THE CITY OF SAN DIEGO

Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant) 2008

City of San Diego
Ocean Monitoring Program

Metropolitan Wastewater Department
Environmental Monitoring and Technical Services Division

THE CITY OF SAN DIEGO

June 30, 2009

Mr. John Robertus
Executive Officer
Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123

Attention: POTW Compliance Unit

Dear Sir:

Enclosed is the 2008 Annual Receiving Waters Monitoring Report for NPDES Permit No. CA0109045, Order No. 2006-067, for the City of San Diego South Bay Water Reclamation Plant (SBWRP) discharge through the South Bay Ocean Outfall. This report contains data summaries and statistical analyses for the various portions of the ocean monitoring program, including oceanographic conditions, microbiology, sediment characteristics, macrobenthic communities, demersal fishes and megabenthic invertebrates, and bioaccumulation of contaminants in fish tissues. These data are also presented in the International Boundary and Water Commission's annual report for discharge from the International Wastewater Treatment Plant (NPDES Permit No. CA0108928, Order No. 96-50).

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, I certify that 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.

Sincerely,

ALAN C. LANGWORTHY
Deputy Metropolitan Wastewater Director

ACL/akl

Enclosure

cc: Department of Environmental Health, County of San Diego
U.S. Environmental Protection Agency, Region 9
Metropolitan Wastewater Department Library, City of San Diego

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Prepared by:

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Metropolitan Wastewater Department
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Cover Photo: Cover Photos (clockwise from top left): surfgrass on the shore of the Silver Strand; Imperial Beach Pier; assorted bivalve and gastropod shells; waves washing ashore; a seagull taking flight; the Tijuana Estuary. Photos by Eliza Moore and Nick Haring

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Executive Summary

Executive Summary

The monitoring and reporting requirements for the City of San Diego's (City) South Bay Water Reclamation Plant (SBWRP) and International Boundary and Water Commission's (IBWC) International Wastewater Treatment Plant (IWTP) are outlined in NPDES Permit Nos. CA0109045 and CA0108928, respectively. Since effluent from the SBWRP and IWTP commingle before discharge to the Pacific Ocean through the South Bay Ocean Outfall (SBOO), the receiving waters monitoring requirements are similar and a single ocean monitoring program is conducted to comply with both permits. The primary objectives of the South Bay ocean monitoring program are to a) measure compliance with NPDES permit requirements and California Ocean Plan (COP) standards, and b) assess the impact of wastewater discharged through the outfall on the marine environment off southern San Diego, including effects on water quality, sediment conditions, and marine organisms. The study area centers around the SBOO discharge site, which is located approximately 5.6 km offshore at a depth of 27 m. Monitoring at sites along the shore extends from Coronado in San Diego, southward to Playa Blanca in northern Baja California (Mexico), while offshore monitoring occurs in an adjacent area overlying the coastal continental shelf at sites ranging from 9 to 55 m in depth.

Prior to the initiation of wastewater discharge in 1999, the City of San Diego conducted a 3½ year baseline study designed to characterize background environmental conditions in the South Bay region in order to provide information against which post discharge data could be compared. Additionally, a region-wide survey of benthic conditions is typically conducted each year at randomly selected sites from Del Mar to the USA/Mexico border in order to evaluate patterns and trends over a broader geographic area. However, no such regional study was conducted in 2008 due to a resource exchange agreement approved by the San Diego Regional Water Quality Control Board and the U.S. Environmental Protection Agency, which allowed the City and IBWC to devote these resources towards participation in the 2008 Southern California Bight Regional Monitoring Program (Bight'08). Data from Bight'08 are not yet available and are therefore not included herein. These data are scheduled to be reported separately in 2011.

The receiving waters monitoring effort for the South Bay region may be divided into several major components, with each comprising a separate chapter in this report entitled: Oceanographic Conditions, Microbiology, Sediment Characteristics, Macrobenthic Communities, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Chapter 1 presents a general introduction and overview of the ocean monitoring program for the region. In Chapter 2 data regarding various physical and chemical oceanographic parameters are evaluated to characterize water mass transport potential in the region. Chapter 3 presents the results of water quality monitoring conducted along the shore and in offshore waters, which includes the measurement of fecal indicator bacteria (FIB) to assess potential effects of both natural and anthropogenic inputs, and to determine compliance with water contact standards specified in the 2001 COP. The results of benthic sampling and analyses of soft-bottom sediments and their associated macrofaunal communities are presented in Chapters 4 and 5, respectively. Chapter 6 presents the results of trawling activities to assess the status of bottom dwelling (demersal) fishes and megabenthic invertebrate communities. Bioaccumulation studies to determine whether contaminants are present in the tissues of local species supplement the monitoring of fish populations and are presented in Chapter 7. In addition to the above activities, the City and IBWC support other projects relevant to assessing ocean quality in the region. One such project is a remote sensing study of the San Diego/Tijuana coastal region. These results are incorporated herein into the interpretations of the oceanographic and microbiological data (see Chapters 2 and 3).

The present report focuses on the results of all ocean monitoring activities conducted in the South Bay region during 2008. An overview and summary of the main findings for each of the major components of the monitoring program are included below.

Oceanographic Conditions

The South Bay outfall region was characterized by relatively normal oceanographic conditions in 2008, which included typical seasonal patterns such as localized upwelling and corresponding phytoplankton blooms in the spring, maximum stratification of the water column in mid-summer, and reduced stratification during the winter. Aerial imagery detected the signature of the wastewater plume in near-surface waters above the outfall discharge site on several occasions between January–April and November–December when the water column was generally well mixed. In contrast, the waste field appeared to remain deeply submerged between late April–October when the water column was stratified. There was no apparent relationship during the year between proximity to the outfall and values of ocean temperature, salinity, pH, transmissivity, chlorophyll *a*, and dissolved oxygen. Instead, conditions in 2008 remained notably consistent with changes in large scale patterns reported for the California Current System, indicating that other factors such as upwelling of deep waters and large-scale oceanographic events (e.g., El Niño, La Niña) continue to explain most of the temporal and spatial variability observed in water quality parameters for the South Bay region.

Microbiology

There was no evidence that contaminated waters associated with the SBOO waste field reached the shoreline or near-shore recreational waters off southern San Diego in 2008. Although elevated FIBs were occasionally detected along the shore and at some nearshore stations, these data do not appear to indicate the shoreward transport of wastewater. Instead, analysis of FIB distributions and remote sensing observations indicate that other sources such as outflows (e.g., turbidity plumes) originating from the Tijuana River and Los Buenos Creek in northern Baja California (Mexico), or associated with stormwater and terrestrial runoff following storm events, are more likely to impact water quality along and near the shore in the South Bay region. For example, the shore stations located near the Tijuana River and Los Buenos Creek have long had higher FIB concentrations than stations located further north. Further, historical analyses of various water quality parameters have demonstrated that the general relationship between rainfall and elevated levels of indicator bacteria has remained consistent since ocean monitoring began in 1995. During 2008, the majority of elevated FIB densities not associated with rainfall occurred at offshore monitoring sites located near (i.e., within 1000 m) the outfall diffuser legs and at depths of 18 m or below.

Sediment Characteristics

The composition of sediments at the various benthic sites sampled in the South Bay region during 2008 varied from fine silts to very coarse sands (or other coarse materials), which is similar to patterns seen in previous years. The large variation in sediment composition may be partially attributed to the multiple geological origins of red relict sands, shell hash, coarse sands, and other detrital sediments. In addition, the transport and deposition of sediments originating from the Tijuana River, and to a lesser extent from San Diego Bay, may contribute to higher silt content at some stations located near the outfall and to the north. There was no evident relationship between sediment composition and proximity to the SBOO discharge site.

Concentrations of contaminants such as sulfides, total nitrogen (TN), total organic carbon (TOC), various trace metals, pesticides, PCBs, and PAHs were generally low in South Bay sediments compared to other areas of the southern California continental shelf. Levels of the organic loading indicator TN, as well as several metals, tended to increase as sediments became finer. Further, levels of all of the organic loading indicators have not shown changes around the outfall or elsewhere coincident with the start of wastewater discharge in early 1999. Concentrations for only two metals exceeded Effects Range Low (ERL) environmental threshold values during the year: (1) the ERL for arsenic was exceeded in sediments from a single site located offshore of the SBOO; (2) the ERL for silver was exceeded in sediments from multiple stations located throughout the monitoring area. Other contaminants were detected either infrequently (i.e., PCBs and pesticides) or in only low concentrations (i.e., PAHs) in sediments during the year. Overall, there was no pattern in sediment contaminant concentrations relative to the SBOO discharge site.

Macrobenthic Communities

Benthic macrofaunal assemblages surrounding the SBOO were similar in 2008 to those that occurred during previous years, including the period prior to wastewater discharge, and varied along gradients of sediment structure, depth, and to a lesser degree, TOC content. These assemblages were typical of those occurring in other sandy, shallow- and mid-water habitats throughout the Southern California Bight (SCB). For example, most of the sandier, shallower sites contained high abundances of the spionid polychaete *Spiophanes bombyx*, a species characteristic of similar habitats and assemblages in the SCB. In contrast, slightly different assemblages occurred at mid-depth stations that had finer sediments characteristic of much of the SCB mainland shelf. Finally, sites with sediments composed of significant quantities of relict red sands, other coarse sands or shell hash were inhabited by unique assemblages characterized by several species of polychaetes (i.e., *Polycirrus* sp, *Protodorvillea gracilis*, *Hesionura coineaui difficilis*, *Micropodarke dubia*, *Typosyllis* sp SD1, and *Pisione* sp).

Benthic community structure parameters such as species richness and total abundance also varied with depth and sediment type, with no clear patterns relative to the outfall. Instead, patterns of region-wide abundance fluctuations appear to mirror historical patterns for *S. bombyx*. The range of values for most parameters was similar in 2008 to that seen in previous years, and results for the benthic response index (BRI) were characteristic of undisturbed sediments. In addition, changes that did occur in macrofaunal community structure during the year were similar in magnitude to those that have occurred previously and elsewhere off southern California. Such changes often correspond to large-scale oceanographic processes or other natural events. Overall, macrofaunal assemblages in the region remain similar to those observed prior to wastewater discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf. There was no evidence that wastewater discharge has caused degradation of the marine benthos in the SBOO monitoring region.

Demersal Fishes and Megabenthic Invertebrate Communities

Speckled sanddabs continued to dominate fish assemblages surrounding the SBOO during 2008 as they have in previous years. This species occurred at all stations and accounted for 59% of the total catch. Other characteristic, but less abundant species included the roughback sculpin, yellowchin sculpin, California lizardfish, longfin sanddab, hornyhead turbot, longspine combfish, English sole, and California tonguefish. Most of these common fishes were relatively small, averaging less than 20 cm in length. Although the composition and structure of fish assemblages varied among stations, these differences mostly reflected variation in speckled sanddab populations.

Assemblages of relatively large (megabenthic) trawl-caught invertebrates in the region were similarly dominated by one prominent species, the sea star *Astropectin verrilli*. Variations in megabenthic invertebrate community structure generally reflected changes in the abundance of this species, as well as other characteristic species including the sea urchin *Lytechinus pictus*, the sand dollar *Dendraster terminalis*, and the shrimp *Crangon nigromaculata*.

Overall, results from the 2008 trawl surveys provide no evidence that wastewater discharge has affected either demersal fish or megabenthic invertebrate communities in the region. The relatively low species richness and small populations that occurred in the region are consistent with the depth and sandy habitat in which the trawl stations are located. Further, patterns in the abundance and distribution of species were similar at stations located near the outfall and farther away, suggesting a lack of significant anthropogenic influence. Changes in these communities instead appear to be more likely due to natural factors such as fluctuating water temperatures associated with large-scale oceanographic events (e.g., El Niño) and the mobile nature of many species. Finally, the absence of any indicators of disease or other physical abnormalities in local fishes suggests that populations in the region remain healthy.

Contaminants in Fish Tissues

There was no clear evidence to suggest that tissue contaminant loads in fish captured at the SBOO monitoring sites were affected by the discharge of wastewater in 2008. Although several tissue samples contained metals that exceeded pre-discharge maximum values, concentrations of most contaminants were not substantially different from pre-discharge data. In addition, the samples that did exceed pre-discharge values were distributed widely among the stations and showed no pattern relative to wastewater discharge. Further, all contaminant values were within the range of those reported previously for SCB fishes.

The occurrence of both metals and chlorinated hydrocarbons in the tissues of South Bay fishes may be due to many factors, including the ubiquitous distribution of many contaminants in coastal sediments off southern California. Other factors that affect the bioaccumulation and distribution of contaminants in local fishes include the different physiologies and life history traits of various species. Exposure to contaminants can vary greatly between species and even among individuals of the same species depending on migration habits. For example, fish may be exposed to pollutants in a highly contaminated area and then move into a region that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many other point and non-point sources in the region that may contribute to contamination.

Chapter 1
General Introduction

Chapter 1. General Introduction

INTRODUCTION

The South Bay Ocean Outfall discharges treated effluent to the Pacific Ocean that originates from two separate sources, including the International Wastewater Treatment Plant (IWTP) operated by the International Boundary and Water Commission (IBWC), and the City of San Diego's South Bay Water Reclamation Plant (SBWRP). Wastewater discharge from the IWTP began on January 13, 1999 and is performed under the terms and conditions set forth in Order No. 96–50, Cease and Desist Order No. 96–52 for NPDES Permit No. CA0108928. Discharge from the SBWRP began on May 6, 2002 and is performed according to the provisions set forth in Order No. R9-2006-0067 for NPDES Permit No. CA0109045. The Monitoring and Reporting Program (MRP) included in each of the above permits and orders defines the requirements for monitoring receiving waters in the South Bay coastal region, including sampling designs, compliance criteria, types of laboratory analyses, and data analysis and reporting guidelines.

All receiving waters monitoring for the South Bay outfall region with respect to the above MRPs has been performed by the City of San Diego since wastewater discharge began in 1999. The City also conducted 3½ years of pre-discharge monitoring in order to characterize background environmental conditions for the region (City of San Diego 2000a). The results of this baseline study provide background information against which post-discharge data and conditions may be compared. In addition, the City has conducted annual region-wide surveys off the coast of San Diego since 1994 either as part of regular South Bay monitoring requirements (e.g., City of San Diego 1998, 1999, 2000b, 2001–2003, 2006–2008) or as part of larger, multi-agency surveys of the entire Southern California Bight (e.g., Bergen et al. 1998, 2001, Noblet et al. 2002, Ranasinghe et al. 2003, 2007, Schiff et al. 2006). Such large-scale surveys are useful in characterizing the ecological health of diverse coastal areas and may help to identify and distinguish reference sites from those impacted by wastewater or stormwater discharges, urban runoff, or other sources of contamination.

Finally, the City of San Diego and the IBWC also contract with Ocean Imaging of Solana Beach, California to conduct a remote sensing program for the San Diego/Tijuana region as part of the ocean monitoring programs for the Point Loma and South Bay areas. Imagery from satellite data and aerial sensors produce a synoptic picture of surface water clarity that is not possible using shipboard sampling alone. However, a major limitation of aerial and satellite images is that they only provide information about surface or near-surface waters (~0–15 m) without providing any direct data regarding the movement, color, or clarity of deeper waters. In spite of these limitations, one objective of this ongoing project is to ascertain relationships between the various types of imagery and data collected in the field. With public health issues being a paramount concern of ocean monitoring programs, any information that helps to provide a clearer and more complete picture of water conditions is beneficial to the general public as well as to program managers and researchers. Having access to a large-scale overview of surface waters within a few hours of image collection also has the potential to bring the monitoring program closer to real-time diagnoses of possible contamination, and adds predictability to the impact that natural events such as storms and heavy rains may have on shoreline water quality. Results from the San Diego/Tijuana remote sensing program for calendar year 2008 are summarized in Svejkovsky (2009).

This report presents the results of all receiving waters monitoring conducted as part of the South Bay monitoring program in 2008. Included are results from all regular fixed monitoring stations that comprise a grid surrounding the South Bay outfall. No sampling was conducted at randomly selected benthic sites in 2008 due to a resource exchange agreement to allow participation in the Bight'08 regional monitoring program (see above). The results of the remote sensing surveys conducted during the year as reported by Svejkovsky (2009) are also considered and integrated into interpretations of oceanographic and water quality data (e.g., fecal indicator bacteria, total suspended solids, oil and grease). Comparisons are also made herein to conditions present during previous years in order to evaluate changes that may be related to wastewater discharge and transport or to other anthropogenic or natural events. The major components of the monitoring program are covered in the following six chapters: Oceanographic Conditions, Microbiology, Sediment Characteristics, Macrobenthic Communities, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Some general background information and procedures for the regular fixed-grid monitoring program are given below and in subsequent chapters and appendices.

Regular Fixed-Grid Monitoring

The South Bay Ocean Outfall is located just north of the border between the United States and Mexico. The outfall terminates approximately 5.6 km offshore at a depth of about 27 m. Unlike other southern California ocean outfalls that are located on the surface of the seabed, the pipeline first begins as a tunnel on land and then continues under the seabed to a distance about 4.3 km offshore. From there it connects to a vertical riser assembly that conveys effluent to a pipeline buried just beneath the surface of the seabed. This subsurface pipeline then splits into a Y-shaped multiport diffuser system, with the two diffuser legs extending an additional 0.6 km to the north and south. The outfall was originally designed to discharge effluent via a total of 165 diffuser ports and risers, which included one riser located at the center of the wye and 82 others spaced along each diffuser leg. However, consistent low flows have required closure of all ports along the northern diffuser leg and many along the southern diffuser as well since discharge began in order to maintain sufficient back pressure within the drop shaft so that the outfall can operate in accordance with the theoretical model. Consequently, wastewater discharge has been generally limited to the distal end of the southern diffuser leg, with the exception of a few intermediate points at or near the center of the diffuser legs.

The regular sampling area for the South Bay outfall region extends from the tip of Point Loma southward to Playa Blanca, northern Baja California (Mexico), and from the shoreline seaward to a depth of about 61 m. The offshore monitoring stations are arranged in a grid that spans the terminus of the outfall, with each site being monitored in accordance with NPDES permit requirements. Sampling at these fixed stations includes monthly seawater measurements of physical, chemical, and bacteriological parameters in order to document water quality conditions in the area. Benthic sediment samples are collected semiannually to monitor macrofaunal communities and sediment conditions. Trawl surveys are performed quarterly to monitor communities of demersal fish and large, bottom-dwelling invertebrates (megabenthos). Additionally, analyses of fish tissues are performed semiannually to assess the bioaccumulation of chemical constituents that may have ecological or human health implications.

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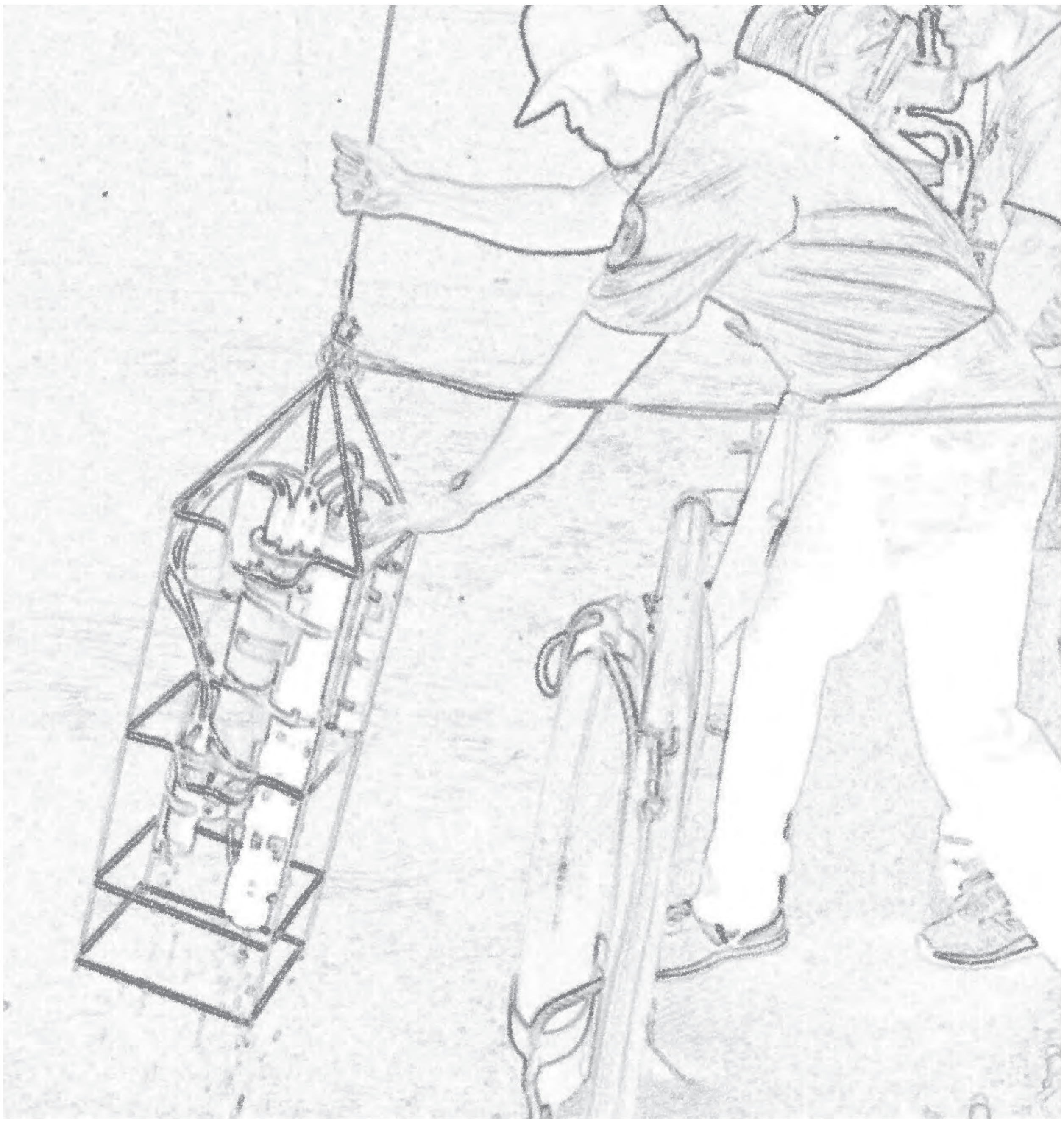
Chapter 2
Oceanographic Conditions



Chapter 2. Oceanographic Conditions

INTRODUCTION

The City of San Diego monitors oceanographic conditions in the region surrounding the South Bay Ocean Outfall (SBOO) to assist in evaluating possible impacts of wastewater discharge on the marine environment. Treated wastewater is discharged to the Pacific Ocean via the SBOO at a depth of ~28 m and at a distance of approximately 5.6 km west of Imperial Beach. During 2008, average daily flow through the outfall was about 25 mgd. The fate of wastewater discharged into offshore waters is determined by oceanographic conditions that impact water mass movement, including horizontal and vertical mixing of the water column and current patterns. These same factors can also affect the distribution of turbidity (or contaminant) plumes that originate from various point and non-point sources. In the South Bay region these include tidal exchange from San Diego Bay, outflows from the Tijuana River north of the border and from Los Buenos Creek in Mexican waters, storm drains or other water discharges, and surface water runoff from local watersheds. For example, flows from San Diego Bay and the Tijuana River are fed by 1075 km^2 and 4483 km^2 of watershed, respectively, and can contribute significantly to nearshore turbidity, sediment deposition, and bacterial contamination (see Largier et al. 2004, Terrill et al. 2009). Overall, these different sources can affect water quality conditions either individually or synergistically.

Because of the above, evaluations of oceanographic parameters such as water temperature, salinity, and density that determine the mixing potential of the water column are important components of ocean monitoring programs (Bowden 1975). Analysis of the spatial and temporal variability of these and other parameters (e.g., light transmittance or transmissivity, dissolved oxygen, pH, and chlorophyll) may also elucidate patterns of water mass movement. Monitoring patterns of change in these parameters for the receiving waters surrounding the SBOO can help: (1) describe deviations from expected oceanographic patterns, (2) assess the impact of the wastewater plume relative to other input sources, (3) determine the extent to which water mass movement or mixing affects the dispersion/dilution potential for discharged materials, and (4) demonstrate the influence of natural events such as storms or El Niño/La Niña oscillations.

The evaluation and interpretation of bacterial distribution patterns and remote sensing observations (e.g., aerial and satellite imagery) may also provide useful information on the horizontal transport of wastewater plumes (Pickard and Emery 1990, Svejkovsky 2009, also see Chapter 3 of this report). Thus, the City of San Diego combines measurements of physical oceanographic parameters with assessments of fecal indicator bacteria (FIB) concentrations and remote sensing data to provide further insight into the transport potential in coastal waters surrounding the SBOO discharge site.

This chapter describes the oceanographic conditions that occurred in the South Bay region during 2008. The results reported herein are also referred to in subsequent chapters to explain patterns of FIB distributions (see Chapter 3) or other changes in the local marine environment (see Chapters 4–7).

Materials and Methods

Field Sampling

Oceanographic measurements were collected once per month at 40 fixed monitoring stations (Figure 2.1). These stations are located between 3.4–14.6 km offshore along the 9, 19, 28, 38, and 55-m depth contours, and form a grid encompassing an area of ~450 km^2 surrounding the outfall. Data for the various oceanographic parameters were collected using a SeaBird conductivity, temperature, and depth (CTD) instrument. The CTD was lowered through the water column at each station to collect

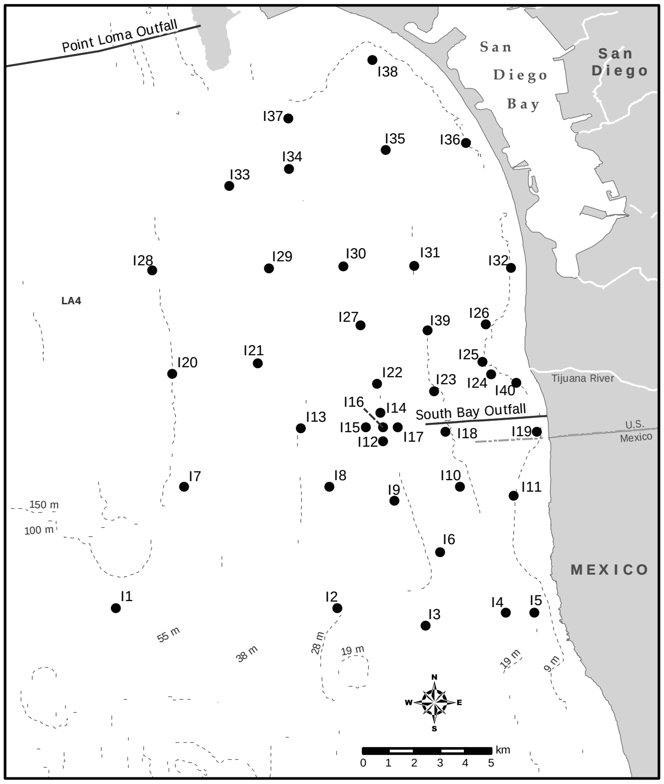


Figure 2.1
Water quality monitoring stations where CTD casts are taken, South Bay Ocean Outfall Monitoring Program.

continuous measurements of water temperature, salinity, density, pH, water clarity (transmissivity), chlorophyll *a*, and dissolved oxygen (DO). Water column profiles of each parameter were then constructed for each station by averaging the data values recorded over 1-m depth intervals. This data reduction ensured that physical measurements used in subsequent analyses could correspond to discrete sampling depths for indicator bacteria (see Chapter 3). Visual observations of weather and water conditions were recorded just prior to each CTD cast.

Remote Sensing – Aerial and Satellite Imagery

Coastal monitoring of the SBOO region during 2008 also included aerial and satellite image analysis performed by Ocean Imaging of Solana Beach, CA (see Svejkovsky 2009). All usable images for the monitoring area captured during the year by the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite were downloaded, and 22 high clarity Landsat Thematic Mapper (TM) images and two Aster images were acquired. High resolution aerial images were collected using Ocean Imaging's DMSC-MKII digital multispectral sensor. The DMSC's four channels were configured to a specific wavelength (color) combination designed to maximize detection of the wastewater discharge signature by differentiating between the waste field and coastal turbidity plumes. Depth of penetration for this sensor varies between 8–15 m depending on water clarity. The spatial resolution of the data is dependent upon aircraft altitude, but is typically maintained at 2 m. Fifteen DMSC overflights were conducted in 2008, which consisted of one to five flights per month during winter when the surfacing potential was greatest for the wastewater plume (see below) and when rainfall was also greatest. In contrast, only three surveys were flown during the spring and late summer months.

Data Treatment

The water column parameters measured in 2008 were summarized by month in two different ways: (1) the mean calculated over the entire water column for each station, and (2) means calculated over all stations located along each depth contour (i.e., 9-m, 19-m, 28-m, 38-m, 55-m). In addition, mean temperature, salinity, DO, pH, and transmissivity data from 2008 were compared with historical profile plots consisting of means for 1995–2007 ± one standard deviation. Data for these historical analyses were summarized at 5-m depth increments and were limited to four quarters and four representative stations located along the 28-m depth contour. These stations included I12 located near the end of the southern diffuser leg, I9 located south of the outfall, and I22 and I27 located north of the outfall.

Results and Discussion

Climate Factors and Seasonality

Southern California weather can generally be classified into wet (winter) and dry (spring–fall) seasons (NOAA/NWS 2009a), and differences between these seasons affect certain oceanographic conditions (e.g., water column stratification, current patterns and direction). Understanding patterns of change in such conditions is important in that they can affect the transport and distribution of wastewater, storm water, or other types of turbidity plumes that may arise from various point or non-point sources. Winter conditions typically prevail in southern California from December through February during which time higher wind, rain, and wave activity often contribute to the formation of a well-mixed or relatively homogenous (non-stratified) water column, and can decrease surface salinity (Jackson 1986). The chance that the wastewater plume from the SBOO may surface is highest during such times when there is little, if any, stratification of the water column. These conditions often extend into March as the frequency of winter storms decreases and the seasons begin to transition from wet to dry. In late March or April the increasing elevation of the sun and lengthening days begin to warm surface waters resulting in increased surface evaporation (Jackson 1986). Mixing conditions diminish with decreasing storm activity, and seasonal thermoclines and pycnoclines become re-established. Once the water column becomes stratified again by late spring, minimal mixing conditions typically remain throughout the summer and early fall months. In October or November, cooler temperatures associated with seasonal changes in isotherms, reduced solar input, along with increases in stormy weather, begin to cause the return of well-mixed or non-stratified water column conditions.

Total rainfall in 2008 was just over 12 inches in the San Diego region, which exceeded the historical average (NOAA/NWS 2009b). Rainfall followed expected seasonal storm patterns, with the greatest and most frequent rains occurring during the winter and fall months (Figure 2.2A). Air temperatures were generally similar during the year to historical values, although exceptions occurred in October and November (Figure 2.2B).

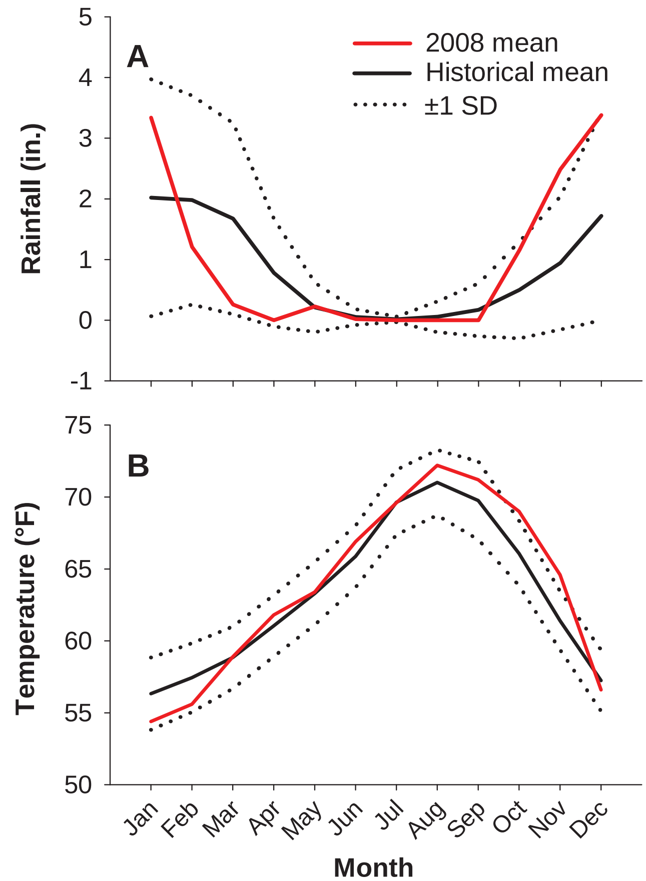


Figure 2.2
Comparison of rainfall (A) and air temperatures (B) at Lindbergh Field (San Diego, CA) for 2008 compared to historical levels. For 2008, rainfall data are expressed as total inches per month, whereas temperature data are monthly averages. Historical rainfall and temperature data are expressed as monthly means ± one standard deviation for the period 1914 through 2007.

Ocean Current Observations

Although assessment of ocean currents is not presently required by the Monitoring and Reporting Program specified in the NPDES permit for the South Bay outfall region (see Chapter 1), relevant information is available for 2008 from two different studies. These special studies include a) the remote sensing project conducted by Ocean Imaging for the IBWC and City of San Diego as mentioned previously (see Svejkovsky 2009), and b) a separate project conducted for the IBWC utilizing HF Radar and AUV technologies (see Terrill et al. 2009). Below is a summary of some of the major observations from these projects.

Results from aerial imagery indicated that the direction of current flow in surface waters was predominantly southward in 2008, although occasional northward flows occurred following

Figure 2.3
TM imagery showing the San Diego water quality monitoring region, acquired on December 26, 2008. A strong northerly current can be seen carrying a sediment turbidity plume along the shore from Los Buenos Creek (Mexico) to Imperial Beach following a rain storm.

storm events (Svejkovsky 2009). For example, the remote sensing observations indicated that increased flows from the Tijuana River during the wet season resulted in large northward-flowing turbidity plumes that extended along the coast as far north as Imperial Beach and Coronado (Figure 2.3). These plumes were often associated with increases in FIB contamination along the shoreline or in nearshore waters (see Chapter 3). These findings are generally consistent with more detailed observations on current flow through the study area measured by Terrill et al. (2009) from January 2008 until mid-November 2008. During this approximately 11-month period, these authors also reported that the major direction of currents over most depths in the vicinity of the outfall was either in a south-southeast or north-northwest direction. Current flows to the south were slightly more frequent than those moving to the north during the summer months. In addition, coincident with periods of strong stratification during the summer, subsurface currents were more likely to shear to an easterly direction as depth increased. During the winter months currents typically moved in a southern direction with fewer northward flowing currents than in the summer. Shearing of the currents during the winter when waters were relatively well mixed was not evident.

Oceanographic Conditions in 2008

Water Temperature

In 2008, mean surface temperatures across the entire SBOO region ranged from 13.4°C in February to 20.8°C in August, while bottom temperatures averaged from 9.6°C in June to 16.0°C in December (Table 2.1). Water temperatures varied by depth and season, with no discernable patterns relative to wastewater discharge (Appendix A.1). As expected, bottom temperatures decreased with depth, with up to a 5.2°C difference between the 9-m and 55-m depth contours. In contrast, surface waters were slightly cooler inshore during 11 months of the year (February–December), with up to a difference of 1.6°C between the 9-m and 55-m depth contours. The lowest temperatures of the year occurred between March and June at the bottom depths of the deeper stations, which probably reflected spring upwelling in the area.

Temperature is the main factor affecting the density and stratification of southern California ocean waters (Dailey et al. 1993, Largier et al. 2004), and differences between surface and bottom temperatures can provide the best indication of surfacing potential for wastewater plumes. This is particularly true for the shallow waters of the SBOO region. During 2008, thermal stratification of the water column generally followed normal seasonal patterns. For example, the water column was least stratified during the winter and late fall (e.g., January–February, November–December) at the 28-m offshore stations (Figure 2.4). In contrast, waters were most stratified from July through August. These patterns were similar to those reported by Svejkovsky (2009) using remote sensing methods and by Terrill et al. (2009) using moored thermistor arrays. For example, the

Table 2.1

Summary of temperature, salinity, dissolved oxygen, pH, transmissivity, and chlorophyll *a* for surface and bottom waters in the SBOO region during 2008. Values are expressed as means for each month pooled over all stations along each depth contour.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)													
9-m	Surface	13.6	13.4	14.2	14.8	16.6	15.2	19.1	20.2	18.9	17.0	17.1	16.6
	Bottom	13.3	12.9	12.4	11.3	14.0	11.8	13.8	14.7	15.2	14.8	15.9	16.0
19-m	Surface	13.6	13.4	14.1	14.2	16.5	15.3	18.0	20.0	18.5	16.9	17.1	16.5
	Bottom	12.9	12.4	11.1	10.5	11.8	10.8	12.2	13.1	14.5	13.3	14.9	14.8
28-m	Surface	13.7	13.4	13.7	14.6	16.4	15.2	18.8	20.8	19.4	17.0	17.3	16.4
	Bottom	12.4	12.1	10.9	10.3	11.2	10.2	11.7	12.6	13.5	12.9	14.7	13.9
38-m	Surface	13.5	13.6	14.1	15.0	16.8	15.7	19.1	20.7	19.7	17.7	16.8	16.8
	Bottom	11.7	11.8	10.7	10.3	10.5	10.0	11.3	12.0	13.3	12.7	13.4	12.9
55-m	Surface	13.5	13.6	14.3	15.1	16.8	16.8	19.2	20.7	20.1	17.9	17.3	16.9
	Bottom	11.1	11.0	10.3	10.2	10.4	9.6	11.0	11.5	12.6	12.0	13.5	12.9
Salinity (ppt)													
9-m	Surface	33.44	33.41	33.52	33.72	33.84	33.75	33.61	33.55	33.43	33.38	33.36	33.32
	Bottom	33.48	33.52	33.60	33.83	33.87	33.81	33.61	33.51	33.42	33.29	33.36	33.38
19-m	Surface	33.45	33.40	33.53	33.74	33.81	33.73	33.62	33.53	33.36	33.38	33.37	33.33
	Bottom	33.52	33.57	33.71	33.87	33.83	33.84	33.61	33.45	33.41	33.27	33.37	33.39
28-m	Surface	33.43	33.44	33.53	33.68	33.79	33.75	33.61	33.53	33.43	33.40	33.36	33.34
	Bottom	33.55	33.58	33.76	33.90	33.85	33.86	33.62	33.42	33.43	33.28	33.38	33.37
38-m	Surface	33.46	33.44	33.51	33.65	33.75	33.75	33.61	33.58	33.41	33.41	33.35	33.36
	Bottom	33.65	33.60	33.83	33.93	33.87	33.88	33.65	33.51	33.43	33.30	33.43	33.39
55-m	Surface	33.43	33.45	33.51	33.60	33.72	33.73	33.60	33.55	33.45	33.45	33.38	33.38
	Bottom	33.78	33.80	33.96	33.99	33.88	34.01	33.69	33.62	33.48	33.39	33.43	33.42
Dissovled Oxygen (mg/L)													
9-m	Surface	8.3	8.5	8.0	8.8	9.2	8.8	9.0	9.2	9.0	8.1	8.1	8.0
	Bottom	7.7	7.0	6.1	5.2	7.3	5.8	6.6	8.3	8.1	7.9	7.3	7.3
19-m	Surface	8.5	8.5	8.1	9.0	9.0	9.1	9.7	9.2	9.1	8.3	8.3	8.2
	Bottom	7.0	5.9	4.5	3.4	5.3	4.4	5.7	7.9	8.4	7.7	7.4	7.3
28-m	Surface	8.7	8.4	7.8	9.2	8.6	8.4	9.6	9.0	9.2	8.3	8.5	8.0
	Bottom	6.1	5.6	4.1	3.4	4.4	3.5	5.6	7.6	7.8	7.4	7.4	7.1
38-m	Surface	8.6	8.7	8.4	9.1	8.3	7.8	9.4	8.6	8.9	8.4	8.4	8.2
	Bottom	4.9	5.1	3.4	3.3	3.5	3.3	5.2	6.7	7.7	7.3	6.5	6.6
55-m	Surface	8.7	8.6	8.7	8.9	8.1	8.0	9.2	8.0	8.4	8.3	8.3	8.1
	Bottom	3.8	4.1	2.9	2.9	3.7	3.2	4.8	5.6	6.5	6.6	6.6	6.5

Table 2.1 *continued*

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pH													
9-m	Surface	8.1	8.2	8.1	8.2	8.3	8.2	8.2	8.3	8.2	8.2	8.1	8.1
	Bottom	8.1	8.0	8.0	8.0	8.1	7.9	8.0	8.2	8.0	8.2	8.0	8.1
19-m	Surface	8.2	8.2	8.2	8.2	8.3	8.2	8.3	8.2	8.2	8.2	8.1	8.1
	Bottom	8.1	8.0	7.8	7.9	7.9	7.8	7.9	8.2	8.1	8.1	8.0	8.0
28-m	Surface	8.2	8.2	8.1	8.3	8.3	8.2	8.3	8.3	8.2	8.2	8.2	8.1
	Bottom	8.0	7.9	7.8	7.9	7.8	7.8	7.9	8.1	8.1	8.1	8.0	8.0
38-m	Surface	8.2	8.2	8.2	8.2	8.3	8.2	8.3	8.2	8.2	8.3	8.1	8.1
	Bottom	7.9	7.9	7.8	7.8	7.8	7.8	7.9	8.0	8.0	8.1	8.0	7.9
55-m	Surface	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.2	8.1	8.3	8.1	8.1
	Bottom	7.8	7.8	7.7	7.8	7.8	7.8	7.8	7.9	7.9	8.0	8.0	7.9
Transmissivity (%)													
9-m	Surface	72	58	64	76	62	63	73	73	63	80	74	70
	Bottom	60	52	64	73	67	71	76	74	73	77	67	64
19-m	Surface	80	72	74	76	71	60	76	75	63	85	82	84
	Bottom	71	74	77	82	80	80	86	82	80	83	78	71
28-m	Surface	82	82	78	77	77	66	79	78	68	87	85	82
	Bottom	79	84	85	86	84	87	89	87	85	88	81	82
38-m	Surface	81	80	79	78	76	77	82	79	71	88	86	85
	Bottom	85	84	82	88	89	88	90	89	87	89	89	87
55-m	Surface	82	83	80	82	81	79	84	88	79	89	89	90
	Bottom	85	88	88	88	90	90	90	89	89	90	90	91
Chlorophyll *a* (µg/L)													
9-m	Surface	4.8	8.5	5.5	7.3	19.9	18.8	7.5	8.5	10.4	3.8	4.7	5.5
	Bottom	7.7	7.4	6.8	23.0	14.2	11.2	9.8	13.4	10.9	6.8	6.7	5.1
19-m	Surface	3.6	4.9	3.7	7.8	7.0	19.2	5.1	4.5	8.1	2.6	2.8	4.4
	Bottom	4.9	3.2	3.1	7.0	7.9	7.3	4.0	7.8	7.4	7.5	3.0	3.2
28-m	Surface	3.8	3.1	3.4	4.9	4.4	14.5	4.6	3.3	5.5	1.9	1.8	5.6
	Bottom	3.0	1.7	1.9	2.0	5.6	3.7	2.4	5.0	4.9	5.3	2.8	2.1
38-m	Surface	3.1	3.8	3.2	4.0	5.2	7.4	1.7	2.0	5.4	1.0	1.8	3.3
	Bottom	1.2	1.5	1.1	1.4	2.6	2.9	2.1	1.9	3.7	4.7	1.1	1.2
55-m	Surface	4.8	4.1	6.1	3.8	3.8	6.4	2.4	1.3	3.7	1.3	1.6	2.0
	Bottom	0.5	0.6	0.4	1.1	1.7	0.5	1.2	1.3	1.8	1.5	1.1	1.1

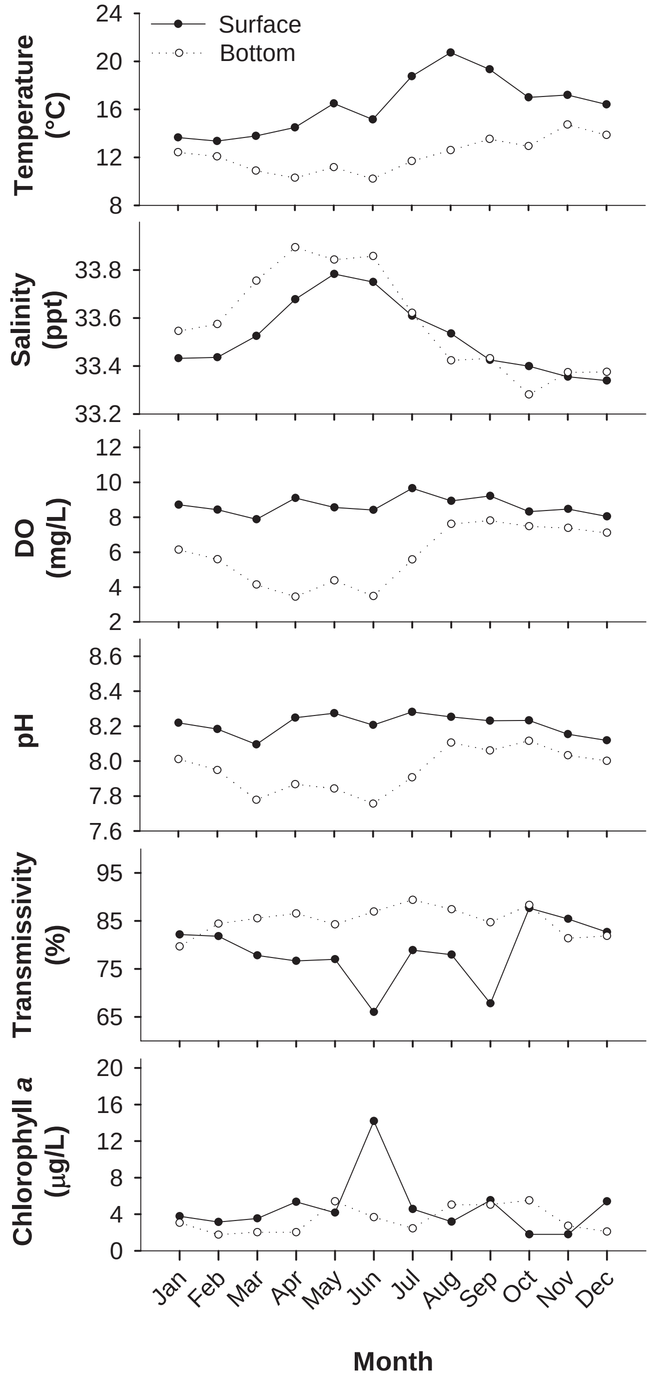


Figure 2.4

Summary of the oceanographic conditions in the South Bay region during 2008: Temperature, Salinity, Dissolved Oxygen (DO), pH, Transmissivity, and Chlorophyll *a*. Values are expressed as monthly averages at the 28-m SBOO stations pooled over surface (≤2m) and bottom (≥25m) depths.

periods mentioned above correspond to months when DMSC aerial imagery detected the near-surface signature of the SBOO wastewater plume above the terminus of the outfall's southern

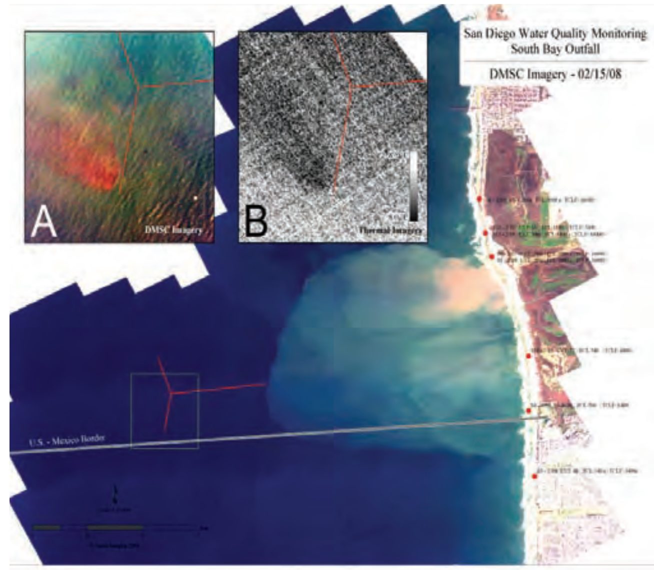


Figure 2.5

DMSC image composite of the SBOO outfall and coastal region acquired on February 15, 2008. Effluent from the south diffuser leg is seen in the inset as (A) a red plume and (B) an infrared image where darker shades of gray indicate colder water. The plume is flowing northwest.

diffuser leg (e.g., see Figure 2.5). Subsequent aerial imagery suggested that the waste field, as usual, remained deeply submerged from late April to October when the water column was stratified (see Svejkovsky 2009).

