goleta Point.

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

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

Sampling Stations	BI	B2	B3	B4	B5	B6	TB3	TB6
Date	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12	23-Oct-12
Time	11:00	10:23	9:57	9:27	8:53	8:02	12:07	13:59
Research Vessel	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*	*Hey Jude*
Survey Program	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Benthic Sediment	Trawl, Bioaccum.	Trawl, Bioaccum.
Dist. From Outfall (m)	1500	500	250	25	25	3000	250	3000
Direc. From Outfall (^{o}M)	270	270	270	270	90	90	270	90
Depth (m)	25.9	26.5	26.5	26.5	26.5	26.2	22.8	25.9
Latitude (N)	34.58261	34.40192	34.40192	34.40192	34.40197	34.40283	34.40247	34.40063
Longitude (W)	119.84103	119.83069	119.82792	119.82547	119.82492	119.79269	119.83282	119.78075
Weather	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Air Vis. (km)	15	15	15	15	15	15	15	15
Tide	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Incoming	Incoming
Swl. Ht. (ft)	6	6	5-6	5	5	4-5	4-6	6
Swl. Dir.	SW	SW	SW	SW	SW	SW	SW	SW
Wind Sp. (Kn)	15	5-10	5	10	5	5	20	25
Wind Dir.	W	W	W	W	W	W	W	W
Water Turbidity	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Color	Green	Green	Green	Green	Green	Green	Green	Green

Table 4-2. Sediment grab descriptions.

Station	Rep	Penetration (cm)	Surface Description	Shell Hash	Surface Color	Subsurface Color	Odor	Analysis
B1	1	7.0	Fine Sand	No	Brown	Black	Hydrogen Sulfide	Biology
B1	2	12.0	Fine Sand	No	Brown	Black	Hydrogen Sulfide	Biology
B1	3	8.0	Fine Sand	No	Brown	Black	None	Chemistry
B1	4	8.0	Fine Sand	No	Brown	Black	None	Biology
B1	5	7.5	Fine Sand	No	Brown	Black	None	Biology
B1	6	8.0	Fine Sand	No	Brown	Black	None	Biology
B2	1	7.0	Mixed	No	Brown	Gray	None	Biology
B2	2	7.5	Mixed	No	Brown	Gray	None	Biology
B2	3	11.0	Mixed	No	Brown	Gray	None	Chemistry
B2	4	8.5	Mixed	No	Brown	Gray	None	Biology
B2	5	8.0	Mixed	No	Brown	Gray	None	Biology
B2	6	12.5	Mixed	No	Brown	Gray	None	Biology
B3	1	7.0	Fine Sand	No	Olive Green	Gray	None	Biology
B3	2	10.0	Fine Sand	No	Olive Green	Gray	None	Biology
B3	3	8.5	Fine Sand	No	Olive Green	Gray	None	Biology
B3	4	10.5	Fine Sand	No	Olive Green	Gray	None	Chemistry
B3	5	7.5	Fine Sand	No	Olive Green	Gray	None	Biology
B3	6	7.5	Fine Sand	No	Olive Green	Gray	None	Biology
B4	1	10.0	Fine Sand	No	Olive Green	Gray	None	Biology
B4	2	7.0	Fine Sand	No	Olive Green	Gray	None	Biology
B4	3	8.5	Fine Sand	No	Olive Green	Gray	None	Chemistry
B4	4	9.0	Fine Sand	No	Olive Green	Gray	None	Biology
B4	5	7.5	Fine Sand	No	Olive Green	Gray	None	Biology
B4	6	8.0	Fine Sand	No	Olive Green	Gray	None	Biology
B5	1	6.5	Fine Sand	No	Brown	Brown	None	Biology
B5	2	7.5	Fine Sand	No	Brown	Brown	None	Biology
B5	3	7.5	Fine Sand	No	Brown	Brown	None	Biology
B5	4	7.0	Fine Sand	No	Brown	Brown	None	Chemistry
B5	5	7.0	Fine Sand	No	Brown	Brown	None	Biology
B5	6	7.0	Fine Sand	No	Brown	Brown	None	Biology
B6	1	9.5	Fine Sand	No	Gray	Gray	None	Biology
B6	2	10.0	Fine Sand	No	Gray	Gray	None	Biology
B6	3	9.0	Fine Sand	No	Gray	Gray	None	Biology
B6	4	10.0	Fine Sand	No	Gray	Gray	None	Biology
B6	5	10.0	Fine Sand	No	Gray	Gray	None	Chemistry
B6	6	10.5	Fine Sand	No	Gray	Gray	None	Biology

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

Station	Median (microns) [1.]	Category	Sorting Index [2.]	Sorting	% Fines
B1	90	very fine sand	2.06	very poorly sorted	34
B2	91	very fine sand	1.72	poorly sorted	25
B3	89	very fine sand	1.89	poorly sorted	29
B4	123	very fine sand	1.34	poorly sorted	18
B5	130	fine sand	1.16	poorly sorted	16
B6	65	very fine sand	1.86	poorly sorted	36

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

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

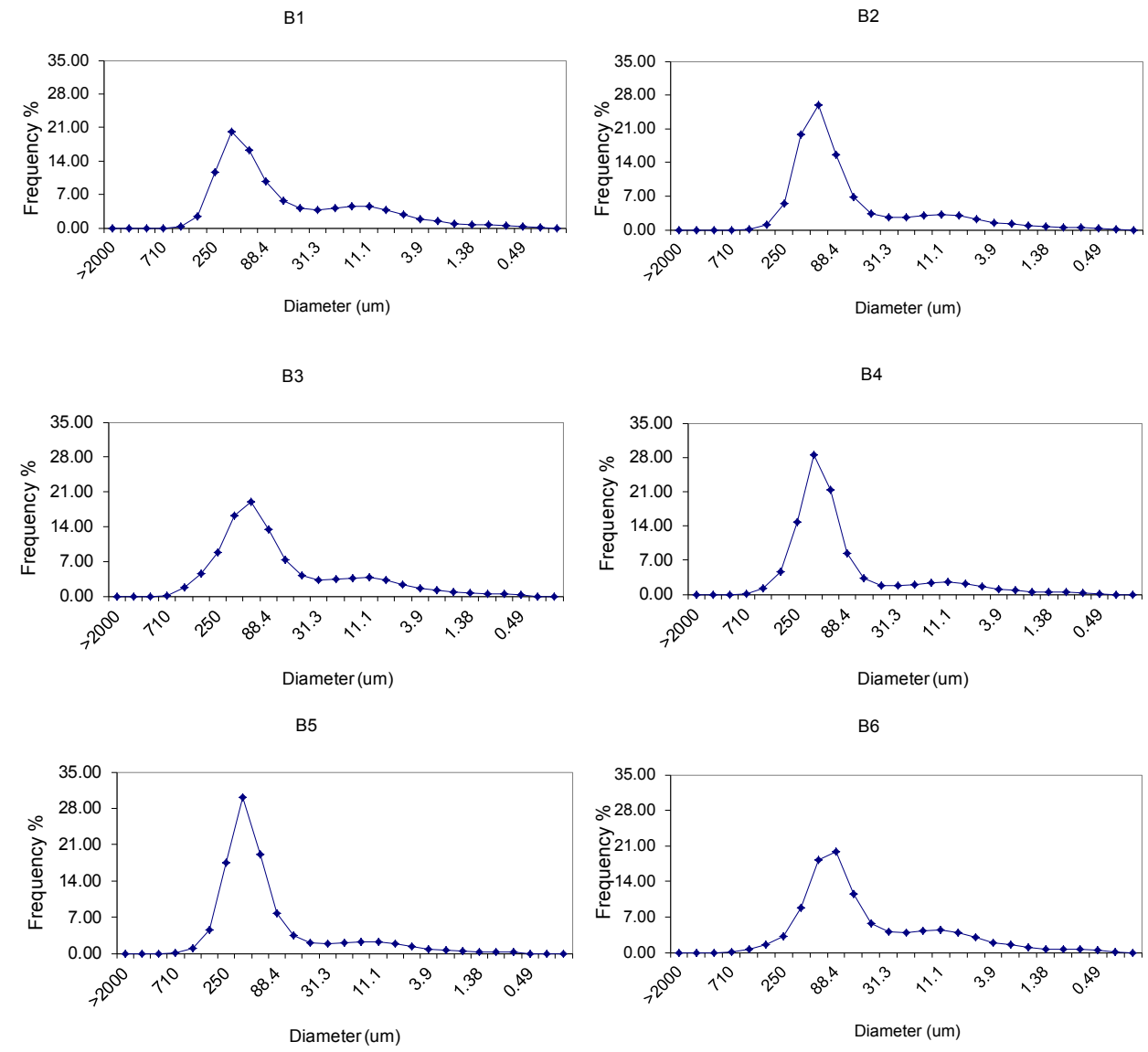


Figure 4-1. Particle size frequency (%) at each station in the Goleta survey area.

CHAPTER 5

Chemical Characteristics of Sediments

5.1. Background

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

5.2. Materials and Methods

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

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

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

In order to determine long-term trends, 2012 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 2011). Data were also compared to results of "reference" sediments from uncontaminated areas collected and analyzed by the Southern California Bight Regional Monitoring Program (SCBRMP) in 1998, 2003 and 2008. Finally, results were compared to the limits presented in two NOAA studies (NOAA 1990 and Long, et. al. 1995). In these studies, researchers compiled published information regarding the toxicity of chemicals to benthic organisms. The data for each compound were sorted, and the lower 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. 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 10-6 and 10-7 present data normalized to percent fine sediments (silt and clay fractions) and percent TOC. Figure 5-2 shows the average (± standard deviation) concentration for all Goleta stations combined, for each constituent measured from 1991 to present. Tables 5-4 and 5-5 compare the Goleta sediment chemistry results with the 1998, 2003 and 2008 SCBRMP surveys and the NOAA ER-L and ER-M values.

5.3.1 Undifferentiated Organics

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

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

5.3.1.1 Undifferentiated Organics Spatial Patterns

The concentrations for each of the undifferentiated organics measured for this survey are listed in Table 5-1. The concentrations of oil and grease were greatest at Station B2 offshore Goleta Point and decreased at stations nearest to the outfall until the lowest concentration was measured at station B5 (121 mg/Kg). Total Kjeldahl nitrogen (TKN) concentrations were greatest at stations furthest west and east of the outfall (B1 and B6) and least just east of the outfall at station B5. TOC concentrations were least at sites nearest the outfall (stations B4 and B5) and greatest at stations further away B6. Acid volatile sulfide (AVS) was greatest at station B2 near Goleta Point (32.78 mg/L) and decreased to lowest concentrations at station B4 (8.92 mg/L) near the outfall.

Each undifferentiated organic correlated unexpectedly (increased) with distance from the outfall and oil and grease and TKN correlated significantly. Of the undifferentiated organics each correlated expectedly with distance to Goleta Point, except TOC. TKN correlated unexpectedly (decreased with decreasing sediment size) and significantly with particle size.

5.3.1.2 Undifferentiated Organic Ranges Compared with Past Years

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

5.3.1.3 Undifferentiated Organics Compared with Reference Surveys

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

5.3.2 Heavy Metals

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

- Aluminum is generally considered to be nontoxic to organisms in its elemental state and is one of the most common elements on earth.
- Antimony is used for alloys and other metallurgical purposes. The salts, primarily sulfides and oxides are employed in the rubber, textile, fireworks, paint, ceramic, and glass industries (SWRCB 1973). Acute and chronic toxicity of antimony to freshwater aquatic life occur at water concentrations as low as 9000 to 1600 ppm, and toxicity to algal species occurs at about 610 ppm. There is no saltwater criterion available for antimony (Long and Morgan 1990).
- Arsenic is carcinogenic and teratogenic (causing abnormal development) in mammals and is mainly used as a pesticide and wood preservative. Inorganic arsenic can affect marine plants at concentrations as low as 13 to 56 ppm and marine animals at about 2000 ppm (Long and Morgan 1990). The USEPA (1983) gives a terrestrial range of 1-50 ppm, with an average of 5 ppm.
- Cadmium is widely used in manufacturing for electroplating, paint pigment, batteries and plastics. Toxicity in water to freshwater animals ranges from 10 ppb to 1 ppm, as low as 2 ppm for freshwater plants, and 320 ppb to 15.5 ppm for marine animals (Long and Morgan 1990). The USEPA (1983) places the terrestrial range for cadmium at 0.01 to 0.7 ppm, with an average of 0.06 ppm.
- Chromium is widely used in electroplating, metal pickling, and many other industrial processes. Chromium typically occurs as either chromium (III) or chromium (VI), the latter being considerably more toxic. Acute effects to marine organisms range from 2,000

to 105,000 ppm for chromium (VI) and 10,300 to 35,500 ppm for chromium (III). Chronic effects range from 445 to 2,000 ppb for chromium (VI) and 2,000 to 3,200 ppb for chromium (III) (Long and Morgan 1990). The terrestrial range is 1 to 1,000 ppm with an average of 100 ppm (USEPA, 1983).

- Copper is widely used in anti-fouling paints. Saltwater animals are acutely sensitive to copper in water at concentrations ranging from 5.8 to 600 ppm. Mysid shrimp indicate chronic sensitivity at 77 ppm (Long and Morgan 1990).
- Iron is generally not considered toxic to marine organisms. Iron, in some organic forms, is a stimulator for phytoplankton blooms. Recent experiments in deep-sea productivity have shown a considerable increase in phytoplankton in normally depauperate mid-ocean waters when iron is added (Soule et al. 1996).
- Older paints and leaded gasoline are a major source of lead. Lead may be washed into the Harbor or become waterborne from aerial particulates. Adverse effects to freshwater organisms range from 1.3 to 7.7 ppm, although marine animals may be more tolerant (Long and Morgan 1990).
- Mercury is a common trace metal once used in industry and as a biocide. Acute toxicity to marine organisms in water ranges from 3.5 to 1678 ppm. Organic mercury may be toxic in the range of 0.1 to 2.0 ppm (Long and Morgan 1990).
- Nickel is used extensively in steel alloys and plating. Nickel is chronically toxic to marine organisms in seawater at 141 ppm (Long and Morgan 1990).
- Selenium is used as a component of electrical apparatuses and metal alloys and as an insecticide. Although there is no data available for selenium toxicity to marine organisms, the present protection criteria range is from 54 to 410 ppb (USEPA 1986). The normal terrestrial range is from 0.1 to 2.0 ppm with a mean of 0.3 ppm. Selenium and lead levels found and reported in Least Tern eggs from Venice Beach and North Island Naval Station in San Diego County were considered to be harmful to development (Soule et al. 1996).
- Silver has many uses in commerce and industry including photographic film, electronics, jewelry, coins, and flatware and in medical applications. Silver is toxic to mollusks and is sequestered by them and other organisms. Silver increases in the Southern California Bight with increased depth; high organic content and percent silt (Mearns et. al., 1991). The range in the rural coastal shelf is from 0.10 to 18 ppm, in bays and harbors from 0.27 to 4.0 ppm, and near outfalls 0.08 to 18 ppm (Soule et al. 1996). The normal terrestrial level ranges from 0.01 to 5.0 ppm, with a mean of 0.05 ppm.
- Soule and Oguri (1987, 1988) found the effects of tributyl tin can be toxic in concentrations as low as 50 parts per trillion in water. The terrestrial range for tin is 2 to 200 ppm, with a mean of 10 ppm. The California Department of Fish and Game considers tributyl tin to be the most toxic substance ever released in the marine environment. Tributyl tin may not be as bio-available in sediments as it is in seawater, and therefore may not affect the benthic biota in the same fashion.
- Zinc is widespread in the environment and is also an essential trace element in human nutrition. It is widely used for marine corrosion protection, enters the waters as airborne particulates, and occurs in runoff and sewage effluent. Acute toxicity of zinc in water to marine fish begins at 192 ppm, and chronic toxicity to marine mysid shrimp can occur as low as 120 ppm (Long and Morgan 1990). The normal terrestrial range is from 10 to 300 ppm, with a mean of 50 ppm (Soule et al. 1996).

5.3.2.1 Heavy Metal Spatial Patterns

The concentrations for each of the heavy metals measured for this survey are listed in Table 5-1. Of the fourteen metals measured, all were above detection at each of the sites. Differences in the concentrations of each metal among sites were small. None of the fourteen metals correlated expectedly (decreased) with distance from the outfall. Four metals (aluminum, arsenic, cadmium and silver) correlated significantly, but unexpectedly (increased) with distance to the outfall. None of the fourteen metals correlated expectedly (decreased) with distance from Goleta Point and none correlated significantly. Only two of the fourteen metals (antimony and selenium) correlated significantly with sediment particle size, but these relationships were not expected (metal concentration increased as particle size increased).

5.3.2.2 Heavy Metal Ranges Compared with Past Years

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

5.3.2.3 Heavy Metals Compared with Reference Surveys

The average concentrations of 14 of the heavy metals measured in this survey were compared to concentrations found during three SCBRMP surveys in 1998, 2003 and 2008 (Tables 5-4). Of the metals where comparisons could be made, aluminum, chromium and copper slightly exceeded the concentrations measured on the inner shelf during the 2008 SCBRMP. Cadmium and nickel concentration ranges in Goleta sediments somewhat exceeded concentrations measured on the inner shelf or near other SPOTWs during each of the three surveys.

5.3.2.4 Heavy Metals Compared with NOAA Effects Range Thresholds

Metals concentrations measured at each station in the Goleta survey area during 2012 were compared to the ER-L and ER-M threshold values (Table 5-4). All metal concentrations were below both the ER-L and ER-M threshold limits.

5.3.3 Complex Organics

5.3.3.1 Pesticides, PCB's and PAH's

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

- DDT is a pesticide that has been banned since the early 1970's, but the presence of non-degraded DDT suggests that either subsurface DDT is being released during erosion and runoff in storms, or that fresh DDT is still in use and finding its way into coastal waters (Soule et al. 1996). DDT has been found to be chronically toxic to bivalves as low as 0.6 ppb in sediment. Toxicity of two of DDT's breakdown products, DDE and DDD, were both chronically toxic to bivalve larvae as low as about 1 ppb (Long and Morgan 1990).
- Of the non-DDT pesticides, concentrations of chlordane between 2.4 and 260 ppm in water are acutely toxic to marine organisms. Heptachlor is acutely toxic in water from 0.03 to 3.8 ppm. Heptachlor epoxide, a degradation product of heptachlor, is acutely toxic to marine shrimp at 0.04 ppm in water. Dieldrin is acutely toxic to estuarine organisms from

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

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

5.3.3.2 Pesticide, PCB, and PAH Spatial Patterns

Pesticides, PCB and PAH concentrations at the six sampling stations are listed in Table 5-1. Similar to the some previous surveys there were no chlorinated hydrocarbons (DDTs, BHCs, total chlordane, or PCBs) detected in Goleta sediments.