Salinity

Average salinities ranged from a low of 33.32 ppt in December to 33.84 ppt during the previous May in surface waters, and from 33.27 ppt in October to 34.01 ppt in June at bottom depths (Table 2.1). As with temperature, salinity values demonstrated no trends relative to the wastewater discharge site (Appendix A.1). Instead, salinity followed normal seasonal patterns, with values peaking between March and June, and followed by a steady decline thereafter (see Figure 2.4). The highest salinities tended to co-occur with the lowest water temperatures, which may be indicative of some upwelling in the region during the spring months.

Density

Seawater density is a product of temperature, salinity, and pressure, which in the shallower coastal waters of southern California is influenced primarily by temperature differences since salinity is relatively uniform (Bowden 1975, Jackson 1986, Pickard and Emery 1990). Therefore, changes in density typically mirror those in water temperatures. This relationship was true in the South Bay region during 2008 (Appendix A.1). The differences between surface and bottom water densities during the year resulted in a pycnocline that started in March and extended through October, with maximum density stratification occurring in August.

Dissolved Oxygen and pH
DO concentrations averaged from 7.8 to 9.7 mg/L in surface waters and from 2.9 to 8.4 mg/L in bottom waters (Table 2.1). Mean pH values ranged from 8.1 to 8.3 in surface waters and from 7.7 to 8.2 in bottom waters. Fluctuations in DO and pH levels followed normal seasonal patterns, and changes in concentrations appeared to co-vary with chlorophyll *a* concentrations indicative of seasonal plankton blooms. Changes in pH patterns were closely linked to changes in dissolved oxygen since both parameters tend to reflect the loss or gain of carbon dioxide associated with biological activity in shallow waters (Skirrow 1975). Stratification of the water column also followed normal seasonal patterns for both parameters with the greatest variations and maximum stratification occurring during the spring and early summer at the 28-m offshore stations (Figure 2.4). For DO, these low bottom water values during the spring may be due to regional upwelling as suggested by temperature and salinity data (see above). Changes in DO and pH levels relative to the wastewater discharge were not discernible.

Transmissivity
Transmissivity values were within normal ranges in the SBOO region during 2008 and there were no apparent patterns relative to wastewater discharge (Appendix A.1). Transmissivity averaged between about 51–91% over all depths during the year (Table 2.1). Additionally, water clarity was consistently greater at the offshore monitoring sites than in inshore waters, by as much as 25% at the surface and 37% at the bottom. Lower transmissivity values along the 9-m depth contour were likely due to wave and storm activity between January and March, while reductions in offshore water clarity in June co-occurred with peaks in chlorophyll *a* concentrations (i.e., phytoplankton blooms).

Chlorophyll **a**
Mean chlorophyll *a* concentrations ranged from a low of 0.4 µg/L in bottom waters at the offshore sites during March to a high of 23 µg/L at inshore bottom depths in April (Table 2.1). The highest chlorophyll concentrations occurred at the 9-m depth contour stations between April and June, which corresponded to red tides observed at these sites. These phytoplankton blooms were likely influenced by the outflow of nutrient rich waters from local rivers (see Gregorio and Pieper 2000) and/or the upwelling of nutrient rich cool waters off the Point Loma headland and their southerly flow into the South Bay region (see Roughan et al. 2005, Terrill et al. 2009). These upwelling events and the subsequent algal blooms were visible in several MODIS images captured during the year (J. Svejkovsky, personal communication). These events were also the likely cause of at least some of the declines in transmissivity and increases in DO and pH levels that occurred during the spring months (see above). The red tides observed during the spring of 2008 were not as large as in the past, and no blooms were visible during the summer months as in previous years (e.g., see City of San Diego 2007, 2008).

Historical Assessment of Oceanographic Conditions

Water column profiles of temperature, salinity, DO, pH, and transmissivity were analyzed for four representative stations (I9, I12, I22, I27) sampled during the January (winter), April (spring), July (summer), and October (fall) monthly surveys in 2008, after which they were compared to historical profiles for 1995–2007 (Figure 2.6). Only DO and pH exceeded historical conditions in the winter of 2008, with values for both being higher than the historical mean at depths of 15 m and above. In contrast, water temperatures were lower than the historical average throughout

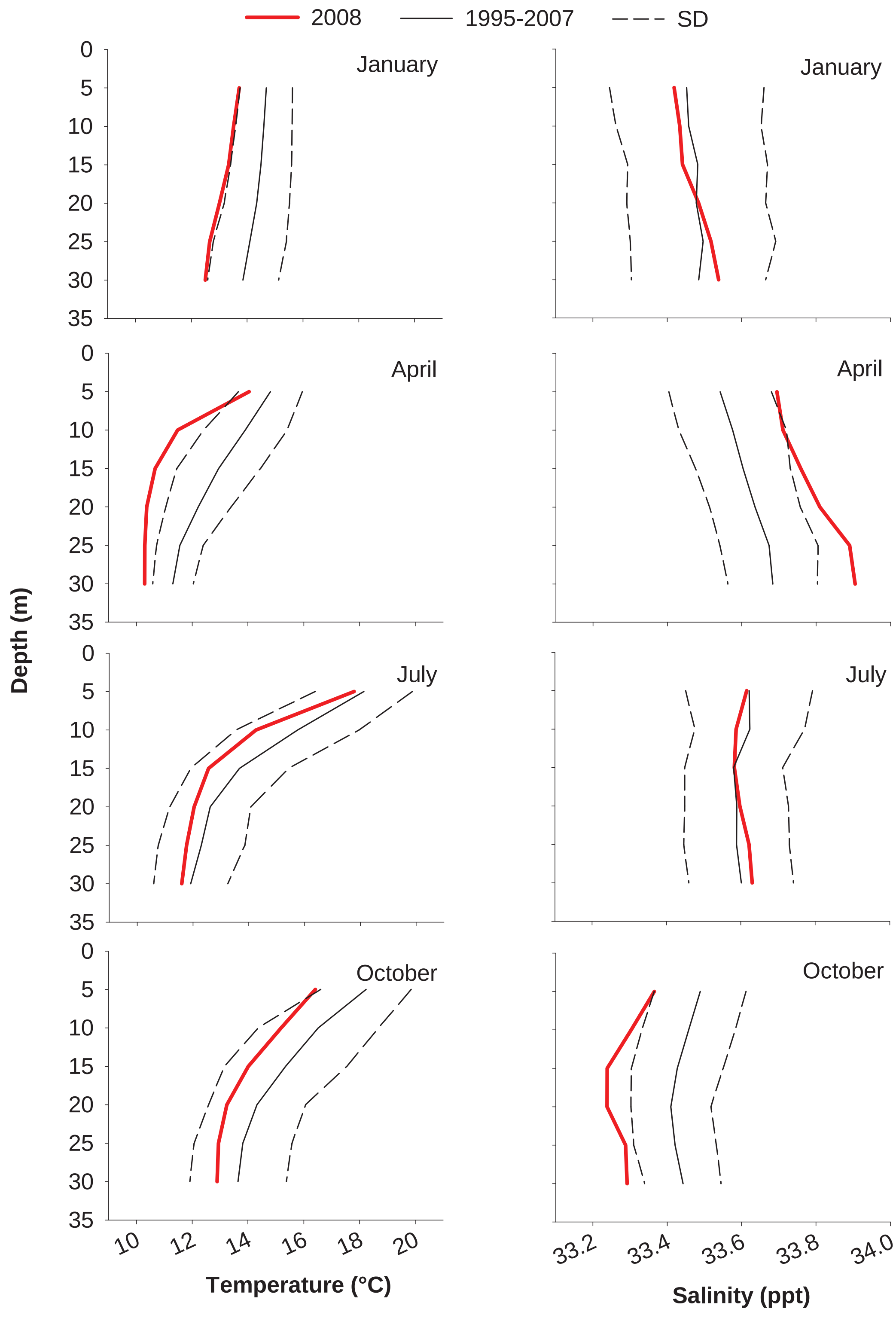


Figure 2.6
Water column temperature , salinity, dissolved oxygen, pH, and transmissivity profiles for 2008 compared to historical data for 1995–2007 at SBOO 28-m stations I9, I12, I22, and I27. Data from 2008 are monthly averages, whereas historical data represent 13-year means ± one standard deviation (SD); both are calculated for each month at 5-m depth intervals.

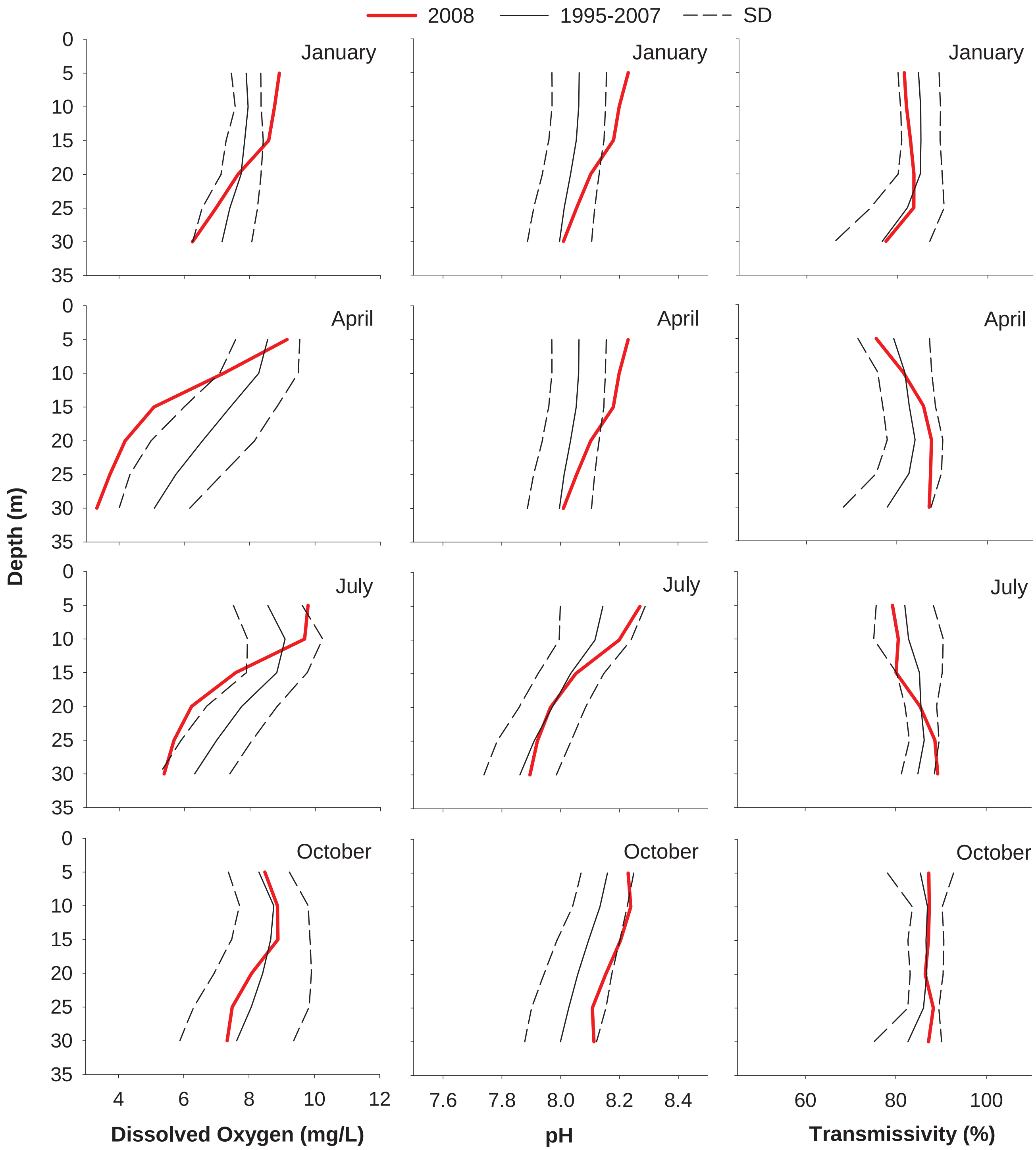


Figure 2.6 *continued*

the year. During the spring survey in April, temperature and DO were below normal at most depths, whereas salinity and pH values were higher than normal. These conditions probably reflect localized upwelling events within the region that occurred from March to June in 2008 (e.g., Svejkovsky 2009; also see previous section). During the summer, only DO values fell outside the range of historical conditions with concentrations less than normal at depths 15 m or below. Values for most parameters were within historical ranges during the fall. The only exception was for salinity, for which values were below normal at all depths.

Summary and Conclusions

The South Bay outfall region was characterized by relatively normal oceanographic conditions in 2008, which included localized upwelling and corresponding phytoplankton blooms in the spring. Upwelling events were indicated by cooler than normal water temperatures, especially at bottom depths, and higher than normal salinity from March through June. Phytoplankton blooms were indicated by high chlorophyll concentrations, which were also confirmed by aerial and satellite imagery (see Svejkovsky 2009).

No apparent relationship was observed during the year between proximity to the outfall discharge site and values of ocean temperature, salinity, pH, transmissivity, chlorophyll *a*, or dissolved oxygen. Instead, oceanographic conditions generally followed normal seasonal patterns. For example, thermal stratification followed typical patterns for the San Diego region, with maximum stratification of the water column occurring in mid-summer and reduced stratification during the winter. DMSC aerial imagery detected the signature of the wastewater plume in near-surface waters above the outfall discharge site on several occasions between January–February and November–December when the water column was well mixed. In contrast, the plume appeared to remain deeply submerged between April–October when the water column was stratified. Results from microbiology surveys further support the conclusion that the SBOO wastewater plume remained offshore and submerged during these months (see Chapter 3).

Oceanographic conditions for the SBOO region in 2008 remained notably consistent with changes in large scale patterns in the California Current System (CCS) observed by CalCOFI (Peterson et al. 2006; Goericke et al. 2007, McClatchie et al. 2008). For example, five significant events relevant to conditions in the region have affected the CCS during the last decade: (1) the 1997–1998 El Niño; (2) a dramatic shift to cold ocean conditions between 1999–2002; (3) a more subtle but persistent return to warm ocean conditions beginning in October 2002; (4) intrusion of subarctic surface waters resulting in lower than normal salinities during 2002–2003; (5) development of a moderate to strong La Niña in 2007 in conjunction with a cooling of the Pacific Decadal Oscillation (PDO). The shift in the PDO has contributed to the coldest ocean temperatures observed off the west coast since the 1950s (McClatchie et al. 2008, NOAA/Northwest Fisheries Science Center 2008, Runcie 2009). Temperature and salinity data for the South Bay region are consistent with all but the third of these CCS events; i.e., the cooler than normal conditions occurred in the region during 2005 and 2006 compared to other CCS surveys. Instead, conditions for the SBOO region during those two years were more consistent with observations from northern Baja California (Mexico) where water temperatures were below the decadal mean (Peterson et al. 2006).

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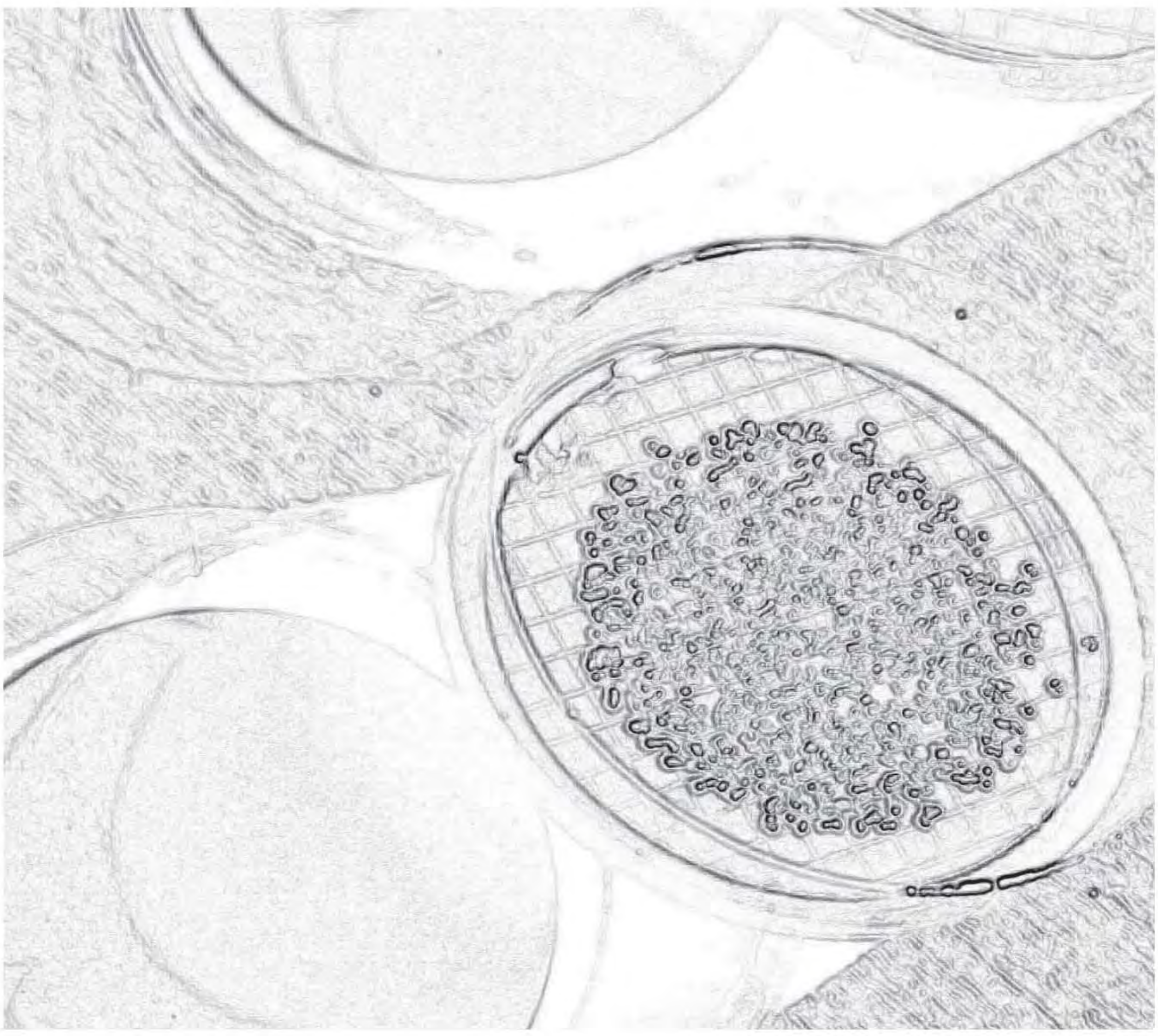
Chapter 3
Microbiology



Chapter 3. Microbiology

INTRODUCTION

The City of San Diego monitors water quality along the shoreline and in offshore ocean waters for the region surrounding the South Bay Ocean Outfall (SBOO). This aspect of the City's ocean monitoring program is designed to assess general oceanographic conditions, evaluate patterns in movement and dispersal of the SBOO wastewater plume, and monitor compliance with water contact standards defined in the 2001 California Ocean Plan (COP) as according to NPDES permit specifications (see Chapter 1). Results of all sampling and analyses, including COP compliance summaries, are submitted to the San Diego Regional Water Quality Control Board in the form of monthly receiving waters monitoring reports. Densities of fecal indicator bacteria (FIB), including total coliforms, fecal coliforms, and enterococcus, are measured and evaluated along with oceanographic data (see Chapter 2) to provide information about the movement and dispersion of wastewater discharged to the Pacific Ocean through the outfall. Analyses of these data may also help identify other point or non-point sources of bacterial contamination (e.g., outflows from rivers or bays, surface runoff from local watersheds). This chapter summarizes and interprets patterns in seawater FIB concentrations collected for the South Bay region during 2008.

Materials and Methods

Field Sampling

Seawater samples for bacteriological analyses were collected at a total of 39 NPDES-mandated shore, kelp bed, or other offshore monitoring sites during 2008 (Figure 3.1). Sampling was performed weekly at 11 shore stations to monitor FIB concentrations in waters adjacent to public beaches. Eight of these stations (S4, S5, S6, S8, S9, S10, S11, S12), located between the USA/Mexico border and Coronado, southern California, are subject to COP water contact standards (see Box 3.1). The other three shore stations (S0, S2, S3) are located in Mexican waters off northern Baja California and are not subject to COP requirements. In addition, 28 other stations were sampled in offshore waters to monitor FIB levels. These sites comprise a grid surrounding the SBOO along the 9, 19, 28, 38, and 55-m depth contours. Three of these sites (stations I25, I26, I39) are considered kelp bed stations because of their proximity to the Imperial Beach kelp bed. These three stations are subject to the COP water contact standards and are each sampled five times per month. The remaining 25 offshore stations are sampled once a month, which usually requires sampling over a 3-day period.

Seawater samples for the shore stations were collected from the surf zone in sterile 250-mL

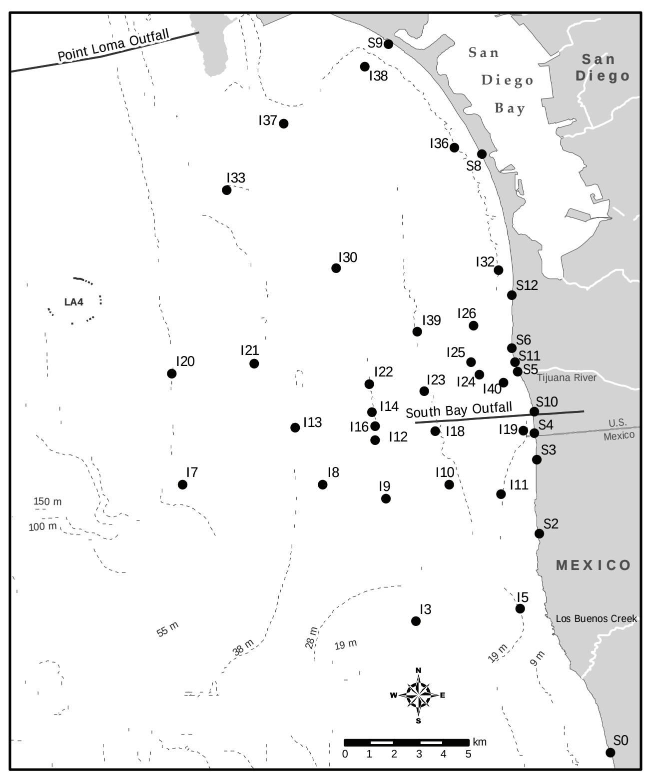


Figure 3.1
Water quality monitoring stations for the South Bay Ocean Outfall Monitoring Program.

Box 3.1

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

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

(b) *10,000 Total Coliform Standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.

(c) *60-day Fecal Coliform Standard* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.

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

bottles. In addition, visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were recorded at the time of collection. The samples were then transported on blue ice to the City of San Diego's Marine Microbiology Laboratory (CSDMML) and analyzed to determine concentrations of total coliform, fecal coliform, and enterococcus bacteria.

Seawater samples were collected at three discrete depths at each of the kelp bed and other offshore stations and analyzed for the above FIBs (i.e., total and fecal coliforms, enterococcus), total suspended solids (TSS), and oil and grease (O&G). These samples were collected using either an array of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Aliquots for each analysis were drawn into appropriate sample containers. All seawater samples were refrigerated on board ship and transported to the CSDMML for subsequent analysis. TSS and O&G samples were taken to the City's Wastewater Chemistry Laboratory for analysis. Visual observations of weather and sea conditions, and human or animal activity were also recorded at the time of sampling. Monitoring of the SBOO area and neighboring coastline also included aerial and satellite image analysis performed by Ocean Imaging of Solana Beach, California (e.g., Svejkovsky 2009; also see Chapter 2).

Laboratory Analyses and Data Treatment

All bacterial analyses were performed within 8 hours of sample collection and conformed to standard membrane filtration techniques (see APHA 1998). The CSDMML follows guidelines issued by the United States Environmental Protection Agency (EPA) Water Quality Office, Water Hygiene Division, and the California State Department of Health Services (CDHS) Environmental Laboratory Accreditation Program (ELAP) with respect to sampling and analytical procedures (Bordner et al. 1978, APHA 1998).

Procedures for counting colonies of indicator bacteria, calculation and interpretation of results, data verification and reporting all follow guidelines established by the EPA (Bordner et al. 1978) and APHA (1998). According to these guidelines, plates with FIB counts above or below the ideal counting range were given greater than (>), less than (<), or estimated (e) qualifiers. However, these qualifiers were dropped and the counts treated as discrete values during calculation of means and in determining compliance with COP standards.

Quality assurance tests were performed routinely on seawater samples to ensure that sampling variability did not exceed acceptable limits. Duplicate and split bacteriological samples were processed according to method requirements to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in City of San Diego (2009).

Bacteriological benchmarks defined in the 2001 COP and Assembly Bill 411 (AB 411) were used as reference points to distinguish elevated FIB values in receiving water samples discussed in this report. These benchmarks are: (a) >1000 CFU/100 mL for total coliforms; (b) >400 CFU/100 mL for fecal coliforms; (c) >104 CFU/100 mL for enterococcus. Data were summarized for analysis as counts of samples in which FIB concentrations exceed any of these benchmarks. Furthermore, any seawater sample with a total coliform concentration ≥1000 CFU/100 mL and a fecal:total (F:T) ratio ≥0.1 was considered representative of contaminated waters (see CDHS 2000). This condition is referred to as the fecal:total ratio (FTR) criteria herein.

Results and Discussion

Shore Stations

Concentrations of indicator bacteria were higher along the South Bay shoreline in 2008 than in 2007 (see City of San Diego 2008), which likely reflects the higher levels of rainfall that occurred during the year (i.e., 12 inches in 2008 vs. 4 inches in 2007). During 2008, monthly FIB densities averaged 7 to 16,000 CFU/100 mL for total coliforms, 2 to 8600 CFU/100 mL for fecal coliforms, and 2 to 7223 CFU/100 mL for enterococcus (Appendix B.1). As expected, the majority of samples with elevated FIBs (91 of 104 samples) and nearly all samples that exceeded the FTR criteria (53 of 54 samples) were collected during the wet season (Table 3.1), primarily during January, February, and December (Appendix B.2). In addition, a MODIS satellite image of the region taken on February 5, 2008 showed turbidity plumes from the Tijuana River and Los Buenos Creek (in Mexico) encompassing all of the SBOO shore stations, six of which had elevated total coliform concentrations >1000 CFU/100 mL on that day (Figure 3.2). These types of turbidity plumes have been observed repeatedly over the past several years following rain events (e.g., see Svejkovsky 2008, 2009).

Table 3.1
The number of samples with elevated bacteria collected at SBOO shore stations during 2008. Elevated FIB=the total number of samples with elevated FIB densities; contaminated=the total number of samples that meet the fecal:total coliform ratio criteria indicative of contaminated seawater; Wet=January–March and November–December; Dry=April–October; n=total number of samples. Rain data are from Lindbergh Field, San Diego, CA. Stations are listed north to south from top to bottom.

Station		Season: Wet	Season: Dry	Total
S9	Elevated FIB	3	—	3
	Contaminated	1	—	1
S8	Elevated FIB	4	—	4
	Contaminated	2	—	2
S12	Elevated FIB	5	—	5
	Contaminated	3	—	3
S6	Elevated FIB	10	—	10
	Contaminated	6	—	6
S11	Elevated FIB	10	—	10
	Contaminated	7	—	7
S5	Elevated FIB	13	1	14
	Contaminated	11	—	11
S10	Elevated FIB	11	—	11
	Contaminated	5	—	5
S4	Elevated FIB	9	—	9
	Contaminated	4	—	4
S3	Elevated FIB	13	3	16
	Contaminated	4	1	5
S2	Elevated FIB	7	3	10
	Contaminated	6	—	6
S0	Elevated FIB	6	6	12
	Contaminated	4	—	4
Total counts	Rain (in)	10.7	1.4	12.1
	Elevated FIB	91	13	104
	Contaminated	53	1	54
	n	242	341	583

The general relationship between rainfall, elevated FIB concentrations, and the number of contaminated samples has remained consistent since monitoring began in 1995 (Figure 3.3). This is particularly evident along the shore near the

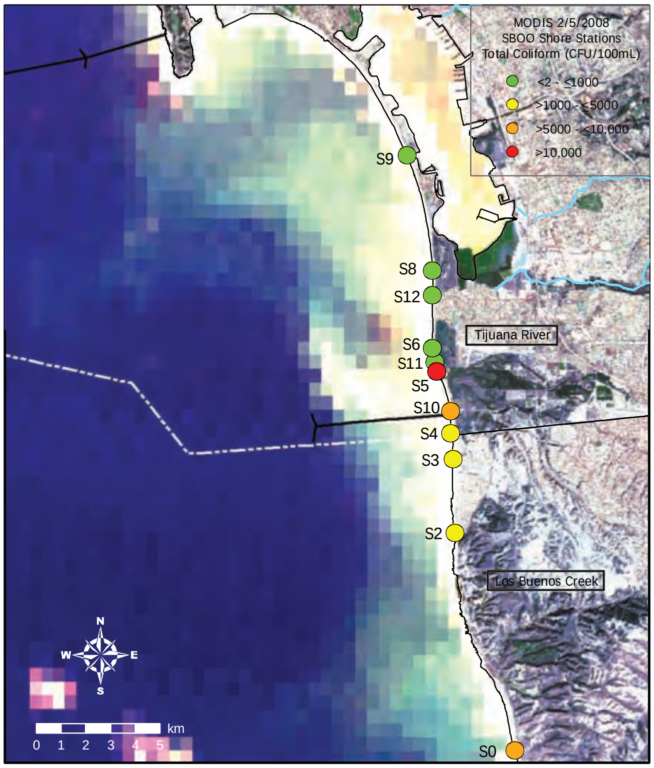


Figure 3.2

MODIS satellite image showing the SBOO monitoring region on February 5, 2008 (Svejkovsky 2009) combined with total coliform concentrations at shore stations sampled on the same day. Turbid waters from the Tijuana River and Los Buenos Creek can be seen moving northwest along the coastline, overlapping southern stations with higher levels of contamination. Waters are clear over the outfall discharge site.

Tijuana River (i.e., at stations S3–S6, S10–S11) and Los Buenos Creek (i.e. at stations S0, S2). These eight stations have historically had higher numbers of samples with elevated FIB densities than stations S8, S9, and S12 located further north (see City of San Diego 2007). Contaminated waters originating from the Tijuana River and Los Buenos Creek during periods of increased flows (e.g., during storms or extreme tidal exchanges) are likely sources of bacteria for nearby monitoring sites (see Largier et al. 2004, Terrill et al. 2009). Such contaminants may be from upstream sources, including sod farms, surface runoff not captured by the canyon collector system, the Tijuana estuary (e.g., decaying plant material), and partially treated effluent from the San Antonio de los Buenos Wastewater Treatment Plant (SABWTP) in Mexico that discharges into Los Buenos Creek.

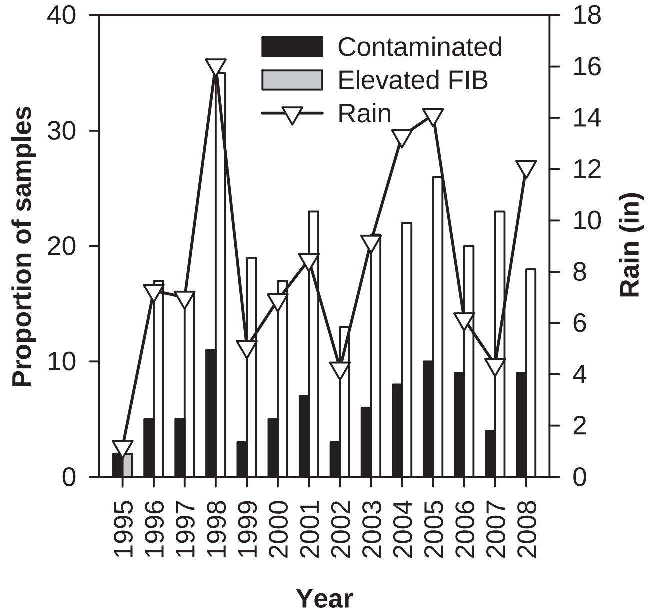


Figure 3.3

Comparison of annual rainfall to the proportion of samples with elevated FIB densities and the proportion of samples that met fecal:total coliform ratio criteria indicative of contaminated seawater (=contaminated) collected at SBOO shore stations between 1995 and 2008. Shoreline sampling began in October 1995. Rain for 1995 includes only October-December. Rain was measured at Lindbergh Field, San Diego, CA.

Shoreline bacterial contamination that occurred during periods of warmer, dry conditions between April–October tended to be limited to a few of the most southern stations (see Table 3.1). For example, 92% of the samples with elevated FIB densities that were not associated with rainfall occurred at stations S0, S2, and S3, all of which are located south of the international border. There are several potential sources of FIB contaminants near these stations, including low-flow Tijuana River water, uncontrolled residential and commercial discharge points in Mexico, and/or northward transport of SABWTP associated wastewater discharge to the ocean via Los Buenos Creek (Terrill et al. 2009).

Kelp Bed Stations

There was no evidence that the wastewater plume from the SBOO impacted any of the three kelp bed stations in 2008. Instead, elevated FIB densities at these sites corresponded to periods of heavy rainfall similar to the pattern seen along the shore. For example, all

Table 3.2

The number of samples with elevated bacteria collected at SBOO kelp stations during 2008. Elevated FIB=the total number of samples with elevated FIB densities; contaminated=the total number of samples that meet the fecal:total coliform ratio criteria indicative of contaminated seawater; Wet=January–March and November–December; Dry=April–October; n=total number of samples. Rain data are from Lindbergh Field, San Diego, CA.

Station			Season		
			Wet	Dry	Total
I25	2 m	Elevated FIB	6	—	6
		Contaminated	2	—	2
	6 m	Elevated FIB	7	—	7
		Contaminated	3	—	3
	9 m	Elevated FIB	6	—	6
		Contaminated	2	—	2
I26	2 m	Elevated FIB	4	—	4
		Contaminated	1	—	1
	6 m	Elevated FIB	5	—	5
		Contaminated	2	—	2
	9 m	Elevated FIB	4	—	4
		Contaminated	2	—	2
I39	2 m	Elevated FIB	2	—	2
		Contaminated	2	—	2
	12 m	Elevated FIB	1	—	1
		Contaminated	—	—	—
	18 m	Elevated FIB	1	—	1
		Contaminated	1	—	1
Total counts		Rain (in)	10.7	1.4	12.1
		Elevated FIB	36	—	36
		Contaminated	15	—	15
		n	180	252	432

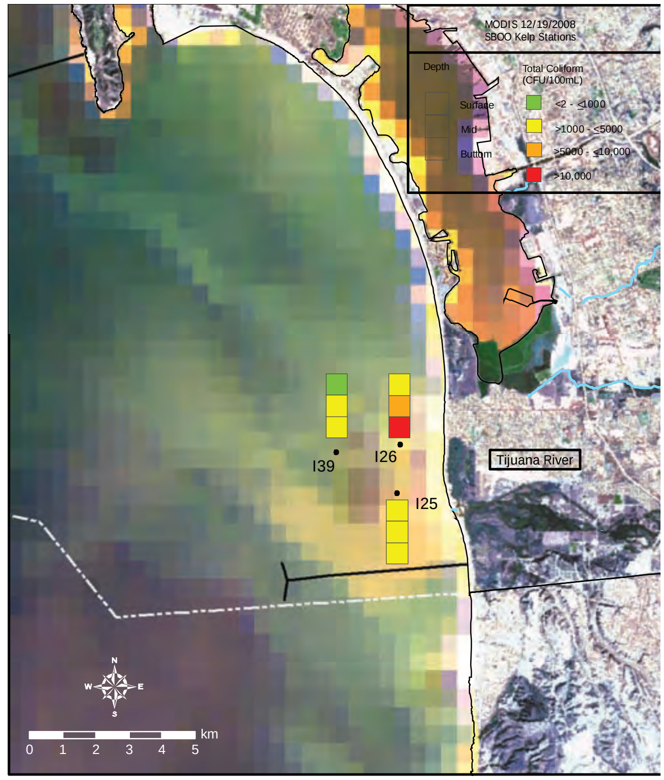


Figure 3.4

MODIS satellite image showing the SBOO monitoring region on December 19, 2008 (Svejkovsky 2009) combined with total coliform concentrations at kelp stations sampled on the same day at each depth. Turbid waters from the Tijuana River and Los Buenos Creek can be seen moving northwest along the coastline overlapping the kelp bed stations. Waters are relatively clear over the outfall discharge site.

samples with elevated FIBs and that met the FTR criteria at the kelp stations occurred during the wet season (Table 3.2). Furthermore, MODIS satellite imaging for December 19, 2009 indicated a rain-influenced turbidity plume moving northeast from the Tijuana River and encompassing all three of the kelp bed stations (Figure 3.4). Elevated total coliforms occurred in all but one of the seawater samples collected on this day at these three sites. Most of the elevated FIBs reported at the kelp bed stations comprised total coliform bacteria (i.e., 26 of 36 samples); 14 of these 26 samples also had elevated fecal coliforms (Appendix B.3). Less than half of the samples with elevated FIB concentrations exceeded the FTR criteria. Densities of enterococcus bacteria were elevated in 28 samples, 10 of which did not co-occur with elevated total or fecal coliforms.

Total suspended solids (TSS) and oil and grease (O&G) are also measured at the kelp bed stations as potential indicators of wastewater. However, previous analyses have demonstrated that these parameters have limited utility as indicators of the waste field (City of San Diego 2007). TSS varied considerably during 2008, ranging between 1.7 and 27.5 mg/L per sample (Table 3.3), while O&G was not detected in any samples. Of the 20 seawater samples with elevated TSS concentrations (≥8.0 mg/L), only two corresponded to samples with elevated FIBs. In contrast, nine of these high TSS samples occurred at bottom depths; these

Table 3.3

Summary of total suspended solid (TSS) concentrations in samples collected from kelp bed stations in 2008. The method detection limit is 1.6 mg/L for TSS; n=number of samples with detected concentrations.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Suspended Solids												
n	9	9	9	9	9	9	9	9	9	9	9	9
Min	3.2	4.2	3.5	5.1	4.5	3.1	4.2	3.8	4.3	3.3	3.4	1.7
Max	27.5	15.0	7.8	9.1	11.0	15.8	6.7	7.9	10.6	6.5	25.5	12.5
Mean	7.5	8.2	5.4	6.6	7.7	7.2	5.3	5.3	6.4	5.0	8.4	5.3

high counts were likely due to the re-suspension of bottom sediments when the CTD reached (touched) the sea floor. The remaining 11 high TSS values were found in surface-water and mid-water samples, and were most likely associated with phytoplankton blooms (see Chapter 2).

Offshore Stations

Elevated FIB concentrations were rare in samples collected from the 25 non-kelp bed offshore stations during 2008. Only 39 of 900 samples (~4.3%) collected at these sites had elevated FIBs and only 15 (~1.7%) met the FTR criteria for contaminated waters (Table 3.4, Appendix B.4). Most samples with elevated FIB levels were collected during the wet season at stations located along the 9 and 19-m depth contours (i.e., stations I11, I19, I23, I24, I32, I40). As with the shore and kelp bed stations, evidence from MODIS satellite imaging suggests that the nearshore region is being affected by contaminants (turbidity plumes) originating from the Tijuana River and Los Buenos Creek. For example, a MODIS image taken January 16, 2008 showed a turbidity plume associated with increased rainfall moving northwest and encompassing stations I19 and I40 (Figure 3.5). Samples collected that day at these two stations had elevated total coliform densities, whereas samples collected at stations located farther offshore (i.e., I12, I14, I16, I22, I23, I24) had low FIB levels. In contrast, only seven samples with elevated FIBs were collected during the dry season at non-outfall stations. These included one sample each from stations I9 and I10 located south of the outfall along the 28-m and 19-m depth contours, respectively, and five samples from station I5 located along the 19-m contour in Mexican waters. Elevated FIB levels at I5 during the current and previous years (e.g., see City of San Diego 2007) are likely related to contaminated outflows from the nearby Los Buenos Creek.

Only eight of the above samples with elevated FIB densities were collected adjacent to the SBOO diffusers (i.e., stations I12, I14, I16) during 2008 (Table 3.4), all of which were collected from a depth of 18 m. Most of these samples also met the FTR

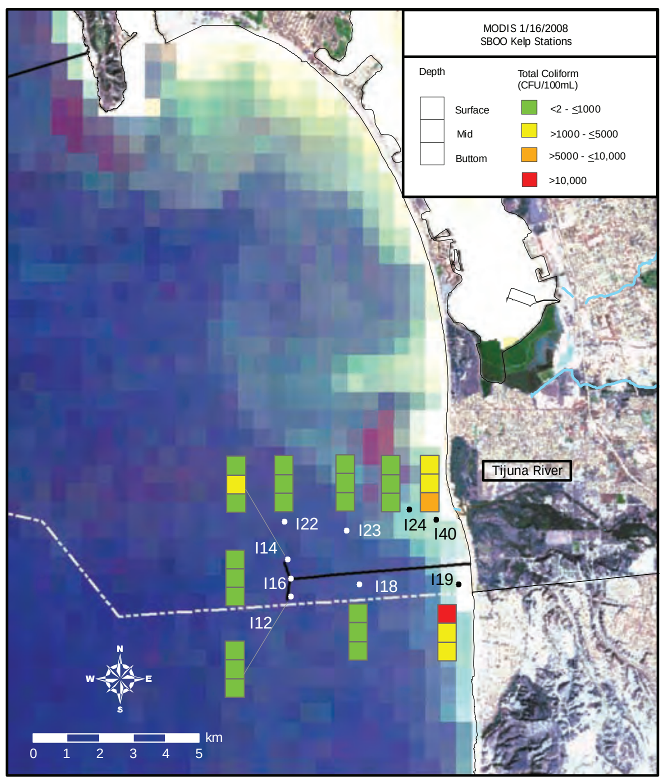


Figure 3.5
MODIS satellite image showing the San Diego monitoring region on January 16, 2008 (Svejkovsky 2009) combined with total coliform concentrations at offshore stations sampled on the same day. Turbid waters from the Tijuana River and Los Buenos Creek can be seen moving north along the coastline and overlapping stations where contamination was high nearshore. Waters are clear over the outfall discharge site.

Table 3.4

The number of samples with elevated bacteria collected at SBOO offshore stations during 2008. Elevated FIB=the total number of samples with elevated FIB densities; contaminated=the total number of samples that meet the fecal:total coliform ratio criteria indicative of contaminated seawater; Wet=January–March and November–December; Dry=April–October; n=total number of samples. Rain data are from Lindbergh Field, San Diego, CA. Offshore stations not listed had no samples with elevated FIB concentrations.

Station		Season: Wet	Season: Dry	Total
9-m Depth Contour				
I19	Elevated FIB	7	—	7
	Contaminated	2	—	2
I11	Elevated FIB	1	—	1
	Contaminated	1	—	1
I24	Elevated FIB	4	—	4
	Contaminated	—	—	—
I32	Elevated FIB	2	—	2
	Contaminated	—	—	0
I40	Elevated FIB	6	—	6
	Contaminated	4	—	4
19-m Depth Contour				
I5	Elevated FIB	—	5	5
	Contaminated	—	—	—
I10	Elevated FIB	—	1	1
	Contaminated	—	—	—
I23	Elevated FIB	3	—	3
	Contaminated	2	—	2
28-m Depth Contour				
I22	Elevated FIB	1	—	1
	Contaminated	—	—	—
I12	Elevated FIB	1	2	3
	Contaminated	—	2	2
I14	Elevated FIB	1	1	2
	Contaminated	—	1	1
I16	Elevated FIB	1	2	3
	Contaminated	1	2	3
I9	Elevated FIB	—	1	1
	Contaminated	—	—	—
	Rain (in)	10.7	1.4	12.1
Total counts	Elevated FIB	27	12	39
	Contaminated	10	5	15
	n	375	525	900

criteria for contaminated waters (Appendix B.4). Consequently, it appears likely that these FIB densities were associated with wastewater discharge from the outfall. No samples with elevated bacteria were collected in surface or near-surface waters during the year, despite the fact that aerial imagery results indicated that the wastewater plume reached near-surface waters above the discharge site on several occasions between January–April and November–December (see Svejkovsky 2009). The low incidence of contaminated waters during winter at the surface and at depth may be due to chlorination of IWTP effluent, which typically occurs between November and April each year. The lack of elevated bacteria levels in surface waters during the summer is expected, as those are the months when the water column is well stratified and the waste field remains trapped beneath the thermocline.