Similar to past years, total PAHs were above detection at each site in the survey area and concentrations were relatively similar across sites with station B4 having the lowest concentration and station B3 having the greatest. Total PAHs, as well as each individual PAH, correlated unexpectedly and non-significantly with the distance to the outfall except benzo[e]oyrene, which was least at the outfall stations. Total PAHs correlated unexpectedly and non-significantly with distance from Goleta Point and sediment particle size.

5.3.3.3 Pesticide, PCB and PAH Ranges Compared with Past Years

Total DDT pesticides and PAH concentrations were within the range of previous years (Figure 5-2). Total PCBs were below detection in the Goleta survey area for the ninth year in a row since 2004.

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 2012 survey were compared to concentrations found during three southern California reference site surveys conducted in 1998, 2003 and 2008 (Table 5-4). Concentrations of each group of organics were similar to or less than those measured on the inner shelf and near SPOTWs in during each of the SCBRMP reference surveys.

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.

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 not as heavily influenced by distance from Goleta Point and particle size during 2012 as in past years (Aquatic Bioassay 1997 to 2009). In fact, the concentrations of each of the metals were similar across sites. Of the fourteen metals measured, none correlated expectedly (decreased) with distance from the outfall. In addition, none of the metals correlated expectedly with distance to Goleta Point or with sediment particle size.

In 2012, chlorinated pesticides (DDTs, chlordane, dieldrin, etc.) and PCBs were below detection. In past surveys, total PAHs were nearly always measured in greatest concentrations near Goleta Point and declined on a gradient toward the outfall. However, in 2012 (as in 2011) this was not the case with PAH concentrations being similar across sites. The reason for the reduction in sediment PAH concentrations are unclear, but indicate that oil seepage from Goleta Point is highly variable.

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 2012 were within the ranges of past years. Acid volatile sulfides (AVS) which were greater on average in 2011 compared to any survey in the past 20 years, returned to normal background concentrations in 2012. Organic contaminants remained either low or below detection in 2012. Total DDTs have been below detection since 2010, after being detected in all surveys but one over the past twenty years. In addition, total PCBs have not been detected in the survey area since 2004.

This year's results were compared to sediment contaminant concentrations measured during the 1998, 2003 and 2008 SCBRMP surveys on the inner shelf (depth < 30m) and near SPOTWs (SCBRMP 1998, 2003 and 2008). Of the metals where comparisons could be made, aluminum, chromium and copper slightly exceeded the concentrations measured on the inner shelf during the 2008 SCBRMP. Cadmium and nickel concentration ranges in Goleta sediments somewhat exceeded concentrations measured on the inner shelf or near other SPOTWs during each of the three surveys. Of the organics measured, none were greater than the SCBRMP 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 2012 each constituent was well below the ER-L thresholds and far below the ER-M thresholds. 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 2012 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, aerial deposition or naturally occurring processes such as the release of oil from the seeps located offshore of Goleta Point. Comparison of Goleta sediments with historical reference data from the southern California Bight showed that most constituents were similar to or below baseline concentrations. Additionally, all sediment chemical concentrations were below those levels thought to cause toxicity to sensitive infauna organisms. Figure 5-1. Benthic sediment sampling locations (Stations B1 – B6) in the Goleta survey area.

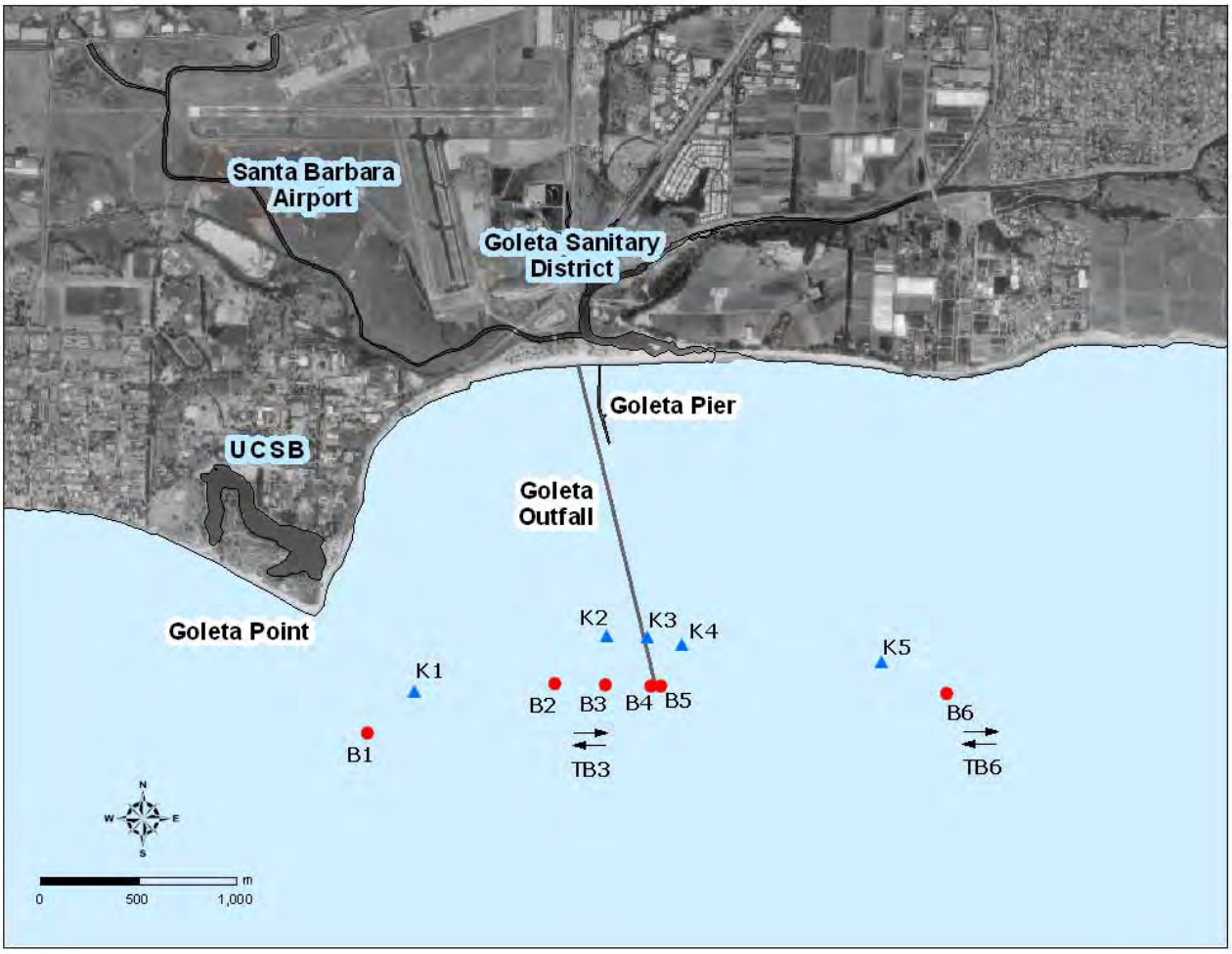


Table 5-1. Sediment contaminant concentrations (dry weight) in the Goleta survey area.

Constituent[1]	Sediment Stations B1	B2	B3	B4	B5	B6	Mean	S.D.	Correlations Outfall[3]	Point[3]	Prt.Sz.
Undifferentiated Organics											
Oil and Grease (detention = 100 µg/g)[3]	504	538	413	254	121	522	392	169	**0.81**	-0.31	0.66[3]
TKN (detection = 0.6 µg/g)	876	692	716	495	381	811	662	189	**0.87**	-0.37	**0.96**
TOC (detection = 100 µg/g)	6800	1800	6900	3700	3100	8500	5133	2628	0.52	0.31	**0.77**[3]
AVS (detection = 0.05 µg/g)[3]	14.36	32.78	23.28	8.92	12.67	24.56	19.43	8.96	0.70	-0.14	0.54[3]
Heavy Metals											
Aluminum (detection = 1.0 µg/g)	8207	12682	9893	8109	7095	13310	9883	2581	**0.81**	0.03	0.58
Antimony (detection = 0.025 µg/g)	0.15	0.15	0.15	0.12	0.11	0.17	0.141	0.023	**0.79**	0.06	**0.89**
Arsenic (detection = 0.025 µg/g)	5.21	6.00	5.45	5.06	4.72	6.55	5.50	0.67	**0.81**	0.03	0.70
Cadmium (detection = 0.025 µg/g)	0.41	0.56	0.49	0.37	0.33	0.63	0.47	0.12	**0.81**	0.03	0.71
Chromium (detection = 0.025 µg/g)	21.50	34.27	29.81	25.56	23.01	39.05	28.87	6.83	0.41	0.43	0.46
Copper (detection = 0.025 µg/g)	4.25	6.25	6.75	4.66	3.41	6.95	5.38	1.47	0.55	0.26	0.59
Iron (detection = 1.0 µg/g)	8233	11812	11406	8780	7905	13168	10217	2192	0.61	0.20	0.57
Lead (detection = 0.025 µg/g)	3.51	4.86	4.84	3.80	3.35	5.17	4.25	0.79	0.61	0.20	0.54
Mercury (detection = 0.00001 µg/g)	0.021	0.023	0.023	0.020	0.017	0.025	0.022	0.003	**0.79**	0.06	**0.79**
Nickel (detection = 0.025 µg/g)	11.76	17.85	18.01	13.05	11.18	21.13	15.50	4.05	0.55	0.26	0.58
Selenium (detection = 0.025 µg/g)	0.27	0.29	0.33	0.22	0.18	0.38	0.28	0.07	**0.75**	0.09	**0.86**
Silver (detection = 0.025 µg/g)	0.05	0.06	0.06	0.04	0.03	0.06	0.05	0.01	**0.81**	0.03	0.75
Tin (detection = 0.025 µg/g)[3]	0.56	0.87	0.66	0.58	0.50	0.92	0.68	0.17	0.61	0.20	0.55
Zinc (detection = 0.025 µg/g)	20.70	31.31	30.72	23.16	19.50	36.88	27.04	6.94	0.61	0.20	0.58

Table 5-1. continued

Constituent[1]	Sediment Stations B1	B2	B3	B4	B5	B6	Mean	S.D.	Correlations Outfall[3]	Point[3]	Prt.Sz.
Complex Organics (ng/g dry weight)[2]											
Chlorinated Pesticides											
DDTs (detection = 1.0 µg/Kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.000	0.000	0.000
HCHs (detection = 1.0 µg/Kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.000	0.000	0.000
Chlordane (detection = 1.0 µg/Kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.000	0.000	0.000
Aldrin (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Dieldrin (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Heptachlor (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Heptachlor epoxide (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Mirex (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Hexachlorobenzene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Polychlorinated Biphenyls											
PCBs (detection = 1.0 µg/Kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.000	0.000	0.000
Aroclors (detection = 10 µg/Kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.000	0.000	0.000
Polycyclic Aromatic Hydrocarbons											
PAHs[3] (detection = 1.0 µg/Kg)	49.9	54.8	116.4	47.4	54.7	70.6	65.63	26.15	0.377	0.200	0.429[3]
1-Methylnaphthalene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
1-Methylphenanthrene (detection = 1.0 µg/Kg)	1.0	3.1	3.4	2.4	1.0	3.8	2.45	1.21	0.456	0.377	0.551[3]
2-Methylnaphthalene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
2,3,5-Trimethylnaphthalene (detection = 1.0 µg/K	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
2,6-Dimethylnaphthalene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Acenaphthene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Biphenyl (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Benz[a]anthracene (detection = 1.0 µg/Kg)	2.9	4.6	13.2	4.8	4.1	6.0	5.93	3.70	0.029	0.429	0.257[3]
Benzo[b]fluoranthene (detection = 1.0 µg/Kg)	7.0	6.2	11.2	4.4	5.6	7.6	7.00	2.34	0.638	-0.086	**0.771**[3]
Benzo[e]pyrene (detection = 1.0 µg/Kg)	4.5	4.4	5.2	2.9	3.3	5.3	4.27	0.98	**0.812**	0.086	**0.887**
Benzo[g,h,i]perylene (detection = 1.0 µg/Kg)	2.8	2.4	3.6	1.1	2.1	2.3	2.38	0.82	0.464	-0.600	0.543[3]
Fluoranthene (detection = 1.0 µg/Kg)	6.4	11.1	18.9	8.9	11.9	12.5	11.62	4.21	0.029	0.543	0.143[3]
Napthalene (detection = 1.0 µg/Kg)	1.0	1.0	1.0	1.0	1.0	1.0	1.00	0.00	0.000	0.000	0.000
Perylene (detection = 1.0 µg/Kg)	22.3	25.8	26.9	11.3	10.3	27.3	20.65	7.84	**0.754**	0.086	0.829[3]

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 10-5
3. Non-normal data, correlations by Spearman's rho.

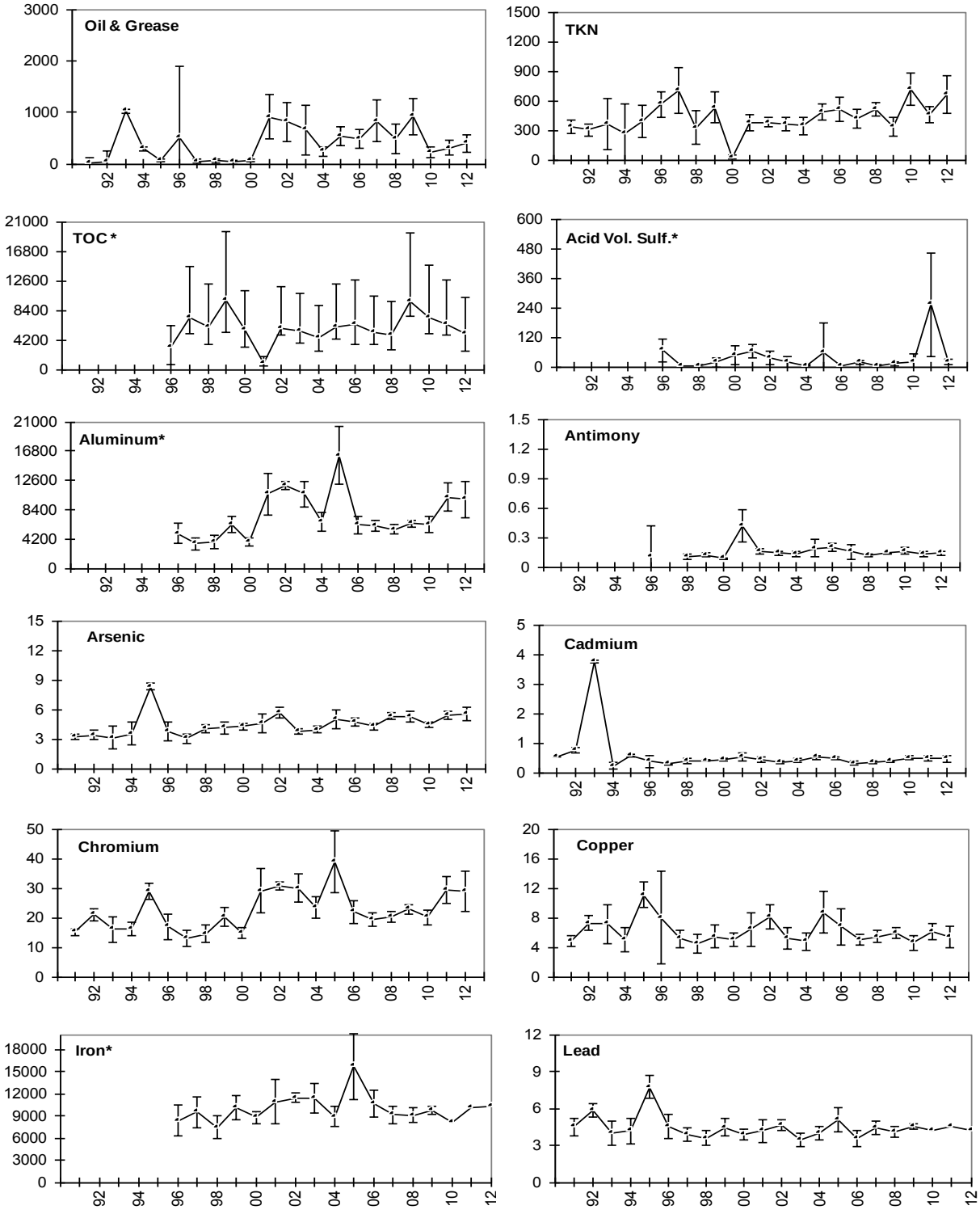


Figure 5-2. Average concentrations (±SD) of sediment contaminants measured between 1991 and 2012 in the Goleta survey area. TOC, acid volatile sulfide, aluminum and iron were not measured from 1991 to 1995.