California Ocean Plan Compliance

Compliance with the 2001 COP water contact standards for samples collected from January through December 2008 at the SBOO shore stations located north of the USA/Mexico border and at the three offshore kelp bed stations is summarized in Appendix B.5. Overall, compliance was a little lower this year than during 2007 (see City of San Diego 2008), which was likely related to the higher rainfall during 2008 and subsequent trends in FIB concentrations. During 2008, compliance along the shore ranged from 61 to 97% for the 30-day total coliform standard, 55 to 96% for the 60-day fecal coliform standard, and 79 to 100% for the 30-day fecal geometric mean standard. In addition, the shore station samples were out of compliance with the 10,000 total coliform standard 20 times during the year. Differences in compliance rates during the year generally reflected trends in elevated bacteria; i.e., compliance was lowest between January–March and November–December when rainfall was greatest, especially at stations closest to the Tijuana River (i.e., S5, S6, S11) and to the south (i.e., SD4, SD10) (see previous discussion).

Compliance rates for samples collected at the three kelp bed stations tended to be higher than

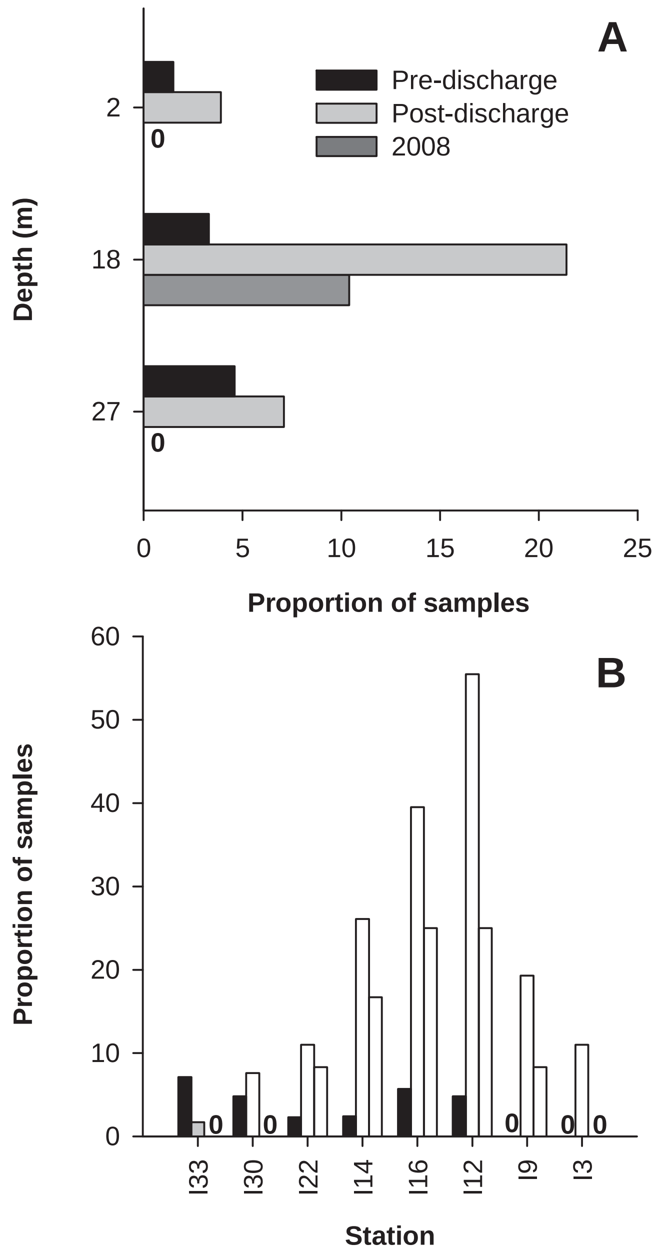


Figure 3.6
Summary of the proportion of samples with elevated FIB densities at SBOO offshore stations along the 28-m depth contour sampled in 2008 (n=288) versus pre-discharge (1995–1998; n=981) and post-discharge periods (1999–2007; n=2856) by depth (A) and by station (B) at the 18-m sample depth.

at the shore stations, which reflects the lower levels of FIBs found in these samples. Compliance at these sites during 2008 ranged from 88 to 100% for the 30-day total coliform standard, 79 to 100% for the 60-day fecal coliform standard, and 100% for the 30-day fecal geometric mean standard. In addition, the kelp bed stations were never out of compliance with the 10,000 total coliform standard. As with the shore stations, the lowest compliance rates tended to occur during months with the most rain (e.g., winter, spring) at station I25 located nearest the Tijuana River.

Summary and Conclusions

There was no evidence that contaminated waters associated with the wastewater discharged to the ocean via the SBOO reached the shoreline or near-shore recreational waters in 2008. Although elevated FIB densities were detected along the shore, and occasionally at the kelp bed or other nearshore stations throughout the year, these data do not represent shoreward transport of the SBOO wastewater plume. Instead, analysis of FIB distributions and the results of satellite imagery data indicate that other sources such as outflows from the Tijuana River and Los Buenos Creek, as well as surface runoff associated with rainfall events are more likely to impact water quality along and near the shore in the South Bay region. For example, the shore stations located near the Tijuana River and Los Buenos Creek have historically had higher numbers of contaminated samples than stations located farther to the north. Further, long-term analyses of various water quality parameters have demonstrated that the general relationship between rainfall and elevated FIB levels has remained consistent since ocean monitoring began in 1995, including the period prior to wastewater discharge (e.g., see City of San Diego 2000).

During 2008, the majority of elevated FIB densities not associated with rainfall events occurred at several offshore monitoring sites located within 1000 m of the SBOO diffuser and at a depth of 18 m. Additionally, no elevated FIBs were collected near or at the surface during the year, although remote sensing observations did detect the signature of the wastewater plume in near-surface waters over the discharge site on several occasions during the winter months. As discussed in the previous section, the lack of coincident contaminated waters at these times was most likely due to chlorination of

Table 3.5

Summary of oil and grease (O&G) and total suspended solid (TSS) concentrations in samples collected from offshore stations in 2008. The method detection limits are 1.4 mg/L for O&G and 1.6 mg/L for TSS; n=number of samples with detected concentrations.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oil & Grease												
n	0	0	2	0	0	1	0	0	0	0	0	2
Min	—	—	1.8	—	—	2.5	—	—	—	—	—	1.6
Max	—	—	5.0	—	—	2.5	—	—	—	—	—	1.7
Mean	—	—	3.4	—	—	2.5	—	—	—	—	—	1.7
Total Suspended Soilds												
n	78	82	84	83	83	83	84	81	84	81	83	59
Min	1.7	1.8	1.8	1.8	1.7	1.7	1.7	1.8	2.3	1.7	1.7	1.6
Max	31.5	14.3	17.6	15.0	14.7	18.1	16.0	15.1	19.1	17.6	14.4	36.6
Mean	4.4	4.9	5.3	5.4	6.3	5.8	5.4	5.2	6.1	4.7	6.0	4.0

IWTP effluent that occurs during the winter. In contrast, the lack of contaminated surface waters during the summer is expected due to waste field entrapment beneath the thermocline.

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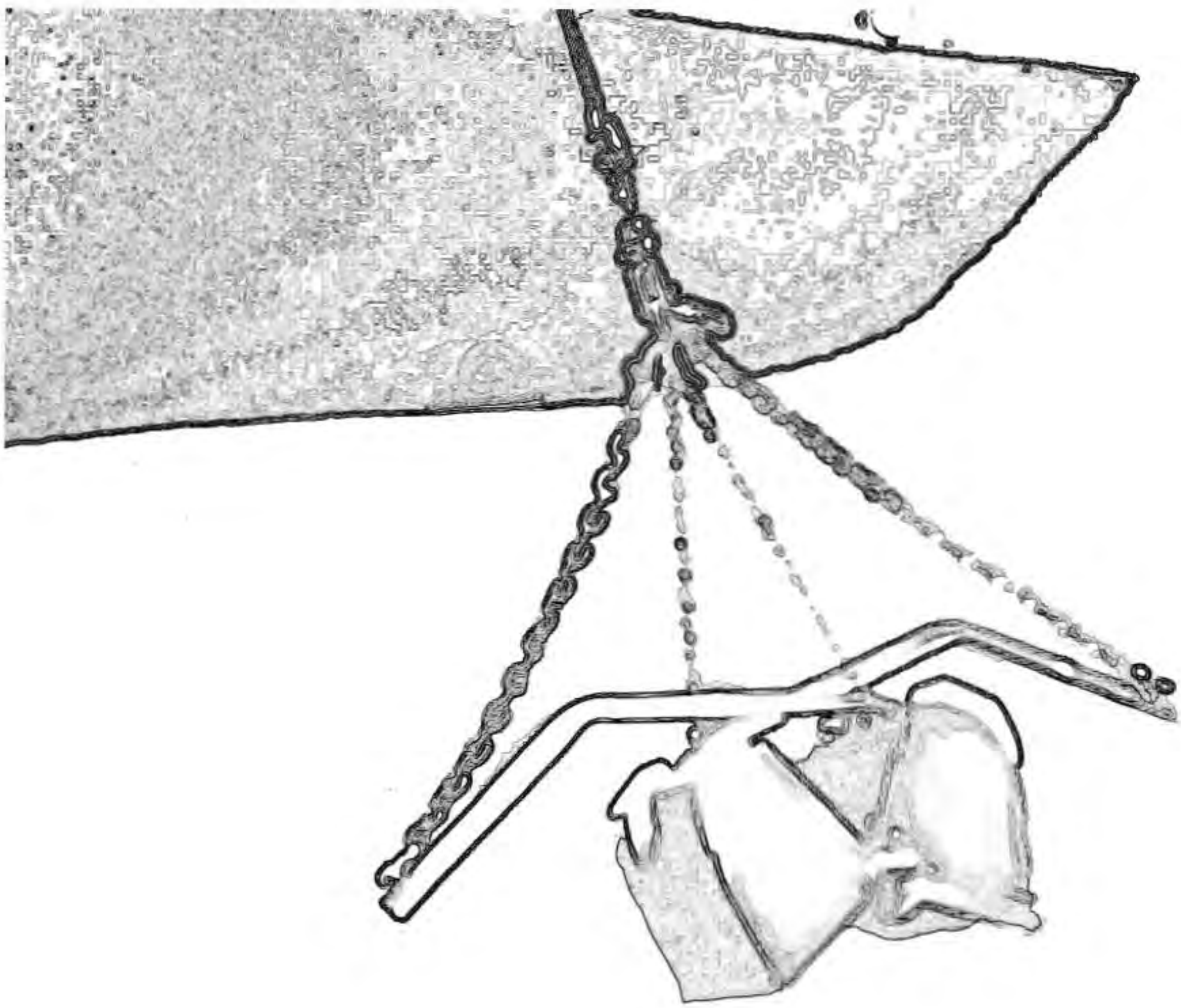
Chapter 4
Sediment Characteristics



Chapter 4. Sediment Characteristics

INTRODUCTION

Ocean sediment samples are collected and analyzed as part of the South Bay Ocean Outfall (SBOO) monitoring program to characterize the surrounding physical environment and assess general sediment conditions. These conditions define the primary habitat for benthic invertebrates that live within or on the surface of sediments and can influence their presence and distribution. In addition, many species of demersal fish are associated with specific sediment types that reflect the habitats of their preferred prey (Cross and Allen 1993). Both natural and anthropogenic factors affect the composition, distribution, and stability of seafloor sediments.

Natural factors that affect sediment conditions on the continental shelf include the strength and direction of bottom currents, exposure to wave action, seafloor topography, inputs associated with outflows from rivers and bays, beach erosion, runoff from other terrestrial sources, and decomposition of calcareous organisms (e.g., Emery 1960). The analysis of parameters such as sediment grain size and the relative percentages of different sediment fractions (e.g., sand, silt, and clay) can provide useful information about current velocity, amount of wave action, and overall habitat stability in an area. Further, understanding sediment particle size distributions facilitates interpretation of the interactions between benthic organisms and the environment. For example, differences in sediment composition (e.g., fine vs. coarse particles) and associated levels of organic loading at a site can affect the burrowing, tube building, and feeding abilities of infaunal invertebrates, thus affecting benthic community structure (Gray 1981, Snelgrove and Butman 1994). Geological history can also affect the chemical composition of local sediments. For example, erosion from coastal cliffs and shores, and flushing of terrestrial sediments and debris from bays, rivers, and streams can contribute to the deposition and accumulation of metals or other contaminants and also affect the overall organic content of sediments. Additionally, primary productivity by phytoplankton is a major source of organics to these sediments (Mann 1982, Parsons et al. 1990). Finally, particle size composition can affect concentrations of chemical constituents within sediments. For example, levels of organic compounds and trace metals within ocean sediments generally rise with increasing amounts of fine particles (Emery 1960, Eganhouse and Venkatesan 1993).

Municipal wastewater outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of sediments through the discharge of treated effluent and the subsequent deposition of a wide variety of organic and inorganic compounds. Some of the most commonly detected compounds discharged via ocean outfalls are trace metals, pesticides, and various organic compounds such as organic carbon, nitrogen, and sulfides (Anderson et al. 1993). Moreover, the presence of large outfall pipes and associated ballast materials (e.g., rock, sand) may alter the hydrodynamic regime in surrounding areas.

This chapter presents summaries and analyses of sediment particle size and chemistry data collected during 2008 at monitoring sites surrounding the SBOO. The primary goals are to: (1) assess possible effects of wastewater discharge on benthic habitats by analyzing spatial and temporal variability of various sediment parameters, (2) determine the presence or absence of sedimentary and chemical footprints near the discharge site, and (3) evaluate overall sediment quality in the region.

Materials and Methods

Field Sampling

Sediment samples were collected at 27 benthic stations in the SBOO region during January and July 2008 (Figure 4.1). These stations range in depth from 18 to 60 m distributed along or adjacent

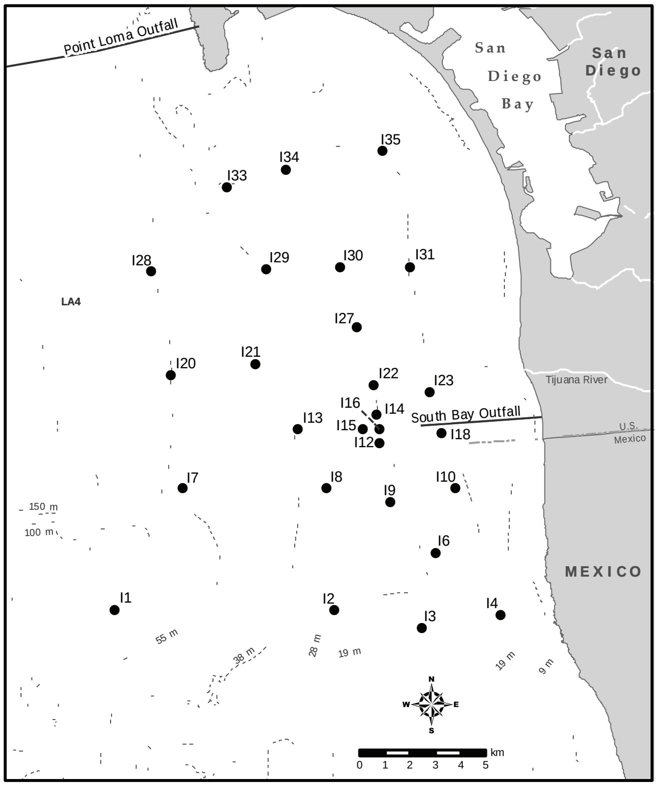


Figure 4.1
Benthic station locations where sediments are sampled for the South Bay Ocean Outfall Monitoring Program.

to four main depth contours. Each sediment sample was collected from one side of a chain-rigged double Van Veen grab with a 0.1-m^2 surface area; the other grab sample from the cast was used for macrofaunal community analysis and visual observations of sediment composition (see Chapter 5). Sub-samples for various analyses were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

Laboratory Analyses

All sediment chemistry and particle size analyses were performed at the City of San Diego's Wastewater Chemistry Services Laboratory. Particle size analysis was performed using a Horiba LA-920 laser scattering particle analyzer, which measures particles ranging in size from 0.00049 to 2.0 mm (i.e., 11 to -1 phi). Coarser sediments (e.g., coarse sand, gravel, shell hash) were removed prior to analysis by screening the samples through a 2.0-mm mesh sieve. These data were expressed as "% coarse" of the total sample sieved. Output from the Horiba particle size analyzer was categorized into sand, silt, and clay fractions as follows: sand was defined as particles ranging between 2.0 and >0.0625 mm in diameter, silt as particles between 0.0625 and 0.0039 mm, and clay as particles <0.0039 mm. These data were standardized and combined with any sieved coarse fraction (i.e., particles >2.0 mm) to obtain a distribution of coarse, sand, silt, and clay fractions totaling 100%. The coarse fraction was included with the 2.0 mm fraction in the calculation of various particle size parameters, which were determined using a normal probability scale (see Folk 1968). These parameters were summarized and expressed as overall mean particle size (mm), phi size (mean, median, skewness, kurtosis), and the proportion of coarse, sand, silt, and clay. The proportion of fine particles (% fines) was calculated as the sum of all silt and clay fractions.

Sediment samples were analyzed on a dry weight basis for total organic carbon (TOC), total nitrogen (TN), total sulfides, trace metals, chlorinated pesticides (e.g., DDT), polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (Appendix C.1). TOC and TN were measured as percent weight (% wt) of the sediment sample; sulfides and metals were measured in units of mg/kg and are expressed in this report as parts per million (ppm); pesticides and PCBs were measured in units of ng/kg and expressed as parts per trillion (ppt); PAHs were measured in units of μg/kg and expressed as parts per billion (ppb). The data reported herein were generally limited to values above the method detection limit (MDL). However, concentrations below MDLs were included as estimated values if the presence of the specific constituent was verified by mass-spectrometry (i.e., spectral peaks confirmed). A detailed description of the analytical protocols is available in City of San Diego (2009).

Data Analyses

Values for total PAH, total DDT, and total PCB were calculated for each sample as the sum of all constituents with reported values. Values for each individual constituent are listed in Appendix C.2. Zeroes were substituted for all non-detects (i.e., null values) when calculating means and medians.

Summaries of parameters included detection rates (i.e., number of reported values/number of samples), annual means by station, annual means for all stations combined (areal mean), and maximum value during the year. Statistical analyses included correlation analyses of all sediment chemistry parameters with percent fine materials, transformed to meet assumptions of the test. Residuals were also inspected for normality after analysis.

Historical analyses included comparisons between annual mean and maximum values for 2008 to those from the pre-discharge period (1995–1998). In addition, data from stations closest to the outfall (nearfield) were compared to all other stations (farfield) over the pre- and post-discharge periods. Stations considered "nearfield" (I12, I14, I15, I16) are located within 1000 m of the outfall wye. Levels of contamination were further evaluated by comparing data for this study to the Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines of Long et al. (1995) when available. The National Status and Trends Program of the National Oceanic and Atmospheric Administration (NOAA) originally calculated the ERLs and ERMs to provide a means for interpreting monitoring data. The ERLs are considered to represent chemical concentrations below which adverse biological effects are rarely observed. Values above the ERL but below the ERM represent values at which effects occasionally occur. Concentrations above the ERM indicate likely biological effects, though these are not always validated by toxicity testing (Schiff and Gossett 1998).

Results and Discussion

Particle Size Distribution

Sediment particle composition was diverse at benthic sites sampled around the SBOO in 2008. Mean particle sizes ranged from about 0.06 to 0.98 mm (Appendix C.3). With few exceptions, there was little difference in intra-station particle size composition between the winter and summer surveys (Appendix C.3), and there was no clear relationship with proximity to the outfall during the

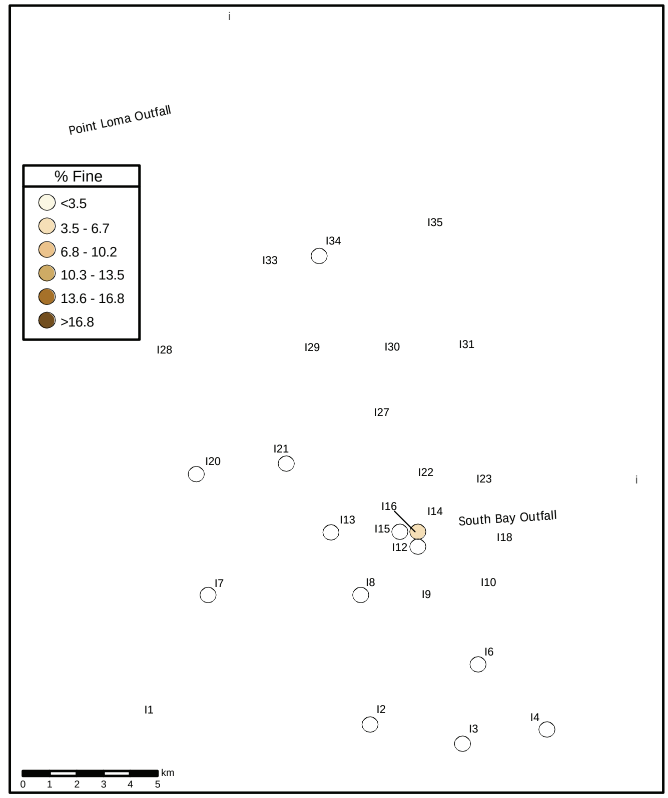


Figure 4.2
Particle size distribution for SBOO benthic stations sampled in 2008. Data are annual means per station (n=2).

year (Figure 4.2). Overall, sediment composition has been highly variable throughout the region since sampling began in 1995, with no significant changes being apparent since wastewater discharge began in early 1999 (Figure 4.3). Instead, intra-station variability near the outfall and at other monitoring sites was most likely attributable to the different sediment types that occur throughout the region. For example, the average percent fines component (i.e., silt and clay combined) ranged from 0 to 43% across all stations in 2008 alone (Table 4.1), with higher values tending to occur in sediments at stations north of the outfall (Figure 4.3). Many sites in the region were also characterized by the presence of different types of coarse sediments, including red relict sands (e.g., stations I6, I7, I20, I21), black sands (e.g., station I28), and shell hash (e.g., stations I4, I13, I23, I33, I34) (see Appendix C.3).

The sorting coefficient reflects the range of particle sizes comprising sediments and is calculated as the standard deviation (SD) in phi size units. In general, areas composed of particles

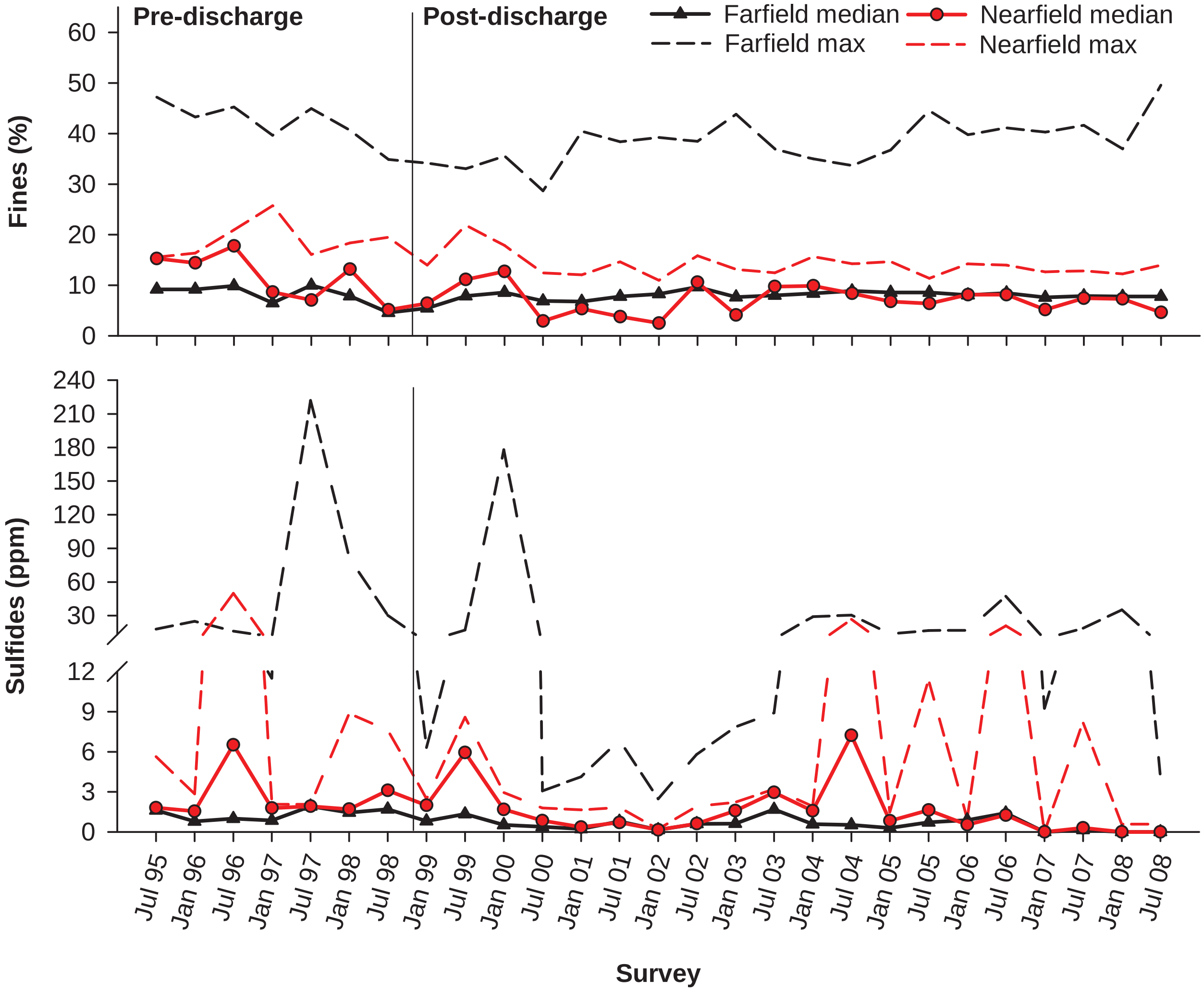


Figure 4.3

Summary of particle size and organic indicator data surrounding the SBOO from between 1995–2008: Percent fines (Fines); Sulfides; Total Nitrogen (TN); Total Organic Carbon (TOC). Data are expressed as median and maximum values pooled over all farfield (n≤23) and nearfield (n≤4) stations; % wt=percent weight. Reference line represents onset of discharge from the SBOO. Note that the y-axis scale differs across a break.

of similar size are considered to have well-sorted sediments (i.e., SD≤0.5 phi) and are indicative of areas subject to fast moving currents or large disturbances (e.g., storm surge, rapid suspension/deposition of materials) (Folk 1968). In contrast, samples with particles of varied sizes are characteristic of poorly sorted sediments (i.e., SD≥1.0 phi). Sediments collected throughout the South Bay region, including at stations near the outfall, tended to be moderately well to poorly sorted, with sorting coefficients ranging from 0.6 to 1.7 on average (Table 4.1). Poorly sorted sediments (i.e., SD≥1.0 phi on average) were present at stations I7, I8, I12, I15, I22, I23, I28, I33, and I35. Of these, station I28 located along the 55-m depth contour, and stations I23 and I35 located along the 19-m depth contour, had the highest mean sorting coefficients of 1.2–1.7 phi. The sorting coefficients for these stations have been >1.0 off and on over the years (e.g., City of San Diego 2006, 2007, 2008).

Indicators of Organic Loading

Sulfides, total organic carbon (TOC) and total nitrogen (TN) are quantified in sediments as measures of potential organic loading in the region from the SBOO discharge. Organic materials may become deposited in marine sediments also via natural sources, including the result of primary productivity,

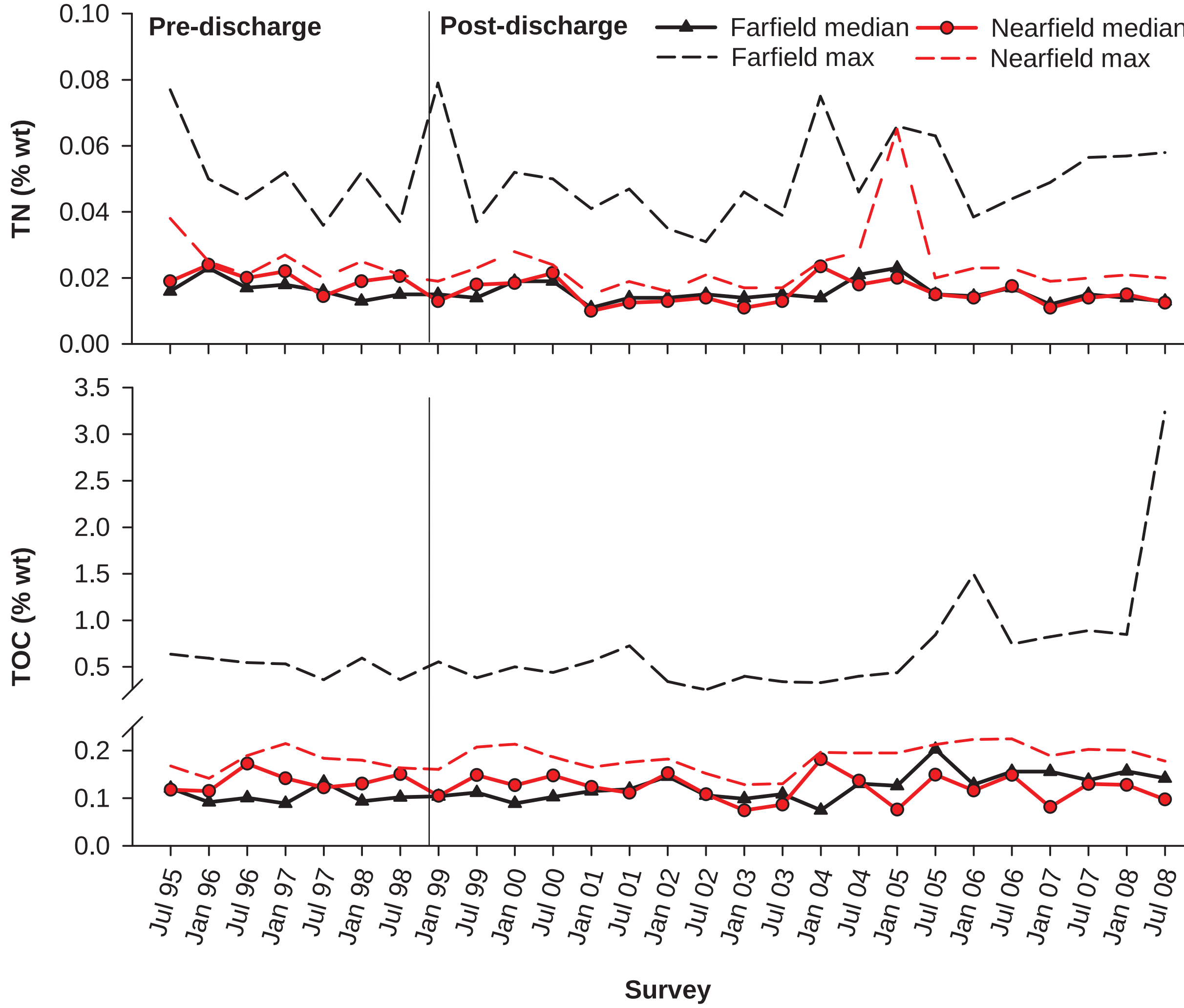


Figure 4.3 *continued*

breakdown of detrital materials, and outflows from rivers (Eganhouse and Venkatesan 1993). Organic enrichment is of concern because it may disrupt ecological processes and impair habitat quality for macrobenthic marine organisms. For example, sulfides, which are the byproducts of anaerobic bacterial breakdown of organic matter, may be toxic to benthic marine organisms if the sediments become excessively enriched (Gray 1981). Nitrogen is typically limiting in marine systems, and when enriched can lead to sudden phytoplankton "blooms" in coastal waters. After such blooms occur, a flux of organic material is again deposited in the sediment as the phytoplankton die and settle to the seafloor.

Generally, the distribution of organic indicators in SBOO sediments during 2008 was similar to that found prior to discharge (City of San Diego 2000) and did not appear to be influenced by wastewater discharge in the region. Detection rates were relatively high for TOC and TN (≥80%) and relatively low for sulfides (35%), with highly variable concentrations (Table 4.1, Appendix C.4). TOC ranged from 0.044 to 1.7 % wt per station on average, whereas TN ranged from 0.004 to 0.057 % wt and sulfides ranged from 0.04 to 18.54 ppm. Concentrations of all three indicators at stations nearest the discharge site (e.g., stations I12, I14, I15, I16) were within the range of values reported elsewhere in the region. For example, the highest concentrations of sulfides occurred in sediments from some of the stations to the north of the SBOO (i.e., I30, I33, I35). None of these indicators demonstrated noticeable changes near the outfall that appear to be coincident with

Table 4.1

Summary of particle size parameters and organic loading indicators at SBOO benthic stations during 2008. Data are annual means per station (n=2); nearfield stations are in bold; nd=not detected; SD=standard deviation; Pre-discharge period=1995–1998.

	Particle Size					Organic Indicators		
	Mean (phi)	SD (phi)	Coarse (%)	Sand (%)	Fines (%)	Sulfides (ppm)	TN (% wt)	TOC (% wt)
19 m stations								
I35	3.7	1.2	0.0	66.5	33.5	18.54	0.032	0.249
I34	1.0	0.9	26.6	73.2	0.2	0.28	0.004	0.161
I31	3.1	0.7	0.0	92.3	7.6	0.72	0.012	0.096
I23	2.2	1.3	15.4	71.7	13.0	0.50	0.025	1.698
I18	3.1	0.6	0.0	91.1	8.9	0.60	0.014	0.118
I10	3.1	0.7	0.3	90.0	9.6	0.24	0.013	0.122
I4	0.8	0.7	9.2	90.8	0.0	nd	nd	0.063
28 m stations								
I33	3.1	1.0	0.0	85.4	14.5	1.04	0.023	0.440
I30	3.4	0.8	0.0	83.4	16.6	2.24	0.022	0.201
I27	3.3	0.7	0.0	86.2	13.8	nd	0.016	0.155
I22	2.8	1.0	0.0	89.3	10.7	nd	0.021	0.173
I16	**2.3**	**0.9**	**1.0**	**94.1**	**4.9**	**0.29**	**0.007**	**0.094**
I15	**2.0**	**1.0**	**2.4**	**91.3**	**6.3**	**nd**	**0.006**	**0.099**
I14	**3.2**	**0.8**	**0.0**	**86.8**	**13.2**	**0.30**	**0.020**	**0.189**
I12	**2.2**	**1.0**	**2.0**	**92.8**	**5.1**	**nd**	**0.014**	**0.120**
I9	3.4	0.8	0.0	82.9	17.1	0.09	0.019	0.197
I6	0.9	0.8	10.5	88.4	1.1	nd	0.012	0.089
I3	1.0	0.7	10.2	89.8	0.0	nd	0.005	0.044
I2	1.5	0.9	4.7	94.3	1.0	nd	nd	0.048
38 m stations								
I29	2.0	0.8	11.2	75.0	13.8	0.16	0.021	0.302
I21	1.1	0.9	7.2	89.5	3.3	nd	0.015	0.177
I13	1.0	0.8	7.6	91.3	1.1	nd	0.005	0.140
I8	1.5	1.0	4.9	91.9	3.2	nd	0.015	0.118
55 m stations								
I28	3.2	1.7	7.2	49.5	43.3	nd	0.057	0.852
I20	0.7	0.7	15.3	83.0	1.6	nd	nd	0.053
I7	0.7	1.0	12.6	83.7	3.6	nd	0.016	0.139
I1	2.9	0.9	0.0	90.9	9.1	0.04	0.020	0.266
Detection rate (%)						35	80	100
2008 area mean	2.2	0.9	5.5	85.0	9.5	0.9	0.015	0.24
2008 area max	4.0	2.1	53.1	99.8	49.6	35.3	0.058	3.24
Pre-discharge mean	2.3	0.8	1.4	87.7	10.2	4.59	0.019	0.143
Pre-discharge max	4.2	2.5	52.5	100.0	47.2	222.00	0.077	0.638

wastewater discharge (see Figure 4.3). TN was positively correlated with percent fines (Table 4.2, Figure 4.4A), indicating that it varied with sediment type. TOC was also positively correlated with percent fines, though an outlier was removed prior to analysis; i.e., the TOC value detected in sediments collected in July from station I23 (3.24 % wt) was the highest ever reported since monitoring began in 1995. In contrast, values for sulfides and TN in this sample were within normal ranges.

Trace Metals

Aluminum, barium, chromium, iron, manganese, nickel, tin, and zinc were detected in 100% of sediment samples collected in the SBOO

Table 4.2

Results of correlation analyses on percent fine material and all other sediment chemistry parameters from samples collected in the SBOO region in 2008. Shown are analytes which had correlation coefficients (R^2 values)≥0.60. Percent fines were square-root transformed and all other analytes were transformed as necessary to meet the assumption of normality for this analysis. Residuals were also inspected for normality.

Analyte	R^2	p-value
Organic indicators (% wt)		
Total Nitrogen	0.84	<0.001
Total Organic Carbon*	0.73	<0.001
Trace metals (ppm)		
Aluminum	0.85	<0.001
Barium	0.80	<0.001
Copper	0.68	<0.001
Manganese	0.78	<0.001
Nickel	0.89	<0.001
Zinc	0.79	<0.001

*Outlier removed (see text)

region during 2008 (Table 4.3, Appendix C.5). Antimony, arsenic, cadmium, copper, lead, mercury, silver, and thallium were also detected, but less frequently (i.e., detection rates of 15–98%), while beryllium and selenium were not detected at all. Concentrations of each metal were highly variable, with no discernable patterns relative to the outfall. None of the highest concentrations occurred in sediments closest to the SBOO. Instead, concentrations for some metals (i.e., aluminum, barium, copper, manganese, nickel, zinc) were correlated with proportions of fine particles (Table 4.2). Nickel was found to be correlated tightest with percent fines (Figure 4.4B), followed by aluminum. Although chromium, iron, and lead were not correlated with percent fines, the highest concentrations of these metals occurred at the two stations with the highest proportion of fine sediments in the region (see Table 4.1); these stations included I35 located near the mouth of San Diego Bay and I28 near the now defunct LA-4 dumpsite. Overall, most metals had mean and maximum concentrations in 2008 that were less than pre-discharge values (Table 4.3). Exceptions were cadmium, antimony, lead, mercury, nickel, thallium, and zinc, which exceeded their pre-discharge areal means, though their maximum values were below those recorded prior to discharge. Only two metals exceeded environmental threshold values during the year (see Appendix C.5). First, the ERL for arsenic was exceeded in sediments from a single sample at station I21 located northwest of the SBOO discharge site. Second, both the ERL and ERM for silver were exceeded in sediments from stations located throughout the monitoring area.

Pesticides

Chlorinated pesticides were detected in up to 41% of the South Bay sediment samples collected in 2008 (Table 4.4, Appendix C.6). Hexachlorobenzene (HCB) was the most prevalent pesticide, occurring in sediments from 17 of 27 stations at concentrations averaging between 19–750 ppt (Table 4.4). Total DDT (primarily p,p-DDE) was detected in 35% of the samples at a total of 13 different stations, with concentrations averaging 43–1050 ppt. With the exception of a single sample collected at station I29 in January, total DDT concentrations were lower than its ERL of 1580 ppt (Appendix C.6), and all concentrations of this pesticide were lower than pre-discharge levels (Table 4.4). One other pesticide, BHC (beta isomer), was also detected, but only in a single sample collected at station I27 in January. As with the various trace metals, pesticide values showed no patterns relative to wastewater discharge.

PCBs and PAHs

PCBs were detected in sediments from only five SBOO stations (I9, I14, I18, I23, I28) during 2008 (Table 4.4). Overall, only 9% of the samples collected had detectable levels of PCBs, with average concentrations ranging from 90 to 696 ppt. Total PCB concentrations at stations I12, I14, I15, and I16 located nearest the discharge site were similar to values reported elsewhere in the region. The highest PCBs were found in sediments collected at station I28 during both the January and July surveys (i.e., 696 and 1392 ppt, respectively) (Appendix C.6).

PAHs were also detected relatively infrequently in sediment samples collected during 2008. Additionally, all concentrations of total PAH were below both the pre-discharge maximum value and

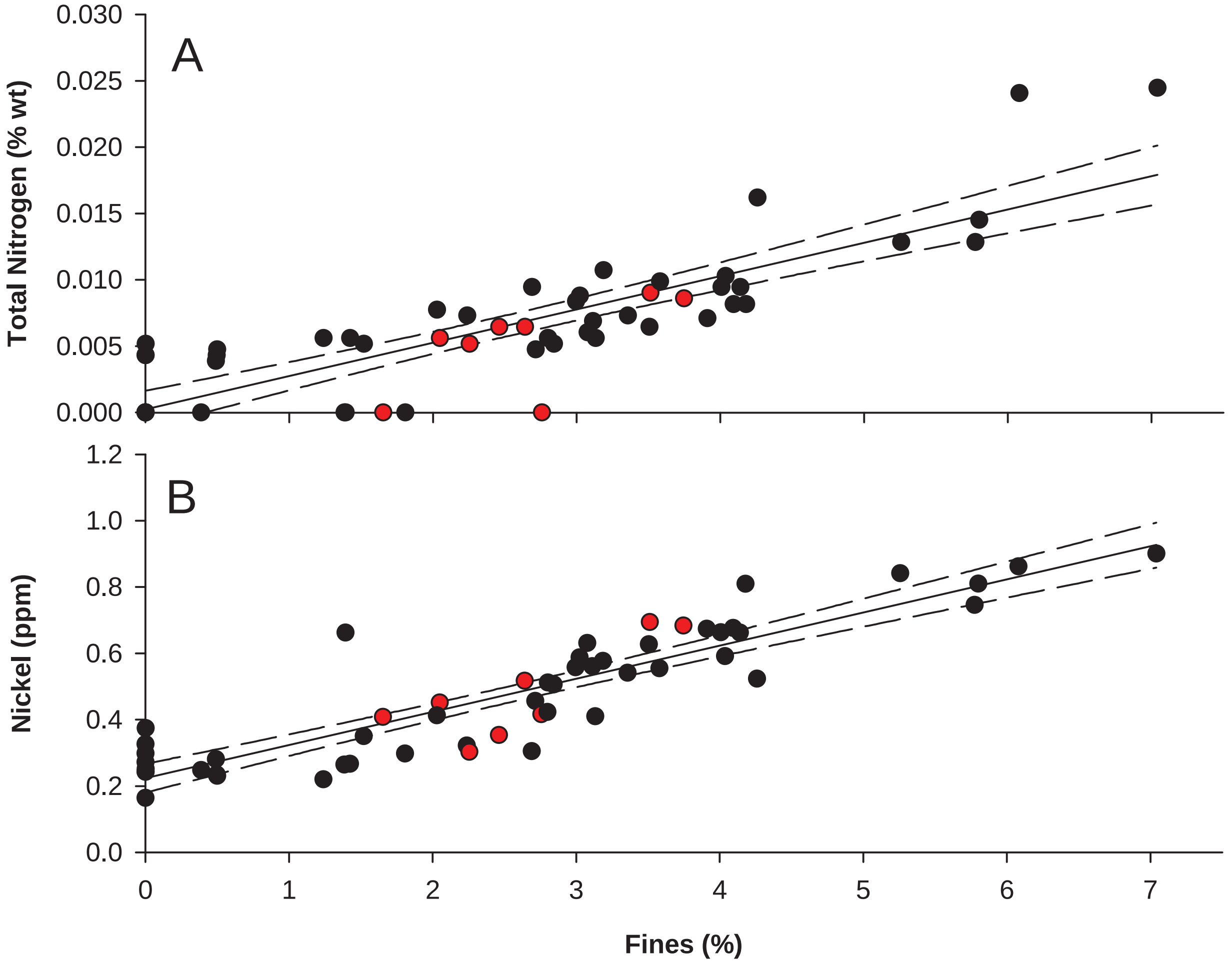


Figure 4.4

(A) Total nitrogen and (B) nickel correlated with percent fine material at SBOO stations in 2008. Data are transformed (fines=square-root; TN and Ni=log(x+1)) to meet normality assumptions for the test. The solid line represents the best fit regression line; dashed lines represent 95% confidence intervals; samples collected from nearfield stations are indicated in red.

ERL of 4022 ppt for this parameter (Table 4.4). Relatively low levels of these compounds were detected in 22% of the samples from 11 different stations, primarily during the January survey (Appendix C.6). The most common PAH detected was naphthalene, which was detected in about 19% of the sediment samples (Appendix C.2). There was no apparent relationship between PAH concentrations and proximity to the outfall discharge site.

Summary and Conclusions

Sediment composition in the South Bay outfall region was diverse in 2008, with grain size distributions ranging from very fine to very coarse particles. The diversity of sediment types may be partially attributed to the multiple geological origins of relict red sands, shell hash, coarse sands, and other detrital materials that occur in the offshore area surrounding the SBOO (Emery 1960). In addition, sediment deposition associated with the transport of materials originating from the Tijuana River, and to a lesser extent from San Diego Bay, may contribute to the higher silt content at some stations located near the outfall, as well as to the north (see City of San Diego 1988). There was no evident relationship between sediment grain size composition and proximity to the outfall discharge site.

Various trace metals, indicators of organic loading (sulfides, TN, TOC), chlorinated pesticides (DDT, BHC, HCB), PCBs, and PAHs were detected in

Table 4.3

Concentrations of trace metals (ppm) detected at SBOO benthic stations during 2008. Data are annual means (n=2); nearfield stations are in bold. ERL=effects range low threshold value; ERM=effects range median threshold value; na=not available; nd=not detected; Pre-discharge period=1995–1998. See Appendix C.1 for MDLs and metals defined by periodic table symbols.

		Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
	ERL:	na	na	8.2	na	na	1.2	81	34	na	46.7	na	0.15	20.9	na	1	na	na	150
	ERM:	na	na	70	na	na	9.6	370	270	na	218	na	0.71	51.6	na	3.7	na	na	410
19-m stations	I35	8795	0.2	2.25	46.75	nd	0.07	14.2	4.3	10355	2.26	104.4	0.009	5.0	nd	3.25	0.42	0.9	29.5
	I34	1510	nd	1.20	5.50	nd	0.05	4.0	0.8	3350	1.54	40.5	0.014	0.8	nd	0.03	nd	1.0	6.6
	I31	4030	nd	1.04	19.20	nd	0.03	7.8	1.4	4020	0.49	54.1	nd	1.8	nd	0.97	nd	0.8	10.6
	I23	4685	0.2	1.74	27.70	nd	0.04	8.4	1.7	5415	0.62	58.0	nd	2.3	nd	0.69	0.26	1.3	12.2
	I18	5410	nd	1.26	44.10	nd	nd	11.3	2.2	7025	nd	77.7	nd	2.4	nd	0.26	nd	1.4	12.8
	I10	4815	0.3	1.38	19.63	nd	0.03	10.9	1.1	6145	0.55	60.9	0.001	2.4	nd	1.88	0.45	1.1	12.5
	I4	956	0.2	1.24	2.86	nd	0.04	4.7	0.5	1990	1.06	18.6	nd	0.7	nd	0.79	nd	0.6	4.8
28-m stations	I33	5165	0.2	1.68	24.25	nd	0.07	8.8	2.6	6365	2.04	74.3	0.016	2.7	nd	0.99	nd	0.9	17.0
	I30	6835	0.2	1.94	34.40	nd	nd	11.2	2.7	6865	0.66	67.5	0.005	3.6	nd	1.85	nd	1.1	18.3
	I27	7200	0.2	1.40	33.15	nd	0.04	11.2	2.7	7035	0.41	73.5	nd	3.5	nd	1.18	0.27	1.7	17.5
	I22	4650	nd	1.39	21.70	nd	0.03	8.8	2.3	5070	0.55	49.6	0.003	2.6	nd	0.74	nd	1.2	11.6
	I16	**4470**	**nd**	**1.48**	**23.10**	**nd**	**nd**	**7.5**	**2.0**	**5555**	**nd**	**56.2**	**nd**	**1.9**	**nd**	**0.66**	**nd**	**1.4**	**12.8**
	I15	**2755**	**nd**	**2.48**	**8.75**	**nd**	**nd**	**9.1**	**0.9**	**4965**	**1.17**	**30.3**	**nd**	**1.3**	**nd**	**0.44**	**nd**	**1.1**	**10.1**
	I14	**8185**	**nd**	**1.69**	**43.10**	**nd**	**nd**	**11.6**	**3.2**	**8200**	**nd**	**82.7**	**nd**	**3.9**	**nd**	**0.28**	**0.32**	**1.3**	**20.5**
	I12	**3235**	**nd**	**1.88**	**16.55**	**nd**	**nd**	**5.9**	**1.0**	**3990**	**nd**	**37.8**	**nd**	**1.5**	**nd**	**0.51**	**nd**	**0.7**	**9.1**
	I9	7975	0.2	1.54	39.25	nd	nd	12.4	3.0	8065	nd	86.0	0.002	4.6	nd	2.29	0.41	1.2	19.9
	I6	1145	0.2	4.69	3.40	nd	0.03	8.4	0.4	4195	1.35	12.8	nd	0.8	nd	0.05	nd	1.3	13.7
	I3	862	0.2	1.18	2.04	nd	nd	6.5	0.6	2060	0.46	9.1	nd	0.9	nd	nd	nd	0.5	3.3
	I2	1195	nd	0.32	2.97	nd	0.09	5.9	1.0	1315	nd	10.8	nd	0.9	nd	0.14	nd	1.3	3.6
38-m stations	I29	5118	0.2	4.74	24.13	nd	nd	10.3	2.4	8420	1.70	53.8	0.008	3.4	nd	1.67	0.40	1.2	15.3
	I21	1345	0.2	7.47	3.18	nd	nd	8.7	0.6	6400	1.70	16.7	nd	0.9	nd	nd	nd	1.5	6.7
	I13	4000	0.3	6.68	22.40	nd	0.02	10.4	1.9	7050	0.96	51.1	nd	2.2	nd	nd	nd	1.1	12.7
	I8	2190	0.2	2.45	6.39	nd	0.04	10.1	0.8	4685	1.02	27.3	0.002	1.4	nd	0.18	nd	1.2	9.1
55-m stations	I28	8055	0.2	2.50	34.75	nd	0.05	12.8	5.1	9375	2.73	78.6	0.023	6.6	nd	1.86	0.28	1.5	24.4
	I20	1925	0.2	3.17	4.08	nd	0.08	11.9	1.2	8930	2.60	23.8	nd	1.2	nd	nd	nd	1.7	9.9
	I7	1285	0.2	5.32	3.16	nd	nd	9.3	0.4	7110	1.81	21.6	nd	0.9	nd	nd	nd	0.5	6.5
	I1	2965	0.4	0.92	10.30	nd	0.07	7.4	1.4	3855	0.86	50.7	0.006	2.7	nd	1.35	nd	1.3	9.0
Detection rate (%)		100	37	98	100	0	35	100	89	100	63	100	30	100	0	50	15	100	100
2008 area mean		4102	0.4	2.42	19.51	—	0.08	9.2	2.0	5845	1.49	49.2	0.011	2.3	—	1.60	0.70	1.1	12.6
2008 area max		10400	0.7	9.00	49.20	—	0.17	17.7	6.3	12500	4.03	118.0	0.029	7.0	—	4.61	0.90	2.0	31.3
Pre-discharge mean		5164	0.08	2.47	21.82	0.13	0.002	10.2	2.6	6568	0.09	55.4	0.002	1.9	0.07	nd	0.2	nd	12.5
Pre-discharge max		15800	5.6	10.9	54.3	2.14	0.4	33.8	11.1	17100	6.8	162	0.078	13.6	0.62	nd	17	nd	46.9

Table 4.4

Concentrations of total DDT, BHC, hexachlorobenzene (HCB), total PCB, and total PAH at SBOO benthic stations in 2008. Data are annual means (n=2); nearfield stations are in bold. ERL=effects range low threshold value; ERM=effects range median threshold value; na=not available; nd=not detected; Pre-discharge period=1995–1998.

		tDDT (ppt)	BHC (ppt)	HCB (ppt)	tPCB (ppt)	tPAH (ppb)
	ERL:	1580	na	na	na	4022
	ERM:	46100	na	na	na	44792
19-m stations	I35	nd	nd	nd	nd	7.3
	I34	nd	nd	nd	nd	8.9
	I31	nd	nd	658	nd	6.6
	I23	190	nd	19	305	nd
	I18	60	nd	34	90	nd
	I10	nd	nd	26	nd	nd
	I4	nd	nd	nd	nd	6.6
28-m stations	I33	55	nd	750	nd	nd
	I30	195	nd	nd	nd	13.2
	I27	130	95	100	nd	7.5
	I22	75	nd	103	nd	nd
	I16	**nd**	**nd**	**nd**	**nd**	**nd**
	I15	**55**	**nd**	**215**	**nd**	**nd**
	I14	**310**	**nd**	**nd**	**102**	**15.2**
	I12	**nd**	**nd**	**33**	**nd**	**nd**
	I9	nd	nd	80	159	nd
	I6	nd	nd	nd	nd	nd
	I3	105	nd	90	nd	nd
	I2	nd	nd	nd	nd	nd
38-m stations	I29	1050	nd	415	nd	26.4
	I21	nd	nd	43	nd	8.3
	I13	43	nd	155	nd	43.2
	I8	65	nd	180	nd	nd
55-m stations	I28	750	nd	340	696	nd
	I20	nd	nd	nd	nd	nd
	I7	nd	nd	113	nd	11.8
	I1	nd	nd	nd	nd	nd
Detection rate (%)		35	2	41	9	22
2008 area mean		114.2	3.5	124.2	50.1	5.7
2008 area max		1690	190	1500	1392	86.4
Pre-discharge mean		568.1	nd	nd	na	3.39
Pre-discharge max		23380	nd	nd	na	636.5

sediment samples collected from SBOO benthic stations during 2008. Concentrations of the various contaminants remained relatively low in the region compared to many other coastal areas off southern California (see Schiff and Gossett 1998, Noblet et al. 2003, Schiff et al. 2006). Only two metals (silver and arsenic) and DDT exceeded ERL values for southern California. For example, relatively high concentrations of silver occurred in sediments throughout the region, while a single sample with elevated arsenic and another sample with elevated DDT were found in sediments from stations quite distant from the outfall.

Overall, sediments in the South Bay region were similar in 2008 to years past (see City of San Diego 2006, 2007, 2008) and there was no evidence of contamination by the discharge of wastewater from the SBOO. Although there were several samples where concentrations exceeded pre-discharge maximums for some metals or DDT, concentrations of most contaminants were not substantially different from those detected before discharge began in early 1999 (see City of San Diego 2000). In addition, the samples that did exceed pre-discharge values were collected from stations widely distributed throughout the region and showed no patterns that could be attributed to wastewater discharge. Instead, concentrations of TN, TOC, as well as for several metals, tended to be higher at sites characterized by finer sediments. This pattern is consistent with that found in other studies, in which the accumulation of fine particles has been shown to influence the organic and metal content of sediments (e.g., Eganhouse and Venkatesan 1993).

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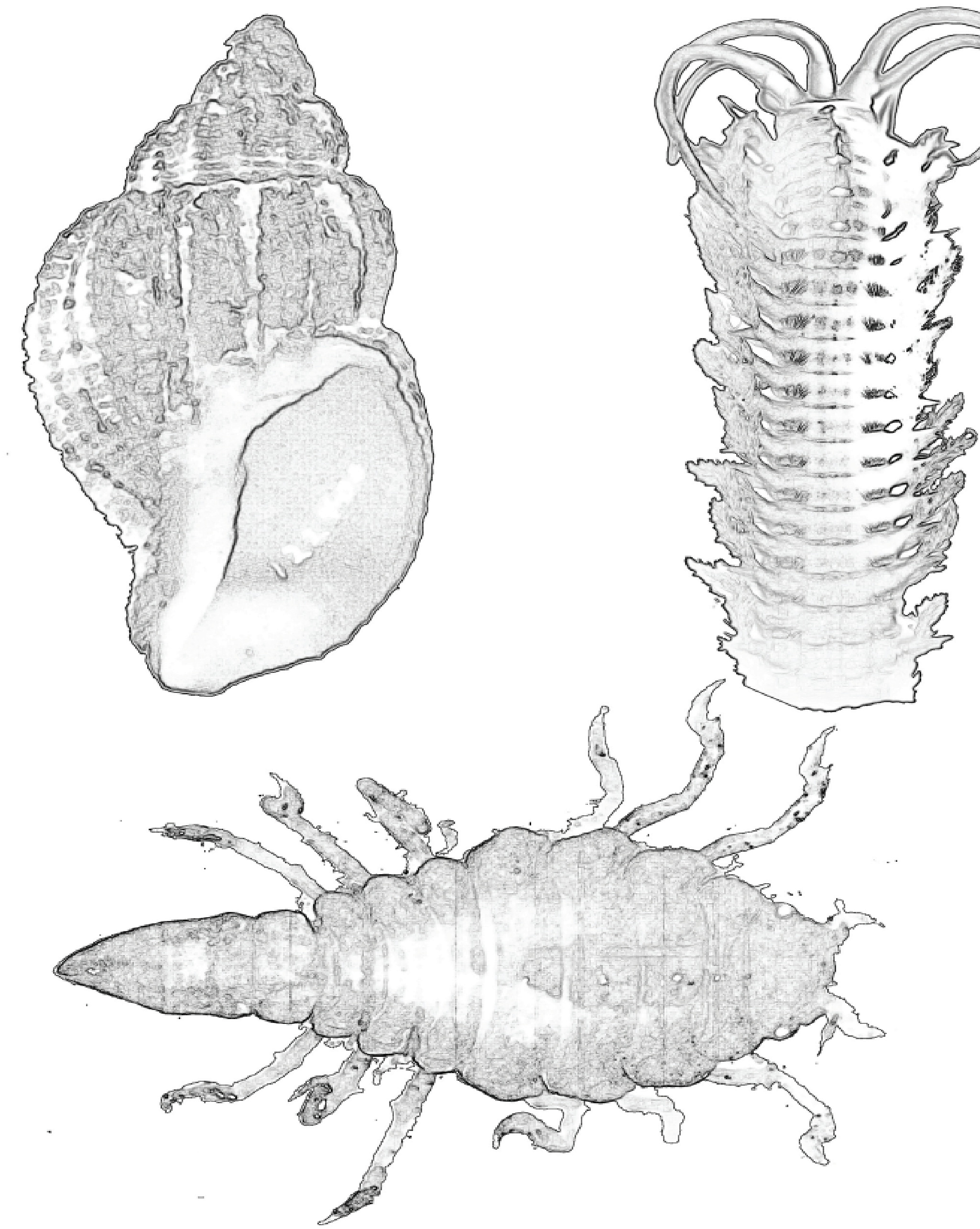
Chapter 5
Macrobenthic Communities



Chapter 5. Macrobenthic Communities

INTRODUCTION

Benthic macroinvertebrates along the coastal shelf of southern California represent a diverse faunal community that is important to the marine ecosystem (Fauchald and Jones 1979, Thompson et al. 1993a, Bergen et al. 2001). These animals serve vital functions in wide ranging capacities (Snelgrove et al. 1997). For example, some species decompose organic material as a crucial step in nutrient cycling; other species filter suspended particles from the water column, thus affecting water clarity. Many species of benthic macrofauna also are essential prey for fish and other organisms.

Human activities that impact the benthos can sometimes result in toxic contamination, oxygen depletion, nutrient loading, or other forms of environmental degradation. Certain macrofaunal species are sensitive to such changes and rarely occur in impacted areas, while others are opportunistic and can persist under altered conditions (Gray 1979). Because various species respond differently to environmental stress, monitoring macrobenthic assemblages can help to identify anthropogenic impact (Pearson and Rosenberg 1978, Bilyard 1987, Warwick 1993, Smith et al. 2001). Also, since many animals in these assemblages are relatively stationary and long-lived, they can integrate local environmental conditions (Hartley 1982, Bilyard 1987). Consequently, the assessment of benthic community structure is a major component of many marine monitoring programs, which are often designed to document both existing conditions and trends over time.

Overall, the structure of benthic communities may be influenced by many factors including depth, sediment composition and quality (e.g., grain size distribution, contaminant concentrations), oceanographic conditions (e.g., temperature, salinity, dissolved oxygen, ocean currents), and biological factors (e.g., food availability, competition, predation). For example, benthic assemblages on the coastal shelf off San Diego typically vary along sediment particle size and/or depth gradients. Therefore, in order to determine whether changes in community structure are related to human impacts, it is necessary to have an understanding of background or reference conditions for an area. Such information is available for the area surrounding the South Bay Ocean Outfall (SBOO) and the San Diego region in general (e.g., City of San Diego 1999, 2000; Ranasinghe et al. 2003, 2007).

This chapter presents analyses and interpretation of the macrofaunal data collected at fixed stations surrounding the SBOO during 2008. Descriptions and comparisons of the different macrofaunal assemblages that inhabit soft bottom habitats in the region and analysis of benthic community structure are included.

Materials and Methods

Collection and Processing of Samples

Benthic samples were collected during January and July 2008 at 27 stations surrounding the SBOO (Figure 5.1). These stations range in depth from 18 to 60 m and are distributed along four main depth contours. Listed from north to south along each contour, these stations include: I35, I34, I31, I23, I18, I10, and I4 (19-m contour); I33, I30, I27, I22, I14, I16, I15, I12, I9, I6, I2, and I3 (28-m contour); I29, I21, I13, and I8 (38-m contour); I28, I20, I7, and I1 (55-m contour). Stations considered “nearfield” herein (I12, I14, I15, I16) are located within 1000 m of the outfall wye.

Samples for benthic community analyses were collected from two replicate 0.1-m^2 van Veen grabs per station during the 2008 surveys. An additional grab was collected at each station for sediment quality analysis (see Chapter 4). The criteria to ensure consistency of grab samples established by the United States Environmental

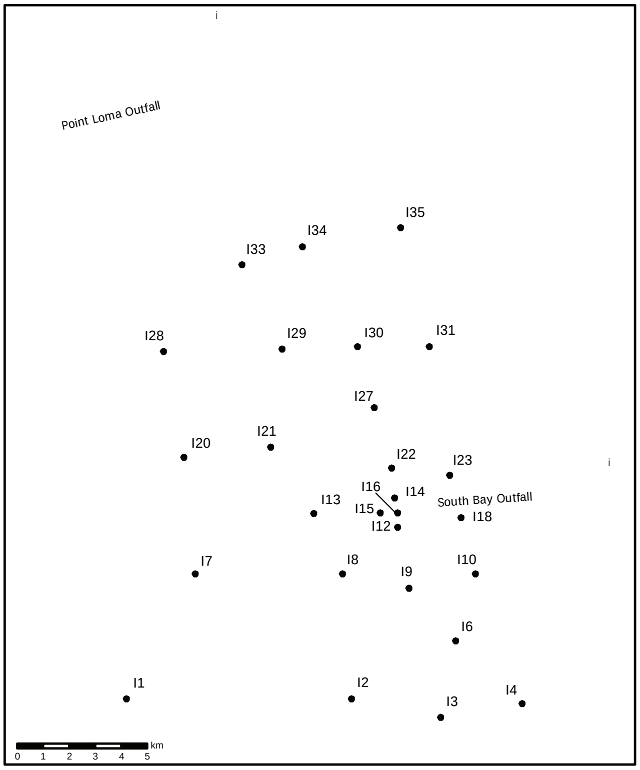


Figure 5.1
Macrobenthic station locations, South Bay Ocean Outfall Monitoring Program.

Protection Agency (USEPA) were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0 mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin. After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All animals were sorted from the debris into major taxonomic groups by a subcontractor and then identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

Data Analyses

The following community structure parameters were calculated for each station per 0.1-m^2 grab: species richness (number of species), abundance (number of individuals), Shannon diversity index (H'), Pielou's evenness index (J'), Swartz dominance (Swartz et al. 1986, Ferraro et al. 1994), and the BRI or benthic response index (Smith et al. 2001). Additionally, the total or cumulative number of species over all grabs was calculated for each station.

Multivariate analyses were performed using PRIMER software to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (Clarke 1993, Warwick 1993, Clarke and Gorley 2006). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling (MDS). The macrofaunal abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for classification. SIMPROF (similarity profile) analysis was used to confirm non-random structure of the dendrogram (Clarke et al. 2008). SIMPER (similarity percentages) analysis was used to identify individual species that typified each cluster group. Patterns in the distribution of macrofaunal assemblages were compared to environmental variables by overlaying the physico-chemical data onto MDS plots based on the biotic data (Field et al. 1982, Clarke and Ainsworth 1993).

Results and Discussion

Community Parameters

Species Richness

A total of 778 macrobenthic taxa (mostly species) were identified during 2008. Of these, 22% (n=169) represented rare taxa that were recorded only once. The average number of taxa per 0.1-m^2 grab ranged from 39 to 143, and the cumulative number of taxa per station ranged from 95 to 304 (Table 5.1). This wide variation in species richness is consistent with patterns seen in previous years, and can probably be attributed to the presence of different habitat (or microhabitat) types in the region (see City of San Diego 2006–2008). Higher numbers of species, for example, have typically occurred at stations such as I28 and I29 (see City of San Diego 2008).

Table 5.1

Summary of macrobenthic community parameters for SBOO stations sampled during 2008. SR=species richness, no. species/0.1 m^2; Tot Spp=cumulative no. species for the year; Abun=abundance, no. individuals/0.1 m^2; H'=Shannon diversity index; J'=evenness; Dom=Swartz dominance; BRI=benthic response index. Nearfield stations in bold. Data are expressed as annual means (n=4); SE=standard error.

Station	SR	Tot spp	Abun	H'	J'	Dom	BRI
19-m stations							
I35	89	175	586	3.3	0.75	19	30
I34	49	127	887	1.9	0.49	5	12
I31	56	114	206	3.1	0.78	18	19
I23	73	189	309	3.5	0.83	21	20
I18	51	112	191	2.9	0.74	16	17
I10	68	140	246	3.4	0.81	24	19
I4	45	123	169	3.2	0.86	17	11
28-m stations							
I33	122	246	710	3.5	0.73	25	26
I30	83	180	288	3.7	0.84	28	23
I27	76	163	281	3.4	0.79	24	24
I22	78	195	305	3.4	0.79	25	23
I14	**94**	**184**	**437**	**3.5**	**0.78**	**26**	**23**
I16	**74**	**174**	**438**	**2.7**	**0.62**	**13**	**22**
I15	**75**	**165**	**703**	**2.2**	**0.51**	**7**	**23**
I12	**83**	**197**	**466**	**2.9**	**0.65**	**16**	**20**
I9	112	240	588	3.7	0.78	29	23
I6	71	148	1203	1.8	0.44	5	17
I2	39	95	198	2.3	0.63	8	18
I3	39	98	349	2.2	0.61	6	11
38-m stations							
I29	132	304	664	3.8	0.80	34	17
I21	60	136	311	2.8	0.68	13	8
I13	60	134	398	2.5	0.63	11	15
I8	61	132	301	2.7	0.66	14	18
55-m stations							
I28	143	267	523	4.4	0.89	49	14
I20	44	116	159	3.1	0.83	15	12
I7	52	119	131	3.5	0.88	22	7
I1	76	169	253	3.7	0.86	27	14
Mean	74	165	419	3.1	0.73	19	18
SE of Mean	5	10	48	0.1	0.02	2	1
Min	39	95	131	1.8	0.44	5	7
Max	143	304	1203	4.4	0.89	49	30

In addition, species richness varied between the two 2008 surveys, averaging about 6% higher in summer than in winter. Although species richness varied spatially and temporally, there were no apparent patterns relative to distance from the outfall (Figure 5.2A).

Polychaete (Annelida) worms comprised the greatest proportion of species per site during 2008, followed by crustaceans (Arthropoda), molluscs, echinoderms, and all other phyla combined (Table 5.2). These proportions generally are similar to those observed during previous years (e.g., see City of San Diego 2000, 2008).

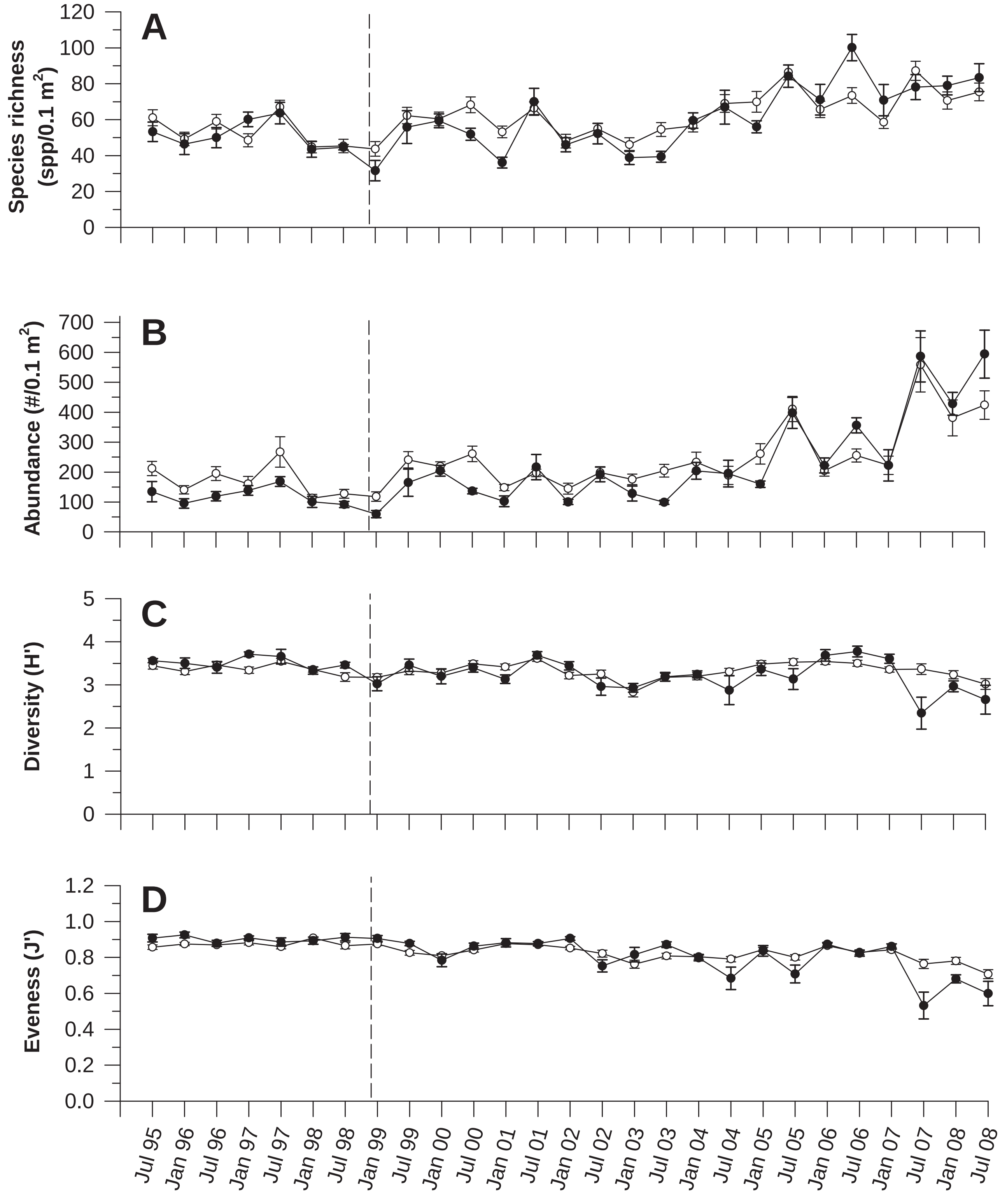


Figure 5.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall from 1995–2008: (A) Species richness; (B) Abundance; (C) Diversity=Shannon diversity index (H'); (D) Eveness=Pielou's evenness index (J'); (E) Swartz dominance index; (F) Benthic response index (BRI). Data are expressed as means per 0.1 m^2 pooled over nearfield stations (dark circles, n=8) versus farfield stations (open circles, n=46) for each survey. Error bars represent standard errors. Dashed line indicates onset of discharge from the SBOO.

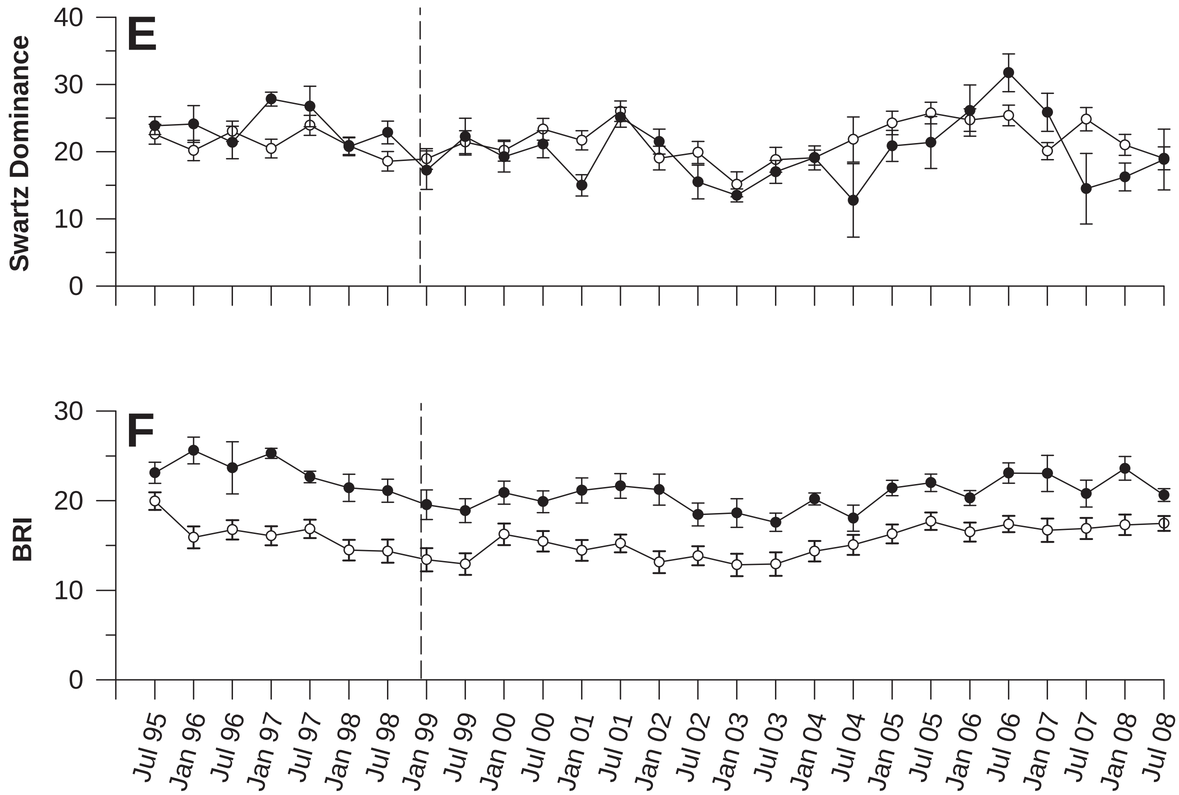


Figure 5.2 *continued*

Macrofaunal abundance

A total of 45,203 macrofaunal individuals were counted in 2008 with mean abundance values ranging from 131 to 1203 animals per 0.1 m^2 sample (Table 5.1). The greatest number of animals occurred at stations I6 and I34, which averaged 1203 and 887 individuals per sample, respectively. In contrast, the fewest number of animals occurred at station I7 (131/0.1 m^2). Average abundance values were about 14% higher during the summer survey than in the winter (Figure 5.2A). Some of this increase was due to large populations of the spionid polychaete *Spiophanes bombyx*, which accounted for 39% of all macrofauna collected in July versus 30% in January (see ‘Dominant Species’ section below).

Polychaetes were the most numerous animals in the SBOO region during the year, accounting for over 50% of the macrobenthic fauna at the individual sites. Crustaceans were the next most abundant, followed in decreasing order by molluscs, miscellaneous phyla (combined), and echinoderms (Table 5.2).

Species diversity and dominance

Species diversity (H') varied during 2008, ranging from 1.8 to 4.4 (Table 5.1). Average diversity values in the region were generally similar to previous years, and there were no apparent patterns relative to distance from the outfall discharge site (Figure 5.2C). Evenness (J') compliments diversity, with higher J' values (on a scale of 0–1) indicating that species are more evenly distributed (i.e., not dominated by a few highly abundant species). The spatial patterns in evenness were similar to those for diversity, and J' values ranged from 0.44 to 0.89 (Figure 5.2F). Sites with evenness values below the mean of 0.73 were dominated by polychaetes.

Swartz dominance is calculated as the minimum number of species whose combined abundance accounts for 75% of the individuals in a sample (Swartz et al. 1986, Ferraro et al. 1994). Therefore, lower index values (i.e., fewer species) indicate higher numerical dominance. Values at the individual SBOO stations averaged between 5 and 49 species per station during the year (Table 5.1). This range reflects the dominance of

Table 5.2
The percent composition of species and abundance by phyla for SBOO stations sampled during 2008. Data are expressed as annual means (range) for all stations combined (n=27).

Phyla	Species (%)	Abundance (%)
Annelida (Polychaeta)	53 (45-62)	78 (51-92)
Arthropoda (Crustacea)	20 (10-27)	10 (2-24)
Mollusca	14 (9-21)	6 (1-20)
Echinodermata	5 (2-10)	2 (1-7)
Other Phyla	8 (4-15)	4 (2-13)

a few species at some sites (e.g., stations I2, I3, I6, I15, I34) versus other stations where many taxa contributed to the overall abundance (e.g., I28, I29). Overall, Swartz dominance values for 2008 were similar to historical values with no clear patterns evident relative to the outfall (Figure 5.2D).

Benthic Response Index (BRI)

BRI values averaged from 7 to 30 at the various SBOO stations during 2008 (Table 5.1). Index values below 25 (on a scale of 100) are considered to represent undisturbed communities or "reference conditions," while those between 25–34 represent "a minor deviation from reference conditions," the latter which may reflect anthropogenic impact (Smith et al. 2001). Stations I33 and I35 were the only stations with a BRI value above 25 (i.e., 26 and 30, respectively). In 2008, there was no gradient of BRI values relative to distance from the outfall, and index values at sites nearest the discharge site did not suggest any deviation from reference conditions. Since monitoring first began in July 1995, mean BRI values at the four nearfield stations (I12, I14, I15, I16) have been slightly higher than mean BRI values of the farfield stations combined (Figure 5.2E). This pattern has remained consistent over time, including the period prior to January of 1999 when wastewater discharge was initiated through the SBOO. The difference is likely due to the effects of lower BRI values at the 38-m and 55-m stations on the farfield mean BRI (see Smith et al. 2001 for a discussion of the influence of depth on the BRI).

Dominant Species

All monitoring sites in the SBOO region were dominated by polychaete worms. For example, polychaetes comprised all of the 10 most abundant and most frequently occurring species (Table 5.3). The most abundant species collected was the spionid polychaete *Spiophanes bombyx,* which occurred at 100% of the stations and averaged 147 (4–1647) individuals per sample. While *S. bombyx* was ubiquitous in the SBOO region, abundances at individual stations varied. For example, two stations (I6 in January and I34 in July) had much higher abundances than the others in the region, with a combined total of 5378 individuals. Overall, *S. bombyx* accounted for about 35% (15,873) of the macrobenthic fauna sampled during 2008, which was similar to that recorded in 2007 (Figure 5.3).

Few macrobenthic species were widely distributed, and of these only the polychaetes *Spiophanes bombyx*, *Scoloplos armiger* complex, *Mediomastus* sp, and *Monticellina siblina* occurred in 80% or more of the samples. Two of the most frequently collected species were also among the top 10 most abundant taxa (i.e., *S. bombyx* and *M. siblina*). In contrast, the phyllodocid polychaete *Hesionura coineaui difficilis* was found in relatively high numbers at only one station, I34, where sediments were comprised almost entirely of sand and coarse materials.

Classification of Macrobenthic Assemblages

Results of the ordination and cluster analyses discriminated five habitat-related macrobenthic assemblages (see Figure 5.4). These assemblages (cluster groups A–E) varied in terms of their species composition (i.e., specific taxa present) and the relative abundance of those species, and occurred at sites separated by different depths and/or sediment types (microhabitats). The SIMPROF procedure

Table 5.3

The 10 most abundant macroinvertebrates collected at the SBOO benthic stations sampled during 2008. Abundance values are expressed as mean number of individuals per 0.1-m^2 grab sample.

Species	Higher taxa	Percent occurrence	Abundance per sample	Abundance per occurrence
Spiophanes bombyx	Polychaeta: Spionidae	100	147.0	147.0
Monticellina siblina	Polychaeta: Cirratulidae	81	22.4	27.5
Euclymeninae sp A	Polychaeta: Maldanidae	78	8.5	10.9
Spiophanes duplex	Polychaeta: Spionidae	74	7.9	10.7
Spiophanes berkeleyorum	Polychaeta: Spionidae	74	5.3	7.2
Nereis sp A	Polychaeta: Nereidae	76	5.3	7.0
Mediomastus sp	Polychaeta: Capitellidae	83	5.3	6.4
Prionospio (*Prionospio*) *jubata*	Polychaeta: Spionidae	72	4.4	6.1
Scoloplos armiger complex	Polychaeta: Orbiniidae	89	4.2	4.7
Hesionura coineaui difficilis	Polychaeta: Phyllodocidae	19	3.8	20.3

indicated statistically significant non-random structure among samples (π=6.59, $p<0.001$), and an MDS ordination of the station/survey entities supported the validity of the cluster groups (Figure 5.4B). SIMPER analysis was used to identify species that were characteristic, though not always the most abundant, of each assemblage; the top three characteristic species for each cluster group are indicated in Figure 5.4A. These analyses identified no patterns that could be attributed to proximity to the SBOO discharge site, but showed some separation based on depth gradients (Figure 5.5). Further, the distribution of cluster groups varied based on sediment types, and to some degree, the concentration of total organic carbon present in sediments (Figure 5.6). A complete list of all species comprising each group can be found in Appendix D.1.

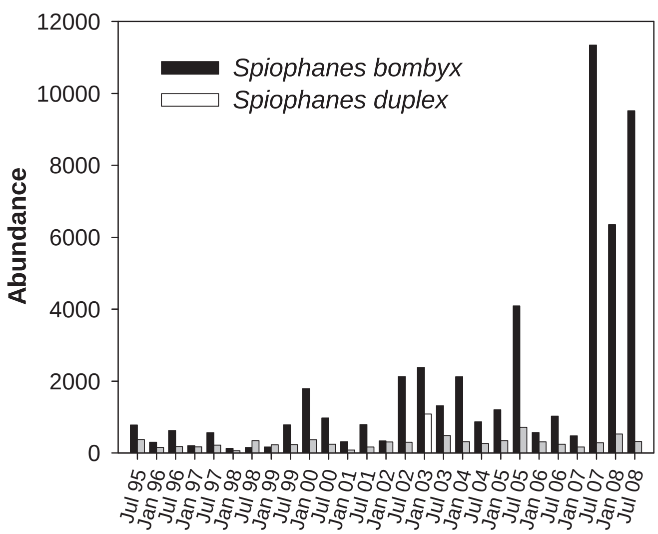
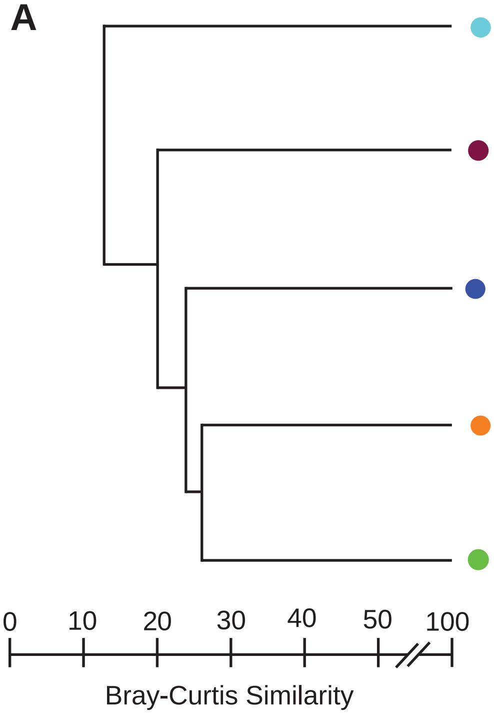


Figure 5.3

Total abundance of the polychaetes *Spiophanes bombyx* and *Spiophanes duplex* for each survey at the SBOO benthic stations from 1995–2008.

Cluster group A represented a shallow-shelf assemblage restricted to the January survey at one station (I34) associated with very coarse sediments. The associated sediments were comprised almost entirely of sand and shell hash (i.e., <1% fines), with total organic carbon (TOC) at 0.2% wt. Species richness averaged 49 taxa and abundance averaged 568 individuals per 0.1 m^2. As in previous years, this assemblage was somewhat unique for the region (see City of San Diego 2007, 2008); it was characterized by several polychaete species commonly found in sediments with coarse particles (e.g., *Hesionura coineaui difficilis*, *Protodorvillea gracilis*, and *Pisione* sp). *Branchiostoma californiense* (Chordata), also associated with coarse sediment habitats, was abundant as well (Appendix D.1).

A



CG	n	% Fines	TOC	SR	Abun	Characteristic Taxa
A	1	0	0.2	49	568	*Hesionura coineaui difficilis* *Polycirrus* sp SD3 *Pisione* sp
B	17	2	0.1	54	412	*Spiophanes bombyx* *Spio maculata* *Scoloplos armiger* complex
C	2	9	1.7	64	817	*Spiophanes bombyx* *Apoprionospio pygmaea* *Glycinde armigera*
D	6	12	0.2	117	480	*Spiophanes bombyx* *Monticellina siblina* *Spiophanes duplex*
E	28	22	0.5	79	375	*Spiophanes bombyx* Euclymeninae sp A *Spiophanes duplex*

B

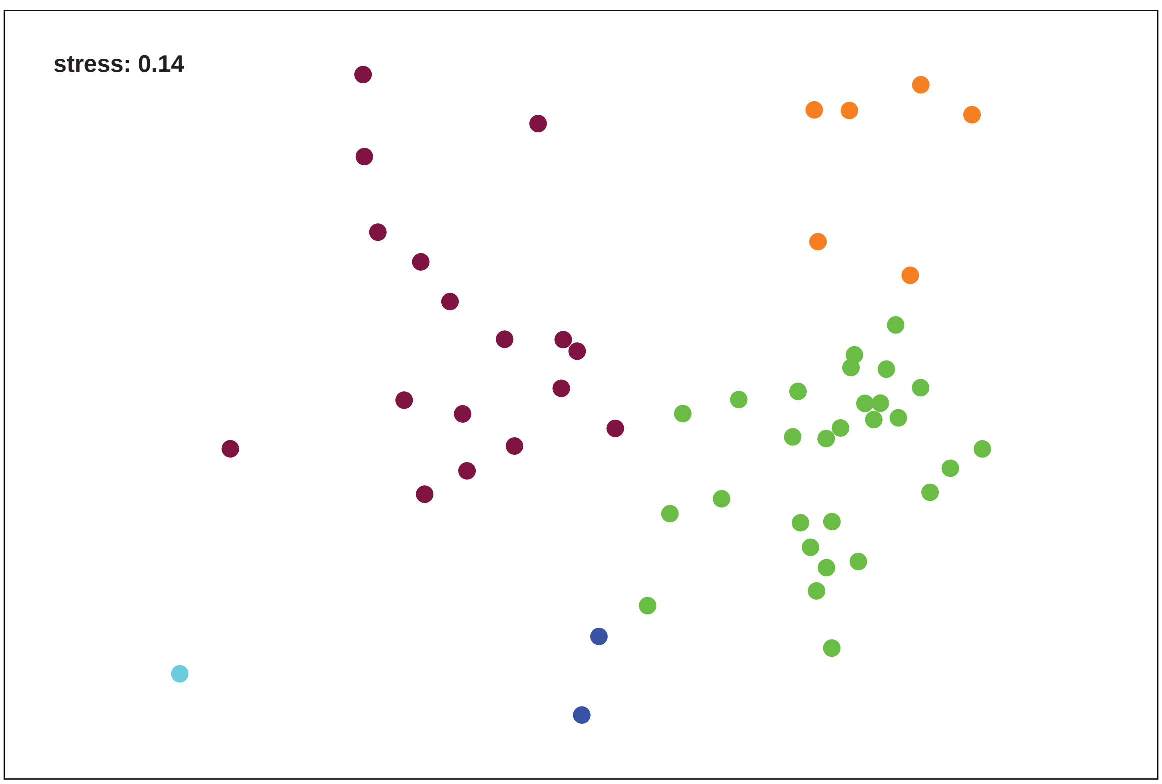


Figure 5.4

(A) Cluster results of the macrofaunal abundance data for the SBOO benthic stations sampled during winter and summer 2008. Data for percent fines, total organic carbon (TOC), species richness (SR), and infaunal abundance (Abun), are expressed as mean values per 0.1-m^2 grab over all stations in each group. (B) MDS ordination based on square-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.

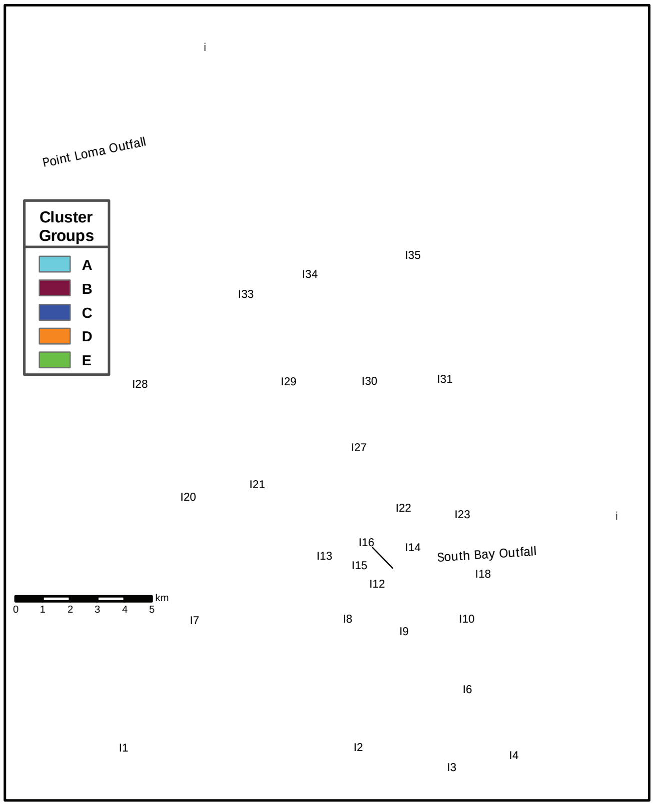


Figure 5.5
Spatial distribution of SBOO macrobenthic assemblages delineated by ordination and classification analyses. Left half of circle represents cluster group affiliation for the January survey; right half represents the July survey.

Cluster group B represented an assemblage that averaged 54 taxa and 412 organisms per 0.1 m^2. This assemblage occurred at nine stations located mostly south of the outfall spanning the 28, 38, and 55-m depth contours. Polychaetes were numerically dominant, with *Spiophanes bombyx*, *Spio maculata*, and *Scoloplos armiger* complex representing the three most characteristic taxa. The habitat at these sites was characterized by mixed sediments containing coarse particles, especially relict red sand, and TOC concentrations that averaged 0.1 % wt.

Cluster group C represented a shallow-shelf assemblage that occurred at two stations (I23, I34) sampled in July and located along the 19-m depth contour. This assemblage averaged 64 taxa and 817 individuals per 0.1 m^2. *Spiophanes bombyx* was characteristic of this group, as were two other polychaetes, another spionid *Aprionospio pygmaea* and the goniadid *Glycinde armigera*. Sediments at these two sites were characterized by a low percentage of fines (9%) and contained shell hash, while the TOC average concentration of 1.7% was the highest of all groups.

Cluster group D represented a mid-shelf assemblage present at three stations located near the 55 and 38-m depth contours. This assemblage averaged 480 individuals and 117 taxa per 0.1 m^2, the latter representing the highest species richness for the region. The three most characteristic species were polychaetes, and included the spionids *S. bombyx* and *S. duplex*, and the cirratulid *Monticellina siblina*. Sediments at these three sites averaged 12% fines with TOC concentrations of 0.2 % wt.

Cluster group E represented the dominant macrobenthic assemblage present in the SBOO region during 2008, occurring at 15 different stations located along the 19 and 28-m depth contours. This shallow shelf assemblage averaged 79 taxa and 375 individuals per 0.1 m^2. The top three characteristic species for this assemblage included *S. bombyx* and *S. duplex*, as well as another polychaete, the maldanid Euclymeninae sp A. The sediments characteristic of these samples contained higher amounts of fine particles (i.e., mean=22%) than for the other groups (i.e., 0–12%), and had TOC concentrations averaging 0.5 % wt.