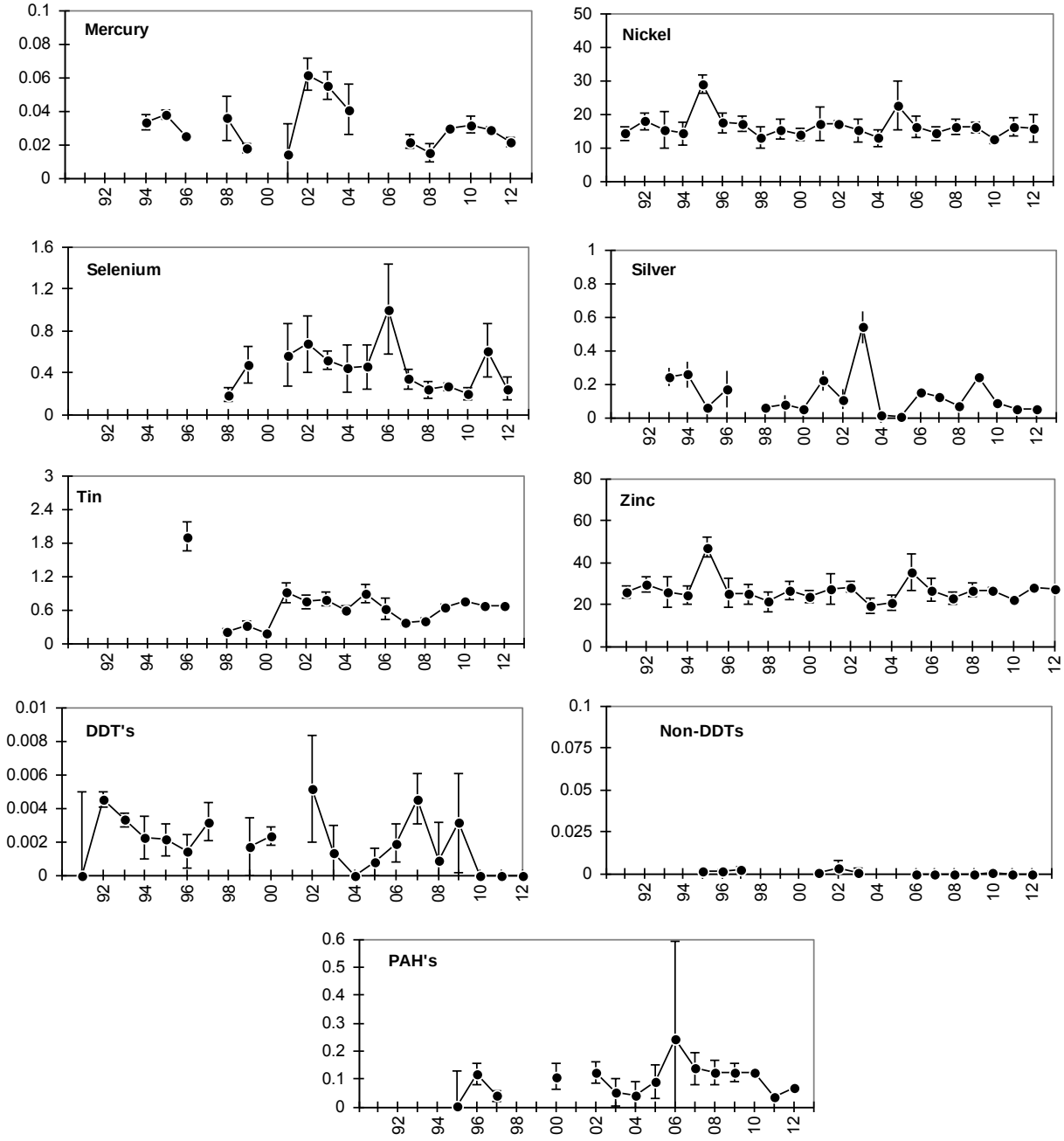


Figure 5-2. (continued)

Table 5-4. Comparison of sediment contaminants found in the Goleta survey area to the Southern California Bight Regional Monitoring Program (SCBRMP) data from 1998, 2003 and 2008; 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. Bolded reference surveys or thresholds were exceeded by 2012 Goleta contaminant concentration ranges.

	GOLETA S.D.		SCBRMP (2008)[1.]				SCBRMP (2003)[2.]				SCBRMP (1998)[3.]		NOAA (1990)[4.],	
			Inner Shelf		So Cal Bight		Inner Shelf		Small POTW		SPOTW	Shallow	Long,et.al. (1995)[5.]	
Constituent	Mean	Range	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	Mean	ER-L	ER-M
Undifferentiated Organics														
Oil and Grease	392.1	121 - 538	---	---	---	---	---	---	---	---	---	---	---	---
TKN	661.8	381 - 876	---	---	---	---	---	---	---	---	---	---	---	---
TOC	5133	1800 - 8500	6600	4100	30000	100	**2700**	800.00	5400	1600	5500	4200	---	---
AVS	19.4	8.9 - 32.8	---	---	---	---	---	---	---	---	---	---	---	---
Heavy Metals														
Aluminum	9883	7095 - 13310	**5256**	726	15372	1594	9212	2233	13244	3585	---	---	---	---
Antimony	0.14	0.11 - 0.17	0.12	0.02	0.28	0.04	0.14	0.04	0.15	0.02	1.09	1.59	2	25
Arsenic	5.50	4.72 - 6.55	4.3	1.2	6.70	1.20	4.2	1.4	4.6	0.67	7.67	4.39	8.2	70
Cadmium	0.47	0.33 - 0.63	**0.23**	0.03	0.88	0.12	**0.20**	0.06	**0.22**	0.05	**0.28**	0.36	1.2	9.6
Chromium	28.87	21.50 - 39.05	**16**	3.8	56.0	9.9	27	6.8	27	5.6	24.72	19.02	81	370
Copper	5.38	3.41 - 6.95	**4.4**	0.8	23.00	5.80	6.6	1.8	9.0	2.5	17.41	6.82	34	270
Iron	10217	7905 - 13168	10239	2233	26218	3125	12952	2784	16255	3655	---	---	---	---
Lead	4.25	3.35 - 5.17	5.0	1.3	12.00	1.40	4.7	1.1	4.90	0.81	15.92	10.14	46.7	218
Mercury	0.022	0.017 - 0.025	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	15.50	11.18 - 21.13	**9**	1.7	27.00	2.80	**13**	3.8	**11**	2.0	**13.85**	15.50	20.9	51.6
Selenium	0.28	0.18 - 0.38	0.44	0.11	3.50	2.60	0.69	0.22	0.55	0.12	0.97	0.47	---	---
Silver	0.05	0.03 - 0.06	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	0.68	0.50 - 0.92	---	---	---	---	---	---	---	---	---	---	---	---
Zinc	27.04	19.50 - 36.88	25	6.8	71.00	5.90	34	7.8	40	8.0	52.14	33.59	150	410
Complex Organics														
DDTs	0.0000	0.0000 - 0.0000	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	0.0000	0.0000 - 0.0000	0.0005	0.0001	0.0016	0.0008	0.00001	0.00001	0.00000	0.00000	---	---	---	---
PCBs	0.0000	0.0000 - 0.0000	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	0.0656	0.0474 - 0.1164	0.0512	0.0449	0.2860	0.0390	0.0512	0.0449	0.0249	0.0087	0.118	0.073	4.022	44.792

Table 5-5. 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 and 2008; 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	
			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	No	No	Yes	No	No	No	---	---
AVS	No	No	---	---	---	---	---	---	---	---
Aluminum	No	No	Yes	No	No	No	---	---	---	---
Antimony	No	No	No	No	No	No	No	No	No	No
Arsenic	No	No	No	No	No	No	No	No	No	No
Cadmium	No	No	Yes	No	Yes	Yes	Yes	No	No	No
Chromium	No	No	Yes	No	No	No	No	No	No	No
Copper	No	No	Yes	No	No	No	No	No	No	No
Iron	No	No	No	No	No	No	---	---	---	---
Lead	No	No	No	No	No	No	No	No	No	No
Mercury	No	No	No	No	No	No	No	No	No	No
Nickel	No	No	Yes	No	Yes	Yes	Yes	No	No	No
Selenium	No	No	No	No	No	No	No	No	No	No
Silver	No	No	No	No	No	No	No	No	No	No
Tin	No	No	---	---	---	---	---	---	---	---
Zinc	No	No	No	No	No	No	No	No	No	No
DDTs	No	No	No	No	No	No	No	No	No	No
HCHs	No	No	No	No	No	No	No	No	No	No
Chlordane	No	No	No	No	No	No	No	No	No	No
PCB'S	No	No	No	No	No	No	No	No	No	No
PAH'S	No	No	No	No	No	No	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 who 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 one-liter plastic bottles, relaxed with a magnesium sulfate solution, and preserved with 10% buffered formalin. Five replicates were collected from six benthic infauna stations (B1, B2, B3, B4, B5, and B6; see Figure 3-1). Screened and preserved sediments collected in the field were delivered to the Ventura laboratory for counting, sorting, and identification. Infauna were sorted out by Aquatic Bioassay staff biologists and separated into five groups: echinoderms, mollusks, polychaetes, crustaceans, and miscellaneous. For each station, organisms were counted and weighed 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*, 2008. 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 crustaceans and polychaetes and other phyla, Megan Lily of the City of San Diego for echinoderms and, and Kelvin Barwick with the Orange County Sanitation District for mollusks. A complete list of infauna is included in Appendix E Table 10.6. Aquatic Bioassay maintains and updates standardized type collections and voucher specimens for most southern California infauna.

Following enumeration of infauna organisms by species, the total and phyla group numbers of individuals, and numbers of separate species were compiled for each station replicate. In addition, several required biological indices were calculated: Shannon Weiner species diversity (H'), Margelef's richness index (d), Simpson's species diversity (SI), Schwartz's dominance (D), the infauna trophic index (ITI) and Benthic Response Index (BRI). Analysis of Variance (ANOVA) was used to compare average metrics values among stations. Species compositions were compared using numerical classification and ordination. Brief descriptions of the indices are presented below.

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

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

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

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

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

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

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

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

where BRI_s is the BRI value for sampling unit *s*, *n* is the number of species in *s*, p_i is the pollution tolerance of species *i*, a_{si} is the abundance of species *i* in *s*, and *f* is an exponent used to transform the abundance values. The primary objective of BRI development is to assign pollution tolerance scores p_i to species based on their position on a pollution gradient. Once

assigned, the scores can be used to assess the condition of the benthic community by calculating the BRI. A reference threshold, below which natural benthic assemblages normally occur, was identified at an index value of 31, the point on the pollution vector where pollution effects first resulted in a net loss of species. Three additional thresholds of response to disturbance were defined at index values of 42, 53 and 73, representing points at which 25%, 50%, and 80% of the species present at the reference threshold were lost.

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

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

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

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

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

For inverse (species group by species group) classifications:

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

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

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

6.3. Results

6.3.1. Benthic Infauna

6.3.1.1. Infauna Abundance

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

Spatial infauna abundance patterns. Infauna abundances at the six sediment sampling stations are listed in Table 6-1. Numbers of individuals were significantly greatest at station B1 (average = 1,457) near Goleta Point compared to reference station B6 (average = 842). Numbers of individuals correlated expectedly and significantly with distance from the outfall, unexpectedly and significantly with distance from Goleta Point, and unexpectedly 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 twenty 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 2012, abundances have remained relatively stable (average ~ 1,000).

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

6.3.1.2. Infauna Species

Another simple measure of population health is the number of separate infauna species collected per sampling effort (i.e. one Van Veen Grab). Because of its simplicity, numbers of species is often underrated as an index. If the sampling effort and area sampled are the same

for each station, however, this index can be one of the most informative. In general, stations with higher numbers of species per grab tend to be in areas of healthier communities.

Spatial infauna species patterns. Infauna species at the six sediment sampling stations are listed in Table 6-1. Numbers of species were significantly greater at station B1 (average = 164) compared to all other stations (average range = 102 to 133) by ANOVA ($p < 0.05$). Lowest numbers of species were collected at outfall stations B4 and B5. Numbers of species correlated expectedly 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 twenty years. Similar to numbers of individuals, numbers of species increased between 1991 and 1994 and then steadily declined through 1999 possibly owing to an El Nino effect. Since 2000 the average number of species has steadily increased through 2006 when it reached a historic high (average = 181). Since 2006 the average number of species declined slightly thru 2012 (average = 124).

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

6.3.1.3. Infauna Diversity

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

Spatial infauna diversity patterns. Infauna diversities at the six sediment-sampling stations are listed in Table 6-1. Diversity, as measured by Shannon's, Margalef's, and Simpson's indices were similar across sites and uniformly elevated in the survey area. Also, each index showed a decreasing trend in diversity from station B1 near Goleta Point to reference station B6. Shannon Diversity was significantly different among stations and was greatest at station B6 (average = 3.96) and least at B6 (average = 3.35). Margalef's Richness was significantly greatest at station B1 (average = 22.33) compared to all other sites. Simpson Diversity was significantly different among stations and ranged from greatest at stations B1 (average = 0.97) to least at B6 (average = 0.90).

All three diversity indices correlated expectedly with distance from the outfall, but only the correlation for Margalef's Richness was significant. Both Shannon and Margalef's Richness correlated unexpectedly and significantly with distance to Goleta Point. Each index correlated unexpectedly with particle size, but only Margalef's significantly so.

Infauna diversity patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty years. Shannon Diversity

has been high in the Goleta survey area during the entire time period, with averages ranging between 3.5 to over 4.0. 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 historic high 2009 and 2010, before decreasing in 2011 and 2012.

Infauna diversity values compared with other surveys. Table 6-2 compares the Shannon Diversity Index reference stations from the SCBRMP surveys conducted in 1998, 2003 and 2008. Shannon Diversity measured in the Goleta survey area was similar to or greater 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 different among sites by ANOVA ranging from greatest at station B6 (average = 32) to least at station B5 (average = 16) near the outfall. Dominance correlated expectedly and significanctly with distance from the outfall, unexpectedly and significantly with distance from Goleta Point, and unexpectedly and significantly with sediment particle size.

Infauna dominance patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty years. Dominance has been high in the Goleta survey area during the entire time period, ranging between 23 and 40. Dominance ranged between 35 and 40 through the 1990's and then began a slight decrease to a low in 2005. In 2006 dominance began to increase to an historic high (average = 36) in 2010, before decreasing back to 2005 levels in 2012.

Infauna dominance values compared with other surveys. Table 6-2 compares the dominance at reference sites from the SCBRMP surveys conducted in 1998, 2003 and 2008. Dominance in the Goleta survey area in 2011 was similar to or slightly less compared to the SCBRMP reference site surveys.

6.3.1.5. Infauna Trophic Index

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

Spatial Infauna Trophic Index patterns. Infauna Trophic Index (ITI) scores at the six sediment-sampling stations is listed in Table 6-1. ITI scores were significantly greatest at

outfall stations B4 (average = 81) and B5 (average = 79) compared to all other sites (average range = 73 to 75). ITI values correlated unexpectedly (decreased) and significantly with distance from the outfall, expectedly and significantly with distance from Goleta Point, and expectedly and significantly with particle size. 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).

Infauna Trophic Index patterns compared with past years. Figure 6-1 illustrates biological metric trends over time in the Goleta survey area during the past twenty years. Average ITI values have remained stable across years and were similar in 2012 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. Average BRI scores were significantly greatest by ANOVA at stations B1 (average = 29), B2 (average = 29) and B6 (average = 29) compared to all other sites with the lowest BRI score at outfall station B5 (average = 24) (Table 6-1). The BRI scores correlated unexpectedly (increased) and significantly with distance to the outfall, expectedly and significantly with distance to Goleta Point, and expectedly (decreased) and significantly with particle size. Scores were below 31 for each station, 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.

This was the fourth year the BRI was calculated for Goleta and therefore was not compared against past survey years. The BRI was calculated using reference site data collected throughout southern California, therefore the BRI results for the 2012 survey are comparable to reference site conditions.

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). Rare species were excluded from the analysis so that

247 species that occurred at > three sites over the eight year period were retained for analysis (97% of the total number of individuals collected).

Stations clustered into three groups that were very similar to one another; with the Bray-Curtis Index values for all station nodes being less than 50% (Figure 6-2). The greatest Bray-Curtis distance between any two station nodes was approximately 40%, which indicates very small differences in species abundances and composition between sites. Station group 1 included the outfall stations B4 and B5, group 2 included Goleta Point station B1, B2 and B3, and group 3 had reference station B6.

Of the twenty most relatively abundant species collected in each cluster group, seven were shared across cluster groups, underscoring the community similarities among stations (Table 6-3). The most common species in the survey area were those typically found in coastal nearshore waters. However, in 2012 the ostracod *Euphilomedes carcharodonta* was the most relatively abundant species representing station groups 1 and 2. This crustacean is typically associated with outfall areas, but was nearly twice as abundant at Goleta Point stations B1, B2 and B3, compared to the outfall stations (B4 and B5). Other abundant species included polychaete worms (*Owenia collaris, Spiophanes duplex, Mediomastus sp,* and *Cossura sp A*.)

When the biological metrics for each station cluster group were averaged together they showed that the infauna population in station groups 2 and 3 had somewhat greater abundances, numbers of species and diversity. However, average BRI scores for outfall station group 1 were lower (25) compared to station groups 2 and 3 (28). This indicates that the biological communities at the outfall sites had retained slightly more reference species.

6.4. Discussion

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

Evaluation of the biological metrics for the 2012 survey showed that there were significant differences among sites for abundance, numbers of taxa, diversity, dominance, ITI and BRI. Each of the standard metrics (excluding ITI and BRI) were greatest at Goleta Point (B1) and graded to least at either the outfall stations (B4 and B5) or reference station B6. While it appears that the infauna populations were slightly depressed near the outfall, it also appears that Goleta Point plays a large role in the distribution of infauna in the Goleta survey area. This pattern of increased infauna abundances and taxa near Goleta Point may be due to the increased availability of organic material emanating from the oil seeps that are present there (Pearson and Rosenberg 1978). These results indicate the difficulty with interpreting the results of hypothesis testing on infauna abundance data. To try to elucidate these patterns and assess what, if any, impacts might be occurring to the infauna community, two indices were calculated and cluster analysis was employed.

The Infaunal Trophic Index (ITI) assesses the health of the benthic community using trophic level feeding strategies. In 2012 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 (73) at Goleta Point (station B1) to greatest at the outfall stations B4 (81) and B5 (79). 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 (Smith et al. 2001) across all stations were below 31 indicating that there was no net loss of reference species in the survey area. In addition, there was a significant correlation with distance to the outfall and among stations by ANOVA, with outfall stations B4 and B5 having significantly lower (better) BRI scores compared to all other sites. The BRI approach differs from other multimetric techniques in using multivariate ordination as the basis for assigning pollution tolerance scores. The primary objective of BRI development 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 2012 survey were compared to results of past surveys at the same sampling locations since 1990. Each of the metrics measured in 2012 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 40% 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 three cluster groups, underscoring the community similarities among stations.

To further investigate the potential influence of the Goleta outfall on the infauna community, cluster analysis and ordination were conducted on infauna data sets collected from 2004 to 2012 (Figure 6-3). Ordination analysis showed that the largest portion of the variation in the infauna community during the time period could be described by ordination axis 1 (28%) which was closely associated with survey year. Stations clustered together on axis 1 by year with 2004 and 2005 infauna communities (cluster groups 1 and 2) furthest from stations collected during 2011 and 2012 (cluster group 6). 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 12% 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). Of note was a reduction in average BRI scores from station group 1 (average = 31) in 2004 through 2006 to group 6 (average = 28) in 2011 and 2012. This indicates a gradual improvement in the biological condition of the survey area during the time period.

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

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

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

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

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

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

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

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

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

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

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

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

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

Constituent	Offshore Stations B1	B2	B3	B4	B5	B6
INDIVIDUALS [1]						
Repl. 1	1595	1102	925	702	1059	898
Repl. 2	1697	913	1366	844	852	1178
Repl. 3	1472	1057	1300	646	541	692
Repl. 4	1142	1341	992	961	586	554
Repl. 5	1379	1483	989	714	1114	890
Mean =	1457	1179	1114	773	830	842
Std. Dev. =	213	229	203	128	263	237
Lower Conf. Int. =	1270	978	937	662	600	635
Upper Conf. Int. =	1644	1380	1292	885	1061	1050
Overall Mean = 1032.8		r (outfall)= **0.34**		r (point) = **-0.69**		r (prt.sz.) = 0.30
Overall S.D. = 315.4		H^{2} = **17.40**		**Comp. of means = B1 > B4, B5, B6**		
SPECIES [1]						
Repl. 1	182	136	108	100	104	115
Repl. 2	181	111	129	120	120	131
Repl. 3	176	146	145	90	79	104
Repl. 4	124	138	103	116	84	104
Repl. 5	156	136	135	95	122	120
Mean =	164	133	124	104	102	115
Std. Dev. =	25	13	18	13	20	11
Lower Conf. Int. =	142	122	108	93	84	105
Upper Conf. Int. =	185	145	140	116	119	125
Overall Mean = 123.7		r (outfall) = **0.46**		r (point) = **-0.65**		r (prt.sz.) = **0.40**
Overall S.D. = 26.5		**F= 8.81**		**Comp. of means = B1 > B3, B4, B5, B6**		
SHANNON DIVERSITY						
Repl. 1	4.21	3.83	3.43	3.49	3.08	3.37
Repl. 2	3.95	3.42	3.63	3.66	3.69	3.19
Repl. 3	3.99	3.89	3.75	3.26	3.27	3.27
Repl. 4	3.74	3.67	3.50	3.41	3.26	3.49
Repl. 5	3.89	3.77	3.92	3.39	3.51	3.42
Mean =	3.96	3.72	3.65	3.44	3.36	3.35
Std. Dev. =	0.17	0.18	0.20	0.15	0.24	0.12
Lower Conf. Int. =	3.81	3.55	3.47	3.31	3.15	3.24
Upper Conf. Int. =	4.11	3.88	3.82	3.57	3.57	3.45
Overall Mean = 3.58		r (outfall) = 0.24		r (point) = **-0.77**		r (prt.sz.) = 0.22
Overall S.D. = 0.28		**F = 8.78**		**Comp. of means = B1 > B2 > B6, B5, B4, B3**		
MARGALEF RICHNESS						
Repl. 1	24.54	19.27	15.67	15.11	14.79	16.76
Repl. 2	24.21	16.14	17.73	17.66	17.64	18.38
Repl. 3	23.99	20.82	20.08	13.75	12.39	15.75
Repl. 4	17.47	19.03	14.78	16.74	13.02	16.31
Repl. 5	21.44	18.49	19.43	14.31	17.25	17.52
Mean =	22.33	18.75	17.54	15.51	15.02	16.95
Std. Dev. =	2.98	1.70	2.30	1.65	2.38	1.03
Lower Conf. Int. =	19.72	17.26	15.52	14.07	12.93	16.04
Upper Conf. Int. =	24.94	20.24	19.56	16.96	17.11	17.85
Overall Mean = 17.68		r (outfall) = **0.48**		r (point) = **-0.60**		**r (prt.sz.) = 0.43**
Overall S.D. = 3.12		**F= 8.00**		**Comp. of means = B1 > 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	0.96	0.94	0.93	0.90	0.90
Repl. 2	0.97	0.91	0.95	0.95	0.96	0.90
Repl. 3	0.97	0.97	0.96	0.92	0.92	0.89
Repl. 4	0.96	0.94	0.95	0.93	0.93	0.92
Repl. 5	0.96	0.96	0.96	0.93	0.94	0.91
Mean =	0.97	0.95	0.95	0.93	0.93	0.90
Std. Dev. =	0.01	0.02	0.01	0.01	0.02	0.01
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 = 0.938		r (outfall) = 0.01		r (point) = **0.79**		r (prt.sz.) = 0.02
Overall S.D. = 0.025		**F = 10.01**		**Comp. of means = B1 > B4, B5, B6; B3 > B6; B2 > B6**		
SCHWARTZ DOMINANCE						
Repl. 1	41	29	16	19	10	21
Repl. 2	31	21	21	23	22	25
Repl. 3	33	33	25	15	14	19
Repl. 4	24	25	18	17	14	25
Repl. 5	31	26	31	19	18	22
Mean =	32	27	22	19	16	22
Std. Dev. =	6	4	6	3	5	3
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 22.93		r (outfall) = **0.59**		r (point) = **-0.58**		r (prt.sz.) = **0.52**
Overall S.D. = 6.87		**F = 7.91**		**Comp. of means = B1 > B3, B4, B5, B6; B2 > B5**		
INFAUNAL INDEX						
Repl. 1	73	73	77	80	83	75
Repl. 2	73	74	73	81	76	70
Repl. 3	71	74	75	81	78	75
Repl. 4	75	73	78	84	79	77
Repl. 5	73	75	75	78	77	73
Mean =	73	74	75	81	79	74
Std. Dev. =	1.4	0.8	1.9	2.0	2.6	2.5
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 75.87		r (outfall) = **-0.73**		r (point) = **0.46**		r (prt.sz.) = **-0.63**
Overall S.D. = 3.42		**F = 12.72**		Comp. of means = B4 > B1, B2, B6, B3; B5 > B1, B2, B6		
BENTHIC RESPONSE INDEX						
Repl. 1	29	29	27	26	23	28
Repl. 2	32	26	30	24	25	30
Repl. 3	29	30	30	27	24	29
Repl. 4	29	27	27	24	24	30
Repl. 5	28	32	27	27	25	29
Mean =	29	29	28	26	24	29
Std. Dev. =	1.5	2.2	1.4	1.5	0.8	1.1
Lower Conf. Int. =	19	22	20	20	25	21
Upper Conf. Int. =	26	25	25	22	28	22
Overall Mean = 27.53		r (outfall) = **0.73**		r (point) = -0.30		r (prt.sz.) = **0.73**
Overall S.D. = 2.40		**F = 9.65**		Comp. of means = B1, B2, B6 > B5, B4		

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

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

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

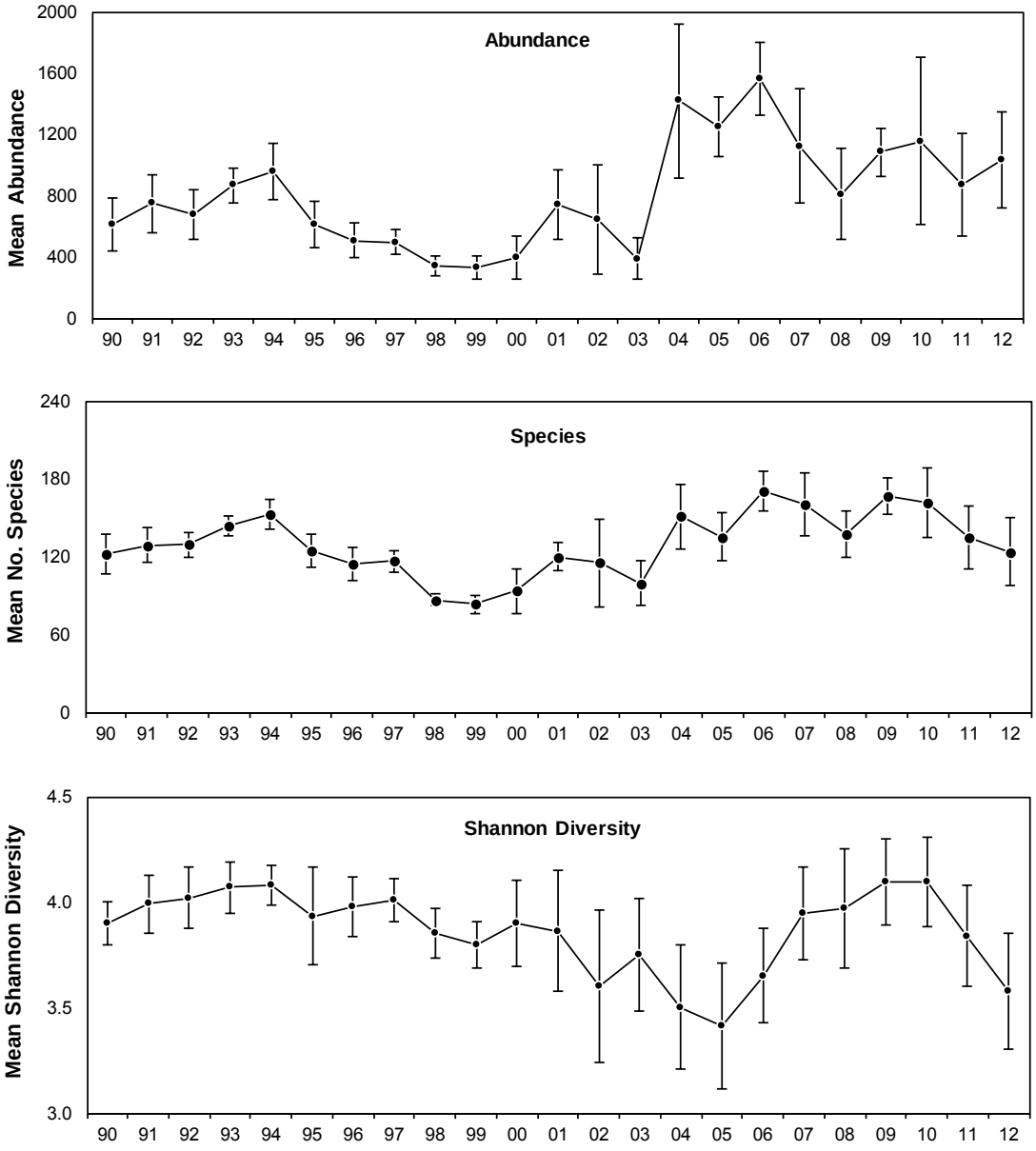


Figure 6-1. (continued).

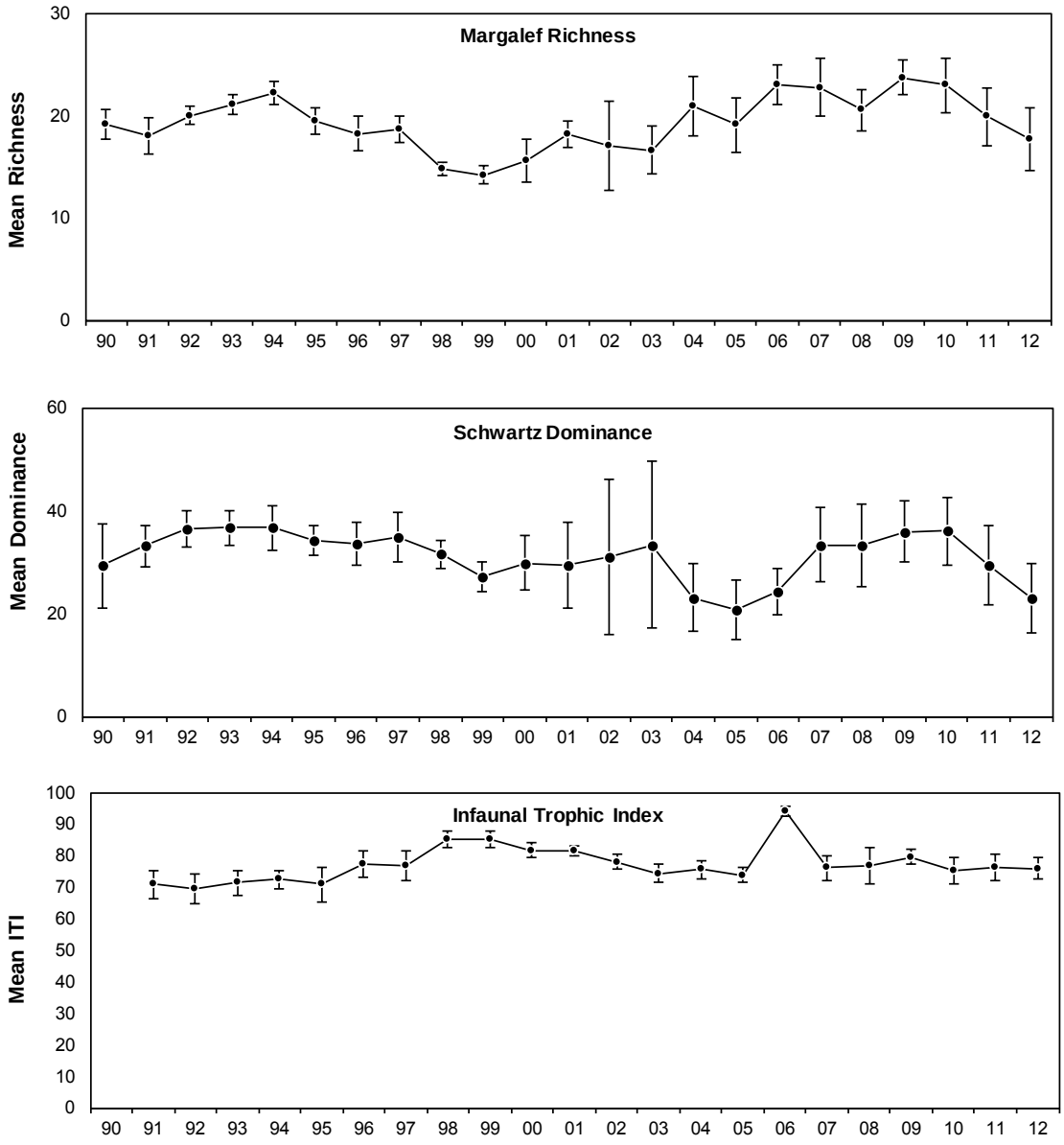


Table 6-2. Comparison of Goleta infauna variables with results from other studies (per 0.1 m^2).

Variable	Goleta 2012		SCBRMP 1998		SCBRMP 2003 Inner Shelf		SCBRMP 2008 Inner Shelf	
	Mean	Range	Mean	Range	Mean	±95% CI	Mean	SE
Number of Individuals	1033	541 - 1697	385	35 - 1696	283	30	346	22
Number of Species	124	79 - 182	85	18 - 162	62	5	85	4
Shannon Diversity Index	3.6	3.1 - 4.2	3.60	2.00 - 4.40	3.48	0.09	3.63	0.06
Dominance	22.9	10.0 - 41.0	---	--- - ---	23	2	27	1

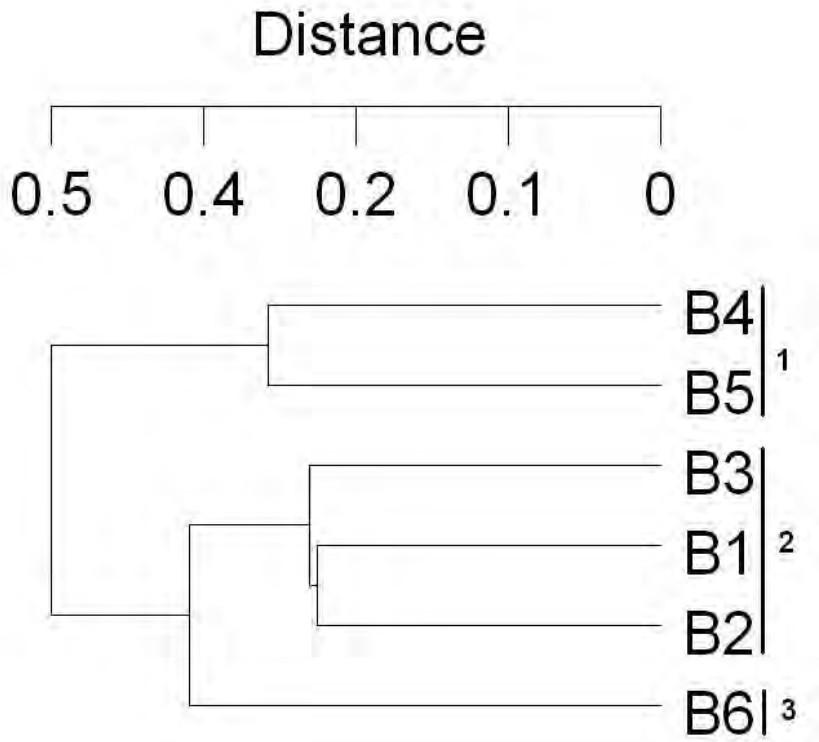


Figure 6-2. Station dendrogram based on cluster analysis (UPGMA, Sneath and Sokal 1973). The Bray-Curtis dissimilarity index was used to calculate the distances among stations and species (Gauch 1982, Jongman et. al. 1995).

Table 6-3. Average abundances of the top twenty species for each cluster group in 2011.