Summary and Conclusions

Benthic macrofaunal assemblages surrounding the SBOO were similar in 2008 to those that occurred during previous years, including the period before initiation of wastewater discharge (e.g., see City of San Diego 2000, 2008). In addition, these assemblages were typical of those occurring in other sandy, shallow-, and mid-depth habitats throughout the Southern California Bight (SCB) (e.g., Thompson et al. 1987, 1993b; City of San Diego 1999, Bergen et al. 2001, Ranasinghe et al. 2003, 2007). For example, assemblages found at the majority of stations (i.e., groups B and E) contained high numbers of the spionid polychaete *Spiophanes bombyx*, a species characteristic of

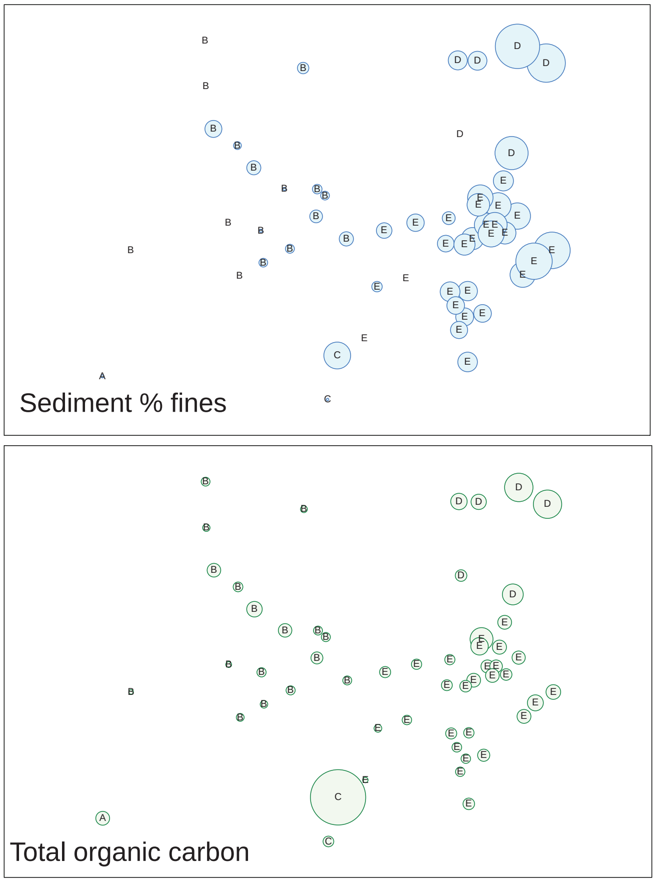


Figure 5.6
MDS ordination of SBOO benthic stations sampled during winter and summer 2008. Cluster groups A–E are superimposed on station/surveys. Percentages of fine particles and total organic carbon in the sediments are further superimposed as circles that vary in size according to the magnitude of each value. Plots indicate associations of benthic assemblages with habitats that differ in sediment grain size and TOC. Stress=0.14.

shallow-water environments with coarser sediments in the SCB (see Bergen et al. 2001). These two groups represented sub-assemblages of the SCB benthos that differed in the relative abundances of dominant and co-dominant species. Such differences probably reflect variation in sediment structure. Consistent with historical values, sediments in the shallow SBOO region generally were coarser south of the outfall relative to the more northern stations (see Chapter 4). In contrast, the group D assemblage occurs in mid-depth shelf habitats that probably represent a transition between the shallow sandy sediments common in the area and the finer mid-depth sediments characteristic of much of the SCB mainland shelf (see Barnard and Ziesenhenne 1961, Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993a, b; EcoAnalysis et al. 1993, Zmarzly et al 1994, Diener and Fuller 1995, Bergen et al. 2001). The group A assemblage, restricted to station I34 located at the northern end of the SBOO region just south of the entrance to San Diego Bay, was different from assemblages found at any other station. Several species of polychaete worms (i.e., *Polycirrus* sp SD3, *Protodorvillea gracilis*, *Hesionura coineaui difficilis*, *Micropodarke dubia*, *Typosyllis* sp SD1, and *Pisione* sp) not common elsewhere in the region were characteristic of this assemblage. This pattern is similar to that observed previously at this station from 2003 through 2007 (see City of San Diego 2004–2008). Analysis of sediment quality data provides some evidence relevant to explaining the occurrence of both the group A and group C assemblages, which represented only a few samples from two different stations (I23 and I34; see Figure 5.6); mean grain sizes at these sites were the highest measured among all stations for 2008 (see Chapter 4).

Results from multivariate analyses revealed no clear spatial patterns relative to the ocean outfall. Comparisons of the biotic data to the physico-chemical data indicated that macrofaunal distribution and abundance in the region varied primarily along gradients of depth and sediment type and to a lesser degree, levels of organic carbon in the sediments (see Hyland et al. 2005 for a discussion on TOC as an indicator of benthos stress). Populations of the spionid polychaete *Spiophanes bombyx* collected during 2008 were the second highest recorded since monitoring began in 1995. Consequently, the high numbers for this species influenced overall abundance values in the SBOO region. Patterns of region-wide abundance fluctuations over time appear to mirror historical patterns of *S. bombyx* (see Figures 5.2A and 5.3). However, temporal fluctuations in the populations of this and similar species occur elsewhere in the region and can correspond to large-scale oceanographic conditions (see Zmarzly et al. 1994). Overall, analyses of temporal patterns suggest that the benthic community in the South Bay region has not been significantly impacted by wastewater discharge. For example, while species richness and total macrofaunal abundance were at or near their historical highs during 2008, values from the four nearfield stations were similar to those located further away (Figure 5.2A, B) (see City of San Diego 2006–2008). Diversity (H') and evenness (J') values have also remained relatively stable since monitoring began in 1995 (Figure 5.2C, 5.2D). In addition, environmental disturbance index values such as the BRI continue to be generally characteristic of assemblages from undisturbed habitats.

Anthropogenic impacts are known to have spatial and temporal dimensions that can vary depending on a range of biological and physical factors. Such impacts can be difficult to detect, and specific effects of the SBOO discharge on the local macrobenthic community could not be identified during 2008. Furthermore, benthic invertebrate populations exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, b; Otway 1995). Although some changes have occurred near the SBOO over time, benthic assemblages in the area remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf.

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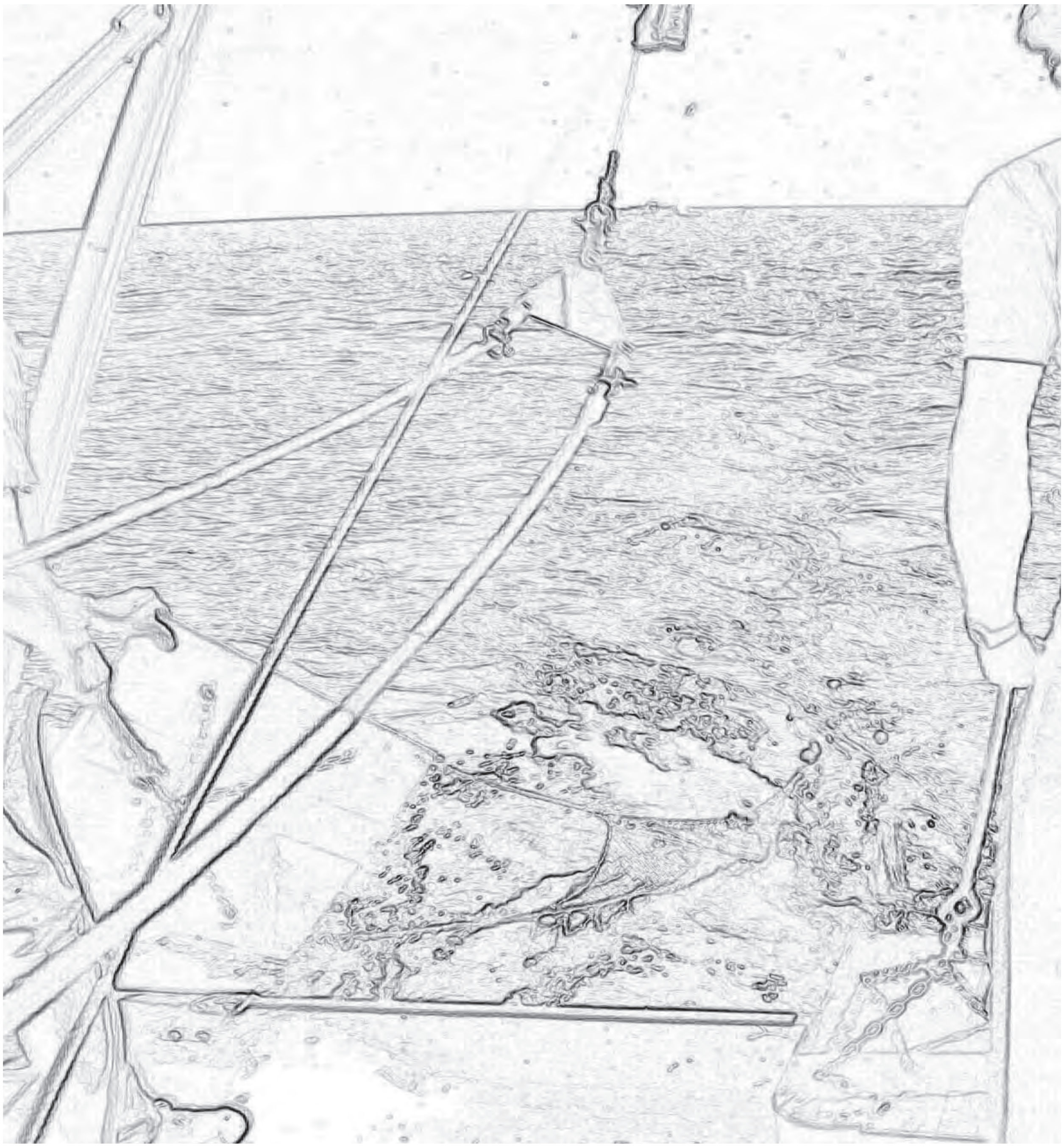
Chapter 6
Demersal Fishes
and Megabenthic Invertebrates



Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Marine fishes and invertebrates are conspicuous members of continental shelf habitats, and assessment of their communities has become an important focus of ocean monitoring programs throughout the world. Assemblages of bottom dwelling (demersal) fishes and relatively large (megabenthic), mobile invertebrates that live on the surface of the seafloor have been sampled extensively for more than 30 years on the mainland shelf of the Southern California Bight (SCB), primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of demersal fishes inhabit the SCB, while the megabenthic invertebrate fauna consists of more than 200 species (Allen 1982, Allen et al. 1998, 2002, 2007). For the region surrounding the South Bay Ocean Outfall (SBOO), the most common trawl-caught fishes include speckled sanddab, longfin sanddab, hornyhead turbot, California halibut, and California lizardfish. Common trawl-caught invertebrates include various echinoderms (e.g., sea stars, sea urchins, sea cucumbers, sand dollars), crustaceans (e.g., crabs, shrimp), molluscs (e.g., marine snails, octopuses), and other taxa.

Demersal fish and megabenthic invertebrate communities are inherently variable and may be influenced by both anthropogenic and natural factors. These organisms live in close proximity to the seafloor and are therefore exposed to contaminants of anthropogenic origin that may accumulate in the sediments via deposition from both point and non-point sources (e.g., discharges from ocean outfalls and storm drains, surface runoff from watersheds, outflows from rivers and bays, disposal of dredge materials). Natural factors that may affect these organisms include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperatures associated with large scale oceanographic events such as El Niño/La Niña oscillations (Karinen et al. 1985). These factors can affect migration patterns of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect species diversity and abundance of both fishes and invertebrates may also be due to the mobile nature of many species (e.g., fish schools, urchin aggregations).

The City of San Diego has been conducting trawl surveys in the area surrounding the SBOO since 1995. These surveys are designed to monitor the effects of wastewater discharge on the local marine biota by assessing the structure and stability of the trawl-caught fish and invertebrate communities. This chapter presents analyses and interpretations of the data collected during the 2008 trawl surveys. A long-term analysis of changes in these communities from 1995 through 2008 is also presented.

Materials and Methods

Field Sampling

Trawl surveys were conducted at seven fixed monitoring stations around the SBOO during 2008 (Figure 6.1). These surveys were conducted during January (winter), April (spring), July (summer), and October (fall) for a total of 28 trawls during the year. These stations, designated SD15–SD21, are located along the 28-m depth contour, and encompass an area ranging from south of Point Loma, California (USA) to an area off Punta Bandera, Baja California (Mexico). During each survey a single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.5 knots along a predetermined heading.

Each trawl catch was brought on board for sorting and inspection. All fish and invertebrates captured were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for

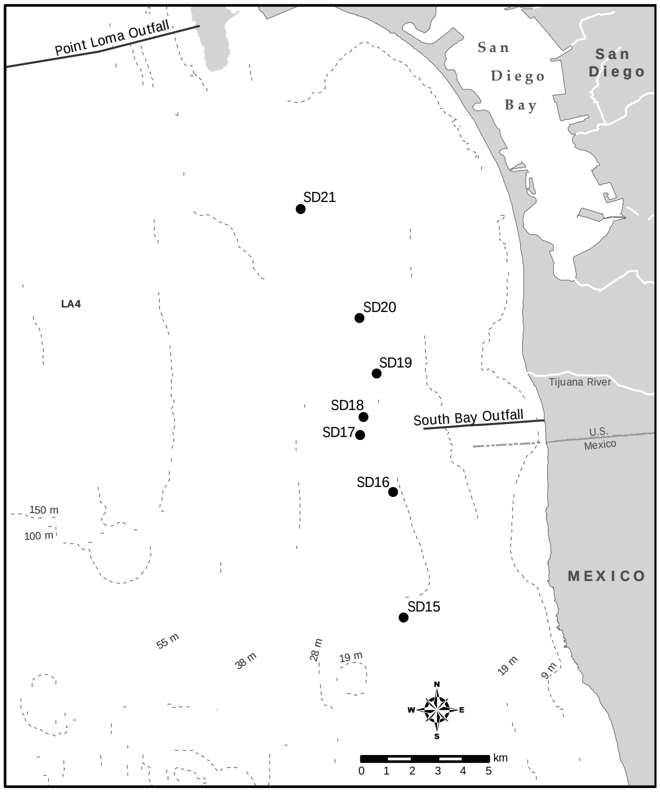


Figure 6.1
Otter trawl station locations, South Bay Ocean Outfall Monitoring Program.

further identification. For fishes, the total number of individuals and total biomass (kg, wet weight) were recorded for each species. Additionally, each individual fish was inspected for physical anomalies or indicators of disease (e.g., tumors, fin erosion, discoloration) as well as the presence of external parasites, and then measured to the nearest centimeter size class (standard lengths). For invertebrates, the total number of individuals was recorded per species. Due to the small size of most organisms, invertebrate biomass was typically measured as a composite weight of all species combined; however, large or exceptionally abundant species were weighed separately.

Data Analyses

Populations of each fish and invertebrate species were summarized as percent abundance, frequency of occurrence, mean abundance per haul, and mean abundance per occurrence. In addition, species richness (number of species), total abundance, total biomass, and Shannon diversity index (H') were calculated for each station. For historical comparisons, the data were grouped as "nearfield" stations (SD17, SD18), "south farfield" stations (SD15, SD16), and "north farfield" stations (SD19, SD20, SD21). The two nearfield stations were those located closest to the outfall (i.e., within 1000 m of the north or south diffuser legs).

A long-term multivariate analysis of demersal fish communities in the region was performed using data collected from 1995 through 2008. However, in order to eliminate noise due to natural seasonal variation in populations, this analysis was limited to data for the July surveys only over these 14 years. PRIMER software was used to examine spatio-temporal patterns in the overall similarity of fish assemblages in the region (see Clarke 1993, Warwick 1993, Clarke and Gorley 2006). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking, and ordination by non-metric multidimensional scaling (MDS). The fish abundance data were square root transformed and the Bray-Curtis measure of similarity was used as the basis for classification. Because species composition was sparse at some stations, a "dummy" species with a value of one was added to all samples prior to computing similarities (see Clarke and Gorley 2006). SIMPER analysis was subsequently used to identify the individual species that distinguished each cluster group.

Results and Discussion

Fish Community

Thirty-six species of fish were collected in the area surrounding the SBOO in 2008 (Table 6.1, Appendix E.1). The total catch for the year was 6221 individuals, representing an average of about 222 fish per trawl. Speckled sanddabs were the dominant fish captured, occurring in every haul and accounting for 59% of the total number of fishes collected during the year. Overall, this species averaged 131 fish per trawl, while all other species averaged less than 25 per haul. No other species contributed more

Table 6.1

Demersal fish species collected in 28 trawls in the SBOO region during 2008. PA=percent abundance; FO=frequency of occurrence; MAH=mean abundance per haul; MAO=mean abundance per occurrence.

Species	PA	FO	MAH	MAO	Species	PA	FO	MAH	MAO
Speckled sanddab	59	100	131	131	Kelp pipefish	<1	11	<1	2
Roughback sculpin	10	93	23	24	Pink seaperch	<1	11	<1	1
Yellowchin sculpin	8	71	19	26	Bigmouth sole	<1	7	<1	2
Pacific pompano	8	4	17	485	Pacific sanddab	<1	7	<1	1
California lizardfish	3	89	6	7	Pygmy poacher	<1	7	<1	1
Longfin sanddab	2	75	5	7	Shiner perch	<1	7	<1	1
Hornyhead turbot	2	96	4	5	Shovelnose guitarfish	<1	7	<1	1
Longspine combfish	2	54	4	8	Queenfish	<1	4	<1	10
Yellowfin croaker	2	4	4	98	Curlfin sole	<1	4	<1	2
English sole	1	71	3	4	Barred sand bass	<1	4	<1	1
California tonguefish	1	61	1	2	Calico rockfish	<1	4	<1	1
California scorpionfish	<1	43	1	2	Deepwater blenny	<1	4	<1	1
California halibut	<1	36	1	1	Giant kelpfish	<1	4	<1	1
Plainfin midshipman	<1	32	1	3	Round stingray	<1	4	<1	1
Specklefin midshipman	<1	25	1	3	Sarcastic fringehead	<1	4	<1	1
Fantail sole	<1	25	<1	1	Slimy snailfish	<1	4	<1	1
Spotted turbot	<1	18	<1	1	Spotted cuskeel	<1	4	<1	1
California skate	<1	18	<1	1	Thornback	<1	4	<1	1

than 10% of the total catch. Only roughback sculpin, yellowchin sculpin, California lizardfish, longfin sanddab, hornyhead turbot, longspine combfish, English sole, and California tonguefish occurred in at least 50% of the trawls. Additionally, an unusually large number of Pacific pompano (485 fish) was collected in a single trawl from station SD21 during the October 2008 survey (see Appendix E.2). The majority of species captured in the South Bay region tended to be relatively small fish with an average length <20 cm (see Appendix E.1). Although larger species such as the California skate, shovelnose guitarfish, thornback and round stingray were also captured during the year, these skates and rays were relatively rare compared to the bony fishes.

During 2008, species richness (number of species) and diversity (H') values for the South Bay fish assemblages were relatively low compared to other areas of the SCB (e.g., Allen et al. 1998, 2002, 2007), while abundance and biomass values varied widely in the region (Table 6.2). No more than 16 species occurred in any one haul, and the corresponding H' values were all less than 2.0. As in previous years, trawls from station SD15 located the farthest south in Mexican waters had the lowest average species richness (7 species) and diversity (H'=0.51) values of all sites. Total abundance ranged from 35 to 628 fishes per haul over all stations, which generally co-varied with speckled sanddab populations that ranged from 7 to 265 fish per catch (see Appendix E.2). The main exception to this trend was the extremely large haul at station SD21 in October that contained large numbers of Pacific pompano (see above), as well as almost 100 yellowfin croaker, but only seven speckled sanddabs. Biomass varied widely from 0.8 to 17.3 kg per haul, with higher biomass values coincident with greater numbers of fishes as expected (Appendix E.3). As with species richness and diversity, the lowest values for total abundance and biomass tended to occur at station SD15.

Although average species richness values for SBOO demersal fish assemblages have remained within a narrow range over the years (i.e., 5–14 species/station/year), the average abundance per haul has fluctuated greatly (i.e., 28–302 fish/station/year) mostly in response to population fluctuations of a few dominant species (see Figures 6.2 and 6.3). For example, the increase in average total abundance per

Table 6.2
Summary of demersal fish community parameters for SBOO stations sampled during 2008. Data are included for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight).

Station	Jan	Apr	Jul	Oct	Annual Mean	Annual SD
Species richness						
SD15	5	11	7	6	7	3
SD16	9	13	9	8	10	2
SD17	14	10	8	12	11	3
SD18	10	13	8	9	10	2
SD19	8	12	12	7	10	3
SD20	9	8	13	10	10	2
SD21	12	12	16	12	13	2
Survey Mean	10	11	10	9		
Survey SD	3	2	3	2		
Diversity						
SD15	0.33	0.56	0.44	0.72	0.51	0.17
SD16	0.45	1.23	0.61	0.94	0.81	0.35
SD17	1.39	1.51	1.02	1.27	1.30	0.21
SD18	1.41	1.61	0.98	1.13	1.28	0.28
SD19	0.90	1.03	1.00	1.11	1.01	0.09
SD20	1.17	1.59	1.28	1.28	1.33	0.18
SD21	1.34	1.77	1.27	1.04	1.36	0.30
Survey Mean	1.00	1.33	0.94	1.07		
Survey SD	0.45	0.42	0.32	0.20		

Station	Jan	Apr	Jul	Oct	Annual Mean	Annual SD
Abundance						
SD15	66	200	67	35	92	74
SD16	332	371	181	72	239	138
SD17	216	291	230	121	215	70
SD18	269	286	119	97	193	99
SD19	282	351	263	191	272	66
SD20	282	341	249	102	244	102
SD21	165	270	144	628	302	224
Survey Mean	230	301	179	178		
Survey SD	90	58	73	204		
Biomass						
SD15	1.3	4.8	4.1	0.8	2.7	2.0
SD16	3.6	5.2	3.5	2.2	3.6	1.2
SD17	7.7	4.2	3.8	5.9	5.4	1.8
SD18	6.0	5.4	2.9	4.5	4.7	1.3
SD19	3.6	5.5	7.4	2.4	4.7	2.2
SD20	3.9	4.3	5.3	1.9	3.8	1.4
SD21	6.5	4.3	6.7	17.3	8.7	5.8
Survey Mean	4.7	4.8	4.8	5.0		
Survey SD	2.2	0.6	1.7	5.7		

station that occurred between 2006 and 2008 at stations SD16, SD19, and SD20 (Figure 6.2), reflects a similar pattern in speckled sanddab populations alone (Figure 6.3). This trend reverses the substantial drop in the speckled sanddab catches that occurred from 2004 to 2006. Trawl catches of roughback sculpin and yellowchin sculpin were also greater in 2008 than in previous years at several stations. Whereas population fluctuations of common species such as speckled sanddab, roughback, and yellowchin sculpin tend to occur across the entire study area, intra-station variability is most often associated with large hauls of schooling species that occur infrequently. For example, large hauls of white croaker were responsible for the high abundance at station SD21 in 1996, a large haul of northern anchovy caused the relatively high abundance at station SD16 in 2001, and the 2008 annual mean for station SD21 reflects the large haul of Pacific pompano discussed previously. Overall, none of the observed changes appear to be associated with wastewater discharge via the SBOO.

Classification analyses of long-term data (1995–2008, July surveys only) discriminated between seven main types of fish assemblages (cluster groups A–G) in the South Bay region (Figure 6.4). These assemblages can be distinguished by differences in the relative abundances of the common species that were present, although most were dominated by speckled sanddabs. The distribution of assemblages in 2008 was generally similar to that seen in previous years, especially between 2003–2007, and no patterns appear to be associated with proximity to the outfall. Instead, most differences seem to be more closely related to large-scale oceanographic events (e.g., El Niño conditions in 1998) or the unique characteristics of a specific station location. For example, station SD15 located far south of the outfall in Mexican waters off northern Baja California often grouped apart from the remaining

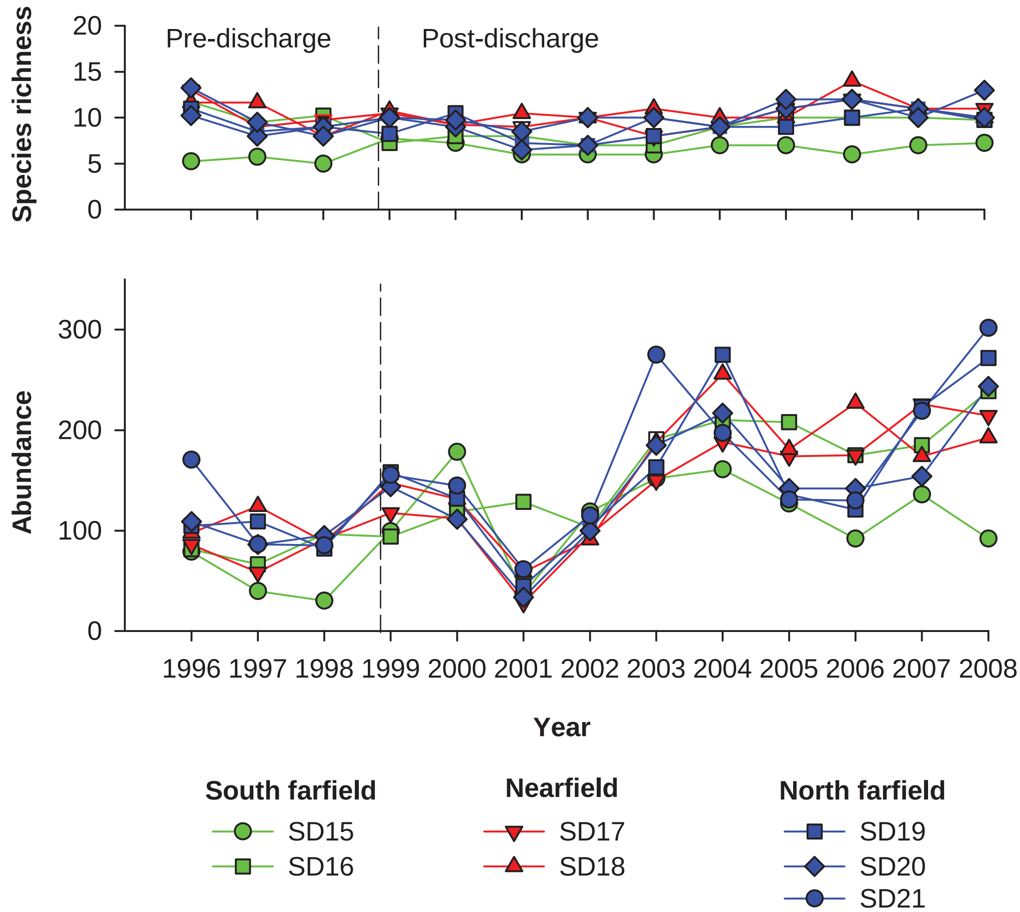


Figure 6.2

Species richness (number of species) and abundance (number of individuals) of demersal fish collected at each SBOO trawl station from 1996 through 2008. Data are annual means (n=4). Dotted line represents initiation of wastewater discharge.

stations. The composition and main characteristics of each cluster group are described below (Table 6.3, Appendix E.4).

Cluster group A represented the fish assemblages present only at stations SD16 and SD17 sampled in July 2006 (Figure 6.4). This group was unique in that it was characterized by more than 200 California lizardfish per haul, which was more than an order of magnitude greater for this species than in any other cluster group (Table 6.3). The second and third most abundant species comprising this group were the speckled sanddab (~56 fish/haul) and yellowchin sculpin (~15 fish/haul). The relative abundance of these three species distinguished this cluster group from all others (Appendix E.4).

Cluster group B was the third largest group and represented assemblages from 11 of the 14 station-surveys during 1995–1996 (i.e., representing all seven sites) and one or two stations each during 1997 (SD19, SD21), 1999 (SD17, SD21), 2000 (SD20, SD21), 2001 (SD21), and 2002 (SD18, SD21) (Figure 6.4). This group also represented assemblages from a few hauls at SD21 in 2005–2006, and a single haul at SD18 in 2008. Similar to most other groups, the dominant species was the speckled sanddab (~62 fish/haul) (Table 6.3). Group B was also characterized by the greatest number of hornyhead turbots on average and had twice as many longfin sanddabs (~23 fish/haul) as in the other groups. The relative abundance of speckled and longfin sanddabs, as well as California tonguefish, yellowchin sculpin, California lizardfish and hornyhead turbot, distinguished this assemblage from the other cluster groups (Appendix E.4).

Cluster group C was the second largest group and comprised assemblages that occurred at a mix of

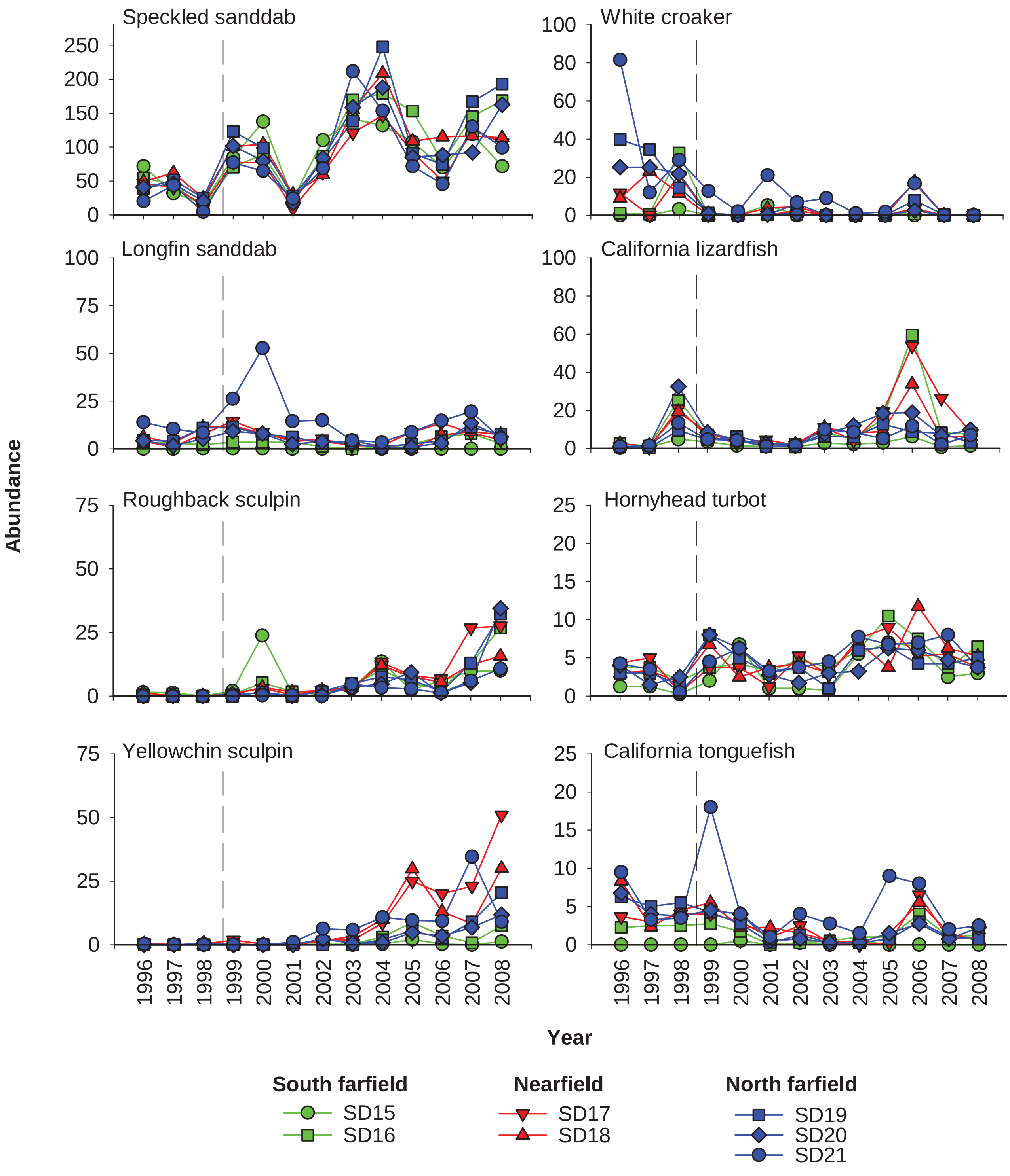


Figure 6.3
Abundance of the eight most abundant fish species collected in the SBOO region from 1996 through 2008. Data are annual means per station (n=4). Dotted line represents initiation of wastewater discharge.

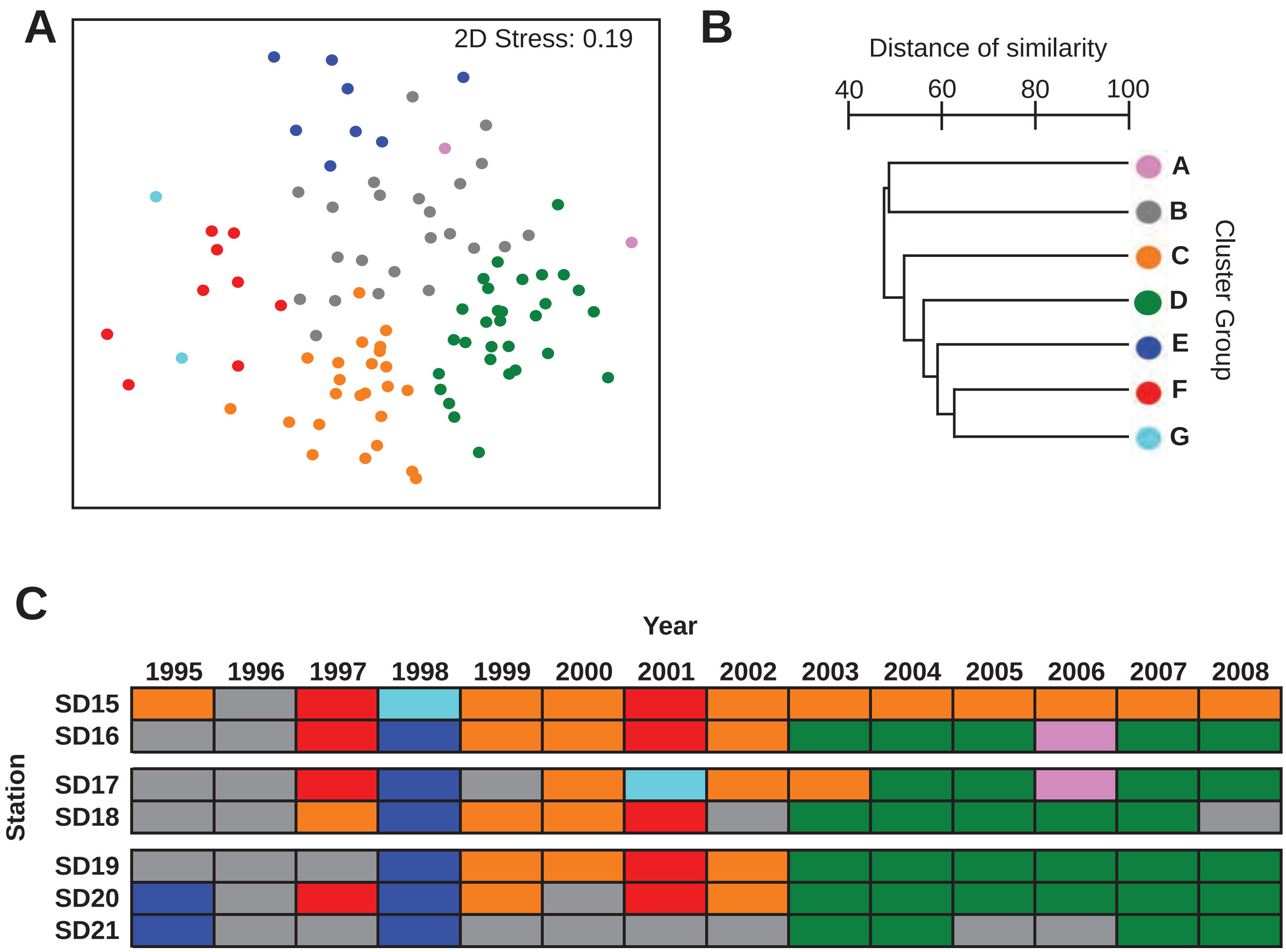


Figure 6.4

Results of classification analysis of demersal fish assemblages collected at SBOO stations SD15–SD21 between 1995 and 2008 (July surveys only). Data are presented as (A) MDS ordination, (B) a dendrogram of major cluster groups, and (C) a matrix showing distribution of cluster groups over time.

sites sampled during all years except 1996, 1998, and 2001. This included station SD15 in 10 out of 14 surveys and a majority of the other stations sampled during 1999, 2000, and 2002 (Figure 6.4). Group C was characterized by the second highest average abundance of speckled sanddabs (~105 fish/haul) and very few other species (Table 6.3). This group differed from most others in the relative abundance of not only speckled sanddabs, but also longfin sanddabs, California lizardfish, and hornyhead turbot (Appendix E.4). In addition, fewer numbers of yellowchin and roughback sculpin distinguished group C from cluster group D.

Cluster group D represented the assemblages from about 71% of the trawls performed from 2003 through 2008 (Figure 6.4). Assemblages represented by this group were characterized by having the highest number of speckled sanddabs (~152 fish/haul; Table 6.3), and were also distinguished from the other cluster groups by relatively high numbers of yellowchin sculpin, roughback sculpin, and California lizardfish (Appendix E.4). The larger hauls of speckled sanddabs that started to occur in 1999 (e.g., represented by cluster group C) versus previous years (e.g., represented by cluster groups B, E, and F), and that continued to increase over the time period represented by group D coincide with colder water conditions associated with oceanographic events such as La Niña (see Chapter 2).

Cluster group E comprised assemblages from the two northernmost stations (SD20, SD21) sampled in 1995, as well as from every station except SD15

Table 6.3

Description of cluster groups A–G defined in Figure 6.4. Data include number of hauls, mean species richness, mean total abundance, and mean abundance of the five most abundant species for each station group. Values that are underlined indicate species that were considered "characteristic" of that group according to SIMPER analyses (i.e., similarity/standard deviation ≥2.0).

	Group A	Group B	Group C	Group D	Group E	Group F	Group G
Number of hauls	2	23	24	30	8	9	2
Mean species richness	8	10	6	10	9	7	6
Mean abundance	299	117	117	218	64	38	28
Species	**Mean Abundance**						
California lizardfish	212	4	3	13	24	1	8
Speckled sanddab	56	<u>62</u>	<u>105</u>	<u>152</u>	<u>12</u>	<u>25</u>	15
Yellowchin sculpin	15	4	<1	20	1	—	—
Longfin sanddab	5	23	<1	7	<u>12</u>	<1	1
Hornyhead turbot	4	<u>6</u>	3	4	<u>3</u>	4	1
Roughback sculpin	3	<1	<1	9	—	—	—
California tonguefish	3	5	1	1	2	1	—
English sole	2	3	<1	3	5	<1	—
California scorpionfish	1	1	1	1	<1	2	2
Fantail sole	—	1	<1	<1	1	<1	1
Spotted turbot	—	1	2	1	1	3	1
California skate	—	—	<1	<1	<1	<1	1

sampled during warm water conditions associated with the 1998 El Niño (Figure 6.4). This group averaged about 64 individuals and 9 species per haul, and was characterized by the lowest abundance of speckled sanddabs (~12 fish/haul) (Table 6.3). The dominant species in this group was California lizardfish (~24 fish/haul) followed by longfin sanddabs (~12 fish/haul) and speckled sanddabs (as above); the relative abundance of these species distinguished this group from all of the others (Appendix E.4).

Cluster groups F and G comprised assemblages also sampled during warmer than normal ocean conditions (see Chapter 2). The fish assemblages represented by group F were collected at four stations sampled in July 1997 (i.e., southern stations SD15 and SD16, station SD17 near the outfall, northern station SD20) and every station except SD17 and SD21 during July 2001 (Figure 6.4). Assemblages represented by group G were from just two trawls, one from station SD15 in 1998 and one from stations SD17 in 2001. Overall, these groups averaged the fewest fish per haul (i.e., 38 fish/7 species for group F; 28 fish/6 species for group G), which reflected the small average number of speckled sanddabs in these two groups. Groups F and G were further distinguished from the other cluster groups by their relative (but usually lower) abundance of several common species, including longfin sanddab, yellowchin sculpin, California lizardfish, hornyhead turbot, roughback sculpin and English sole (Appendix E.4). Assemblages represented by group G differed from those represented by group F in the relative contribution of speckled sanddabs, California lizardfish, and hornyhead turbot.

Physical Abnormalities and Parasitism

Demersal fish populations appeared healthy in the SBOO region during 2008. There were no incidences of fin rot, discoloration, skin lesions, tumors, or any other physical abnormalities or indicators of disease among fishes collected during the year. Evidence of parasitism was also very low for trawl-caught fishes in the region. Only two external parasites were observed still attached to their host. These included a leech (Annelida, Hirudinea) attached to a hornyhead turbot at station SD17 in October, and the cymothoid isopod *Elthusa vulgaris* attached to

Table 6.4

Species of megabenthic invertebrates collected in 28 trawls in the SBOO region during 2008. PA=percent abundance; FO=frequency of occurrence; MAH=mean abundance per haul; MAO=mean abundance per occurrence.

Species	PA	FO	MAH	MAO	Species	PA	FO	MAH	MAO
Astropecten verrilli	51	93	13	14	*Aphrodita* sp	<1	4	<1	2
Dendraster terminalis	13	18	3	18	*Crangon alaskensis*	<1	4	<1	2
Crangon nigromaculata	9	39	2	6	*Dortyteuthis opalescens*	<1	4	<1	2
Pisaster brevispinus	4	50	1	2	*Lovenia cordiformis*	<1	4	<1	2
Lytechinus pictus	3	18	1	4	*Pandalus platyceros*	<1	4	<1	2
Hemisquilla californiensis	2	29	1	2	*Armina californica*	<1	4	<1	1
Heterocrypta occidentalis	2	18	<1	3	*Calliostoma canaliculatum*	<1	4	<1	1
Octopus rubescens	1	14	<1	3	*Calliostoma gloriosum*	<1	4	<1	1
Acanthodoris brunnea	1	11	<1	3	*Crangon alba*	<1	4	<1	1
Pyromaia tuberculata	1	18	<1	1	*Dendronotus frondosus*	<1	4	<1	1
Elthusa vulgaris	1	14	<1	2	*Dendronotus iris*	<1	4	<1	1
Halosydna latior	1	18	<1	1	*Euspira lewisii*	<1	4	<1	1
Ophiothrix spiculata	1	14	<1	1	*Flabellina pricei*	<1	4	<1	1
Kelletia kelletii	1	11	<1	2	*Heptacarpus palpator*	<1	4	<1	1
Philine auriformis	1	11	<1	2	*Heptacarpus stimpsoni*	<1	4	<1	1
Metacarcinus gracilis	1	7	<1	3	*Loxorhynchus crispatus*	<1	4	<1	1
Randallia ornata	1	11	<1	1	*Loxorhynchus* sp	<1	4	<1	1
Romaleon antennarius	1	7	<1	2	*Megastraea turbanica*	<1	4	<1	1
Luidia armata	<1	11	<1	1	*Paguristes ulreyi*	<1	4	<1	1
Platymera gaudichaudii	<1	11	<1	1	*Panulirus interruptus*	<1	4	<1	1
Pugettia producta	<1	4	<1	3	*Pinnixa franciscana*	<1	4	<1	1
Metacarcinus anthonyi	<1	7	<1	1	*Podochela hemphillii*	<1	4	<1	1
Crossata californica	<1	7	<1	1	*Pugettia richii*	<1	4	<1	1
Flabellina iodinea	<1	7	<1	1	*Sicyonia ingentis*	<1	4	<1	1
Loxorhynchus grandis	<1	7	<1	1	*Stylatula elongata*	<1	4	<1	1
Pagurus spilocarpus	<1	7	<1	1	*Thesea* sp B	<1	4	<1	1
Pandalus danae	<1	7	<1	1	*Tritonia diomedea*	<1	4	<1	1

a spotted turbot at station SD18 in July. In addition to the specimen identified on the spotted turbot, six other *E. vulgaris* were identified as part of the trawl catch throughout the year (see Appendix E.5). Since cymothoids often become detached from their hosts during retrieval and sorting of the trawl catch, it is unknown which fishes were actually parasitized by these isopods. However, *E. vulgaris* is known to be especially common on sanddabs and California lizardfish in southern California waters, where it may reach infestation rates of 3% and 80%, respectively (see Brusca 1978, 1981).

Invertebrate Community

A total of 698 megabenthic invertebrates (~25 per trawl), representing 54 taxa, were collected during 2008 (Table 6.4, Appendix E.5). As in previous years, the asteroid *Astropecten verrilli* was the most abundant and most frequently captured species. This sea star was captured in 93% of the trawls and accounted for 51% of the total invertebrate abundance. Another sea star, *Pisaster brevispinus*, occurred in 50% of the trawls but accounted for only 4% of the total abundance. The remaining taxa occurred infrequently, with only two species occurring in 20% or more of the hauls. With the exception of *A. verrilli*, all of the species collected averaged no more than three individuals per haul.

Megabenthic invertebrate community structure varied among stations and between surveys during the year (Table 6.5). Species richness ranged from 1 to 12 species per haul, diversity (H') values ranged from 0 to 2.11 per haul, and total abundance ranged from 3 to 144 individuals per haul. The biggest hauls

Table 6.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2008. Data are included for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight).

Station	Jan	Apr	Jul	Oct	Annual Mean	Annual SD
Species richness						
SD15	4	5	6	6	5	1
SD16	7	4	3	4	5	2
SD17	6	3	9	12	8	4
SD18	5	1	9	12	7	5
SD19	3	3	4	5	4	1
SD20	4	8	3	7	6	2
SD21	5	5	9	6	6	2
SurveyMean	5	4	6	7		
Survey SD	1	2	3	3		
Diversity						
SD15	0.79	0.84	0.54	0.51	0.67	0.17
SD16	1.33	1.19	0.96	0.57	1.01	0.33
SD17	1.50	1.10	2.11	1.86	1.64	0.44
SD18	1.48	0.00	1.80	2.11	1.35	0.94
SD19	0.85	0.87	1.17	1.02	0.97	0.15
SD20	1.03	1.77	0.80	1.85	1.36	0.53
SD21	1.38	1.23	2.02	1.50	1.53	0.34
SurveyMean	1.19	1.00	1.34	1.34		
Survey SD	0.30	0.54	0.63	0.65		

Station	Jan	Apr	Jul	Oct	Annual Mean	Annual SD
Abundance						
SD15	13	144	90	65	78	54
SD16	23	10	7	21	15	8
SD17	17	3	14	28	16	10
SD18	14	6	21	46	22	17
SD19	21	6	10	19	14	7
SD20	19	16	7	11	13	5
SD21	18	12	20	17	17	3
SurveyMean	18	28	24	30		
Survey SD	4	51	30	19		
Biomass						
SD15	0.6	0.5	0.3	0.3	0.4	0.1
SD16	0.8	0.1	0.3	0.3	0.4	0.3
SD17	1.2	0.2	1.1	0.2	0.7	0.5
SD18	1.4	0.1	0.5	0.1	0.5	0.6
SD19	0.1	0.7	0.5	0.1	0.3	0.3
SD20	0.5	1.6	0.1	2.0	1.0	0.9
SD21	0.7	0.4	1.4	0.6	0.8	0.4
SurveyMean	0.8	0.5	0.6	0.5		
Survey SD	0.4	0.5	0.5	0.7		

all occurred at station SD15 and were characterized by large numbers of *A. verrilli* (Appendix E.6). Although biomass was also somewhat variable (0.1–1.60 kg), the highest values generally corresponded to the collection of relatively large sea stars or crabs.