Species	Cluster Group		
	1	2	3
Euphilomedes carcharodonta	234	458	
Owenia collaris	230	167	
Glottidia albida	108	172	15
Spiophanes duplex	72	204	32
Mediomastus sp	63	210	60
Macoma yoldiformis	60	81	
Prionospio (Prionospio) jubata	55	97	
Ampelisca cristata cristata	55		
Rhepoxynius stenodes	53		
Westwoodilla tone	42	53	9
Tellina modesta	41		
Leptochelia dubia	30	139	19
Foxiphalus obtusidens	27		
Monticellina siblina	22		
Cossura sp A	18	187	57
Phyllodoce longipes	18		
Kurtiella tumida	15	65	
Parvilucina tenuisculpta	15	47	
Foxiphalus golfensis	14	58	28
Magelona berkeleyi	14		
Levinsenia gracilis		106	
Monticellina cryptica		55	21
Ampelisca brevisimulata		43	22
Spiochaetopterus costarum Cmplx		41	7
Oligochaeta		40	
Phoronis sp		38	
Pectinaria californiensis		37	
Nuculana taphria			19
Haliophasma geminatum			15
Clymenella sp A			12
Heterophoxus oculatus			12
Glycinde armigera			9
Tubulanus polymorphus			8
Xenoleberis californica			8
Exogone dwisula			7
Metasychis disparidentatus			7
Petaloclymene pacifica			6

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

Station	Cluster Group	Number of Species	Total Abundance	BRI	ITI	Evenness	Margalef Richness	Schwartz Dominance	Shannon Diversity	Simpson Diversity
B4	1	214	773	25.48	80.9	0.69	32.026	21	3.7	0.937
B5	1	222	830	24.38	78.9	0.676	32.878	19	3.65	0.94
average	**1**	**218**	**802**	**24.9**	**80**	**0.683**	**32.452**	**20**	**3.68**	**0.939**
B1	2	332	1457	28.65	72.8	0.748	45.441	44	4.34	0.972
B2	2	262	1179	28.76	73.7	0.726	36.903	33	4.04	0.957
B3	2	257	1114	27.91	75.3	0.71	36.488	28	3.94	0.958
average	**2**	**284**	**1250**	**28.4**	**74**	**0.728**	**39.611**	**35**	**4.11**	**0.962**
B6	**3**	**228**	**842**	**28.71**	**73.5**	**0.678**	**33.698**	**28**	**3.68**	**0.912**

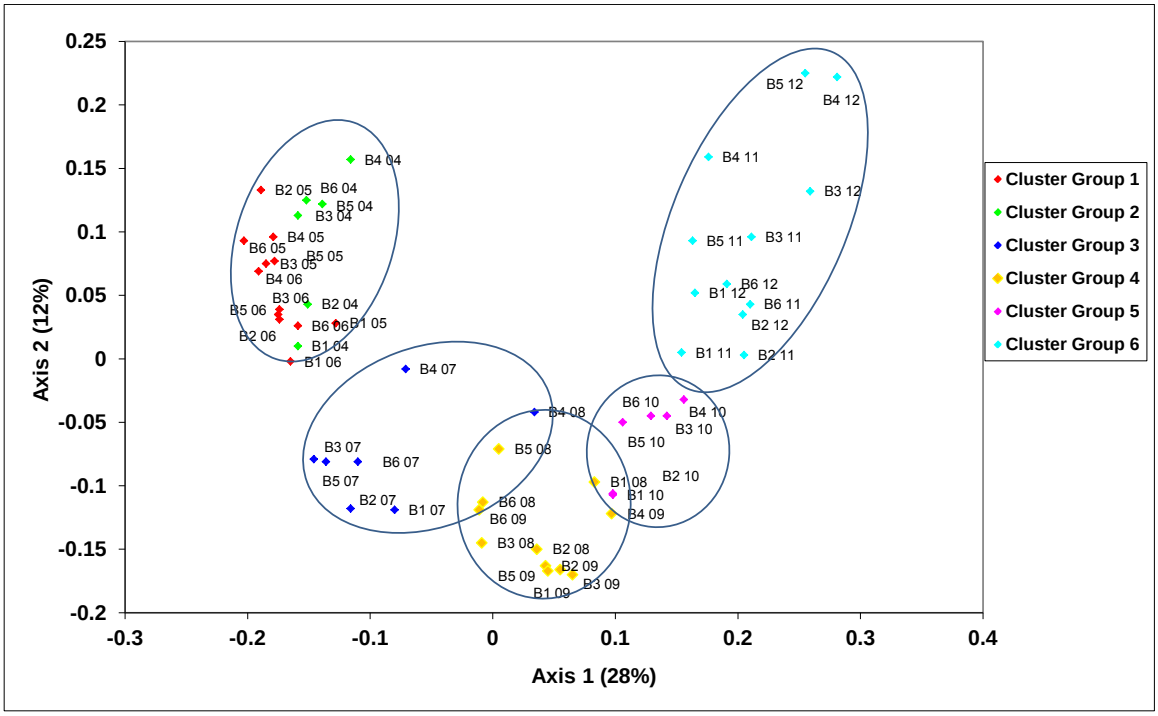


Figure 6-3. Plot of ordination scores for infauna communities at stations measured from 2004 to 2012.

Table 6-5. Biological metrics for each station for each year individually from 2004 thru 2012 and averaged by cluster group.

Station/Year	Cluster Group	Number of Species	Total Abundance	BRI	ITI	Shannon Diversity
B1 05	1	320	1246	29.94	78.3	4.25
B1 06	1	310	1386	29.99	74.3	4.11
B2 05	1	249	1302	32.94	71.6	3.41
B2 06	1	304	1580	31.59	72.7	3.66
B3 05	1	290	1499	30.5	74.3	3.77
B3 06	1	304	1775	31	73.6	3.77
B4 05	1	266	1112	31.51	71	3.4
B4 06	1	295	1580	32.24	71.5	3.58
B5 05	1	308	1221	29.75	73.5	3.75
B5 06	1	319	1804	29.95	72.1	3.83
B6 05	1	272	1124	30.7	74.9	3.67
B6 06	1	295	1270	30.43	73.9	3.7
	average	**294**	**1408**	**30.9**	**73**	**3.74**
B1 04	2	372	2159	32.8	72.8	3.62
B2 04	2	331	1616	30.55	76.6	3.95
B3 04	2	249	1430	30.71	74	3.49
B4 04	2	242	1132	31.31	71.5	3.2
B5 04	2	262	1220	27.84	74.9	3.77
B6 04	2	260	945	26.56	78.9	3.88
	average	**286**	**1417**	**30**	**75**	**3.65**
B1 07	3	320	1022	31	75.9	4.38
B2 07	3	251	729	31.66	79.8	4.37
B3 07	3	265	1400	32.78	73.4	3.85
B4 07	3	249	1023	31.98	71.2	3.89
B4 08	3	238	854	32.2	63.4	3.97
B5 07	3	281	1220	31.18	75.2	4.08
B6 07	3	322	1349	30.49	78.3	4.22
	average	**275**	**1085**	**31.6**	**74**	**4.11**
B1 08	4	255	582	26.06	80.6	4.56
B1 09	4	315	1203	28.07	77.9	4.29
B2 08	4	227	677	30.57	80.5	4.39
B2 09	4	289	1024	29.77	76.4	4.39
B3 08	4	262	1093	30.14	77.2	4.08
B3 09	4	278	1124	29.24	79.9	4.15
B4 09	4	251	950	27.11	80.5	4.07
B5 08	4	247	741	29.38	76.6	4.08
B5 09	4	296	1154	27.16	81.4	4.17
B6 08	4	259	910	27.72	76.1	4.02
B6 09	4	269	1037	26.71	80.8	4.5
	average	**268**	**954**	**28.4**	**79**	**4.25**
B1 10	5	300	1210	28.05	74.5	4.29
B2 10	5	295	920	27.29	75	4.55
B3 10	5	276	985	28.29	75.3	4.41
B4 10	5	272	995	30.39	71.5	4.21
B5 10	5	355	1973	28.55	79.6	4.18
B6 10	5	268	855	26.23	79.3	4.37
	average	**294**	**1156**	**28.1**	**76**	**4.34**
B1 11	6	328	1343	28.7	72.8	4.36
B1 12	6	335	1457	28.65	72.8	4.42
B2 11	6	243	973	28.02	76.7	3.97
B2 12	6	264	1179	28.76	73.7	4.07
B3 11	6	228	816	26.5	82.1	3.81
B3 12	6	259	1114	27.91	75.3	3.98
B4 11	6	243	735	29.42	72.7	4.17
B4 12	6	215	773	25.48	80.9	3.71
B5 11	6	247	738	31.67	75.1	4.28
B5 12	6	222	830	24.38	78.9	3.65
B6 11	6	245	617	26.24	77.3	4.32
B6 12	6	228	842	28.71	73.5	3.68
	average	**255**	**951**	**27.9**	**76**	**4.04**

CHAPTER 7

Trawled Fish and Invertebrate Populations

7.1. Background

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

7.2. Materials and Methods

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

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

7.3. Results

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

7.3.1. Trawled Fish

7.3.1.1. Fish Community Metrics

The averaged fish community metrics and biomass for replicate trawls are presented in Table 7-1, with results by replicate presented in Appendix 10.7 (Tables 10.7-1 and 10.7-2). A total of 502 individual fish were collected from both stations combined during the 2012 survey with 166 and 133 fish collected at station TB3 replicate 1 and 2, and 87 and 116 fish collected at station TB6, replicate 1 and 2 (Table 10.7-1). This represents a decrease over the previous year when a total of 730 fish were collected during the survey. Average numbers of fish were 150 and 102 at stations TB3 and TB6 respectively and there was no statistically significant difference between sites ($p > 0.05$; Table 7-1). Similar average numbers of species

were collected at Stations TB3 and TB6 (11 and 9, respectively) with no significant difference between sites. Average biomass was 1.04 kg at station TB3 and 0.89 kg at station TB6, and there was no significant difference between sites. Shannon Diversity was greater near the outfall (TB3), but not significantly so. Simpson Diversity, Margalef's Richness, Schwartz's Dominance were similar between the two sites and there were no significant differences.

7.3.1.2. Species Composition

As with past years, the fish caught in the 2012 trawls were typical of those found on most southern California near shore soft bottom habitats (Table 7-2). A total of 15 and 12 unique taxa, were collected at stations TB3 and TB6, respectively. The most abundant species collected in the Goleta survey area was the speckled sanddab (*Citharichthys sordidus*) followed by the kelp pipefish (Syngnathus exilis). Copper rockfish (*Sebastes caurinus*), pink seaperch (*Zalembius rosaceus*) and spotted turbot (*Pleuronichthys ritteri*) were in the top five most abundant species at TB3, while pink seaperch, curlfin turbot (Pleuronichthys decurrens) and hornyhead turbot (*Pleuronichthys verticalis*) were abundant at TB6.

7.3.1.3. Fish Community Metrics Compared to Past Surveys

Fish assemblage community metrics for 2012 were compared to previous Goleta area surveys starting in 1991 (Figure 7-1). The numbers of individuals collected in 2012 decreased compared to the 2011 survey, but were within the range of past surveys. Fish biomass was again very low during 2012 and similar to the past 20 years. Numbers of species decreased slightly in 2012, but was still greater than 2008, when taxa richness reached an all-time low. In 2012, Shannon Diversity and dominance were low and similar to past surveys.

7.3.1.4. Fish Community Metrics Compared to Reference Surveys

Fish community metrics for the 2012 Goleta survey were compared to fish assemblage data collected in the northern region on the inner continental shelf in the southern California bight during the 2008 Southern California Bight Regional Monitoring Survey (SCBRMP) (SCCWRP 2011; Table 7-3). Number of individuals, number of species, Shannon Diversity and biomass were all well within the range fish assemblages found in the vicinity of the northern region inner shelf.

7.3.1.5. Fish Length

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

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

Fish						
Station	TB3		TB6		T-test	
Metric	Avg	SD	Avg	SD	t score	p =
Individuals	150	23	102	21	2.19	0.16
Species	11	2	9	1	0.83	0.49
Biomass (kg)	1.04	0.20	0.89	0.47	0.43	0.71
Shannon Diversity	0.92	0.16	0.86	0.18	0.35	0.76
Simpson Diversity	0.38	0.05	0.36	0.07	0.25	0.83
Margalef Richness	1.90	0.36	1.73	0.23	0.55	0.64
Schwartz Dominance	1	0	1	0	NA	NA

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

Bold - Significant ($p < 0.05$)

1. Non-normal data: T-test by Mann-Whitney U test.

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

Trawl TB3				Trawl TB6			
Scientific Name	Common Name	Mean Abundance	Mean Weight (kg)	Scientific Name	Common Name	Mean Abundance	Mean Weight (kg)
Citharichthys stigmaeus	speckled sanddab	117	0.73	*Citharichthys stigmaeus*	speckled sanddab	80	0.47
Syngnathus californiensis	kelp pipefish	13	<0.1	*Syngnathus californiensis*	kelp pipefish	7	<0.1
Sebastes caurinus	copper rockfish	5	<0.1	*Zalembius rosaceus*	pink seaperch	5	0.12
Zalembius rosaceus	pink seaperch	4	0.06	*Pleuronichthys decurrens*	curlfin sole	2	0.07
Pleuronichthys ritteri	spotted turbot	3	<0.1	*Pleuronichthys verticalis*	hornyhead turbot	2	0.23
Citharichthys sordidus	Pacific sanddab	2	<0.1	*Synodus lucioceps*	California lizardfish	2	<0.1
Pleuronichthys decurrens	curlfin sole	2	0.06	*Citharichthys sordidus*	Pacific sanddab	1	<0.1
Odontopyxis trispinosa	pygmy poacher	1	<0.1	*Icelinus quadriseriatus*	yellowchin sculpin	1	<0.1
Sebastes dallii	calico rockfish	1	<0.1	Odontopyxis trispinosa	pygmy poacher	1	<0.1
Neoclinus blanchardi	sarcastic fringehead	1	<0.1	*Porichthys notatus*	plainfin midshipman	1	<0.1
Oxylebius pictus	painted greenling	1	<0.1	*Ophiodon elongatus*	lingcod	1	<0.1
Scorpaenichthys marmorat	cabezon	1	<0.1	*Sebastes caurinus*	copper rockfish	1	<0.1
Sebastes auriculatus	brown rockfish	1	<0.1		composite weight*		<0.1
Sebastes miniatus	vermilion rockfish	1	<0.1				
Symphurus atricaudus	California tonguefish	1	<0.1				
	composite weight*		0.19				

*Species <0.01 kg are weighed together as a composite weight.

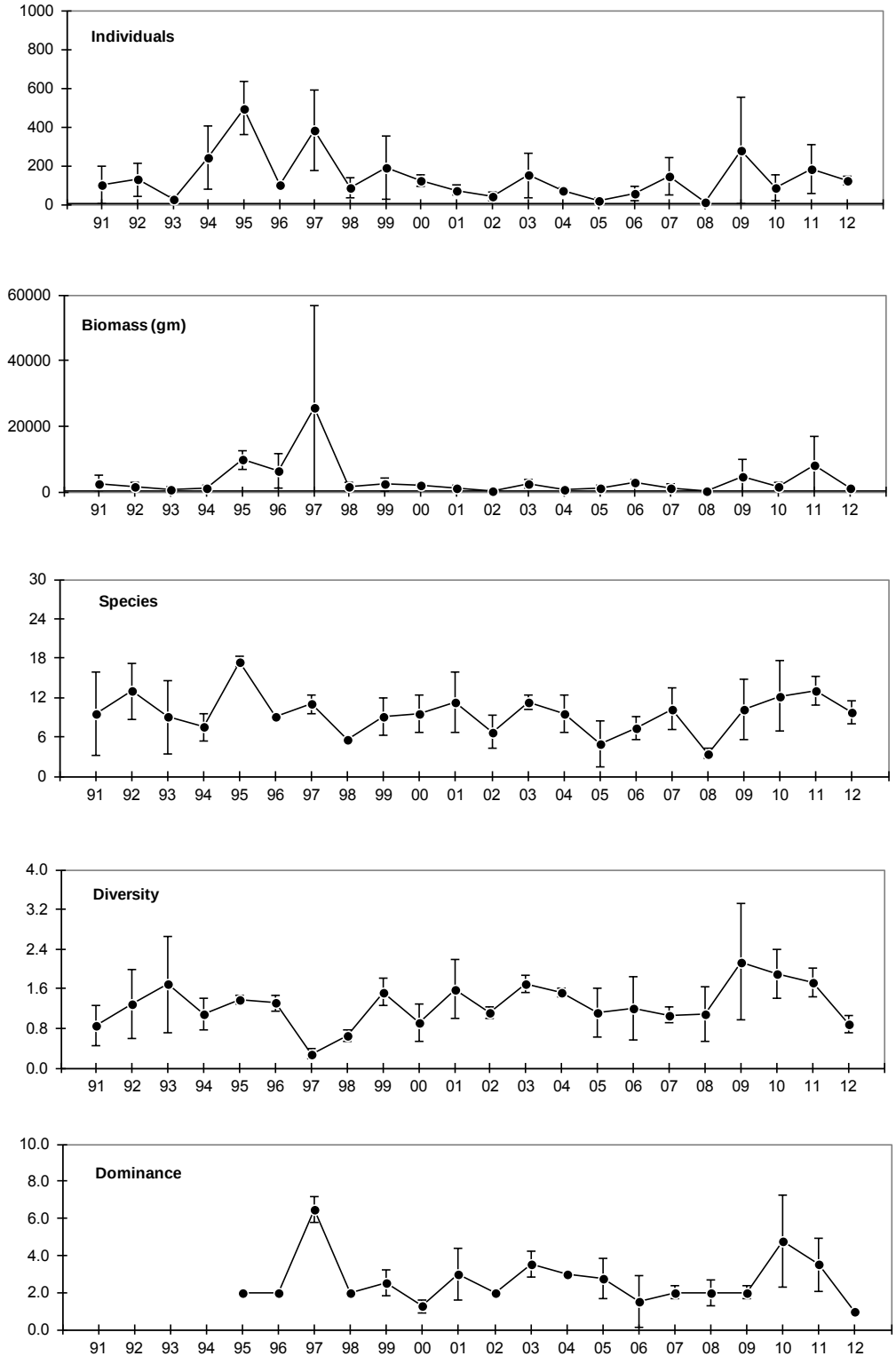


Figure 7-1. Fish community metric annual averages (± SD) for Goleta trawl transect data (n=2) since 1991.

Table 7-3. Comparison of trawl fish metrics with results from the Southern California Regional Survey, Bight 2008 (SCCWRP 2011).

Metric	Trawl Fish		
	Goleta Range	Bight '08 Northern Region Inner Shelf	Below Range?
Biomass (kg)	**0.89 - 1.04**	0.7 - 4.7	No
Individuals	**102 - 150**	24 - 467	No
Species	**9 - 11**	5 - 22	No
Shannon Diversity	**0.86 - 0.92**	0.5 - 2.31	No

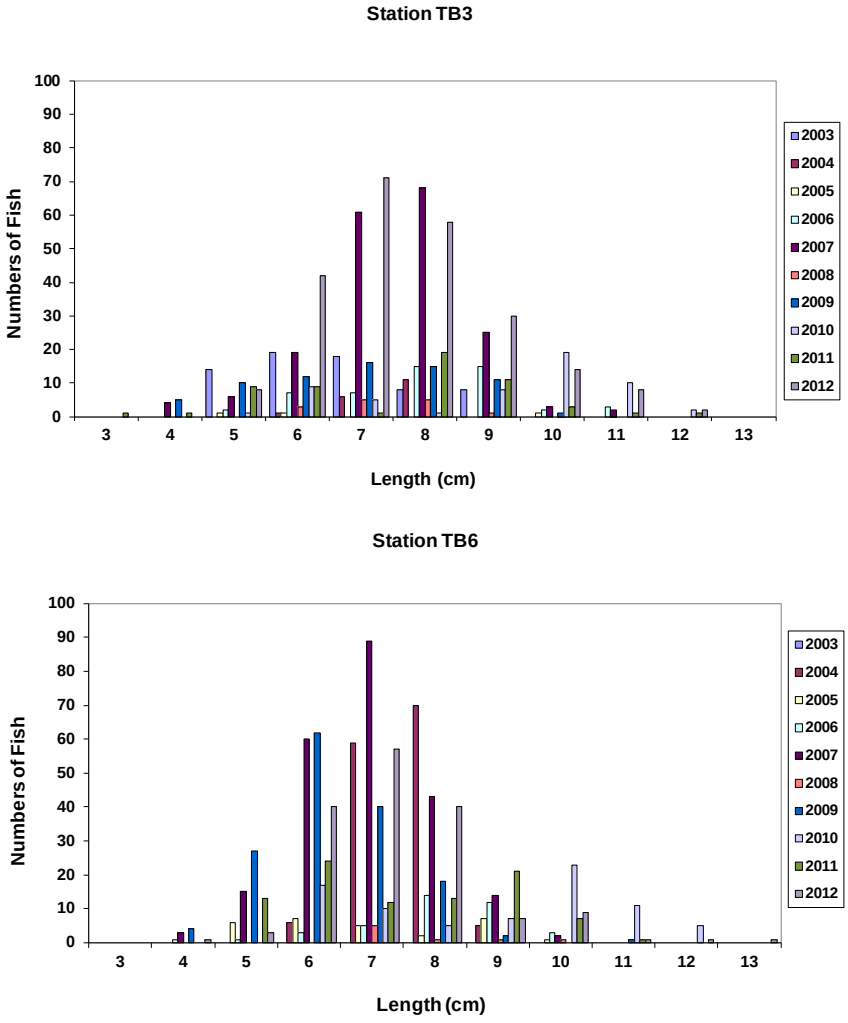


Figure 7-2. Length (cm) frequency distributions for speckled sanddabs (*Citharichthys stigmaeus*) collected from 2003 to 2012 from stations TB3 and TB6 in the Goleta survey area.

7.3.2. Trawl Macroinvertebrates

7.3.2.1. Macroinvertebrate Community Metrics

The averaged macroinvertebrate community metrics and biomass for replicate trawls are presented in Table 7-4, with results by replicate presented in Appendix 10.7 (Tables 10.7-3 and 10.7-4). A total of 49 individual invertebrates were collected from both stations combined during the 2012 survey, with 5 and 12 macroinvertebrates collected at station TB3, replicate 1 and 2 respectively, and 28 and 4 macroinvertebrates at station TB6, replicate 1 and 2 respectively (Table 10.7-3). A little over two times the number of average individual macroinvertebrates was collected at Station TB6 compared to TB3, but there was no significant difference between sites (Table 7-4). Numbers of species collected averaged 4 at station TB3 and station TB6, with no significant difference between sites. Biomass was two times greater at TB6 (1.04 Kg) when compared to TB3 (0.50 Kg), but not significantly so. Shannon Diversity, Simpson Diversity and Margalef Richness were very similar at both stations while Schwartz Dominance was greater at station TB3. None were significantly different between sites.

7.3.2.2. Species Composition

As with past years, the invertebrates in the 2012 trawls were typical of those found on most southern California near shore soft bottom habitats (Table 7-5). A total of 8 individual taxa were collected in the survey area. The most abundant species collected at station TB3 was the red octopus (*Octopus rubescens*) followed by the smalleyed shrimp (*Heptacarpus carinatus*) and the graceful rock crab (*Cancer gracilis*). At station TB6, the most abundant species collected was the graceful rock crab, followed by red octopus.

7.3.2.3 Macroinvertebrate Community Metrics Compared to Past Surveys

Macroinvertebrate community metrics for 2012 were compared to previous Goleta area surveys starting in 1991 (Figure 7-2). The numbers of individuals and average biomass in 2012 was similar to the previous ten years. Numbers of species, Shannon Diversity and Dominance were also similar to the previous decade. These three metrics declined in 2000 from historic highs in 1997 and 1998 and have been relatively stable since. The reasons for these reductions are unclear.

7.3.2.4. Macroinvertebrate Community Metrics Compared to Reference Surveys

Macroinvertebrate community metrics for the 2012 Goleta survey were compared to invertebrate assemblage data collected in the northern region on the inner continental shelf in the southern California bight during the 2008 Southern California Bight Regional Monitoring Survey (SCBRMP) (SCCWRP 2011; Table 7-6). Biomass, numbers of individuals, numbers of species and Shannon Diversity were all within the range or fish assemblages found in the northern region inner shelf.

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

Invertebrates						
Station	TB3		TB6		T-test	
Metric	Avg	SD	Avg	SD	t score	p =
Individuals	9	5	19	13	-0.99	0.43
Species[1.]	4	1	4	0	0.00	1.00
Biomass (kg)	0.50	0.19	1.04	0.89	-0.50	0.62
Shannon Diversity	1.24	0.26	1.01	0.19	1.00	0.42
Simpson Diversity	0.68	0.06	0.56	0.08	1.66	0.24
Margalef Richness	1.40	0.26	1.03	0.33	0.97	0.43
Schw artz Dominance[1.]	3	1	1	0	1.00	0.42

Bold - Marginally Significant (0.05 < p < 0.10)

Bold - Significant (p < 0.05)

1. Non-normal data: T-test by Mann-Whitney U test.

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

Trawl TB3				Trawl TB6			
Scientific Name	Common Name	Mean Abundance	Mean Weight (kg)	Scientific Name	Common Name	Mean Abundance	Mean Weight (kg)
Octopus rubescens	red octopus	3	<0.1	*Cancer gracilis*	graceful rock crab	9	0.96
Heptacarpus carinatus	smalleyed shrimp	3	<0.1	*Octopus rubescens*	red octopus	5	0.09
Cancer gracilis	graceful rock crab	2	0.18	*Astropecten verrilli*	California sand star	1	<0.1
Cancer anthonyi	yellow rock crab	1	0.15	*Crangon nigromaculata*	blackspotted bay shrimp	1	<0.1
Cancer antennarius	Pacific rock crab	1	0.11	*Loxorhynchus grandis*	sheep crab	1	<0.1
Loxorhynchus grandis	sheep crab	1	0.07		composite weight*		<0.1
	composite weight*		<0.1				

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

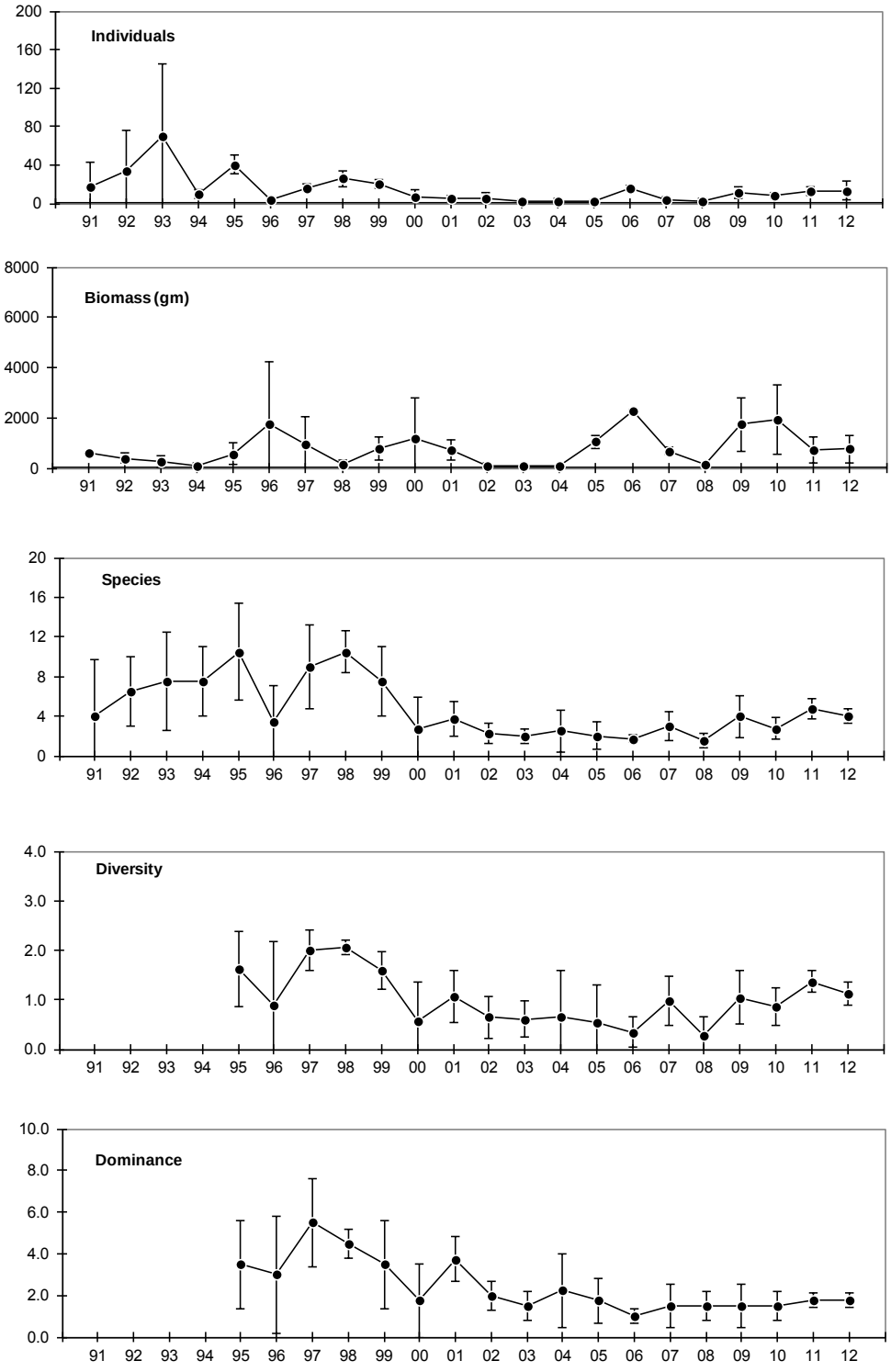


Figure 7-2. Invertebrate community metric annual averages (± SD) for Goleta trawl transect data (n=2) since 1991.

Table 7-6. Comparison of trawl invertebrate metrics with results from the Southern California Regional Survey, Bight 2008 (from SCCWRP, 2011).

Metric	Trawl Fish		
	Goleta Range	Bight '08 Northern Region Inner Shelf	Below Range?
Biomass (kg)	**0.50 - 1.04**	0.0 - 3.0	No
Individuals	**9 - 19**	3 - 135	No
Species	**4 - 4**	2 - 20	No
Shannon Diversity	**1.01 - 1.24**	0.64 - 2.30	No

7.4. Discussion

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

A total of 502 individual fish were collected from both stations combined during the 2012 survey, a decrease over 2011 when a total of 730 fish were collected. A total of 49 individual invertebrates were collected from both stations in 2011 and 2012. There were no statistically significant differences ($p < 0.05$) between stations near to and far from the outfall when metrics for fish or invertebrates total abundance, biomass, and numbers of taxa, diversity and dominance were compared. In addition, both fish and invertebrate population indices measured in 2012 (including abundance, numbers of species and biomass) were within the range of reference sites sampled during the 2008 Southern California Bight Regional Monitoring Program.

As with past years, the fishes and macroinvertebrates caught in the 2012 trawls were typical of those found on most southern California near shore soft bottom habitats. A total of 15 and 12 individual fish taxa were collected at stations TB3 and TB6, respectively. The most abundant species collected at station TB3 and TB6 was the speckled sanddab (*Citharichtys stigmaeus)* followed by the kelp pipefish (*Syngnathus exilis*). The pink seapearch (Zalembius rosaceus) was in the top five most abundant species at both TB3 and TB6.

A total of 8 unique invertebrate taxa were collected in the trawl area. The most abundant species collected at station TB3 was the red octopus (*Octopus rubescens*) followed by smalleyed shrimp (*Heptacarpus carinatus*), graceful rock crab (*Cancer gracilis*) and the yellow rock crab (*Cancer anthonyi*). At station TB6, the most abundant species collected was the graceful rock crab, followed by red octopus, California sand star (*Astropecten verrilli*) and blackspotted bay shrimp (*Crangon nigromaculata*).

When the 2012 trawled fish and invertebrate results were compared against past surveys, average abundances, numbers of species, biomass, diversity and dominance were within the ranges of the previous twenty years. This was especially true of the trawled fish community. In contrast, the trawled invertebrate community has been very similar for each biological metric over the past ten years, but prior to 2001 the

numbers of invertebrate taxa and diversity were much greater. The reasons for the decrease in trawled invertebrate diversity are unclear. Since an outfall related impact has never been detected, it is probable that some larger oceanographic condition has influenced this community. Frequent cold water upwelling events which are typical of this coastal region, coupled with warm water El Nino events over the past 15 years may be playing a significant role in the recruitment to and stability of this community.

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

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

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

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

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

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

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

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

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

CHAPTER 8

Fish and Bivalve Tissue Bioaccumulation

8.1. Background

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

8.2. Materials and Methods

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

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

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

For the purposes of statistical analysis, all analytes from each of four groups (DDT and its derivatives (i.e. DDD and DDE), PCB's, PAH's, and non-DDT chlorinated pesticides) were combined. Results for individual analytes are presented in Appendix 10.8-3 and 10.8-4. All

data were converted to mg/Kg or µg/Kg, dry weight and statistically compared among stations using either t-test for two stations or analysis of variance (ANOVA) for three or more stations (see Section 3.4). When assumptions of parametric statistics could not be met (such as non-normality or excessive variability), the tests were replaced with nonparametric analogues (Aspin-Welch Unequal Variance Test, Mann-Whitney U, and Kruskal-Wallace Rank Test, respectively). Significance was noted when $p \leq 0.05$ and marginal significance was noted when $0.05 < p \leq 0.10$). *A posteriori* tests were utilized for significant ANOVA results to determine which stations were significantly different (see Zar 1996 or Sokal and Rohlf 1981 for a general description of statistical testing).

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

8.3. Results

Table 8-1 lists the physical and general descriptions of the animals utilized in the Goleta bioaccumulation study. Appendix Tables 10.8-1 and 10.8-2 lists lengths and weights of organisms, as well as tissue weights. Tables 8-2 to 8-4 and Figures 8-1 and 8-2 present average concentrations for each chemical constituent measured in the three types of animal tissues at each Station. Appendix Table 10.8-3 lists each constituent by replicate and averages by stations. Figures 8-3 through 8-5 compare historical contamination trends in the three tissue types. Tables 8-5 to 8-6 compare the Goleta tissue chemistry results with reference surveys and state OEHHA thresholds and NOAA status and trends tissue levels. Appendix 10.8-4 and 10.8-5 lists the concentrations of the derivatives of total DDT, non-DDT chlorinated hydrocarbons, total PCBs, and total PAHs. General descriptions of all chemical constituents have been presented earlier in Chapter 5, and so will not be repeated here.

8.3.1. Spatial contaminant patterns in tissues

Speckled Sanddabs

A total of 152 speckled sanddabs (*Citharichthys stigmaeus*) were collected for tissue dissections from trawl transects TB3 (n = 78) and TB6 (n = 74), respectively. Average standard lengths (82 and 74 mm) and weights (9.6 and 7.2 g), were also similar between sites. Dissected tissue weights were greater for muscle tissue (1.8 and 1.3 wet g, respectively) compared to liver (0.2 wet g, each).

Of the ten metals measured in sanddab muscle tissue all were above detection except silver (Table 8-2 and Figure 8-1). Arsenic, copper, mercury, selenium and zinc were each slightly, but significantly greater by t-test ($p < 0.05$) at station TB3 nearest the outfall, compared to concentrations TB6. Of the groups of complex organic compounds measured in sanddab muscle tissue, total chlordane, total PCBs, arochlors, total HCHs and total PAHs were below detection at both stations. Total DDTs were detected at each site, but there was no significant difference between sites. 2,3,5-trimethylnaphthalene was detected at TB6 only and was below detection at TB3.

Of the ten metals measured in sanddab liver, all were above detection (Table 8-3 and Figure 8-1). Cadmium and lead were slightly, but significantly greater at TB6 compared to TB3 by t-test ($p < 0.05$). Copper and selenium were significantly greatest at TB3. HCHs, PCBs and arochlors were below detection. Total DDT, chlordane and total PAH were detected at both stations. Total DDT was significantly greater by t-test at the reference site (B6) and chlordane was

significantly greater at the outfall station (B3). Total PAHs were marginally significantly greater at B6 ($1.0 < p < 0.05$). It should be noted that where significant differences in muscle or liver tissue concentrations were detected by t-test, the differences in average metal concentrations between stations was extremely small.

Bivalves

Of the ten metals measured in bivalve *(Mytilus californianus)* tissue, all were above detection (Table 8-4, Figure 8-1). None of the ten metals measured in bivalve tissues were significantly different among the three stations by ANOVA. Of the complex organic compounds measured in bivalve tissue, total HCHs, total PCBs and arochlors were below detection in each replicate for all stations. Total DDT, chlordane and total PAHs were detected at each station, but there were no significant differences among sites. Three individual PAHs (2-methylnaphthalene, 2,6-dimethylnaphthalene and napththalene) were significantly greater at reference station TB6.

8.3.2 Tissue contaminant concentrations compared with past years

Sanddabs

The average concentration of contaminants in sanddab muscle and liver tissues remained within range of previous years (Figures 8-3 and 8-4). Increases in sanddab muscle concentrations of chromium, nickel and silver reported for the 2009 survey returned to lower concentrations in 2010 and remained low thru 2012. Arsenic concentrations increased seven fold in muscle tissue from 2010 (2 mg/dry Kg) to 2011 (15 mg/dry Kg), but dropped to 6 mg/dry Kg in 2012. Increases in liver DDT and PCB concentrations, which had increased between 2010 and 2011, dropped to lower concentrations in 2012.