Variations in megabenthic invertebrate community structure in the South Bay region generally reflect changes in species abundance (Figures 6.5, 6.6). Although species richness has varied little over the years (e.g., 4–14 species/trawl), annual abundance values have averaged between 7 and 273 individuals per haul. These large differences have typically been due to fluctuations in populations of several dominant species, including especially *A. verrilli*, the sea urchin *Lytechinus pictus*, the sand dollar *Dendraster terminalis*, and the shrimp *Crangon nigromaculata* (Figure 6.6). For example, trawls at station SD15 have had the highest average abundance compared to the other stations for 8 out of 14 years due to relatively large populations of *A. verrilli*, *L. pictus*, and *D. terminalis*. In addition, the high abundances recorded at station SD17 in 1996 were due to large hauls of *L. pictus*. None of the observed variability in the invertebrate communities appears to be related to the South Bay outfall.

Summary and Conclusions

As in previous years, speckled sanddabs continued to dominate fish assemblages surrounding the SBOO during 2008. This species occurred at all stations and accounted for 59% of the total catch. Other characteristic, but less abundant species included the roughback sculpin, yellowchin sculpin, California lizardfish, longfin sanddab, hornyhead turbot, longspine combfish, English sole, and California tonguefish. Most of these common fishes were relatively small, averaging less than 20 cm in length. Although the composition and structure of the fish assemblages varied among stations, these differences were mostly due to variations in speckled sanddab populations.

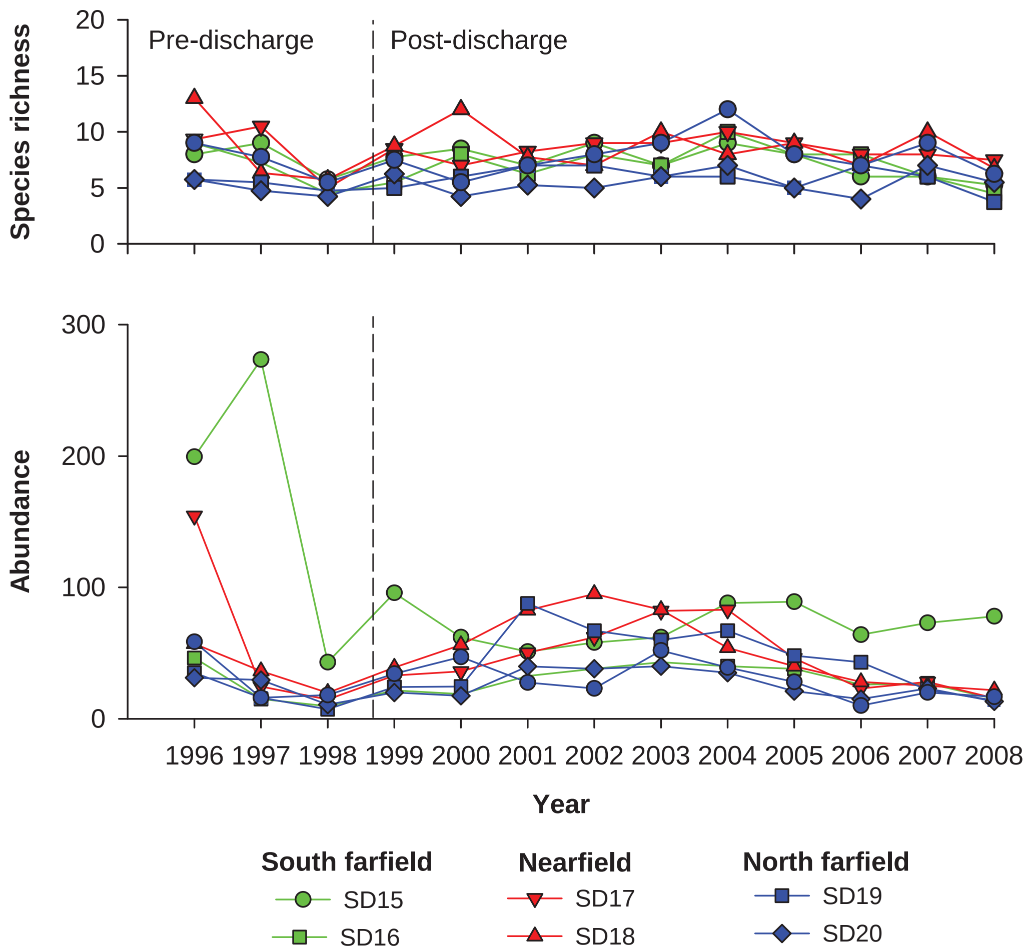


Figure 6.5
Species richness (number of species) and abundance (number of individuals) of megabenthic invertebrates collected in the SBOO region from 1996 through 2008. Data are annual means (n=4). Dotted line represents initiation of wastewater discharge.

Assemblages of relatively large (megabenthic) invertebrates in the region were similarly dominated by one prominent species, the sea star *Astropecten verrilli*. Variations in community structure of the trawl-caught invertebrates generally reflect changes in the abundance of this sea star, as well as other dominant species such as the urchin *Lytechinus pictus*, the sand dollar *Dendraster terminalis*, and the shrimp *Crangon nigromaculata*.

Overall, results of the 2008 trawl surveys provide no evidence that wastewater discharged through the SBOO has affected either demersal fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance and distribution of species were similar at stations located near the outfall and farther away, with no discernable changes in the region following the onset of the SBOO wastewater discharge. Instead, the high degree of variability in these communities observed during 2008 was similar to those that occurred in previous years (e.g., City of San Diego 2006–2008), including the period before initiation of wastewater discharge (City of San Diego 2000). In addition, the low species richness and abundances of fish and invertebrates found during the 2008 surveys are consistent with what is expected for the relatively shallow, sandy habitats in which the SBOO stations are located (see Allen et al. 1998, 2002, 2007). Changes in these communities appear to be more likely due to natural factors such as changes in ocean water temperatures associated with large-scale oceanographic events (e.g., El Niño or La Niña) or to the mobile nature of many of the resident species collected. Finally, the

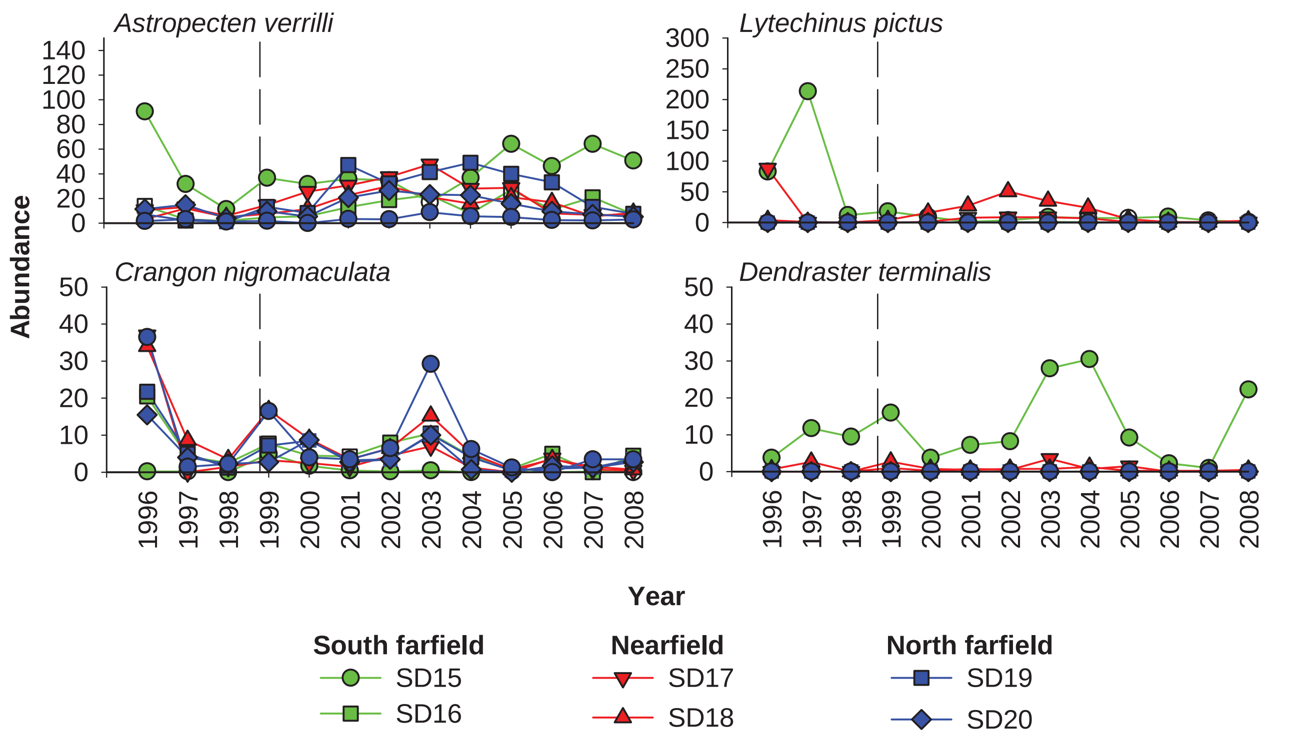


Figure 6.6
Abundance (number of individuals) of the four most abundant megabenthic species collected in the SBOO region from 1996 through 2008. Data are annual means (n=4). Dotted line represents initiation of wastewater discharge.

absence of disease or other physical abnormalities in local fishes suggests that populations in the area continue to be healthy.

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Chapter 7
Bioaccumulation of Contaminants in Fish Tissues

Chapter 7. Bioaccumulation of Contaminants in Fish Tissues

INTRODUCTION

Bottom dwelling (i.e., demersal) fishes are collected as part of the South Bay Ocean Outfall (SBOO) monitoring program to assess the accumulation of contaminants in their tissues. Bioaccumulation of contaminants in fish occurs through the biological uptake and retention of chemical contaminants derived via various exposure pathways (USEPA 2000). The main exposure routes for demersal fishes include uptake of dissolved chemicals in seawater and the ingestion and assimilation of pollutants contained in different food sources (Rand 1995). Because of their proximity to seafloor sediments, these fish may also accumulate contaminants through ingestion of suspended particulates or sediments that contain pollutants. For this reason, the levels of many contaminants in the tissues of demersal fish are often related to those found in the environment (Schiff and Allen 1997), thus making these types of assessments useful in biomonitoring programs.

The bioaccumulation portion of the South Bay monitoring program consists of two components: (1) liver tissues are analyzed for trawl-caught fishes; (2) muscle tissues are analyzed for fishes collected by hook and line (rig fishing). Species of fish collected by trawling activities (see Chapter 6) are representative of the general demersal fish community, and certain species are targeted based on their prevalence in the community and therefore ecological significance. The chemical analysis of liver tissues in these fish is especially important for assessing population effects because this is the organ where contaminants typically concentrate (i.e., bioaccumulate). In contrast, fishes targeted for capture by rig fishing represent species that are characteristic of a typical sport fisher's catch, and are therefore considered of recreational and commercial importance and more directly relevant to human health concerns. Consequently, muscle tissue is analyzed from these fishes because it is the tissue most often consumed by humans, and therefore the results may have public health implications.

This chapter presents the results of all tissue analyses that were performed on fishes collected in the SBOO region during 2008. All liver and muscle samples were analyzed for contaminants as specified in the NPDES discharge permits that govern the SBOO monitoring program (see Chapter 1). Most of these contaminants are also sampled for the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program. NOAA initiated this program to detect and monitor changes in the environmental quality of the nation's estuarine and coastal waters by tracking contaminants thought to be of environmental concern (Lauenstein and Cantillo 1993).

Materials and Methods

Field Collection

Fishes were collected during April and October of 2008 at seven trawl and two rig fishing stations (Figure 7.1). Trawl-caught fishes were collected following City of San Diego guidelines (see Chapter 6 for a description of collection methods). Fishes targeted at the rig fishing sites were caught using standard rod and reel procedures. Species analyzed from each station are summarized in Table 7.1 and included brown rockfish (*Sebastes auriculatus*), California scorpionfish (*Scorpaena guttata*), English sole (*Parophrys vetulus*), hornyhead turbot (*Pleuronichthys verticalis*), longfin sanddab (*Citharichthys xanthostigma*), and vermilion rockfish (*Sebastes miniatus*). Efforts to collect targeted fish species at the trawl stations were limited to five 10-minute (bottom time) trawls per site. Occasionally, insufficient numbers of the target species were obtained despite this effort, thus resulting in reduced number of composite samples at a particular station. In order to facilitate the collection of sufficient tissue for subsequent chemical analysis, only fish ≥13 cm in standard length were retained. These fish were sorted into no more than three composite samples per station, each containing a minimum of three individuals. Composite samples were typically made up of a

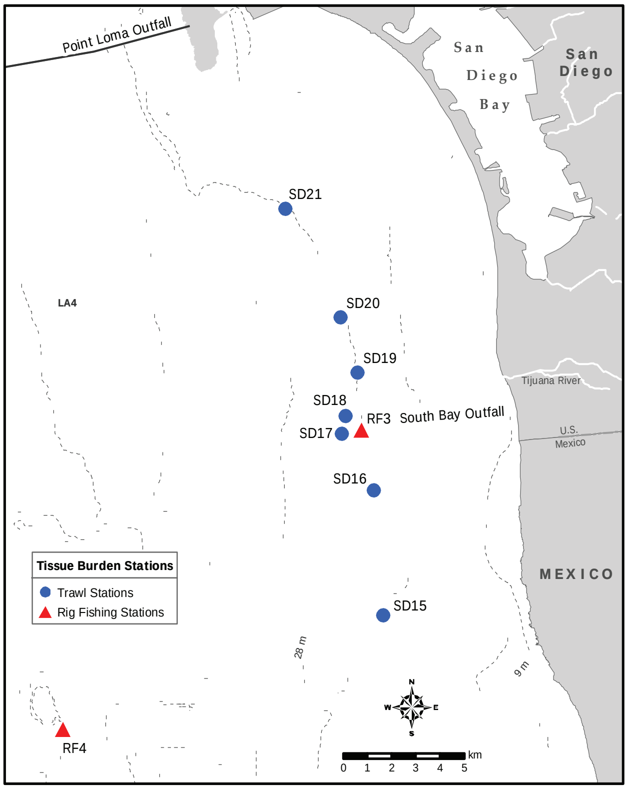

Figure 7.1
Otter trawl and rig fishing station locations for the South Bay Ocean Outfall Monitoring Program.

single species; the only exceptions were samples that consisted of mixed species of rockfish. All fish collected were wrapped in aluminum foil, labeled, sealed in re-sealable plastic bags, placed on dry ice, and then transported to the City's Marine Biology Laboratory where they were held in the freezer at -80°C until dissection and tissue processing.

Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis. A brief summary follows, but see City of San Diego (2004) for additional details. Prior to dissection, each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus. The standard length (cm) and weight (g) of each fish were recorded (Appendix F.1). Dissections were carried out on Teflon® pads that were cleaned between samples. The tissues (liver or muscle) from each dissected fish were then placed in separate glass jars for each composite sample, sealed, labeled, and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City's Wastewater Chemistry Services Laboratory for analysis within 10 days of dissection.

The chemical constituents analyzed for each tissue sample were measured on a wet weight basis, and included trace metals, chlorinated pesticides, polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (see Appendix F.2). Metals were measured in units of mg/kg and are expressed herein as parts per million (ppm), while pesticides, PCBs, and PAHs were measured as µg/kg and expressed as parts per billion (ppb). Totals for DDT, PCBs, BHC (=lindane and derivatives), chlordane, and PAHs were calculated as the sum of the detected constituents (i.e., total PCB=sum of all congeners detected). The detected values for each individual constituent are listed in Appendix F.3. This report includes estimated values for some parameters determined to be present in a sample with high confidence (i.e., peaks confirmed by mass-spectrometry), but that otherwise occurred at levels below the method detection limit (MDL). A detailed description of the protocols for chemical analyses is available in City of San Diego (2009).

Results and Discussion

Contaminants in Trawl-Caught Fishes

Metals

Twelve metals occurred in >75% of the liver samples analyzed from trawl-caught fishes in 2008, including arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, selenium, silver, tin, and zinc (Table 7.2). Another five metals (i.e., aluminum, antimony, lead, nickel, thallium) were also detected, but less frequently at rates between 3-69%. Beryllium was not detected in any sample during the year. Tissue concentrations of most metals were <25 ppm over all species. Exceptions occurred for aluminum, iron, and

Table 7.1
Species of fish collected at each SBOO trawl and rig fishing station during April and October 2008.

Station	Composite 1	Composite 2	Composite 3
April 2008			
SD15	Hornyhead turbot	California scorpionfish	(no sample)
SD16	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD17	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD18	Longfin sanddab	Longfin sanddab	English sole
SD19	English sole	Longfin sanddab	Longfin sanddab
SD20	English sole	Longfin sanddab	Longfin sanddab
SD21	Longfin sanddab	Longfin sanddab	English sole
RF3	Vermilion rockfish	Brown rockfish	Brown rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish
October 2008			
SD15	Hornyhead turbot	(no sample)	(no sample)
SD16	(no sample)	(no sample)	(no sample)
SD17	Hornyhead turbot	Longfin sanddab	California scorpionfish
SD18	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD19	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD20	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD21	Longfin sanddab	Hornyhead turbot	California scorpionfish
RF3	Brown rockfish	Brown rockfish	Brown rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish

zinc, which all had concentrations >45 ppm in at least one sample. Several metals occurred in quantities that varied greatly among the different species of fish. For example, arsenic ranged from 14 to 18.5 ppm in English sole livers, but was less than 8 ppm on average in liver samples from California scorpionfish, hornyhead turbot, and longfin sanddab. In contrast, zinc ranged from 94 to 137 ppm in liver samples from California scorpionfish, but was less than 46 ppm on average for each of the other three species. These differences are not unexpected, as it has been well documented that the bioaccumulation of contaminants can vary greatly between fish species due to differences in physiology and life history (see Groce 2002 and references therein).

The distribution of frequently detected metals in fishes collected in the SBOO region was assessed by comparing concentrations in fishes collected at the two stations located within a kilometer of the SBOO (SD17, SD18) to those from stations located farther away to the south (SD15, SD16) or north (SD19–SD21) (Figure 7.2). Because concentrations of contaminants varied so much among the species collected, only intra-species comparisons were used for this evaluation. These comparisons suggest that there was no clear relationship between contaminant loads and proximity to the outfall (Figure 7.2). Contaminant concentrations were similar among stations and most were close to or below the maximum levels detected in the same species prior to discharge. Exceptions occurred for two of the four species; arsenic, cadmium, manganese, and zinc occurred at concentrations above the maximum value reported during the pre-discharge period for hornyead turbot and English sole. However, these relatively high concentrations occurred throughout the region and showed no pattern relative to the outfall.

Table 7.2

Summary of metals in liver tissues of fishes collected at SBOO trawl stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max) and mean detected concentrations for each species. Concentrations are expressed as parts per million (ppm); the number of samples per species is indicated in parentheses; nd=not detected. See Appendix F.2 for MDLs and names for each metal represented by periodic table symbol.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
California scorpionfish																		
n (out of 3)	2	3	3	3	nd	3	3	3	3	nd	3	3	2	3	2	nd	3	3
Min	4.10	0.11	0.39	0.103	—	2.40	0.20	13.00	89.8	—	0.60	0.189	0.10	0.47	0.07	—	2.94	94.2
Max	36.80	0.54	1.02	0.359	—	2.81	0.49	21.10	263.0	—	1.27	0.347	0.23	0.64	0.22	—	4.25	137.0
Mean	20.45	0.29	0.65	0.212	—	2.58	0.37	17.43	147.9	—	0.84	0.277	0.17	0.57	0.14	—	3.54	117.7
English sole																		
n (out of 4)	3	4	4	4	nd	4	4	4	4	3	4	4	nd	4	nd	nd	4	4
Min	3.09	0.28	14.00	0.089	—	0.90	0.10	5.30	174.0	0.15	2.14	0.057	—	0.95	—	—	1.93	27.6
Max	12.70	0.65	18.50	0.158	—	1.40	0.26	7.85	218.0	0.24	2.32	0.071	—	1.39	—	—	2.39	44.9
Mean	6.44	0.50	16.62	0.108	—	1.06	0.18	6.50	197.5	0.21	2.25	0.062	—	1.26	—	—	2.10	38.1
Hornyhead turbot																		
n (out of 9)	2	4	9	9	nd	9	9	9	9	nd	9	8	nd	9	8	nd	9	9
Min	12.50	0.26	2.22	0.056	—	3.82	0.17	6.98	29.7	—	0.94	0.091	—	0.53	0.09	—	1.71	35.5
Max	13.00	0.68	8.50	0.172	—	12.00	0.27	11.00	99.5	—	2.02	0.198	—	0.99	0.23	—	2.40	59.4
Mean	12.75	0.39	5.07	0.098	—	6.77	0.22	8.47	54.6	—	1.42	0.127	—	0.75	0.14	—	2.08	46.4
Longfin sanddab																		
n (out of 20)	8	14	20	20	nd	20	20	20	20	7	20	20	13	20	18	1	20	20
Min	3.13	0.28	4.47	0.088	—	1.04	0.11	4.78	50.0	0.25	0.78	0.044	0.21	0.56	0.05	0.50	1.99	17.7
Max	49.10	0.97	13.00	0.275	—	3.71	0.31	11.80	157.0	0.41	2.22	0.095	0.62	1.73	0.22	0.50	4.61	35.8
Mean	10.33	0.64	7.77	0.163	—	2.14	0.22	8.40	104.2	0.35	1.44	0.069	0.32	1.10	0.11	0.50	3.40	26.7
All species:																		
Detection rate (%)	42	69	100	100	0	100	100	100	100	28	100	97	42	100	78	3	100	100
Max value	49.10	0.97	18.50	0.359	—	12.00	0.49	21.10	263.0	0.41	2.32	0.347	0.62	1.73	0.23	0.50	4.61	137.0

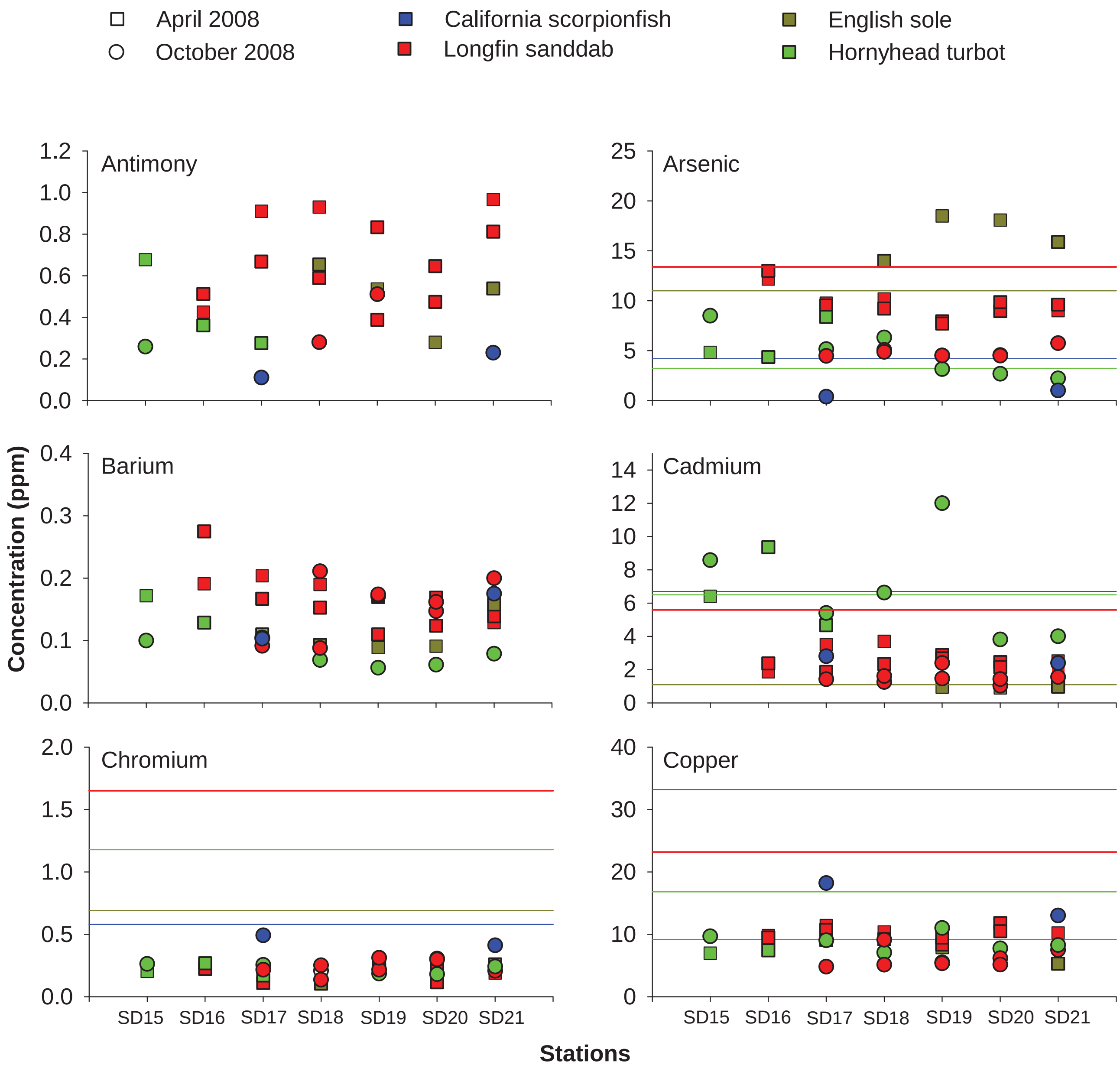

Figure 7.2

Concentrations of frequently detected metals in liver tissues of fishes collected from each SBOO trawl station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for each species; antimony, barium, and tin were not detected during the pre-discharge period because of substantially higher detection limits. Therefore, no reference lines are present for these contaminants. Except where samples were not collected (see Table 7.1), missing values=non-detects.

Pesticides

Several chlorinated pesticides were detected in fish tissues during the 2008 trawl surveys (Table 7.3). Individual components of total chlordane and total DDT are listed in Appendix F.2, while detected values of all pesticides are included in Appendix F.3. DDT was found in every tissue sample with total DDT concentrations ranging from about 31 to 1383 ppb. Other pesticides detected in fish tissues during the past year included hexachlorobenzene (HCB) in 83% of the samples at concentrations up to 16 ppb, and chlordane in 42% of the samples at concentrations up to 32 ppb. Pesticide concentrations tended to vary with lipid content, which ranged widely among and within species. For example, California scorpionfish and longfin sanddab liver tissues had

GLOSSARY

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

Adsorption
The adhesion of dissolved substances to the surface of sediment or on the surface of an organism (e.g., a flatfish).

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

Assemblage
An association of interacting populations in a given habitat (e.g., an assemblage of benthic invertebrates on the ocean floor).

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

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

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

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

Biota
The living organisms within a habitat or region.

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

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

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

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

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

Crustacea
A group (subphylum) of marine invertebrates characterized by jointed legs and an exoskeleton (e.g., crabs, shrimp, and lobster).

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

These parameters are used to assess the physical ocean environment.

Demersal
Organisms living on or near the bottom of the ocean and capable of active swimming.

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

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

Diversity
A measurement of community structure which describes the abundances of different species within a community, taking into account their relative rarity or commonness.

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

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

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

FIB
Fecal indicator bacteria (FIB) are the bacteria (total coliform, fecal coliform, and enterococcus) measured and evaluated to provide information about the movement and dispersion of wastewater discharged to the Pacific Ocean through the outfall.

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

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

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

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

Invertebrate
An animal without a backbone (e.g., sea star, crab, and worm).

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

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

Macrobenthic invertebrate
Epifaunal or infaunal benthic invertebrates that are visible with the naked eye. This group typically includes those animals larger than meiofauna and

smaller than megafauna. These animals are collected in grab samples from soft-bottom marine habitats and retained on a 1-mm mesh screen.

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

Megabenthic invertebrate
A larger, usually epibenthic and motile, bottom-dwelling animal such as a sea urchin, crab, or snail. These animals are typically collected by otter trawl nets with a minimum mesh size of 1 cm.

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

Motile
Self-propelled or actively moving.

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

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

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

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

PAHs
The USGS defines polycyclic aromatic hydrocarbons (PAHs) as, "hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases."

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

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

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

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

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

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

Polychaeta
A taxonomic group (class) of invertebrates characterized as having worm-like features,

segments, and bristles or tiny hairs. Examples include bristle worms and tube worms.

Pycnocline
A depth zone in the ocean where sea water density changes rapidly with depth and typically is associated with a decline in temperature and increase in salinity.

Recruitment
The retention of young individuals into the adult population in an open ocean environment.

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

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

SBOO
The South Bay Ocean Outfall (SBOO) is the underwater pipe originating at the International Wastewater Treatment Plant and used to discharge treated wastewater. It extends 5.6 km (3.5 miles) offshore and discharges into about 27 m (90 ft) of water.

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

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

Shell hash
Sediments composed of shell fragments.

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

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

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

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

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

Tissue burden
The total amount of measured chemicals that are present in the tissue (e.g., fish muscle).

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

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

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

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

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

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

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

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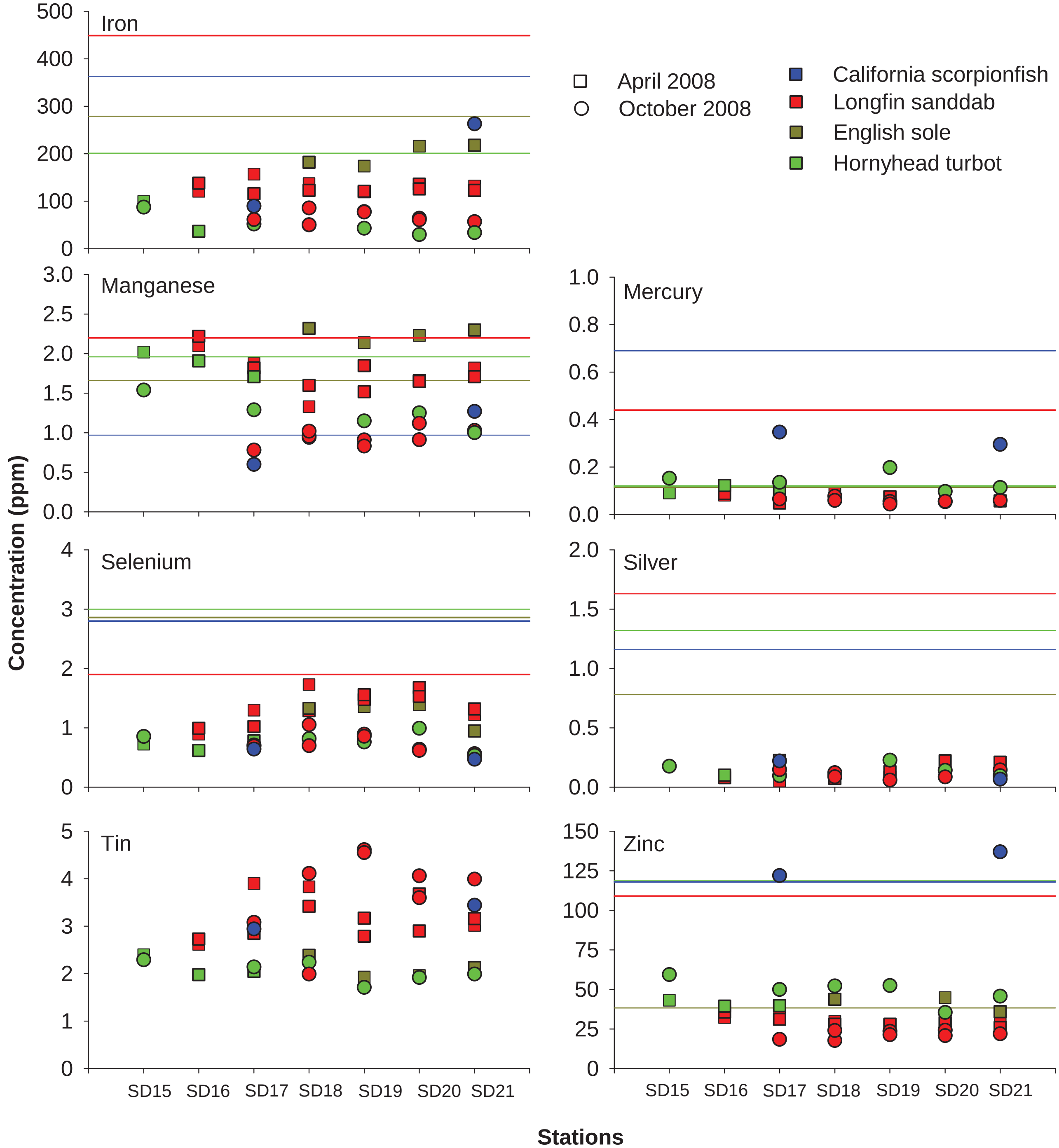

Figure 7.2 *continued*

the highest lipid content, as well as the highest levels of chlordane and DDT.

As with metals, there was no clear relationship between concentrations of these pesticides in fish tissues and proximity to the outfall (Figure 7.3). In addition, most pesticide concentrations were near or below the maximum levels detected in the same species prior to wastewater discharge. Two of the liver samples had HCB concentrations that were much higher than all the others; these included one elevated value from a hornyhead turbot sample collected at station SD15, and a second elevated value from a longfin sanddab sample collected at station SD17. Due to differences in analytical techniques, HCB was not detected in tissue samples collected during the pre-discharge surveys, and therefore, no pre- vs. post-discharge comparisons

Table 7.3

Summary of chlorinated pesticides, total PCB, and lipids in liver tissues of fishes collected at SBOO trawl stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. HCB=hexachlorobenzene; tChl=total chlordane; tDDT=total DDT; tPCB=total PCB; nd=not detected. Data are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt); the number of samples per species is indicated in parentheses; See Appendix F.2 for MDLs and Appendix F.3 for values of individual constituents summed for total chlordane, total DDT, and total PCB.

	Pesticides				
	HCB	tChl	tDDT	tPCB	Lipids
California scorpionfish					
n (out of 3)	3	2	3	3	3
Min	2.3	10.0	355.1	138.2	16.8
Max	2.7	25.5	744.9	508.4	27.4
Mean	2.5	17.7	598.3	299.6	22.7
English sole					
n (out of 4)	4	1	4	4	4
Min	0.7	1.4	97.0	38.1	3.8
Max	3.3	1.4	288.7	76.1	5.4
Mean	1.6	1.4	198.5	60.7	4.4
Hornyhead turbot					
n (out of 9)	4	nd	9	9	9
Min	0.8	—	31.0	2.6	3.1
Max	16.0	—	237.0	36.8	10.3
Mean	4.9	—	107.0	19.9	6.1
Longfin sanddab					
n (out of 20)	19	12	20	20	20
Min	1.4	2.4	185.3	63.4	12.1
Max	12.0	31.6	1382.6	758.6	46.7
Mean	3.2	11.0	739.2	373.6	24.3
All species:					
Detection rate (%)	83	42	100	100	100
Max value	16.0	31.6	1382.6	758.6	46.7

can be made. However, all HCB concentrations that have been detected in South Bay fishes were below 10 ppb across all of the stations.

PAHs and PCBs

PAHs were not detected in fish liver samples during 2008. In contrast, PCBs occurred in every tissue sample; see Appendix F.3 for a summary of all detected PCB congeners. Total PCBs were highly variable in South Bay fish tissues, ranging from about 3 to 759 ppb, and also tended to vary with lipid content (Table 7.3). For the most part, total PCB concentrations during the year were substantially less than pre-discharge values, with no clear relationship with proximity to the outfall (Figure 7.3).

Contaminants in Fishes Collected by Rig Fishing

Aluminum, antimony, arsenic, barium, chromium, copper, iron, manganese, mercury, selenium, tin, and zinc occurred in ≥75% of the muscle tissue samples collected from the two rig fishing stations in 2008 (Table 7.4). Thallium was only detected in 50% of the samples, while beryllium, cadmium, lead, nickel, and silver were not detected at all. The metals present in the highest concentrations were aluminum (up to 24 ppm), iron (up to 16 ppm), zinc (up to about 6 ppm) and arsenic (up to about 3 ppm). DDT was detected in 92% of the muscle samples, while PCBs and the pesticide HCB were detected in 50–58% of the samples (Table 7.5). Concentrations of these contaminants ranged from <0.1 ppb for HCB to 9.2 ppb for total DDT.

To address human health concerns, contaminant concentrations found in the muscle tissues of fishes collected as part of the SBOO monitoring program were compared to state, national, and international limits and standards (see Table 7.4, Table 7.5). These include: 1) the California Office of Environmental Health Hazard Assessment (OEHHA), which has developed fish contaminant goals for chlordane, DDT, methylmercury, PCBs, and selenium (Klasing and Brodberg 2008); 2) the United States Food and Drug Administration (U.S. FDA), which has set limits on the amount of mercury, total DDT, and chlordane in seafood that is to be sold for human consumption (see Mearns et al. 1991); 3) international standards for acceptable concentrations of various metals and DDT (see Mearns et al. 1991). Of the contaminants detected in these muscle tissues during 2008, the metals arsenic and selenium occurred in concentrations slightly higher than median international standards,

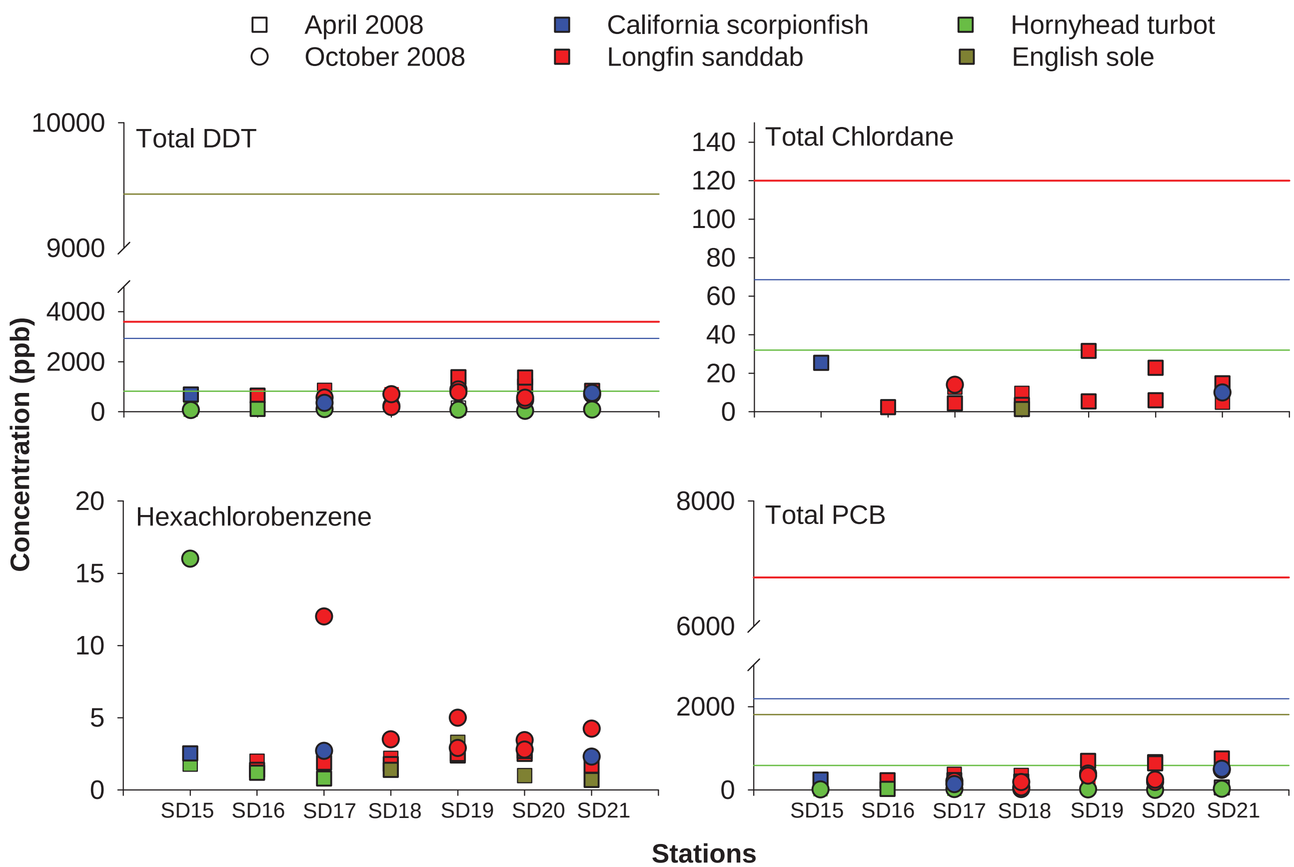

Figure 7.3

Concentrations of frequently detected chlorinated pesticides (total DDT, total chlordane, hexachlorobenzene) and total PCBs in liver tissues of fishes collected from each SBOO trawl station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for each species; chlordane and hexachlorobenzene were not detected as frequently during the pre-discharge period because of substantially higher detection limits. Therefore, reference lines for these two contaminants are absent for some or all of the species. Except where samples were not collected (see Table 7.1), missing values=non-detects.

while mercury (as a proxy for methylmercury) exceeded the OEHHA fish contaminant goal. Exceedences for arsenic and selenium occurred in both California scorpionfish and vermilion rockfish muscle tissues, while the exeedance for mercury occurred only in scorpionfish. Additionally, the OEHHA fish contaminant goal for total PCB was exceeded in a single California scorpionfish sample.

In addition to addressing health concerns, spatial patterns were analyzed for total DDT and total PCB, as well as for all metals that occurred frequently in muscle tissue samples (Figure 7.4). Overall, concentrations of DDT, PCB, and various metals in the muscle tissues of fishes captured at rig fishing stations RF3 and RF4 were fairly similar, which suggests that there was no relationship with proximity to the outfall. However, comparisons of contaminant loads in fishes from these stations should be considered with caution since different species of fish were collected at the two sites, and the bioaccumulation of contaminants may differ between species because of differences in physiology, diet, and exposure to contaminant sources due to migration habits and/or other large scale movements. This potential problem may be minimal in the South Bay region as all fish specimens sampled in 2008 belong to the same family (Scorpaenidae), have similar life histories (i.e., bottom dwelling tertiary carnivores), and are therefore likely to have similar mechanisms of exposure to and uptake of contaminants (e.g., direct contact with sediments, similar food sources). However, species such as those reported herein are known to traverse large areas and may be exposed

Table 7.4

Summary of metals in muscle tissues of fishes collected at SBOO rig fishing stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. Concentrations are expressed as parts per million (ppm); the number of samples per species is indicated in parentheses; nd=not detected. Data are compared to OEHHA fish contaminant goals (OEHHA), U.S. FDA action limits, and median international standards for parameters where these exist. Bold values meet or exceed these standards. See Appendix F.2 for MDLs and names for each metal represented by periodic table symbol.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
Brown rockfish																		
n (out of 5)	3	4	5	5	nd	nd	5	5	5	nd	5	5	nd	5	nd	3	5	5
Min	5.15	0.225	0.58	0.078	—	—	0.143	0.58	3.10	—	0.106	0.105	—	0.156	—	0.607	1.64	3.30
Max	18.70	0.538	0.91	0.195	—	—	0.203	1.81	9.72	—	0.176	0.165	—	0.258	—	0.815	2.01	5.34
Mean	14.15	0.311	0.75	0.116	—	—	0.176	1.41	6.16	—	0.148	0.127	—	0.205	—	0.718	1.86	4.47
California scorpionfish																		
n (out of 6)	5	4	6	6	nd	nd	6	6	6	nd	6	6	nd	6	nd	3	6	6
Min	4.67	0.232	**1.43**	0.079	—	—	0.109	0.72	4.22	—	0.111	0.113	—	0.235	—	0.685	1.81	4.41
Max	13.00	0.515	**2.65**	0.227	—	—	0.222	1.97	16.00	—	0.203	**0.231**	—	**0.345**	—	0.753	2.28	6.39
Mean	8.31	0.390	**2.06**	0.138	—	—	0.142	1.16	7.88	—	0.152	0.183	—	0.282	—	0.730	1.94	5.23
Vermilion rockfish																		
n (out of 1)	1	1	1	1	nd	nd	1	1	1	nd	1	1	nd	1	nd	nd	1	1
Min	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
Max	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
Mean	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
All species:																		
Detection rate (%)	75	75	100	100	0	0	100	100	100	0	100	100	0	100	0	50	100	100
Max	24.00	0.555	2.65	0.227	—	—	0.222	1.97	16	—	0.259	**0.231**	—	**0.345**	—	0.815	2.28	6.39
OEHHA*												0.22		7.4				
U.S. FDA Action Limit**												1						
Median IS**			1.4				1	20				0.5		0.3			175	70

* From the California Office of Environmental Health Hazard Assessment (OEHHA) (Klasing and Brodberg 2008).

** From Mearns et al. 1991. U.S. FDA mercury action limits and all international standards (IS) are for shellfish, but are often applied to fish.

Table 7.5

Summary of chlorinated pesticides, total PCB, and lipids in muscle tissues of fishes collected at SBOO rig fishing stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. HCB=hexachlorobenzene; tDDT=total DDT; tPCB=total PCB. Values are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt); the number of samples per species is indicated in parentheses. Data are compared to OEHHA fish contaminant goals (OEHHA), U.S. FDA action limits, and median international standards for parameters where these exist. Bold values meet or exceed these standards. See Appendix F.2 for MDLs and Appendix F.3 for values of individual constituents summed for total DDT and total PCB.

	Pesticides			
	HCB	tDDT	tPCB	Lipids
Brown rockfish				
n (out of 5)	2	4	2	5
Min	0.05	1.8	0.6	0.1
Max	7.20	9.2	1.0	0.6
Mean	3.62	3.8	0.8	0.3
California scorpionfish				
n (out of 6)	3	6	4	6
Min	0.10	1.7	0.4	0.2
Max	1.00	8.5	**5.2**	1.6
Mean	0.50	4.6	2.1	0.8
Vermilion rockfish				
n (out of 1)	1	1	1	1
Min	0.10	7.7	2.1	0.9
Max	0.10	7.7	2.1	0.9
Mean	0.10	7.7	2.1	0.9
All species:				
Detection rate (%)	50	92	58	100
Max	7.20	9.2	**5.2**	1.6
OEHHA*		21	3.6	
U.S. FDA Action Limit**		5000		
Median IS**		5000		

* From the California Office of Environmental Health Hazard Assessment (OEHHA) (Klasing and Brodberg 2008).
** From Mearns et al. 1991. U.S. FDA action limits and all international standards (IS) are for shellfish, but are often applied to fish.

to contaminants present instead in other locations. For example, it has been previously reported that California scorpionfish tagged in Santa Monica Bay have been recaptured as far south as the Coronado Islands (e.g., Hartmann 1987, Love et al. 1987).