Bivalves

The average concentration of each contaminant in bivalve tissues remained the same in 2012 (Figure 8-5). In all cases, mussel tissue concentrations in 2011 were at or below the concentrations measured in any survey since 1991. Similar to sanddab muscle and liver, silver concentrations which had increased to the greatest concentrations of all past surveys in 2009, decreased in 2010 and remained low thru 2012.

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

The concentrations of the contaminants measured in sanddab and bivalve tissues during the 2012 survey were compared to the concentrations measured at other sites throughout southern California (Table 8-5 and 8-6). Where comparisons were available, sanddab muscle and liver tissues, and mussel tissues were below or within the range of contaminant concentrations reported from other surveys (see references in Table 8-5 and 8-6 footnotes). Sanddab and muscle tissue concentrations of metals and organic constituents did not exceed OEHHA consumption thresholds. Finally, mussel tissue concentrations were in the 'low' range reported by the NOAA Status and Trends Mussel Watch program, except for cadmium which was in the 'medium' range.

8.4. Discussion

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

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

A total of 15 chemical compounds or groups of compounds were analyzed in speckled sanddab muscle tissue from the two trawl locations. Sanddab muscle tissues had one metal (silver), as well as total chlordane, total PCBs, arochlors, total HCHs and total PAHs that were each below method detection. Among the remaining compounds, arsenic, copper, mercury, selenium and zinc were each slightly, but significantly greater at station TB3 nearest the outfall, compared to concentrations measured at TB6. In sanddab liver tissues each metal was above detection at each site, while HCHs, PCBs and arochlors were below detection. Cadmium and lead were slightly, but significantly greater at reference station TB6, while copper and selenium were significantly greatest at outfall station TB3. Even when significant differences occurred between in muscle and liver tissues collected from near and far outfall sites, the average differences were small.

A total of 15 chemical compounds or groups of compounds were analyzed in the whole body tissues of bivalves. Each of the metals were above method detection limits, but none of their concentrations were significantly different among sites. Of the complex organic compounds measured, total HCHs, total PCBs and arochlors were below detection in each replicate for all stations. Three individual PAHs (2-methylnaphthalene, 2,6-dimethylnaphthalene and napththalene) were significantly greater at reference station TB6.

Comparison of the 2012 tissue concentrations from the Goleta survey area against results from the past nineteen years revealed that in all cases contaminant concentrations were similar to or less than in past years. Increases in sanddab muscle chromium, nickel and silver reported for the 2009 survey returned to lower concentrations in 2010 and remained low thru 2012. Arsenic concentrations increased seven fold in sanddab muscle tissue from 2010 (2 mg/dry Kg) to 2011 (15 mg/dry Kg), dropped to 6 mg/dry Kg in 2012.

The concentrations of the contaminants measured in sanddab and bivalve tissues during the 2012 survey were compared to the concentrations measured at other sites throughout southern California. Where comparisons were available, sanddab muscle and liver tissues, and mussel tissues were below or within the range of contaminant concentrations reported from other surveys. Sanddab and bivalve tissue concentrations of metals and organic constituents did not exceed OEHHA consumption thresholds. Since the speckled sanddab is not caught for human consumption due to its small size, comparison of its tissue burdens against the OEHHA

standard is included to provide context. Finally, bivalve tissue concentrations were in the 'low' range reported by the NOAA Status and Trends Mussel Watch program, except for cadmium which was in the 'medium' range (Kimbrough et al. 2008).

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

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

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

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

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

		Fish Muscle		Fish Liver		Bivalves			
Constituent	Replicate	T3	T6	T3	T6	Control	B3	B4	B6
Number of Animals		78	74	78	74	45	45	45	45
Average Standard Length (mm)	Mean =	81.6	73.8	81.6	73.8	6.7	8.1	7.6	7.8
	S.D. =	9.3	10.1	9.3	10.1	0.6	0.6	0.7	0.5
Average Weight/Animal (g)	Mean =	9.6	7.2	9.6	7.2	29.8	52.0	48.1	50.4
	S.D. =	3.3	3.1	3.3	3.1	7.6	11.5	14.5	10
Average Tissue Weight (g)	Mean =	1.8	1.3	0.2	0.2	5.8	17.4	15.8	16
	S.D. =	0.9	0.6	0.1	0.1	16.1	5.7	5.1	4

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

	Fish Muscle								
	TB3			TB6			T-Test		
Constituent	mean	±	SD	mean	±	SD	n	t	p
Metals (µg/dry g)									
Arsenic	6.301	±	0.113	5.816	±	0.151	**3**	**4.44**	**0.01**
Cadmium	0.032	±	0.007	0.033	±	0.004	3	-0.14	0.89
Chromium	0.145	±	0.142	0.060	±	0.011	3	1.09[1.]	0.40
Copper	0.876	±	0.043	0.790	±	0.028	**3**	**2.91**	**0.04**
Lead	0.030	±	0.006	0.027	±	0.002	3	1.01	0.37
Mercury	0.117	±	0.004	0.091	±	0.004	**3**	**8.00**	**<0.01**
Nickel	0.025	±	0.000	0.025	±	0.000	3	NA	NA
Selenium	1.547	±	0.098	1.114	±	0.025	**3**	**2.09[1.]**	**0.04**
Silver	0.025	±	0.000	0.025	±	0.000	3	NA	NA
Zinc	18.315	±	0.365	17.413	±	0.141	**3**	**3.90**	**0.02**
Complex Organics (ng/dry Kg)									
DDTs[1.]	6.7	±	1.4	9.0	±	1.4	3	-2.06	0.11
Chlordane[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
HCHs[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Mirex	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Arochlors[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
PAHs[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
1-Methylnaphthalene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
1-Methylphenanthrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2-Methylnaphthalene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2,3,5-Trimethylnaphthalene	1.0	±	0.0	37.6	±	63.4	3	-1.00	0.32
2,6-Dimethylnaphthalene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Acenaphthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Biphenyl	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benz[a]anthracene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[b]fluoranthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[e]pyrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[g,h,i]perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Napthalene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA

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

	Fish Liver								
	TB3			TB6			T-Test		
Constituent	mean	±	SD	mean	±	SD	n	t	p
Metals (µg/dry g)									
Arsenic	4.741	±	0.147	4.402	±	0.192	**3**	**2.43**	**0.07**
Cadmium	3.955	±	0.043	4.687	±	0.124	**3**	**-9.64**	**<0.01**
Chromium	0.118	±	0.009	0.106	±	0.007	3	1.79	0.15
Copper	7.764	±	0.229	6.676	±	0.228	**3**	**5.84**	**0.00**
Lead	0.391	±	0.013	0.421	±	0.013	**3**	**-2.84**	**0.05**
Mercury	0.044	±	0.005	0.041	±	0.004	3	0.72	0.51
Nickel	0.078	±	0.072	0.025	±	0.000	3	1.55[1.]	0.12
Selenium	3.794	±	0.112	2.979	±	0.106	**3**	**9.16**	**<0.01**
Silver	0.080	±	0.005	0.091	±	0.006	**3**	**-2.38**	**0.08**
Zinc	44.873	±	1.358	44.027	±	2.258	3	0.56	0.61
Complex Organics (ng/dry Kg)							3		
DDTs[1.]	797.5	±	38.8	1113.5	±	418.3	**3**	**-1.96[1.]**	**0.05**
Chlordane[1.]	26.9	±	5.8	13.8	±	3.9	**3**	**3.23**	**0.03**
HCHs[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Mirex	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Arochlors[1.]	0.0	±	0.0	0.0	±	0.0	3	NA	NA
PAHs[1.]	90.2	±	24.4	168.9	±	47.0	**3**	**-2.58**	**0.06**
1-Methylnaphthalene	10.6	±	2.0	17.4	±	5.4	3	-2.05	0.11
1-Methylphenanthrene	1.0	±	0.0	16.0	±	26.0	3	-1.00[1.]	0.32
2-Methylnaphthalene	20.4	±	9.4	42.6	±	12.8	**3**	**-2.42**	**0.07**
2,3,5-Trimethylnaphthalene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2,6-Dimethylnaphthalene	11.0	±	2.4	7.7	±	11.6	3	0.48	0.66
Acenaphthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Biphenyl	10.0	±	2.5	14.8	±	3.0	3	-2.11	0.10
Benz[a]anthracene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[b]fluoranthene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[e]pyrene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[g,h,i]perylene	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene	16.9	±	1.4	24.8	±	9.4	3	-0.65[1.]	0.51
Napthalene	36.1	±	3.7	51.1	±	15.6	3	-1.62	0.18
Perylene	8.1	±	6.2	1.0	±	0.0	3	1.55[1.]	0.12

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

	Bivalve Tissue											
	B3			B4			B6			ANOVA		
Constituent	**mean**	**±**	**SD**	**mean**	**±**	**SD**	**mean**	**±**	**SD**	**n**	**F**	**p**
Metals (µg/dry g)												
Arsenic	10.564	±	0.705	9.871	±	0.638	10.155	±	0.129	3	1.19	0.37
Cadmium	4.022	±	0.190	3.918	±	0.690	3.344	±	0.360	3	1.87	0.23
Chromium	0.938	±	0.088	0.919	±	0.107	0.976	±	0.046	3	0.36	0.71
Copper	7.080	±	0.706	6.816	±	0.114	6.877	±	0.576	3	0.20	0.82
Lead	1.777	±	0.028	1.731	±	0.183	1.502	±	0.284	3	1.69	0.26
Mercury	0.038	±	0.001	0.035	±	0.003	0.036	±	0.004	3	0.75	0.51
Nickel	0.924	±	0.068	0.860	±	0.059	0.994	±	0.071	3	3.05	0.12
Selenium	2.794	±	0.242	2.619	±	0.011	2.771	±	0.152	3	1.00	0.42
Silver	0.198	±	0.065	0.193	±	0.099	0.192	±	0.021	3	0.01	0.99
Zinc	139.065	±	8.802	133.772	±	8.397	127.146	±	13.117	3	1.00	0.42
Complex Organics (ng/dry Kg)												
DDTs[1.]	37.0	±	14.5	33.6	±	4.9	30.5	±	5.5	3	0.35	0.72
Chlordane[1.]	4.3	±	1.0	3.7	±	1.1	2.7	±	2.4	3	0.76	0.51
HCHs[1.]	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Aldrin	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Dieldrin	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Heptachlor	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Hexachlorobenzene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Mirex	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
PCBs[1.]	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0	3	NA	NA
Arochlors[1.]	0.0	±	0.0	0.0	±	0.0	0.0	±	0.0	3	NA	NA
PAHs[1.]	17.2	±	2.2	18.7	±	4.5	21.2	±	4.5	3	0.80	0.49
1-Methylnaphthalene	1.3	±	1.2	2.3	±	0.4	3.3	±	0.8	**3**	**4.00**	**0.08**
1-Methylphenanthrene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2-Methylnaphthalene	5.3	±	2.2	7.4	±	1.1	9.8	±	1.0	**3**	**6.57**	**0.03**
2,3,5-Trimethylnaphthalene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
2,6-Dimethylnaphthalene	1.5	±	0.4	1.9	±	0.3	2.9	±	0.6	**3**	**9.41**	**0.01**
Acenaphthene	1.7	±	1.3	1.7	±	1.2	2.8	±	2.5	3	0.40	0.69
Biphenyl	2.4	±	0.6	2.8	±	0.6	3.3	±	0.1	3	2.00	0.22
Benz[a]anthracene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[b]fluoranthene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[e]pyrene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Benzo[g,h,i]perylene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Fluoranthene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA
Napthalene	4.9	±	1.3	6.8	±	1.0	9.2	±	1.7	**3**	**7.20**	**0.03**
Perylene	1.0	±	0.0	1.0	±	0.0	1.0	±	0.0	3	NA	NA

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

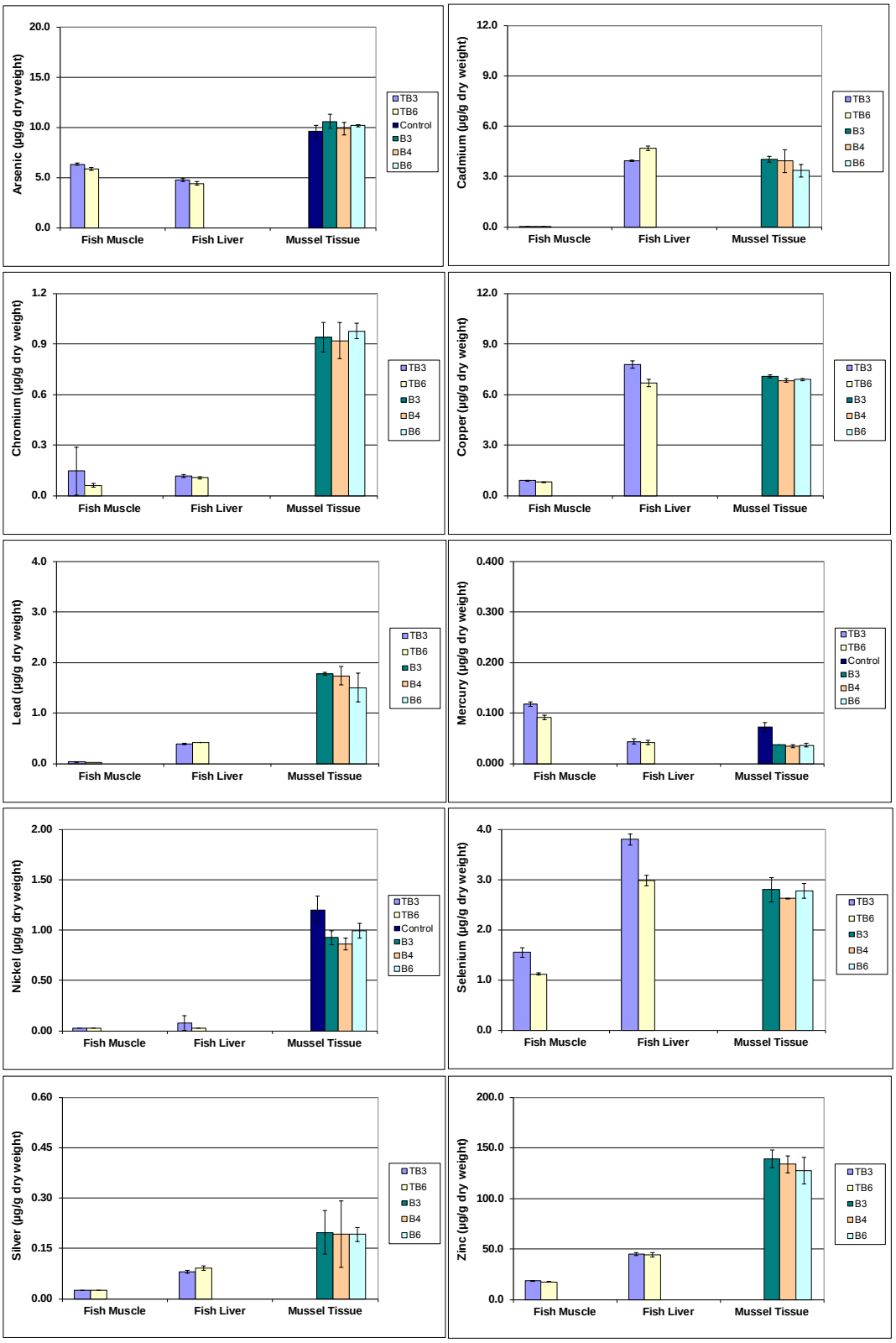


Figure 8-2. Organic concentrations (µg/dry Kg) measured in fish muscle and liver tissues (Stations TB3 and TB6), and mussels (B3, B4, B6 and lab control).

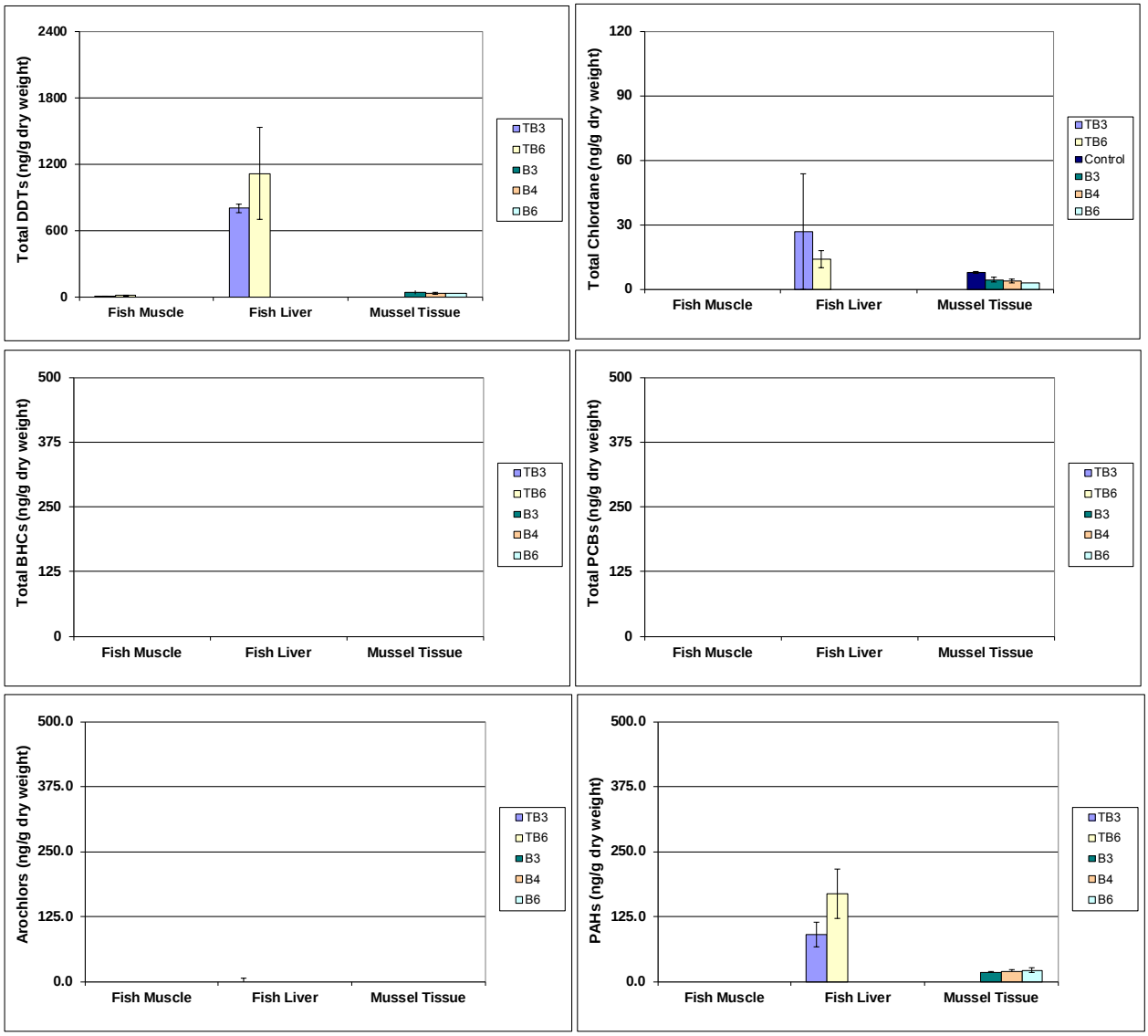


Figure 8-3. Contaminants (mg/dry Kg) measured in speckled sanddab muscle (Citharichthys stigmaeus) from Goleta since 1991 (mean ± SD, n=6).