Summary and Conclusions

Several trace metals, the pesticides DDT, HCB, and various chlordane components, and a combination of PCB congeners were detected in liver tissue samples collected from four different species of fish in the SBOO region during 2008. Many of the same metals, DDT, HCB, and PCB congeners were also detected in muscle tissues during the year, although often less frequently and/or in lower concentrations. Tissue contaminant values ranged widely within and among species and stations. However, all were within the range of values reported previously for the Southern California Bight (SCB) (see Mearns et al. 1991, City of San Diego 1996–2001, Allen et al. 1998). In addition, while some muscle tissue samples from sport fish collected in the area had concentrations of arsenic and selenium above the median international standard for shellfish, and some had concentrations of mercury and total PCB that exceeded OEHHA fish contaminant goals, concentrations of mercury and DDT were below FDA human consumption limits.

The frequent occurrence of metals and chlorinated hydrocarbons in SBOO fish tissues may be due to multiple factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals occur naturally in the environment, although little information is available on background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998, 2002). The lack of contaminant-free reference areas in the SCB clearly pertains to the South Bay region, as demonstrated by the presence of many contaminants in fish tissues prior to wastewater discharge (see City of San Diego 2000b).

Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species (see Groce 2002 and references therein). Exposure to

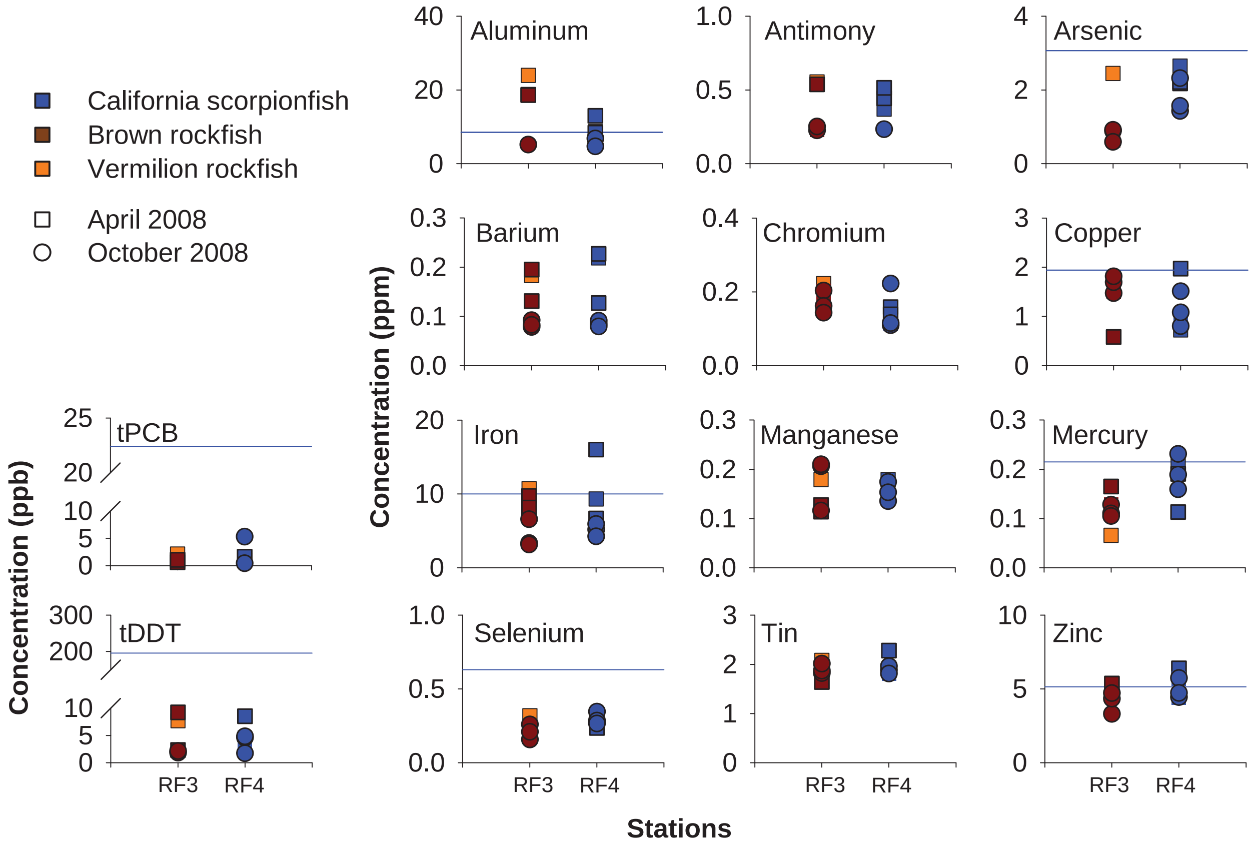

Figure 7.4
Concentrations of frequently detected metals, total DDT, and total PCB in muscle tissues of fishes collected from each SBOO rig fishing station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for California scorpionfish. Vermilion and brown rockfish were not collected during that period. All missing values=non-detects.

contaminants can vary greatly between different species and among individuals of the same species depending on migration habits (Otway 1991). Fishes may be exposed to contaminants in an area that is highly contaminated and then move into an area that is not. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many point and non-point sources that may contribute to contamination in the region (see Chapters 2–4); some monitoring stations are located near the Tijuana River, San Diego Bay, and dredged materials disposal sites, and input from these sources may affect fish in surrounding areas.

Overall, there was no evidence that fishes collected in 2008 were contaminated by the discharge of wastewater from the SBOO. Although several individual tissue samples contained concentrations of some metals that exceeded pre-discharge maximums, concentrations of most contaminants were not substantially different from pre-discharge levels (see City of San Diego 2000b). In addition, the few tissue samples that did exceed pre-discharge values were widely distributed among the sampled stations and showed no patterns that could be attributed to wastewater discharge. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot, other indicators of disease, or any physical anomalies (see Chapter 6).

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Glossary

GLOSSARY

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

Adsorption
The adhesion of dissolved substances to the surface of sediment or on the surface of an organism (e.g., a flatfish).

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

Assemblage
An association of interacting populations in a given habitat (e.g., an assemblage of benthic invertebrates on the ocean floor).

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

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

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

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

Biota
The living organisms within a habitat or region.

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

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

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

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

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

Crustacea
A group (subphylum) of marine invertebrates characterized by jointed legs and an exoskeleton (e.g., crabs, shrimp, and lobster).

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

These parameters are used to assess the physical ocean environment.

Demersal
Organisms living on or near the bottom of the ocean and capable of active swimming.

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

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

Diversity
A measurement of community structure which describes the abundances of different species within a community, taking into account their relative rarity or commonness.

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

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

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

FIB
Fecal indicator bacteria (FIB) are the bacteria (total coliform, fecal coliform, and enterococcus) measured and evaluated to provide information about the movement and dispersion of wastewater discharged to the Pacific Ocean through the outfall.

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

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

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

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

Invertebrate
An animal without a backbone (e.g., sea star, crab, and worm).

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

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

Macrobenthic invertebrate
Epifaunal or infaunal benthic invertebrates that are visible with the naked eye. This group typically includes those animals larger than meiofauna and

smaller than megafauna. These animals are collected in grab samples from soft-bottom marine habitats and retained on a 1-mm mesh screen.

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

Megabenthic invertebrate
A larger, usually epibenthic and motile, bottom-dwelling animal such as a sea urchin, crab, or snail. These animals are typically collected by otter trawl nets with a minimum mesh size of 1 cm.

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

Motile
Self-propelled or actively moving.

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

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

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

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

PAHs
The USGS defines polycyclic aromatic hydrocarbons (PAHs) as, "hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases."

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

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

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

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

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

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

Polychaeta
A taxonomic group (class) of invertebrates characterized as having worm-like features,

segments, and bristles or tiny hairs. Examples include bristle worms and tube worms.

Pycnocline
A depth zone in the ocean where sea water density changes rapidly with depth and typically is associated with a decline in temperature and increase in salinity.

Recruitment
The retention of young individuals into the adult population in an open ocean environment.

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

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

SBOO
The South Bay Ocean Outfall (SBOO) is the underwater pipe originating at the International Wastewater Treatment Plant and used to discharge treated wastewater. It extends 5.6 km (3.5 miles) offshore and discharges into about 27 m (90 ft) of water.

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

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

Shell hash
Sediments composed of shell fragments.

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

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

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

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

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

Tissue burden
The total amount of measured chemicals that are present in the tissue (e.g., fish muscle).

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

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

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

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

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

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

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

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Appendices

Appendix A

Supporting Data

2008 SBOO Stations

Oceanographic Conditions

Appendix A.1

Summary of temperature, salinity, density, dissolved oxygen, pH, transmissivity, and chlorophyll *a* at all SBOO stations during 2008. Values are expressed as averages over the entire water column for each month; data are organized by depth contour, with stations listed north to south.

		Temperature (°C)											
Contour	**Station**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
9-m	I37	13.3	13.1	13.1	13.1	14.3	11.4	14.9	15.2	15.8	15.0	16.0	16.7
	I38	13.2	13.4	14.2	13.5	16.1	11.6	16.3	16.5	16.9	16.3	15.8	16.6
	I36	13.0	13.2	14.4	14.0	16.8	13.7	16.6	16.5	17.3	17.2	16.1	16.5
	I32	13.3	13.2	12.8	12.6	16.0	12.1	17.1	17.5	17.1	16.9	15.4	16.7
	I26	13.4	13.4	13.5	12.1	14.8	13.4	16.5	18.2	17.2	15.8	17.3	16.5
	I25	13.5	13.0	13.5	12.9	15.8	15.0	16.1	18.3	16.8	16.0	17.4	16.4
	I24	13.6	13.0	13.3	12.9	16.0	14.7	15.1	17.3	16.5	15.0	17.4	16.1
	I40	13.6	12.9	12.7	11.9	15.2	15.4	15.3	16.7	16.3	15.2	17.4	15.8
	I19	13.7	12.8	12.5	11.5	14.4	15.4	15.3	16.8	16.4	15.5	17.2	15.6
	I11	13.5	13.1	12.5	11.5	15.9	14.3	13.9	16.2	15.7	14.5	15.9	15.8
19-m	I34	13.0	13.1	12.1	11.7	12.7	10.7	14.9	14.4	15.4	14.9	15.6	15.8
	I35	13.2	12.8	12.6	12.1	13.9	11.3	15.2	15.0	15.7	15.0	15.3	16.3
	I31	12.9	12.8	12.4	12.3	13.3	11.2	15.0	14.9	16.0	14.9	14.7	16.1
	I39	13.4	12.7	11.9	11.7	14.9	12.7	13.5	14.9	16.0	15.4	16.8	15.5
	I23	13.5	13.0	12.4	11.6	14.6	14.4	14.2	16.9	15.5	14.3	16.9	15.9
	I18	13.4	12.8	12.3	11.8	14.9	12.9	14.4	14.9	15.2	14.4	16.9	15.5
	I10	13.4	13.0	12.1	11.5	14.4	12.8	14.2	15.4	15.5	15.2	15.6	15.6
	I5	13.5	13.3	12.0	10.9	15.9	13.3	13.1	17.3	16.0	15.0	16.0	15.7
	I4	13.4	13.0	11.9	10.8	13.9	12.8	12.9	15.1	15.3	14.9	15.5	15.3
28-m	I33	12.8	13.0	11.7	11.6	12.0	10.4	13.5	14.8	14.7	14.6	14.9	15.3
	I30	12.6	12.9	11.8	11.4	12.5	11.4	14.2	14.3	15.0	13.9	14.8	14.9
	I27	12.9	12.6	11.7	11.1	13.5	11.6	13.4	16.1	14.9	14.0	16.6	15.0
	I22	13.4	12.8	12.0	11.3	13.8	12.3	13.0	15.0	15.1	13.9	16.7	14.7
	I14	13.4	12.7	12.0	11.3	13.6	12.0	13.6	15.0	14.8	14.3	16.5	15.0
	I17	13.4	12.8	11.7	11.5	13.7	12.1	13.7	15.6	15.3	14.3	16.5	15.2
	I16	13.3	12.6	11.5	11.2	13.7	11.9	13.5	15.0	14.9	14.3	16.4	15.1
	I15	13.1	12.7	11.8	11.2	13.6	11.2	13.3	14.6	14.7	14.2	16.4	14.8
	I12	13.4	12.6	11.9	11.2	13.3	11.8	13.5	14.6	15.1	14.1	16.2	14.9
	I9	12.9	12.6	12.3	11.2	13.2	11.7	13.3	14.2	15.0	14.3	15.2	14.5
	I6	13.2	12.9	11.9	11.1	13.4	12.1	13.3	14.6	15.6	15.0	15.4	15.4
	I3	13.3	13.0	11.9	11.0	13.3	11.8	13.3	14.4	15.1	15.3	15.4	15.2
	I2	12.4	12.8	12.1	11.4	13.5	11.9	13.2	14.3	15.2	15.0	15.7	14.6
38-m	I29	12.9	12.8	11.5	11.1	12.2	10.8	13.3	14.1	14.9	13.4	14.8	14.3
	I21	12.5	12.4	11.0	11.6	12.9	10.8	12.6	13.1	14.8	15.6	14.6	14.6
	I13	12.6	12.8	11.7	11.6	12.8	11.0	12.8	13.5	14.6	14.4	14.8	14.7
	I8	12.6	12.9	11.8	11.1	12.9	11.1	13.1	13.4	14.9	14.4	15.1	14.6
55-m	I28	12.0	12.1	11.3	10.9	11.5	10.5	12.1	13.3	14.2	14.1	14.7	14.0
	I20	11.9	12.5	11.2	11.0	12.2	10.7	12.2	12.6	13.4	13.9	14.6	14.5
	I7	12.1	12.9	11.5	11.4	12.5	10.5	12.4	13.9	13.7	13.8	15.1	14.8
	I1	12.5	12.4	11.4	11.6	12.7	10.6	12.3	14.0	14.5	14.3	15.6	14.9

Appendix A.1 *continued*

Contour	Station	Salinity (ppt)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	33.43	33.46	33.53	33.75	33.87	33.84	33.61	33.51	33.43	33.31	33.39	33.32
	I38	33.48	33.43	33.54	33.75	33.90	33.75	33.62	33.50	33.44	33.32	33.37	33.33
	I36	33.50	33.47	33.53	33.75	33.93	33.75	33.61	33.52	33.45	33.38	33.36	33.33
	I32	33.49	33.50	33.57	33.80	33.88	33.79	33.63	33.53	33.45	33.37	33.37	33.32
	I26	33.45	33.43	33.55	33.81	33.87	33.82	33.63	33.56	33.46	33.33	33.33	33.34
	I25	33.45	33.39	33.55	33.80	33.83	33.76	33.63	33.55	33.43	33.34	33.34	33.34
	I24	33.44	33.46	33.59	33.80	33.81	33.78	33.61	33.56	33.43	33.30	33.36	33.37
	I40	33.44	33.51	33.61	33.82	33.82	33.77	33.63	33.53	33.44	33.30	33.37	33.37
	I19	33.43	33.54	33.58	33.84	33.81	33.75	33.62	33.54	33.39	33.32	33.36	33.38
	I11	33.48	33.47	33.61	33.85	33.83	33.77	33.62	33.54	33.38	33.29	33.36	33.37
19-m	I34	33.50	33.47	33.60	33.78	33.84	33.86	33.63	33.45	33.42	33.33	33.38	33.36
	I35	33.48	33.50	33.59	33.78	33.86	33.84	33.61	33.46	33.41	33.31	33.38	33.34
	I31	33.52	33.51	33.59	33.81	33.82	33.83	33.61	33.43	33.42	33.31	33.39	33.35
	I39	33.47	33.52	33.62	33.85	33.83	33.80	33.62	33.47	33.43	33.33	33.35	33.37
	I23	33.47	33.41	33.61	33.84	33.84	33.76	33.61	33.52	33.43	33.30	33.37	33.36
	I18	33.47	33.44	33.63	33.84	33.83	33.79	33.61	33.46	33.43	33.30	33.38	33.37
	I10	33.46	33.50	33.64	33.81	33.81	33.79	33.63	33.47	33.37	33.32	33.35	33.38
	I5	33.46	33.45	33.66	33.89	33.82	33.76	33.63	33.52	33.33	33.26	33.35	33.38
	I4	33.47	33.49	33.65	33.85	33.83	33.79	33.62	33.46	33.34	33.29	33.35	33.38
28-m	I33	33.52	33.49	33.65	33.81	33.80	33.90	33.60	33.47	33.41	33.32	33.40	33.37
	I30	33.55	33.50	33.62	33.82	33.86	33.84	33.61	33.42	33.39	33.30	33.38	33.37
	I27	33.50	33.50	33.64	33.81	33.84	33.81	33.62	33.48	33.44	33.29	33.34	33.37
	I22	33.44	33.50	33.62	33.79	33.84	33.80	33.61	33.45	33.43	33.29	33.37	33.35
	I14	33.44	33.49	33.61	33.79	33.84	33.81	33.60	33.44	33.43	33.30	33.36	33.35
	I17	33.46	33.48	33.65	33.80	33.85	33.81	33.60	33.45	33.44	33.32	33.36	33.36
	I16	33.46	33.50	33.65	33.80	33.83	33.81	33.59	33.44	33.42	33.30	33.35	33.35
	I15	33.47	33.50	33.63	33.77	33.83	33.82	33.59	33.45	33.43	33.30	33.34	33.36
	I12	33.44	33.49	33.62	33.80	33.84	33.82	33.58	33.45	33.43	33.27	33.33	33.33
	I9	33.50	33.53	33.63	33.76	33.80	33.80	33.60	33.43	33.41	33.29	33.36	33.37
	I6	33.49	33.50	33.64	33.78	33.79	33.79	33.61	33.45	33.39	33.31	33.35	33.37
	I3	33.48	33.49	33.63	33.77	33.76	33.80	33.60	33.41	33.42	33.32	33.35	33.38
	I2	33.52	33.50	33.64	33.72	33.76	33.81	33.55	33.41	33.44	33.30	33.36	33.37
38-m	I13	33.54	33.51	33.69	33.75	33.78	33.83	33.62	33.47	33.43	33.29	33.37	33.38
	I21	33.55	33.54	33.78	33.77	33.79	33.84	33.62	33.51	33.44	33.34	33.38	33.37
	I29	33.51	33.52	33.67	33.82	33.82	33.88	33.59	33.46	33.41	33.31	33.41	33.37
	I8	33.53	33.49	33.66	33.75	33.77	33.81	33.62	33.44	33.43	33.28	33.36	33.37
55-m	I28	33.62	33.57	33.75	33.78	33.83	33.87	33.65	33.45	33.41	33.35	33.41	33.40
	I20	33.62	33.55	33.80	33.81	33.80	33.89	33.64	33.46	33.43	33.30	33.39	33.37
	I7	33.59	33.50	33.75	33.73	33.82	33.90	33.60	33.47	33.40	33.23	33.37	33.37
	I1	33.57	33.59	33.78	33.71	33.69	33.89	33.56	33.47	33.42	33.32	33.36	33.39

Appendix A.1 *continued*

Contour	Station	Density (δ/θ) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	25.11	25.18	25.23	25.40	25.24	25.80	24.91	24.76	24.58	24.66	24.51	24.30
	I38	25.17	25.10	25.02	25.31	24.87	25.70	24.61	24.47	24.32	24.38	24.53	24.33
	I36	25.24	25.16	24.97	25.22	24.73	25.28	24.53	24.49	24.24	24.22	24.47	24.34
	I32	25.17	25.20	25.33	25.54	24.89	25.61	24.41	24.25	24.29	24.28	24.63	24.30
	I26	25.12	25.10	25.17	25.64	25.12	25.38	24.56	24.10	24.27	24.51	24.15	24.36
	I25	25.08	25.14	25.17	25.47	24.89	25.01	24.67	24.07	24.34	24.46	24.16	24.39
	I24	25.06	25.20	25.24	25.47	24.83	25.08	24.86	24.32	24.42	24.64	24.17	24.46
	I40	25.05	25.26	25.37	25.69	25.01	24.93	24.83	24.44	24.47	24.61	24.17	24.53
	I19	25.04	25.30	25.39	25.77	25.18	24.92	24.82	24.42	24.43	24.56	24.20	24.59
	I11	25.11	25.18	25.40	25.78	24.85	25.16	25.12	24.55	24.56	24.75	24.50	24.55
19-m	I34	25.23	25.19	25.47	25.69	25.52	25.93	24.90	24.89	24.65	24.70	24.59	24.53
	I35	25.18	25.26	25.38	25.61	25.29	25.80	24.84	24.75	24.59	24.66	24.65	24.40
	I31	25.26	25.28	25.41	25.59	25.40	25.82	24.88	24.77	24.52	24.67	24.79	24.45
	I39	25.13	25.30	25.54	25.75	25.08	25.50	25.21	24.79	24.53	24.60	24.29	24.60
	I23	25.11	25.16	25.42	25.75	25.16	25.15	25.05	24.39	24.64	24.81	24.29	24.51
	I18	25.13	25.22	25.47	25.70	25.07	25.47	25.00	24.80	24.70	24.78	24.30	24.60
	I10	25.11	25.23	25.50	25.75	25.17	25.47	25.06	24.67	24.60	24.63	24.56	24.59
	I5	25.09	25.13	25.53	25.91	24.87	25.35	25.29	24.29	24.47	24.62	24.47	24.57
	I4	25.12	25.22	25.56	25.91	25.29	25.48	25.34	24.73	24.63	24.67	24.60	24.66
28-m	I33	25.28	25.22	25.59	25.72	25.64	26.01	25.20	24.80	24.80	24.75	24.74	24.64
	I30	25.34	25.24	25.55	25.77	25.58	25.79	25.05	24.89	24.73	24.88	24.76	24.73
	I27	25.24	25.31	25.60	25.82	25.37	25.73	25.22	24.53	24.78	24.87	24.33	24.71
	I22	25.10	25.28	25.52	25.77	25.31	25.58	25.31	24.73	24.73	24.88	24.34	24.75
	I14	25.09	25.28	25.50	25.77	25.35	25.65	25.16	24.73	24.78	24.80	24.37	24.71
	I17	25.13	25.25	25.58	25.74	25.34	25.63	25.14	24.61	24.68	24.81	24.36	24.66
	I16	25.14	25.31	25.63	25.79	25.32	25.67	25.17	24.74	24.77	24.79	24.39	24.69
	I15	25.19	25.29	25.56	25.78	25.35	25.81	25.21	24.81	24.80	24.82	24.38	24.75
	I12	25.09	25.30	25.54	25.80	25.41	25.70	25.16	24.82	24.72	24.81	24.41	24.70
	I9	25.26	25.33	25.45	25.77	25.39	25.70	25.23	24.91	24.73	24.79	24.65	24.82
	I6	25.18	25.25	25.56	25.79	25.35	25.61	25.23	24.83	24.57	24.67	24.60	24.64
	I3	25.16	25.22	25.54	25.81	25.35	25.68	25.22	24.86	24.72	24.60	24.61	24.67
	I2	25.36	25.26	25.50	25.70	25.32	25.64	25.20	24.86	24.69	24.64	24.55	24.79
38-m	I13	25.34	25.29	25.62	25.69	25.46	25.84	25.33	25.09	24.82	24.77	24.75	24.79
	I21	25.37	25.37	25.82	25.69	25.43	25.89	25.38	25.20	24.80	24.55	24.80	24.80
	I29	25.25	25.28	25.64	25.82	25.62	25.93	25.21	24.93	24.74	25.00	24.79	24.85
	I8	25.32	25.24	25.57	25.79	25.43	25.82	25.27	25.09	24.77	24.77	24.68	24.81
55-m	I28	25.51	25.45	25.74	25.84	25.76	25.97	25.51	25.10	24.89	24.86	24.80	24.95
	I20	25.54	25.37	25.81	25.84	25.58	25.95	25.48	25.27	25.08	24.86	24.80	24.81
	I7	25.47	25.24	25.71	25.70	25.54	25.99	25.40	24.99	24.99	24.84	24.69	24.75
	I1	25.38	25.41	25.75	25.66	25.41	25.97	25.40	24.97	24.82	24.81	24.57	24.74

Appendix A.1 *continued*

Contour	Station	Dissolved Oxygen (mg/L)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	8.0	7.4	7.3	8.3	7.3	5.3	9.3	8.7	8.5	7.7	6.9	8.0
	I38	8.0	8.6	8.2	9.3	7.7	6.2	9.7	9.5	9.0	8.4	7.4	7.7
	I36	7.1	8.0	8.1	9.0	8.6	7.4	9.5	9.3	8.6	8.2	7.9	7.8
	I32	7.6	7.4	6.1	6.6	8.4	5.2	8.2	8.7	7.5	7.7	7.5	7.9
	I26	8.1	8.1	7.5	6.5	8.3	7.0	7.6	8.3	7.0	7.8	8.4	6.8
	I25	8.4	8.2	7.4	6.6	10.1	9.0	5.0	9.6	9.1	7.6	8.0	7.8
	I24	8.6	7.7	7.5	6.9	9.2	9.4	7.8	9.5	9.3	7.8	8.3	7.7
	I40	8.5	7.1	6.4	6.0	8.2	9.2	6.4	8.5	9.1	8.3	8.2	7.6
	I19	8.5	6.7	6.0	4.4	7.7	8.4	6.5	8.9	9.1	7.9	7.9	7.7
	I11	8.1	8.6	6.6	5.6	8.9	9.0	6.5	8.6	9.0	8.1	7.8	7.8
19-m	I34	7.4	7.4	6.0	6.0	6.4	4.3	8.4	8.5	8.4	7.7	7.8	7.6
	I35	7.8	7.2	6.4	6.9	6.9	5.0	9.0	8.9	9.1	7.8	7.5	8.0
	I31	7.1	7.1	6.5	7.1	7.2	5.1	8.8	9.4	8.6	8.2	7.3	8.0
	I39	8.0	6.8	5.8	6.0	8.9	7.1	7.3	8.3	8.4	8.4	8.3	7.6
	I23	8.3	7.9	6.8	5.8	8.6	9.3	8.0	9.8	9.1	7.8	8.2	7.9
	I18	8.2	7.5	6.4	5.8	8.6	7.5	8.5	9.3	9.1	8.1	8.4	7.9
	I10	8.4	7.8	6.0	5.9	7.4	7.4	7.7	8.9	9.4	8.6	8.0	8.1
	I5	8.6	8.6	5.9	4.9	9.1	7.7	7.4	9.6	9.1	8.3	7.8	7.8
	I4	8.3	7.5	5.9	4.7	7.1	7.2	7.5	8.9	9.2	8.6	7.7	7.6
28-m	I33	7.1	7.6	5.5	5.7	5.2	3.8	7.4	8.4	8.8	7.9	7.3	7.4
	I30	6.6	7.7	5.6	5.8	6.4	5.2	7.7	8.8	9.1	7.9	7.4	7.6
	I27	7.3	7.1	5.5	5.3	7.0	5.8	7.5	8.8	8.6	8.1	8.5	7.5
	I22	8.5	7.4	6.0	5.6	7.4	6.7	7.3	8.7	9.0	8.3	8.3	7.7
	I14	8.5	7.2	6.1	5.7	7.2	6.1	8.0	8.7	9.2	8.3	8.4	7.7
	I17	8.1	7.4	5.6	6.0	7.5	6.2	7.7	8.8	9.0	8.0	8.4	7.8
	I16	8.1	6.9	5.4	5.7	7.3	5.9	7.6	8.7	9.1	8.0	8.4	7.7
	I15	7.8	7.2	5.8	5.5	6.9	5.2	7.0	8.4	8.8	8.3	8.4	7.7
	I12	8.6	6.9	5.8	5.7	6.9	5.8	7.1	8.6	9.0	7.9	8.3	7.7
	I9	7.4	6.8	6.3	5.4	6.5	5.5	7.9	8.3	9.1	8.5	7.8	7.5
	I6	7.8	7.5	5.8	5.5	6.8	6.1	7.8	8.3	9.4	8.6	7.9	7.8
	I3	7.9	7.8	5.9	5.1	6.9	5.8	7.7	8.4	8.9	8.8	7.9	7.6
	I2	6.9	7.7	5.9	6.0	7.1	5.3	7.4	8.3	8.3	8.6	8.0	7.6
38-m	I13	7.1	7.5	5.5	6.0	6.3	4.7	7.2	7.7	8.4	8.6	7.6	7.5
	I21	7.0	6.8	4.4	5.7	6.3	4.6	7.1	7.3	8.2	8.6	7.3	7.5
	I29	7.5	7.3	5.2	5.3	5.8	4.5	7.7	8.2	8.7	7.7	7.3	7.3
	I8	7.2	7.6	5.6	5.3	6.5	4.7	7.2	7.9	8.5	8.8	7.7	7.5
55-m	I28	5.6	6.6	4.5	5.0	4.9	4.5	6.2	7.9	7.9	8.0	7.4	7.2
	I20	5.9	6.8	4.6	4.8	5.6	4.4	6.2	7.4	7.6	8.3	7.5	7.5
	I7	6.4	7.6	4.9	5.8	5.9	4.1	6.5	7.6	7.9	8.2	7.8	7.7
	I1	6.7	6.7	4.8	5.5	6.3	4.1	6.7	7.5	7.8	8.0	8.0	7.7

Appendix A.1 *continued*

Contour	Station	pH Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	8.0	8.0	8.1	8.1	8.1	7.9	8.2	8.2	8.0	8.1	8.0	8.1
	I38	8.1	8.2	8.2	8.2	8.2	8.0	8.2	8.3	8.0	8.2	8.0	8.1
	I36	8.1	8.1	8.2	8.2	8.3	8.1	8.2	8.3	8.0	8.2	8.1	8.1
	I32	8.1	8.0	8.0	8.1	8.2	7.9	8.2	8.3	7.9	8.2	8.0	8.1
	I26	8.1	8.1	8.1	8.2	8.2	8.0	8.1	8.2	8.1	8.2	8.1	8.0
	I25	8.2	8.1	8.1	8.2	8.3	8.2	7.9	8.3	8.2	8.2	8.1	8.1
	I24	8.2	8.1	8.1	8.2	8.3	8.2	8.1	8.3	8.3	8.1	8.1	8.1
	I40	8.2	8.0	8.0	8.1	8.2	8.2	8.0	8.2	8.2	8.2	8.1	8.1
	I19	8.2	8.0	7.9	8.0	8.1	8.2	8.0	8.2	8.2	8.2	8.1	8.1
	I11	8.2	8.2	8.0	8.1	8.3	8.2	8.0	8.2	8.1	8.2	8.1	8.1
19-m	I34	8.1	8.1	8.0	8.0	8.0	7.9	8.1	8.2	8.0	8.1	8.1	8.1
	I35	8.1	8.1	8.0	8.0	8.1	7.9	8.2	8.2	8.0	8.1	8.0	8.1
	I31	8.1	8.1	8.0	8.1	8.1	7.9	8.1	8.3	8.0	8.2	8.0	8.1
	I39	8.1	8.0	7.9	8.2	8.2	8.0	8.0	8.2	8.2	8.2	8.1	8.1
	I23	8.2	8.1	8.0	8.1	8.2	8.2	8.1	8.3	8.2	8.1	8.1	8.1
	I18	8.2	8.1	8.0	8.1	8.2	8.0	8.1	8.2	8.2	8.2	8.1	8.1
	I10	8.2	8.1	8.0	8.1	8.1	8.1	8.1	8.2	8.1	8.3	8.1	8.1
	I5	8.2	8.2	8.0	8.0	8.3	8.1	8.0	8.2	8.1	8.2	8.1	8.1
	I4	8.2	8.1	8.0	8.0	8.1	8.0	8.0	8.2	8.1	8.3	8.1	8.0
28-m	I33	8.1	8.1	7.9	8.0	7.9	7.8	8.0	8.2	8.0	8.1	8.0	8.0
	I30	8.0	8.1	7.9	8.0	8.0	7.9	8.1	8.2	8.0	8.1	8.0	8.1
	I27	8.1	8.0	7.6	8.0	8.1	7.9	8.1	8.2	8.2	8.1	8.1	8.1
	I22	8.2	8.1	7.9	8.0	8.1	8.0	8.0	8.2	8.2	8.2	8.1	8.1
	I14	8.2	8.1	7.9	8.0	8.1	7.9	8.1	8.2	8.2	8.2	8.1	8.1
	I17	8.2	8.1	7.9	8.1	8.1	7.9	8.1	8.2	8.2	8.1	8.1	8.1
	I16	8.2	8.1	7.9	8.1	8.1	7.9	8.1	8.2	8.2	8.1	8.1	8.1
	I15	8.1	8.1	7.9	8.0	8.1	7.8	8.0	8.2	8.2	8.2	8.1	8.1
	I12	8.2	8.0	7.9	8.0	8.1	7.9	8.0	8.2	8.2	8.1	8.1	8.1
	I9	8.1	8.1	8.0	8.0	8.1	7.9	8.1	8.1	8.1	8.3	8.1	8.0
	I6	8.2	8.1	8.0	8.0	8.1	8.0	8.1	8.2	8.1	8.3	8.1	8.1
	I3	8.2	8.1	8.0	8.0	8.1	7.9	8.1	8.2	8.1	8.3	8.1	8.0
	I2	8.1	8.1	8.0	8.1	8.1	7.9	8.1	8.2	8.1	8.2	8.1	8.0
38-m	I13	8.1	8.1	7.9	8.1	8.0	7.9	8.0	8.1	8.1	8.3	8.1	8.0
	I21	8.1	8.1	7.8	8.0	8.0	7.9	8.0	8.1	8.1	8.3	8.0	8.0
	I29	8.1	8.1	7.9	7.9	7.9	7.9	8.1	8.2	8.0	8.1	8.0	8.0
	I8	8.1	8.1	7.9	8.0	8.0	7.9	8.1	8.1	8.1	8.3	8.1	8.0
55-m	I28	8.0	8.0	7.8	7.9	7.9	7.9	7.9	8.1	7.9	8.1	8.0	8.0
	I20	8.0	8.0	7.8	8.0	8.0	7.8	8.0	8.0	8.0	8.2	8.0	8.0
	I7	8.0	8.1	7.9	8.0	8.0	7.8	8.0	8.1	8.0	8.2	8.1	8.0
	I1	8.1	8.1	7.9	8.0	8.0	7.8	8.0	8.1	8.0	8.2	8.1	8.0

Appendix A.1 *continued*

Contour	Station	Transmissivity (%)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	78	62	78	75	71	79	81	76	75	80	75	81
	I38	69	74	72	77	69	78	81	79	69	78	73	70
	I36	43	66	58	75	60	65	81	77	61	84	75	71
	I32	47	44	40	61	63	65	74	74	62	73	63	50
	I26	69	38	72	75	69	76	82	78	73	81	80	66
	I25	74	58	68	77	73	65	75	79	70	84	65	70
	I24	78	50	68	79	60	61	78	77	71	79	76	66
	I40	68	39	45	72	54	55	74	67	66	74	70	65
	I19	67	49	60	63	54	57	54	62	66	73	55	69
	I11	78	73	74	77	71	60	74	72	72	77	77	71
19-m	I34	74	73	74	79	78	83	81	81	75	85	85	72
	I35	78	74	76	78	72	81	83	80	73	81	82	82
	I31	75	74	78	78	73	83	84	82	73	85	83	87
	I39	71	76	83	79	75	76	83	82	76	87	83	79
	I23	78	70	78	77	76	57	80	78	75	84	72	77
	I18	83	78	79	81	74	68	79	81	77	85	87	84
	I10	83	80	80	82	77	69	81	79	75	86	87	87
	I5	79	77	75	79	71	61	76	72	71	73	68	72
	I4	82	83	81	82	78	71	78	78	75	83	79	83
28-m	I33	78	83	83	82	80	84	85	82	81	85	85	80
	I30	81	81	86	82	78	80	83	84	80	88	85	85
	I27	81	82	86	84	79	79	84	81	80	88	81	87
	I22	81	84	85	84	79	76	83	83	82	88	84	86
	I14	83	85	84	83	80	79	84	83	83	88	86	86
	I17	83	84	84	83	79	74	83	83	81	88	85	86
	I16	84	85	85	84	80	78	83	83	83	88	85	86
	I15	83	85	84	84	80	81	84	84	83	89	86	86
	I12	82	85	84	84	80	78	83	83	82	87	82	86
	I9	84	85	81	84	79	84	85	85	79	86	88	86
	I6	85	84	82	84	80	80	84	86	75	86	88	85
	I3	85	83	84	85	78	82	86	86	79	88	88	87
	I2	86	84	85	85	78	86	87	87	84	91	89	89
38-m	I13	85	83	85	85	81	87	86	87	84	89	89	87
	I21	85	83	86	86	79	88	86	87	84	88	87	88
	I29	83	83	85	85	77	84	87	85	81	90	86	85
	I8	85	84	84	86	81	87	87	87	83	89	89	87
55-m	I28	85	88	88	88	84	88	88	87	87	90	89	91
	I20	87	86	86	87	84	88	89	89	88	90	90	91
	I7	86	87	87	86	85	89	89	89	88	91	89	91
	I1	87	86	87	86	88	89	90	89	88	90	89	91

Appendix A.1 *continued*

Contour	Station	Chlorophyll *a* (µg/L) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9-m	I37	6.1	8.7	5.2	16.9	14.8	9.5	8.7	19.9	10.4	6.4	5.1	6.5
	I38	6.3	10.3	8.2	18.2	10.3	12.1	5.9	7.0	13.7	7.1	5.2	5.7
	I36	7.2	11.8	14.2	15.1	19.1	26.0	6.6	5.3	22.2	3.7	7.2	6.8
	I32	7.3	14.0	10.2	28.9	16.6	10.6	9.8	8.4	19.4	7.0	6.4	8.9
	I26	7.3	10.2	6.1	14.9	20.7	8.5	8.8	7.1	6.4	5.2	5.3	3.9
	I25	6.6	5.4	5.4	8.1	13.4	18.1	12.5	4.7	12.0	3.1	5.7	6.6
	I24	7.4	6.1	5.8	8.7	22.2	22.9	8.6	7.9	7.4	4.4	7.3	5.9
	I40	9.4	5.1	7.6	19.1	31.2	35.2	16.5	15.4	11.6	6.4	6.6	4.1
	I19	8.2	3.9	6.4	30.4	18.2	27.2	29.9	30.1	14.5	8.1	11.7	5.6
	I11	4.3	10.9	8.0	8.4	14.6	23.7	7.6	7.8	7.9	6.0	3.6	5.0
19-m	I34	5.1	6.7	3.6	14.9	10.8	5.6	6.7	9.5	9.1	4.4	3.4	4.1
	I35	6.3	6.2	3.9	13.3	10.1	5.4	6.9	6.8	13.4	6.1	4.4	4.5
	I31	4.6	5.5	3.9	12.9	11.6	5.2	6.5	9.7	12.6	5.9	4.0	4.5
	I39	6.9	3.4	3.8	9.8	14.1	15.6	7.1	9.8	7.4	5.2	5.5	4.2
	I23	5.5	5.7	5.0	10.8	13.0	34.7	7.2	6.3	8.1	5.0	3.7	6.3
	I18	4.8	4.0	4.9	7.2	13.1	21.4	9.4	8.3	7.5	6.4	3.2	5.4
	I10	5.0	5.9	5.9	7.3	9.3	22.1	6.4	7.1	8.1	6.2	2.6	4.7
	I5	6.4	8.3	6.8	8.1	13.3	21.2	9.8	8.8	7.2	7.5	4.7	4.3
	I4	5.1	4.5	7.8	5.7	9.2	18.6	15.8	9.9	6.7	6.6	3.1	4.0
28-m	I33	4.3	4.9	2.8	7.3	7.9	3.4	6.7	9.3	6.4	4.5	2.5	3.1
	I30	3.5	6.3	2.8	5.6	11.7	8.4	7.9	7.0	7.4	3.3	4.7	3.7
	I27	4.5	3.3	3.8	5.3	8.2	12.0	6.8	6.9	4.4	5.5	5.0	3.5
	I22	6.5	3.4	3.5	4.3	8.5	17.0	8.5	6.9	4.1	5.6	4.5	3.5
	I14	5.9	3.3	3.6	5.9	8.9	12.3	6.7	6.4	3.9	5.0	3.2	4.0
	I17	5.5	3.4	2.8	5.5	9.3	14.7	5.8	7.2	4.3	5.3	3.3	4.6
	I16	6.0	2.8	2.7	5.5	9.1	12.7	7.6	6.9	3.9	3.8	3.5	4.2
	I15	5.3	3.5	3.5	5.7	8.2	9.1	3.2	5.6	7.6	4.6	3.5	3.8
	I12	6.7	2.4	3.7	5.1	8.6	11.7	3.8	7.1	3.8	4.6	4.0	4.0
	I9	3.3	2.8	7.5	3.8	8.0	5.9	8.5	4.5	6.9	8.5	2.6	3.0
	I6	3.5	4.1	6.9	3.9	6.6	12.0	8.8	4.4	8.2	7.0	2.8	4.4
	I3	4.2	6.1	5.8	4.5	9.9	8.3	4.0	5.6	7.7	5.4	2.4	4.2
	I2	2.7	6.1	5.3	5.4	13.2	4.2	3.2	4.4	5.1	1.7	2.7	3.1
38-m	I13	3.3	6.0	3.8	3.3	9.7	3.1	6.7	3.7	4.5	5.1	2.3	3.2
	I21	3.5	4.5	1.5	2.3	9.0	2.8	7.3	3.1	4.0	3.5	2.1	1.8
	I29	4.9	4.5	2.1	4.2	11.4	5.6	3.8	5.7	7.0	2.9	2.7	2.8
	I8	3.5	4.8	4.6	3.6	7.8	4.1	3.4	3.7	5.5	5.4	2.5	3.8
55-m	I28	2.0	2.8	1.8	3.1	6.0	1.9	3.3	4.3	3.5	2.0	2.7	2.4
	I20	2.5	3.8	2.9	3.1	6.0	2.5	2.7	3.5	3.6	2.2	2.6	2.1
	I7	2.4	4.2	3.4	4.9	6.2	1.5	2.3	2.9	3.9	2.5	3.2	2.2
	I1	2.6	4.0	3.7	4.1	4.2	1.4	1.9	2.4	3.2	2.8	3.0	2.8

Appendix B

Supporting Data

2008 SBOO Stations

Microbiology

Appendix B.1

Summary of rainfall and bacteria levels at shore stations in the SBOO region during 2008. Rain data are from Lindbergh Field, San Diego, CA. Total coliform (Total), fecal coliform (Fecal), and enterococcus (Entero) densities are expressed as mean CFU/100 mL per month and for the entire year. Stations are listed north to south from left to right.

Month	Rain (in)		S9	S8	S12	S6	S11	S5	S10	S4	S3	S2	S0
Jan	3.3	*Total*	308	1643	1532	4688	9744	9628	3768	3420	2280	1740	997
		Fecal	50	191	265	1969	1996	7209	154	241	252	295	266
		Entero	94	450	573	2002	1505	7223	537	534	332	170	205
Feb	1.2	*Total*	12	156	1111	5425	8065	>16,000	5450	3145	2551	1275	1435
		Fecal	3	7	187	881	1814	8600	593	302	136	163	64
		Entero	5	12	31	99	192	6853	99	52	65	88	34
Mar	0.3	*Total*	56	7	70	4441	4385	11,250	4021	1681	4006	1253	392
		Fecal	3	2	11	462	3058	3886	231	28	107	47	20
		Entero	3	2	5	226	818	3701	10	10	6	17	14
Apr	0.0	*Total*	13	9	13	9	10	53	13	16	24	40	7128
		Fecal	2	2	2	2	2	2	2	2	4	7	251
		Entero	2	2	2	2	2	14	2	2	3	5	143
May	0.2	*Total*	61	61	72	25	42	30	11	26	41	465	4035
		Fecal	3	2	3	2	4	3	2	3	6	32	173
		Entero	2	2	6	12	8	6	3	5	8	12	112
Jun	Trace	*Total*	20	65	65	151	65	34	14	14	38	616	6515
		Fecal	37	3	3	4	3	4	3	2	6	37	346
		Entero	15	2	3	3	5	5	3	2	3	21	153
Jul	0.0	*Total*	164	20	20	20	20	128	16	52	16	17	3776
		Fecal	7	2	8	2	2	78	2	4	2	3	130
		Entero	2	2	2	2	2	110	2	4	3	2	46
Aug	0.0	*Total*	110	40	20	17	20	16	20	17	12	11	52
		Fecal	4	16	5	2	2	4	2	14	3	2	4
		Entero	8	2	11	2	4	2	2	4	3	6	5
Sep	0.0	*Total*	110	61	16	11	61	11	61	66	21	827	48
		Fecal	7	3	19	2	3	4	5	11	13	22	12
		Entero	6	4	4	2	8	8	10	23	36	125	22
Oct	1.2	*Total*	54	16	34	16	13	16	16	20	373	18	20
		Fecal	4	2	10	2	2	2	2	2	44	3	6
		Entero	4	3	4	3	2	3	2	4	51	4	4
Nov	2.5	*Total*	30	65	61	16	16	20	4081	32	201	11	606
		Fecal	7	3	26	8	2	5	203	5	16	4	103
		Entero	6	19	44	10	3	2	302	14	91	8	46
Dec	3.4	*Total*	456	1916	3356	3564	2544	8496	9924	10,922	10,606	6952	5624
		Fecal	161	285	2006	992	505	3064	2972	3996	3305	1480	1174
		Entero	171	1016	2410	2501	1133	3874	2908	3092	3253	1684	839
		n	60	60	60	60	60	60	60	60	60	60	60
Annual means		*Total*	116	338	531	1532	2082	3807	2283	1617	1681	1102	2552
		Fecal	24	43	212	361	616	1905	348	384	324	174	212
		Entero	26	126	258	405	307	1817	323	312	321	178	135

Appendix B.2

Summary of samples with elevated (bold) total coliform (>1000 CFU/100 mL), fecal coliform (>400 CFU/100 L), and/or enterococcus (>104 CFU/100 mL) densities collected at SBOO shore stations during 2008. Values are expressed as CFU/100 mL; Total=total coliform; Fecal=fecal coliform; Entero=enterococcus; F:T=fecal to total coliform ratio.