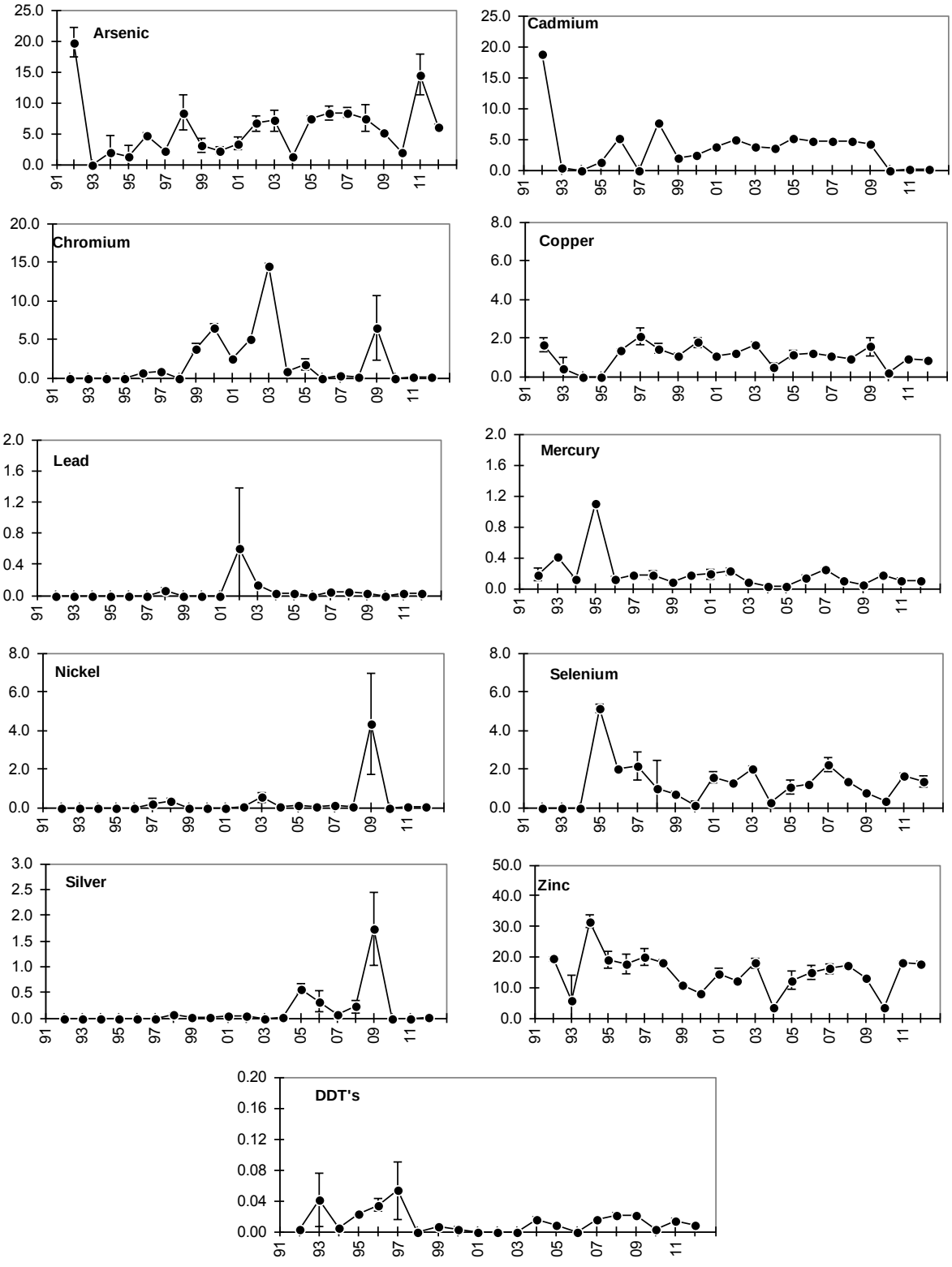


Figure 8-4. Contaminants (mg/dry Kg) measured in speckled sanddab liver (Citharichthys stigmaeus) from Goleta since 1991 (mean ± SD).

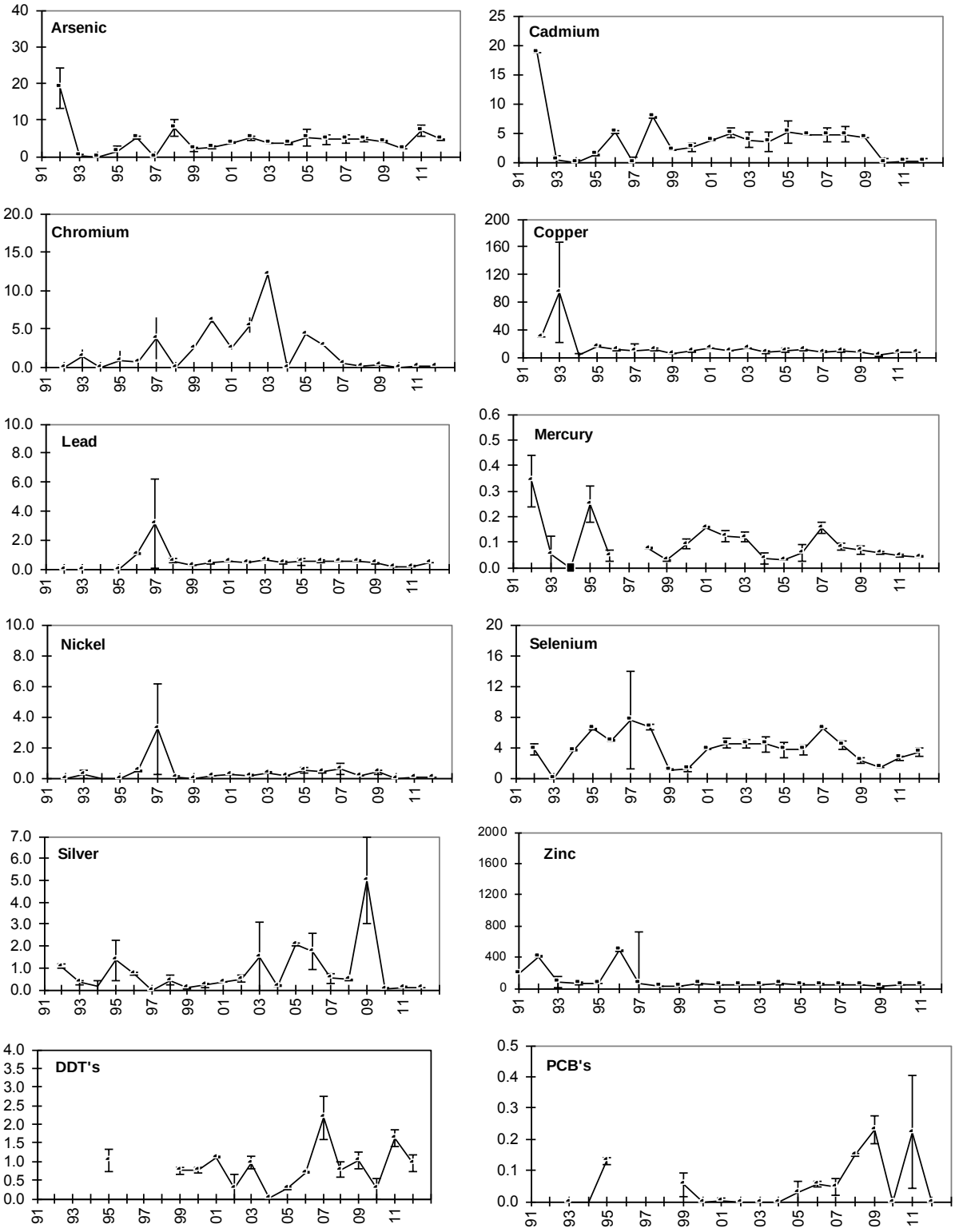


Figure 8-5. Contaminants (mg/dry Kg) measured in whole bivalves (*Mytilus californianus*) from Goleta since 1991 (mean ± SD, n = 3).

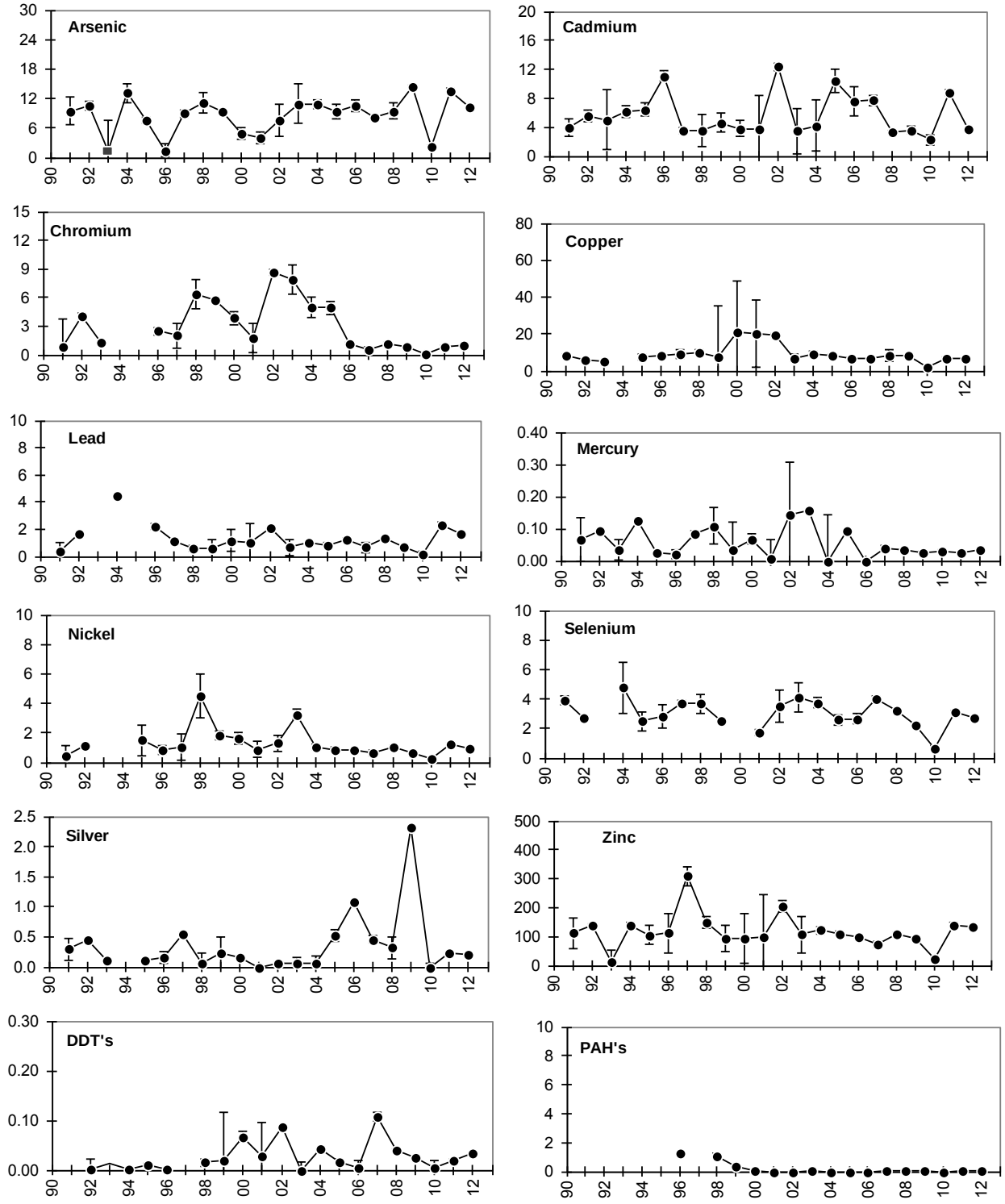


Table 8-5. Comparison of Goleta tissue chemistry with results from other studies (ug/wet g) and state and federal limits.

Constituent	GOLETA S.D. µg/g Wet Weight Means	GOLETA S.D. µg/g Wet Weight Ranges	Reference µg/g Wet Weight Stations[1.]	OEHHA[2.] µg/g Wet Weight FCG[3.]	OEHHA[2.] µg/g Wet Weight ATL[4.]
Fish Muscle					
Arsenic	**4.853**	**4.530 - 5.116**	42.2 - 57.8	---	---
Cadmium	**0.026**	**0.022 - 0.032**	<0.01 - 0.045	---	---
Chromium	**0.082**	**0.042 - 0.247**	0.08 - 2.8	---	---
Copper	**0.667**	**0.607 - 0.730**	0.45 - 2.4	---	---
Lead	**0.023**	**0.020 - 0.030**	1.2	---	---
Mercury	**0.084**	**0.070 - 0.098**	0.36 - 0.78	0.22	≤0.07[5.]
Nickel	**0.020**	**0.020 - 0.020**	0.4 - 5.1	---	---
Selenium	**1.066**	**0.870 - 1.317**	2.8 - 3.95	7.4	≤2.5
Silver	**0.020**	**0.020 - 0.020**	<0.005 - 1.4	---	---
Zinc	**14.309**	**13.877 - 14.919**	12.4 - 30.5	---	---
DDTs	**0.006**	**0.004 - 0.008**	0.005 - 2.15	0.021	≤0.52
Chlordane	**0.000**	**0.000 - 0.000**	---	0.0056	≤0.052
PCBs	**0.000**	**0.000 - 0.000**	0.005 - 2.7	0.0036	≤0.021
PAHs	**0.000**	**0.000 - 0.000**	---	---	---
Fish Liver					
Arsenic	**2.63**	**2.46 - 2.82**	---	---	---
Cadmium	**2.48**	**2.25 - 2.78**	---	---	---
Chromium	**0.06**	**0.06 - 0.07**	0.5	---	---
Copper	**4.15**	**3.75 - 4.59**	---	---	---
Lead	**0.23**	**0.22 - 0.25**	---	---	---
Mercury	**0.02**	**0.02 - 0.03**	---	---	---
Nickel	**0.03**	**0.01 - 0.09**	---	---	---
Selenium	**1.95**	**1.65 - 2.25**	---	---	---
Silver	**0.05**	**0.04 - 0.05**	---	---	---
Zinc	**25.56**	**24.00 - 26.60**	---	---	---
DDTs	**0.549**	**0.433 - 0.917**	28	---	---
Chlordane	**0.012**	**0.005 - 0.019**	---	---	---
PCBs	**0.000**	**0.000 - 0.000**	4	---	---
PAHs	**0.074**	**0.036 - 0.128**	---	---	---

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

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

Constituent	GOLETA S.D. µg/g Wet Weight Means	GOLETA S.D. µg/g Wet Weight Ranges	Reference µg/g Wet Weight Stations[1.]	OEHHA[2.] µg/g Wet Weight FCG[3.]	OEHHA[2.] µg/g Wet Weight ATL[4.]	NOAA Status & Trends, 1986 to 2005 µg/g Wet Weight low	NOAA Status & Trends, 1986 to 2005 µg/g Wet Weight medium	NOAA Status & Trends, 1986 to 2005 µg/g Wet Weight high
Mussel Tissue								
Arsenic	**8.23**	**7.40 - 9.32**	16.0 - 23.8	---	---	5 - 11	12 - 22	23 - 41
Cadmium	**3.77**	**2.45 - 6.26**	1.9 - 54	---	---	0 - 3	4 - 9	10 - 20
Chromium	**0.86**	**0.65 - 1.34**	1.23 - 3.9	---	---	---	---	---
Copper	**5.41**	**4.45 - 6.34**	4.0 - 21.8	---	---	5 - 16	17 - 39	40 - 857
Lead	**1.69**	**1.02 - 2.89**	1.09 - 11	---	---	0 - 3	4 - 6	7 - 13
Mercury	**0.04**	**0.03 - 0.07**	0.01 - 0.4	0.22	≤0.07[5.]	0.00 - 0.17	0.18 - 0.35	0.36 - 1.28
Nickel	**0.81**	**0.65 - 1.10**	3.2 - 5.3	---	---	0 - 5	6 - 14	15 - 44
Selenium	**2.17**	**1.81 - 2.52**	2.70 - 4.57	---	---	---	---	---
Silver	**0.17**	**0.09 - 0.35**	0.36 - 0.7	---	---	---	---	---
Zinc	**114.39**	**93.74 - 147.16**	133 - 336	---	---	48 - 139	140 - 320	321 - 11500
DDTs	**0.0312**	**0.0192 - 0.0527**	0.017 - 0.35	0.21	≤0.52	0 - 0.112	0.113 - 0.286	0.287 - 0.520
Chlordane	**0.0038**	**0.0000 - 0.0069**	---	0.0056	≤0.19	0 - 0.008	0.009 - 0.020	0.021 - 0.049
PCBs	**0.0000**	**0.0000 - 0.0000**	0.017 - 0.35	0.0036	≤0.021	0.003 - 0.153	0.154 - 0.478	0.479 - 1.413
PAHs	**0.0232**	**0.0115 - 0.0536**	0.81	---	---	0.063 - 1.187	1.118 - 4.434	4.435 - 7.561

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