Station	Date	Total	Fecal	Entero	F:T
S0	08 Jan 2008	**4800**	**1300**	**1000**	**0.27**
S2	02 Jan 2008	**5800**	**1100**	42	**0.19**
S2	08 Jan 2008	**2600**	260	**740**	**0.10**
S3	02 Jan 2008	**1200**	**420**	36	**0.35**
S3	08 Jan 2008	**8600**	**720**	**1400**	0.08
S3	15 Jan 2008	**1200**	54	10	0.05
S3	29 Jan 2008	60	10	**160**	0.17
S4	08 Jan 2008	**>16,000**	**1100**	**2600**	0.07
S5	08 Jan 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S5	15 Jan 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S5	29 Jan 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S6	08 Jan 2008	**5800**	**680**	**1600**	**0.12**
S6	15 Jan 2008	**1600**	160	6	**0.10**
S6	29 Jan 2008	**>16,000**	**9000**	**8400**	**0.56**
S8	08 Jan 2008	600	90	**240**	0.15
S8	29 Jan 2008	**7600**	**840**	**2000**	**0.11**
S9	08 Jan 2008	880	86	**140**	0.10
S9	29 Jan 2008	600	140	**320**	0.23
S10	08 Jan 2008	**>16,000**	**640**	**2600**	0.04
S10	15 Jan 2008	**2600**	88	36	0.03
S11	08 Jan 2008	**>16,000**	**800**	**2000**	0.05
S11	15 Jan 2008	**>16,000**	360	72	0.02
S11	29 Jan 2008	**>16,000**	**8800**	**5400**	**0.55**
S12	08 Jan 2008	**2400**	120	**440**	0.05
S12	22 Jan 2008	20	2	**220**	0.10
S12	29 Jan 2008	**5200**	**1200**	**2200**	**0.23**
S0	05 Feb 2008	**5200**	220	**110**	0.04
S2	05 Feb 2008	**4600**	**620**	**320**	**0.13**
S3	05 Feb 2008	**4000**	120	**160**	0.03
S3	19 Feb 2008	**3400**	340	48	**0.10**
S3	26 Feb 2008	**2800**	80	42	0.03
S4	05 Feb 2008	**1600**	100	100	0.06
S4	19 Feb 2008	**6400**	**760**	76	**0.12**
S4	26 Feb 2008	**4400**	320	18	0.07
S5	05 Feb 2008	**>16,000**	**>12,000**	**15,000**	**0.75**
S5	12 Feb 2008	**>16,000**	**8000**	**130**	**0.50**
S5	19 Feb 2008	**>16,000**	**2400**	**280**	**0.15**
S5	26 Feb 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S6	12 Feb 2008	**5400**	**500**	64	0.09
S6	19 Feb 2008	**>16,000**	**3000**	**300**	**0.19**
S10	05 Feb 2008	**7800**	**780**	**280**	**0.10**
S10	19 Feb 2008	**6800**	**740**	72	**0.11**
S10	26 Feb 2008	**6600**	**740**	32	**0.11**
S11	12 Feb 2008	**>16,000**	**3800**	**380**	**0.24**
S11	19 Feb 2008	**>16,000**	**3400**	**300**	**0.21**
S12	26 Feb 2008	**3800**	**600**	66	**0.16**
S2	18 Mar 2008	**5000**	180	4	0.04

Appendix B.2 *continued*

Station	Date	Total	Fecal	Entero	F:T
S3	18 Mar 2008	**>16,000**	**420**	14	0.03
S4	18 Mar 2008	**6600**	64	10	0.01
S5	04 Mar 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S5	11 Mar 2008	**13,000**	**2600**	**1600**	**0.20**
S5	18 Mar 2008	**>16,000**	**940**	**1200**	0.06
S6	04 Mar 2008	**>16,000**	**1800**	**800**	**0.11**
S6	11 Mar 2008	**1700**	40	100	0.02
S10	18 Mar 2008	**>16,000**	**880**	24	0.06
S11	04 Mar 2008	**>16,000**	**>12,000**	**3200**	**0.75**
S11	11 Mar 2008	**1500**	220	64	**0.15**
S0	08 Apr 2008	**>16,000**	**1100**	**340**	0.07
S0	15 Apr 2008	**19,000**	120	**360**	0.01
S0	06 May 2008	**>16,000**	**660**	**440**	0.04
S2	13 May 2008	**1800**	120	40	0.07
S0	03 Jun 2008	**>16,000**	**1000**	**520**	0.06
S0	24 Jun 2008	**10,000**	380	80	0.04
S2	10 Jun 2008	**1300**	100	34	0.08
S0	08 Jul 2008	**18,000**	**600**	**220**	0.03
S5	08 Jul 2008	560	380	**540**	0.68
S2	17 Sep 2008	**3200**	80	**480**	0.03
S3	17 Sep 2008	40	40	**120**	1.00
S3	14 Oct 2008	20	16	**140**	0.80
S3	28 Oct 2008	**1800**	200	94	**0.11**
S0	04 Nov 2008	**1600**	160	**110**	**0.10**
S3	04 Nov 2008	180	10	**340**	0.06
S10	04 Nov 2008	**>16,000**	**800**	**1200**	0.05
S0	02 Dec 2008	**>16,000**	**4800**	**420**	**0.30**
S0	16 Dec 2008	**3200**	**440**	**2600**	**0.14**
S0	23 Dec 2008	**8000**	**520**	**1100**	0.07
S2	02 Dec 2008	**>16,000**	**1800**	**200**	**0.11**
S2	16 Dec 2008	**2600**	380	**2200**	**0.15**
S2	23 Dec 2008	**>16,000**	**5200**	**6000**	**0.33**
S3	02 Dec 2008	**>16,000**	**3200**	**1000**	**0.20**
S3	16 Dec 2008	**10,000**	**700**	**2400**	0.07
S3	23 Dec 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S3	31 Dec 2008	**11,000**	**620**	**860**	0.06
S4	02 Dec 2008	**>16,000**	**4200**	100	**0.26**
S4	16 Dec 2008	**6600**	**580**	**3000**	0.09
S4	23 Dec 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S4	31 Dec 2008	**>16,000**	**3200**	**360**	**0.20**
S5	02 Dec 2008	**8600**	**500**	80	0.06
S5	16 Dec 2008	**>16,000**	**2400**	**7200**	**0.15**
S5	23 Dec 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S6	02 Dec 2008	800	130	**300**	0.16
S6	16 Dec 2008	**>16,000**	**4800**	**>12,000**	**0.30**
S6	23 Dec 2008	1000	24	**180**	0.02
S8	16 Dec 2008	**9400**	**1400**	**4800**	**0.15**
S8	23 Dec 2008	80	20	**260**	0.25
S9	16 Dec 2008	**2200**	**780**	**760**	**0.35**
S10	02 Dec 2008	**>16,000**	**1600**	**180**	**0.10**

Appendix B.2 *continued*

Station	Date	Total	Fecal	Entero	F:T
S10	16 Dec 2008	**5600**	**480**	**2200**	0.09
S10	23 Dec 2008	**>16,000**	**>12,000**	**>12,000**	**0.75**
S10	31 Dec 2008	**12,000**	**780**	**160**	0.07
S11	02 Dec 2008	**3800**	**420**	**130**	**0.11**
S11	16 Dec 2008	**7400**	**2000**	**5400**	**0.27**
S11	23 Dec 2008	**1200**	100	**120**	0.08
S12	16 Dec 2008	**>16,000**	**10,000**	**>12,000**	**0.63**

Appendix B.3

Summary of samples with elevated (bold) total coliform (>1000 CFU/100 mL), fecal coliform (>400 CFU/100 mL), and/or enterococcus (>104 CFU/100 mL) densities collected at SBOO kelp bed stations during 2008. Values are expressed as CFU/100 mL; Total=total coliform; Fecal=fecal coliform; Entero=enterococcus; F:T=fecal to total coliform ratio.

Station	Date	Depth (m)	Total	Fecal	Entero	F:T
I25	12 Jan 2008	2	**4600**	180	38	0.04
I25	12 Jan 2008	6	**1400**	**500**	64	**0.36**
I25	12 Jan 2008	9	**4800**	260	62	0.05
I25	28 Jan 2008	2	700	58	**200**	0.08
I25	28 Jan 2008	6	720	64	**240**	0.09
I25	28 Jan 2008	9	880	66	**240**	0.08
I26	28 Jan 2008	6	200	74	**200**	0.37
I26	28 Jan 2008	9	400	86	**130**	0.22
I25	13 Feb 2008	2	**2800**	**420**	40	**0.15**
I25	13 Feb 2008	6	**3000**	**820**	76	**0.27**
I25	13 Feb 2008	9	**3200**	**1000**	82	**0.31**
I26	24 Feb 2008	2	**1800**	220	76	**0.12**
I26	24 Feb 2008	6	**2000**	320	**130**	**0.16**
I25	01 Mar 2008	6	**>16,000**	**1000**	**120**	0.06
I25	16 Dec 2008	2	**6600**	**460**	**600**	0.07
I25	16 Dec 2008	6	**1500**	68	80	0.05
I25	16 Dec 2008	9	**5400**	**480**	**1400**	0.09
I25	19 Dec 2008	2	**5000**	**900**	**1600**	**0.18**
I25	19 Dec 2008	6	**3000**	**540**	**980**	**0.18**
I25	19 Dec 2008	9	**2200**	360	**780**	**0.16**
I25	22 Dec 2008	2	**3000**	160	**180**	0.05
I25	22 Dec 2008	6	**8800**	400	**660**	0.05
I25	22 Dec 2008	9	600	120	**300**	0.20
I26	16 Dec 2008	2	**7800**	**540**	**700**	0.07
I26	16 Dec 2008	6	**2200**	120	**200**	0.05
I26	16 Dec 2008	9	800	76	**220**	0.10
I26	19 Dec 2008	2	**3800**	94	**1800**	0.02
I26	19 Dec 2008	6	**9000**	**1000**	**1400**	**0.11**
I26	19 Dec 2008	9	**11,000**	**2600**	**1400**	**0.24**
I26	22 Dec 2008	2	300	40	**240**	0.13
I26	22 Dec 2008	6	400	74	**620**	0.19
I26	22 Dec 2008	9	**1400**	140	**2400**	**0.10**
I39	16 Dec 2008	2	**4600**	**620**	**2200**	**0.13**
I39	19 Dec 2008	2	1000	100	**580**	**0.10**
I39	19 Dec 2008	12	**1300**	120	**300**	0.09
I39	19 Dec 2008	18	**3200**	**780**	**1400**	**0.24**

Appendix B.4

Summary of samples with elevated (bold) total coliform (>1000 CFU/100 mL), fecal coliform (>400 CFU/100 mL), and/or enterococcus (>104 CFU/100 mL) densities collected at SBOO offshore stations during 2008. Values are expressed as CFU/100 mL; Total=total coliform; Fecal=fecal coliform; Entero=enterococcus; F:T=fecal to total coliform ratio.

Station	Date	Depth (m)	Total	Fecal	Entero	F:T
I14	16 Jan 2008	18	**1600**	2	2	0.00
I19	16 Jan 2008	2	**>16,000**	**800**	68	0.05
I19	16 Jan 2008	6	**2000**	220	8	**0.11**
I19	16 Jan 2008	11	**1500**	70	20	0.05
I40	16 Jan 2008	2	**1400**	120	24	0.09
I40	16 Jan 2008	6	**2800**	400	48	**0.14**
I40	16 Jan 2008	9	**5400**	340	54	0.06
I16	06 Feb 2008	18	**11,000**	**1400**	**340**	**0.13**
I19	06 Feb 2008	11	**4600**	120	**340**	0.03
I23	06 Feb 2008	2	**1200**	240	60	**0.20**
I24	06 Feb 2008	6	**1300**	120	42	0.09
I40	06 Feb 2008	2	**1200**	120	56	**0.10**
I19	18 Mar 2008	2	**>16,000**	**720**	40	0.05
I19	18 Mar 2008	11	**1200**	42	8	0.04
I9	03 Apr 2008	18	**2800**	2	2	0.00
I12	15 Jul 2008	18	**1100**	320	66	**0.29**
I16	15 Jul 2008	18	**2600**	**800**	**400**	**0.31**
I5	05 Aug 2008	6	**1300**	12	26	0.01
I14	09 Sep 2008	18	**2800**	**1000**	**180**	**0.36**
I5	11 Sep 2008	2	**>16,000**	140	**1000**	0.01
I5	11 Sep 2008	6	340	12	**110**	0.04
I12	14 Oct 2008	18	**>16,000**	**>12,000**	**8200**	**0.75**
I16	14 Oct 2008	18	**2200**	**1100**	**200**	**0.50**
I10	15 Oct 2008	12	**1100**	2	**130**	0.00
I5	15 Oct 2008	6	**8200**	320	**140**	0.04
I5	15 Oct 2008	11	**>16,000**	**1200**	**160**	0.08
I11	03 Dec 2008	11	**1600**	200	12	**0.13**
I12	03 Nov 2008	18	**3200**	200	36	0.06
I19	02 Dec 2008	2	**>16,000**	**1600**	60	**0.10**
I32	01 Dec 2008	6	700	50	**110**	0.07
I32	01 Dec 2008	9	800	160	**200**	0.20
I22	02 Dec 2008	18	**1200**	2	2	0.00
I23	02 Dec 2008	2	**2400**	380	**6**	**0.16**
I23	02 Dec 2008	18	520	100	**140**	0.19
I24	02 Dec 2008	2	**>16,000**	**1400**	80	0.09
I24	02 Dec 2008	6	**9200**	**640**	58	0.07
I24	02 Dec 2008	11	**2400**	220	**180**	0.09
I40	02 Dec 2008	2	**2000**	280	**110**	**0.14**
I40	02 Dec 2008	6	1000	110	70	**0.11**
I40	02 Dec 2008	9	600	140	**120**	0.23

Appendix B.5

2001 California Ocean Plan water contact standards for SBOO shore and kelp bed stations during 2008. Values reflect the number of days that the standards were exceeded at each station (the 30-day Total Coliform, 10,000 Total Coliform, the 60-day Fecal Coliform, and 30-day Fecal Geometric Mean Standards; see Box 3.1). Shore stations are listed north to south from left to right.

		Shore stations								Kelp bed stations		
Month	# days	S9	S8	S12	S6	S11	S5	S10	S4	I25	I26	I39
30-day Total Coliform Standard												
January	31	0	0	17	30	30	31	31	30	3	0	0
February	29	0	19	25	29	29	29	29	27	0	0	0
March	31	0	0	18	31	31	31	26	31	13	0	0
April	30	0	0	0	7	7	16	0	10	0	0	0
May	31	0	0	0	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0	0	0	0
November	30	0	0	0	0	0	0	26	0	0	0	0
December	31	11	11	15	15	26	26	31	29	28	13	0
Percent compliance		**97%**	**92%**	**80%**	**69%**	**66%**	**66%**	**61%**	**65%**	**88%**	**97%**	**100%**
10,000 Total Coliform Standard												
January	31	0	0	0	0	0	2	1	0	0	0	0
February	29	0	0	0	0	1	4	0	0	0	0	0
March	31	0	0	0	1	1	2	0	0	0	0	0
April	30	0	0	0	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0	0	0	0
November	30	0	0	0	0	0	0	1	0	0	0	0
December	31	0	0	0	1	0	2	2	2	0	0	0
Total		**0**	**0**	**0**	**2**	**2**	**10**	**4**	**2**	**0**	**0**	**0**

Appendix B.5 *continued*

Month	# days	Shore stations S9	S8	S12	S6	S11	S5	S10	S4	Kelp stations I25	I26	I39
60-day Fecal Coliform Standard												
January	31	0	3	3	24	7	28	31	28	0	0	0
February	29	0	29	29	29	29	29	29	21	17	0	0
March	31	0	28	31	31	31	31	31	31	31	0	0
April	30	0	0	25	30	30	30	28	18	12	0	0
May	31	0	0	0	3	3	17	6	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0	0	0	0
November	30	0	0	0	0	0	0	26	0	0	0	0
December	31	16	16	16	16	30	30	31	29	16	0	0
Percent compliance		**96%**	**79%**	**72%**	**65%**	**65%**	**55%**	**55%**	**65%**	**79%**	**100%**	**100%**
30-day Fecal Geometric Mean Standard												
January	31	0	0	0	0	0	18	0	0	0	0	0
February	29	0	0	0	11	25	29	0	0	0	0	0
March	31	0	0	0	15	24	31	2	0	0	0	0
April	30	0	0	0	0	0	0	0	0	0	0	0
May	31	0	0	0	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	0	0	0	0	0	0
November	30	0	0	0	0	0	0	0	0	0	0	0
December	31	0	0	0	0	0	0	0	0	0	0	0
Percent compliance		**100%**	**100%**	**100%**	**93%**	**87%**	**79%**	**99%**	**100%**	**100%**	**100%**	**100%**

Appendix C

Supporting Data

2008 SBOO Stations

Sediment Characteristics

Appendix C.1

Constituents and method detection limits (MDL) for sediment samples analyzed for the SBOO monitoring program during 2008.

Parameter	MDL	Parameter	MDL
Sulfides-Total (ppm)	0.14	Total Solids (% wt)	0.24
Total Nitrogen (% wt)	0.005	Total Volatile Solids (% wt)	0.11
Total Organic Carbon (% wt)	0.01		
Metals (ppm)			
Aluminum (Al)	2	Lead (Pb)	0.8
Antimony (Sb)	0.3	Manganese (Mn)	0.08
Arsenic (As)	0.33	Mercury (Hg)	0.003
Barium (Ba)	0.02	Nickel (Ni)	0.1
Beryllium (Be)	0.01	Selenium (Se)	0.24
Cadmium (Cd)	0.06	Silver (Ag)	0.04
Chromium (Cr)	0.1	Thallium (Tl)	0.5
Copper (Cu)	0.2	Tin (Sn)	0.3
Iron (Fe)	9	Zinc (Zn)	0.2
Pesticides (ppt)			
Aldrin	700	Cis Nonachlor	700
Alpha Endosulfan	700	Gamma (trans) Chlordane	700
Beta Endosulfan	700	Heptachlor	700
Dieldrin	700	Heptachlor epoxide	700
Endosulfan Sulfate	700	Methoxychlor	700
Endrin	700	Oxychlordane	700
Endrin aldehyde	700	Trans Nonachlor	700
Hexachlorobenzene	400	o,p-DDD	400
Mirex	700	o,p-DDE	700
BHC, Alpha isomer	400	o,p-DDT	700
BHC, Beta isomer	400	p,p-DDMU	*
BHC, Delta isomer	400	p,p-DDD	700
BHC, Gamma isomer	400	p,p-DDE	400
Alpha (cis) Chlordane	700	p,p-DDT	700

* No MDL available for this parameter

Appendix C.1 *continued*

Parameter	MDL	Parameter	MDL
Polychlorinated Biphenyl Congeners (PCBs) (ppt)			
PCB 18	700	PCB 126	1500
PCB 28	700	PCB 128	700
PCB 37	700	PCB 138	700
PCB 44	700	PCB 149	700
PCB 49	700	PCB 151	700
PCB 52	700	PCB 153/168	700
PCB 66	700	PCB 156	700
PCB 70	700	PCB 157	700
PCB 74	700	PCB 158	700
PCB 77	700	PCB 167	700
PCB 81	700	PCB 169	700
PCB 87	700	PCB 170	700
PCB 99	700	PCB 177	700
PCB 101	700	PCB 180	400
PCB 105	700	PCB 183	700
PCB 110	700	PCB 187	700
PCB 114	700	PCB 189	400
PCB 118	700	PCB 194	700
PCB 119	700	PCB 201	700
PCB 123	700	PCB 206	700
Polycyclic Aromatic Hydrocarbons (PAHs) (ppb)			
1-methylnaphthalene	70	Benzo[K]fluoranthene	82
1-methylphenanthrene	41	Benzo[e]pyrene	57
2,3,5-trimethylnaphthalene	134	Biphenyl	89
2,6-dimethylnaphthalene	106	Chrysene	36
2-methylnaphthalene	102	Dibenzo(A,H)anthracene	32
3,4-benzo(B)fluoranthene	63	Fluoranthene	24
Acenaphthene	11	Fluorene	18
Acenaphthylene	11	Indeno(1,2,3-CD)pyrene	76
Anthracene	14	Naphthalene	21
Benzo[A]anthracene	34	Perylene	58
Benzo[A]pyrene	55	Phenanthrene	32
Benzo[G,H,I]perylene	56	Pyrene	35

Appendix C.2

Summary of the constituents that make up total DDT, total PCB, and total PAH in each sediment sample collected as part of SBOO monitoring program during 2008; nd=not detected.

Station	Class	Constituent	January	July	Units
I3	Pesticide	p,p-DDE	nd	210.00	ppt
I4	PAH	Naphthalene	13.20	nd	ppb
I7	PAH	1-methylnaphthalene	5.20	nd	ppb
I7	PAH	2-methylnaphthalene	7.90	nd	ppb
I7	PAH	Biphenyl	10.50	nd	ppb
I8	Pesticide	p,p-DDE	130.00	nd	ppt
I9	PCB	PCB 156	nd	91.00	ppt
I9	PCB	PCB 157	nd	74.00	ppt
I9	PCB	PCB 167	nd	43.00	ppt
I9	PCB	PCB 177	nd	110.00	ppt
I13	Pesticide	p,p-DDE	85.00	nd	ppt
I13	PAH	1-methylnaphthalene	9.40	nd	ppb
I13	PAH	2-methylnaphthalene	15.20	nd	ppb
I13	PAH	Biphenyl	11.00	nd	ppb
I13	PAH	Naphthalene	50.80	nd	ppb
I14	Pesticide	p,p-DDD	110.00	nd	ppt
I14	Pesticide	p,p-DDE	220.00	290.00	ppt
I14	PAH	2-methylnaphthalene	6.00	nd	ppb
I14	PAH	Naphthalene	24.40	nd	ppb
I14	PCB	PCB 118	160.00	nd	ppt
I14	PCB	PCB 153/168	43.00	nd	ppt
I15	Pesticide	p,p-DDE	nd	110.00	ppt
I18	Pesticide	p,p-DDE	120.00	nd	ppt
I18	PCB	PCB 28	180.00	nd	ppt
I21	PAH	Naphthalene	16.60	nd	ppb
I22	Pesticide	p,p-DDE	nd	150.00	ppt
I23	Pesticide	p,p-DDE	210.00	170.00	ppt
I23	PCB	PCB 105	47.00	nd	ppt
I23	PCB	PCB 110	140.00	nd	ppt
I23	PCB	PCB 118	140.00	nd	ppt
I23	PCB	PCB 149	130.00	nd	ppt
I23	PCB	PCB 153/168	60.00	nd	ppt
I23	PCB	PCB 180	31.00	nd	ppt
I23	PCB	PCB 187	38.00	nd	ppt
I23	PCB	PCB 66	24.00	nd	ppt
I27	Pesticide	p,p-DDE	110.00	150.00	ppt
I27	PAH	Naphthalene	15.00	nd	ppb

Appendix C.2 *continued*

Station	Class	Constituent	January	July	Units
I28	Pesticide	p,p-DDE	590.00	650.00	ppt
I28	Pesticide	p,p-DDT	nd	260.00	ppt
I28	PCB	PCB 101	nd	440.00	ppt
I28	PCB	PCB 110	nd	290.00	ppt
I28	PCB	PCB 138	nd	73.00	ppt
I28	PCB	PCB 149	nd	190.00	ppt
I28	PCB	PCB 153/168	nd	79.00	ppt
I28	PCB	PCB 180	nd	320.00	ppt
I29	Pesticide	p,p-DDD	200.00	nd	ppt
I29	Pesticide	p,p-DDE	1300.00	410.00	ppt
I29	Pesticide	p,p-DDT	190.00	nd	ppt
I29	PAH	Benzo[G,H,I]perylene	nd	37.60	ppb
I29	PAH	Naphthalene	15.20	nd	ppb
I30	Pesticide	p,p-DDE	210.00	180.00	ppt
I30	PAH	Naphthalene	26.40	nd	ppb
I31	PAH	Naphthalene	13.30	nd	ppb
I33	Pesticide	p,p-DDE	nd	110.00	ppt
I34	PAH	Naphthalene	17.90	nd	ppb
I35	PAH	Naphthalene	14.50	nd	ppb

Appendix C.3

SBOO sediment statistics for the January 2008 survey. Stations nearest the outfall are in bold.

	Mean (mm)	Mean (phi)	SD (phi)	Median (phi)	Skewness (phi)	Kurtosis (phi)	Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Fines (%)	Visual Observations
19-m stations												
I35	0.08	3.7	1.19	3.5	0.3	1.2	0.0	66.3	32.3	1.4	33.7	Organic debris
I34	0.98	0.0	1.18	-0.2	0.3	0.7	53.1	46.7	0.2	0.0	0.2	Sand, shell hash
I31	0.12	3.1	0.66	3.1	0.2	1.3	0.0	92.6	7.3	0.1	7.4	Organic debris
I23	0.12	3.1	0.53	3.0	0.3	2.4	0.0	92.2	7.8	0.1	7.8	Organic debris, shell hash
I18	0.11	3.1	0.53	3.1	0.2	1.3	0.0	91.9	8.1	0.0	8.1	Fine sand and silt
I10	0.12	3.1	0.59	3.0	0.4	2.7	0.0	90.5	9.4	0.0	9.5	Organic debris
I4	0.57	0.8	0.68	0.8	0.2	1.0	9.0	91.0	0.0	0.0	0.0	Sand, shell hash
28-m stations												
I33	0.11	3.2	1.07	2.9	0.5	1.8	0.0	83.6	15.1	1.2	16.3	Organic debris, shell hash
I30	0.10	3.4	0.79	3.4	0.2	1.5	0.0	83.9	15.5	0.5	16.1	Organic debris
I27	0.10	3.3	0.65	3.2	0.3	1.3	0.0	87.7	12.1	0.2	12.3	Organic debris
I22	0.14	2.9	1.02	2.8	0.2	1.4	0.0	88.7	10.9	0.4	11.3	Organic debris
I16	**0.15**	**2.8**	**0.84**	**2.7**	**0.2**	**1.4**	**0.0**	**93.0**	**7.0**	**0.0**	**7.0**	**Sand, shell hash**
I15	**0.19**	**2.4**	**0.96**	**2.4**	**0.2**	**1.3**	**0.0**	**92.4**	**7.6**	**0.0**	**7.6**	**Organic debris**
I14	**0.10**	**3.3**	**0.72**	**3.3**	**0.1**	**1.3**	**0.0**	**87.6**	**12.1**	**0.2**	**12.3**	**Organic debris**
I12	**0.18**	**2.5**	**0.95**	**2.5**	**0.1**	**1.2**	**0.0**	**93.9**	**6.1**	**0.0**	**6.1**	**Sand, organic debris, shell hash**
I9	0.09	3.4	0.79	3.4	0.2	1.5	0.0	82.5	17.0	0.5	17.5	Organic debris, worm tubes
I6	0.56	0.8	0.78	0.7	0.3	1.2	10.9	87.1	2.0	0.0	2.0	Red relict sand, shell hash
I3	0.71	0.5	0.59	0.4	0.4	1.2	16.0	84.0	0.0	0.0	0.0	Red relict sand
I2	0.36	1.5	0.85	1.5	-0.1	0.9	4.8	95.2	0.0	0.0	0.0	Sand
38-m stations												
I29	0.08	3.6	1.06	3.5	0.3	1.5	0.0	72.4	26.4	1.2	27.6	Organic debris, worm tubes
I21	0.42	1.3	1.10	1.2	0.3	1.2	6.0	89.0	5.0	0.0	5.0	Red relict sand, shell hash
I13	0.51	1.0	0.78	0.9	0.2	1.0	7.7	92.1	0.2	0.0	0.2	Sand, organic debris, shell hash
I8	0.38	1.4	0.91	1.5	0.0	0.9	5.2	92.5	2.3	0.0	2.3	Organic debris
55-m stations												
I28	0.06	4.0	1.74	3.6	0.3	1.2	4.0	59.0	34.0	3.0	37.0	Coarse black sand, shell hash
I20	0.56	0.8	0.87	0.7	0.4	1.1	13.5	83.3	3.3	0.0	3.3	Red relict sand
I7	0.57	0.8	1.28	0.7	0.5	2.7	12.7	80.1	7.1	0.1	7.2	Red relict sand
I1	0.13	3.0	0.92	3.0	0.2	2.6	0.0	91.0	8.6	0.4	9.0	Organic debris

Appendix C.3 *continued*

SBOO sediment statistics for the July 2008 survey. Stations nearest the outfall are in bold.

	Mean (mm)	Mean (phi)	SD (phi)	Median (phi)	Skewness (phi)	Kurtosis (phi)	Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Fines (%)	Visual Observations
19-m stations												
I35	0.08	3.7	1.20	3.5	0.3	1.2	0.0	66.6	32.1	1.2	33.4	Organic debris
I34	0.25	2.0	0.57	2.1	-0.1	1.0	0.0	99.8	0.2	0.0	0.2	Shell hash
I31	0.12	3.1	0.68	3.1	0.2	1.3	0.0	92.1	7.8	0.0	7.8	Fine sand
I23	0.41	1.3	2.09	0.8	0.2	0.9	30.7	51.2	18.1	0.0	18.1	Coarse shell hash
I18	0.11	3.1	0.61	3.1	0.3	1.5	0.0	90.3	9.7	0.0	9.7	Fine sand w/ silt
I10	0.12	3.1	0.83	3.0	0.1	4.2	0.7	89.5	9.6	0.2	9.8	Fine sand w/ silt
I4	0.59	0.8	0.65	0.7	0.2	1.1	9.4	90.6	0.0	0.0	0.0	Organic debris, shell hash
28-m stations												
I33	0.12	3.0	1.01	2.9	0.4	1.8	0.0	87.1	12.0	0.8	12.8	Organic debris, shell hash
I30	0.10	3.4	0.88	3.3	0.3	1.8	0.0	82.9	16.4	0.7	17.1	Organic debris
I27	0.10	3.3	0.81	3.2	0.3	1.7	0.0	84.7	14.8	0.5	15.3	Fine sand w/ silt
I22	0.15	2.8	0.99	2.8	0.1	1.6	0.0	89.8	9.9	0.2	10.2	Sand, shell hash
I16	**0.27**	**1.9**	**0.92**	**2.0**	**-0.2**	**0.9**	**2.1**	**95.2**	**2.7**	**0.0**	**2.7**	**Coarse black sand, organic debris, shell hash**
I15	**0.36**	**1.5**	**1.08**	**1.5**	**0.1**	**1.3**	**4.7**	**90.2**	**5.1**	**0.0**	**5.1**	**Sand**
I14	**0.11**	**3.2**	**0.84**	**3.2**	**0.3**	**1.6**	**0.0**	**86.0**	**13.6**	**0.5**	**14.0**	**Organic debris, worm tubes**
I12	**0.26**	**1.9**	**1.12**	**2.1**	**-0.1**	**1.0**	**4.1**	**91.8**	**4.2**	**0.0**	**4.2**	**Organic debris**
I9	0.10	3.4	0.84	3.3	0.3	1.6	0.0	83.2	16.2	0.5	16.8	Clay w/ silt, organic debris, worm tubes
I6	0.54	0.9	0.76	0.8	0.2	1.1	10.1	89.6	0.2	0.0	0.2	Fine red relict sand, Shell hash
I3	0.36	1.5	0.79	1.5	-0.1	0.9	4.5	95.5	0.0	0.0	0.0	Fine sand
I2	0.37	1.4	0.86	1.5	0.0	0.9	4.7	93.4	1.9	0.0	1.9	Fine sand
38-m stations												
I29	0.78	0.4	0.45	0.3	0.2	1.0	22.4	77.6	0.0	0.0	0.0	Red relict sand, organic debris, worm tubes
I21	0.52	0.9	0.75	0.9	0.2	1.1	8.5	89.9	1.5	0.0	1.5	Red relict sand, shell hash
I13	0.49	1.0	0.86	0.9	0.2	1.0	7.6	90.5	1.9	0.0	1.9	Red relict sand, shell hash
I8	0.34	1.6	1.03	1.5	0.1	1.1	4.6	91.3	4.1	0.0	4.1	Sand
55-m stations												
I28	0.18	2.5	1.75	2.9	-0.4	0.6	10.5	40.0	49.6	0.0	49.6	Coarse black sand
I20	0.71	0.5	0.53	0.5	0.1	1.1	17.2	82.8	0.0	0.0	0.0	Red relict sand
I7	0.63	0.7	0.62	0.6	0.1	1.2	12.6	87.4	0.0	0.0	0.0	Red relict sand, shell hash
I1	0.14	2.8	0.94	2.7	0.4	2.0	0.0	90.8	8.9	0.3	9.1	Fine sand w/ silt

Appendix C.4

Summary of organic loading indicators at SBOO benthic stations for the January (A) and July (B) 2008 surveys. Stations nearest the outfall are in bold. nd=not detected.

A	Sulfides (ppm)	TN (% wt)	TOC (% wt)	B	Sulfides (ppm)	TN (% wt)	TOC (% wt)
19-m stations				*19-m stations*			
I35	35.30	0.034	0.228	I35	1.79	0.030	0.270
I34	0.26	0.009	0.202	I34	0.31	nd	0.121
I31	nd	0.011	0.094	I31	1.45	0.013	0.099
I23	nd	0.013	0.157	I23	1.00	0.038	3.240
I18	0.79	0.012	0.095	I18	0.41	0.016	0.142
I10	0.28	0.014	0.114	I10	0.20	0.013	0.130
I4	nd	nd	0.032	I4	nd	nd	0.095
28-m stations				*28-m stations*			
I33	1.62	0.024	0.558	I33	0.47	0.023	0.323
I30	0.28	0.022	0.204	I30	4.20	0.022	0.198
I27	nd	0.015	0.141	I27	nd	0.016	0.169
I22	nd	0.017	0.144	I22	nd	0.025	0.202
I16	**0.58**	**0.015**	**0.125**	**I16**	**nd**	**nd**	**0.063**
I15	**nd**	**nd**	**0.113**	**I15**	**nd**	**0.012**	**0.085**
I14	**nd**	**0.021**	**0.201**	**I14**	**0.60**	**0.020**	**0.178**
I12	**nd**	**0.015**	**0.131**	**I12**	**nd**	**0.013**	**0.110**
I9	0.18	0.019	0.185	I9	nd	0.019	0.210
I6	nd	0.013	0.088	I6	nd	0.011	0.090
I3	nd	nd	0.023	I3	nd	0.010	0.065
I2	nd	nd	0.036	I2	nd	nd	0.061
38-m stations				*38-m stations*			
I29	0.33	0.030	0.462	I29	nd	0.012	0.142
I21	nd	0.017	0.255	I21	nd	0.013	0.100
I13	nd	0.010	0.193	I13	nd	nd	0.087
I8	nd	0.012	0.085	I8	nd	0.018	0.152
55-m stations				*55-m stations*			
I28	nd	0.057	0.850	I28	nd	0.058	0.855
I20	nd	nd	0.050	I20	nd	nd	0.057
I7	nd	0.022	0.196	I7	nd	0.010	0.083
I1	0.08	0.019	0.247	I1	nd	0.020	0.286

Appendix C.5

Concentrations of detected trace metals (ppm) for the January 2008 survey. Stations nearest the outfall are in bold; ERL=effects range low threshold value; ERM=effects range median threshold value; na=not available; nd=not detected.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
ERL:	na	na	8.2	na	na	1.2	81	34	na	46.7	na	0.15	20.9	na	1	na	na	150
ERM:	na	na	70	na	na	9.6	370	270	na	218	na	0.71	51.6	na	3.7	na	na	410
19-m stations																		
I35	10400	0.442	2.070	49.20	nd	nd	15.40	4.040	11700	1.800	118.0	0.0040	5.460	nd	4.610	0.832	1.050	31.30
I34	1440	nd	1.200	5.29	nd	0.0910	3.25	0.532	3120	1.250	52.5	0.0290	0.909	nd	0.059	nd	1.530	6.65
I31	4800	nd	0.777	19.60	nd	nd	8.35	0.889	4910	nd	70.2	nd	1.860	nd	1.810	nd	1.310	11.50
I23	5680	0.307	1.240	37.70	nd	nd	9.70	1.010	6060	nd	74.6	nd	2.250	nd	1.380	0.524	1.180	12.60
I18	5340	nd	1.090	41.80	nd	nd	11.20	1.400	7080	nd	76.6	nd	2.210	nd	0.515	nd	1.390	11.70
I10	7450	0.668	1.320	32.20	nd	0.0670	11.60	1.110	7590	nd	95.8	0.0030	3.280	nd	3.770	0.899	1.460	16.10
I4	1320	0.440	1.130	4.08	nd	0.0830	5.62	0.353	2630	1.260	30.9	nd	0.988	nd	1.590	nd	0.440	6.76
28-m stations																		
I33	5570	0.332	1.500	27.30	nd	0.0620	9.33	2.040	7030	1.790	83.0	0.0240	2.910	nd	1.420	nd	1.040	16.80
I30	7250	0.434	1.540	33.20	nd	nd	11.30	2.050	7130	nd	69.8	0.0080	3.610	nd	2.530	nd	1.630	17.40
I27	7100	0.407	1.230	32.10	nd	nd	10.80	1.670	6900	nd	72.8	nd	3.240	nd	2.360	0.543	1.560	16.30
I22	4570	nd	1.030	21.80	nd	nd	8.76	1.490	5100	nd	53.4	0.0060	2.480	nd	1.490	nd	1.600	11.30
I16	**5550**	**nd**	**1.200**	**28.00**	**nd**	**nd**	**8.41**	**1.590**	**6050**	**nd**	**63.6**	**nd**	**2.290**	**nd**	**1.320**	**nd**	**1.440**	**13.90**
I15	**3730**	**nd**	**2.140**	**12.00**	**nd**	**nd**	**9.36**	**0.778**	**5570**	**0.909**	**40.7**	**nd**	**1.610**	**nd**	**0.874**	**nd**	**1.480**	**12.40**
I14	**8820**	**nd**	**1.870**	**43.80**	**nd**	**nd**	**12.00**	**2.260**	**8520**	**nd**	**83.9**	**nd**	**3.950**	**nd**	**0.561**	**0.633**	**1.640**	**20.40**
I12	**2860**	**nd**	**2.170**	**12.50**	**nd**	**nd**	**4.44**	**0.355**	**3110**	**nd**	**31.6**	**nd**	**1.260**	**nd**	**1.020**	**nd**	**0.654**	**7.19**
I9	9490	0.460	1.420	45.30	nd	nd	14.60	2.520	9540	nd	108.0	0.0040	5.450	nd	4.590	0.820	1.850	23.40
I6	1140	0.411	4.170	3.40	nd	0.0680	8.38	nd	4150	1.040	14.4	nd	0.851	nd	0.103	nd	1.760	4.60
I3	845	0.349	1.260	2.18	nd	nd	6.03	0.355	2820	nd	10.8	nd	1.120	nd	nd	nd	0.349	3.81
I2	1200	nd	nd	3.42	nd	0.0920	5.90	0.477	1380	nd	12.6	nd	0.870	nd	0.273	nd	1.660	3.99
38-m stations																		
I29	9340	0.452	2.200	45.80	nd	nd	14.80	3.760	10300	1.680	93.1	0.0160	5.940	nd	3.350	0.810	1.920	24.20
I21	1550	0.434	5.940	4.06	nd	nd	12.70	nd	8000	2.370	17.1	nd	1.100	nd	nd	nd	1.560	7.31
I13	1350	0.378	7.810	3.11	nd	nd	9.79	nd	6590	1.930	23.2	nd	0.717	nd	nd	nd	1.370	6.02
I8	2190	0.331	2.390	5.78	nd	0.0810	10.30	nd	4990	0.986	30.5	0.0040	1.240	nd	0.359	nd	1.670	9.93
55-m stations																		
I28	8500	0.464	2.130	34.10	nd	nd	13.10	4.010	9780	2.270	84.2	0.0270	6.280	nd	2.550	0.566	2.020	23.90
I20	1780	nd	2.890	3.55	nd	nd	6.05	nd	5360	1.180	24.5	nd	0.985	nd	nd	nd	1.520	8.35
I7	1520	0.463	5.060	3.81	nd	nd	9.74	nd	7760	1.920	26.2	nd	1.020	nd	nd	nd	0.463	7.19
I1	3290	0.418	0.916	10.00	nd	0.0475	7.50	0.831	4120	0.496	65.7	0.0075	2.610	nd	2.710	nd	1.860	9.64

Appendix C.5 *continued*

Concentrations of detected trace metals (ppm) for the July 2008 survey. Stations nearest the outfall are in bold; ERL=effects range low threshold value; ERM=effects range median threshold value; na=not available; nd=not detected.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
ERL:	na	na	8.2	na	na	1.20	81	34	na	46.7	na	0.15	20.9	na	1	na	na	150
ERM:	na	na	70	na	na	9.6	370	270	na	218	na	0.71	51.6	na	3.7	na	na	410
19-m stations																		
I35	7190	nd	2.430	44.30	nd	0.1340	13.00	4.51	9010	2.73	90.90	0.0140	4.570	nd	1.890	nd	0.770	27.70
I34	1580	nd	1.210	5.72	nd	nd	4.76	1.04	3580	1.84	28.60	nd	0.770	nd	nd	nd	0.480	6.63
I31	3260	nd	1.310	18.80	nd	0.0620	7.22	1.95	3130	0.98	38.10	nd	1.650	nd	0.124	nd	0.390	9.70
I23	3690	nd	2.240	17.70	nd	0.0750	7.06	2.44	4770	1.24	41.50	nd	2.340	nd	nd	nd	1.430	11.90
I18	5480	nd	1.440	46.40	nd	nd	11.40	3.01	6970	nd	78.80	nd	2.640	nd	nd	nd	1.470	13.90
I10	2180	nd	1.450	7.06	nd	nd	10.30	1.18	4700	1.11	26.00	nd	1.570	nd	nd	nd	0.740	8.85
I4	591	nd	1.360	1.65	nd	nd	3.75	0.74	1350	0.87	6.23	nd	0.460	nd	nd	nd	0.750	2.80
28-m stations																		
I33	4760	nd	1.860	21.20	nd	0.0740	8.25	3.26	5700	2.29	65.70	0.0090	2.590	nd	0.560	nd	0.760	17.20
I30	6420	nd	2.350	35.60	nd	nd	11.20	3.38	6600	1.32	65.20	0.0030	3.600	nd	1.170	nd	0.540	19.30
I27	7300	nd	1.570	34.20	nd	0.0780	11.60	3.67	7170	0.83	74.20	nd	3.720	nd	nd	nd	1.780	18.70
I22	4730	nd	1.760	21.60	nd	0.0610	8.84	3.12	5040	1.11	45.80	nd	2.780	nd	nd	nd	0.870	12.00
I16	**3390**	**nd**	**1.770**	**18.20**	**nd**	**nd**	**6.54**	**2.33**	**5060**	**nd**	**48.80**	**nd**	**1.560**	**nd**	**nd**	**nd**	**1.420**	**11.80**
I15	**1780**	**nd**	**2.820**	**5.50**	**nd**	**nd**	**8.85**	**0.98**	**4360**	**1.43**	**20.00**	**nd**	**1.010**	**nd**	**nd**	**nd**	**0.760**	**7.86**
I14	**7550**	**nd**	**1.510**	**42.40**	**nd**	**nd**	**11.20**	**4.17**	**7880**	**nd**	**81.60**	**nd**	**3.830**	**nd**	**nd**	**nd**	**0.950**	**20.60**
I12	**3610**	**nd**	**1.590**	**20.60**	**nd**	**nd**	**7.45**	**1.68**	**4870**	**nd**	**44.00**	**nd**	**1.830**	**nd**	**nd**	**nd**	**0.650**	**11.10**
I9	6460	nd	1.660	33.20	nd	nd	10.20	3.44	6590	nd	64.00	nd	3.750	nd	nd	nd	0.610	16.50
I6	1150	nd	5.220	3.40	nd	nd	8.38	0.82	4240	1.67	11.20	nd	0.700	nd	nd	nd	0.910	22.90
I3	879	nd	1.110	1.90	nd	nd	6.98	0.88	1300	0.92	7.38	nd	0.750	nd	nd	nd	0.610	2.70
I2	1190	nd	0.632	2.52	nd	0.0790	5.83	1.44	1250	nd	8.99	nd	0.840	nd	nd	nd	0.860	3.24
38-m stations																		
I29	895	nd	7.290	2.47	nd	nd	5.89	1.06	6540	1.73	14.60	nd	0.785	nd	nd	nd	0.400	6.31
I21	1140	nd	9.000	2.30	nd	nd	4.72	1.28	4800	1.03	16.30	nd	0.660	nd	nd	nd	1.510	6.01
I13	6650	0.155	5.550	41.70	nd	0.0305	11.00	3.90	7510	nd	79.00	nd	3.600	nd	nd	nd	0.785	19.40
I8	2190	nd	2.510	7.01	nd	nd	9.87	1.67	4380	1.05	24.20	nd	1.590	nd	nd	nd	0.780	8.31
55-m stations																		
I28	7610	nd	2.880	35.40	nd	0.0950	12.60	6.26	8970	3.20	73.10	0.0190	6.960	nd	1.170	nd	0.930	25.00
I20	2070	0.350	3.460	4.62	nd	0.1670	17.70	2.45	12500	4.03	23.00	nd	1.370	nd	nd	nd	1.850	11.50
I7	1050	nd	5.580	2.52	nd	nd	8.90	0.73	6460	1.71	17.10	nd	0.750	nd	nd	nd	0.630	5.75
I1	2640	0.315	0.921	10.60	nd	0.1010	7.25	1.88	3590	1.23	35.70	0.0045	2.870	nd	nd	nd	0.820	8.33

Appendix C.6

Concentrations of pesticides, total PAH, and total PCB detected at each SBOO benthic station during the January (A) and July (B) 2008 surveys. Stations nearest the outfall are in bold; ERL=effects range low threshold value; ERM=effects range median threshold value; na=not available; nd=not detected.

A	tDDT (ppt)	BHC (ppt)	HCB (ppt)	tPCB (ppt)	tPAH (ppb)
ERL:	1580	na	na	na	4022
ERM:	46100	na	na	na	44792
19-m stations					
I35	nd	nd	nd	nd	14.5
I34	nd	nd	nd	nd	17.9
I31	nd	nd	16	nd	13.3
I23	210	nd	38	610	nd
I18	120	nd	68	180	nd
I10	nd	nd	52	nd	nd
I4	nd	nd	nd	nd	13.2
28-m stations					
I33	nd	nd	nd	nd	nd
I30	210	nd	nd	nd	26.4
I27	110	190	200	nd	15
I22	nd	nd	120	nd	nd
I16	**nd**	**nd**	**nd**	**nd**	**nd**
I15	**nd**	**nd**	**430**	**nd**	**nd**
I14	**330**	**nd**	**nd**	**203**	**30.4**
I12	**nd**	**nd**	**65**	**nd**	**nd**
I9	nd	nd	nd	nd	nd
I6	nd	nd	nd	nd	nd
I3	nd	nd	nd	nd	nd
I2	nd	nd	nd	nd	nd
38-m stations					
I29	1690	nd	470	nd	15.2
I21	nd	nd	nd	nd	16.6
I13	85	nd	310	nd	86.4
I8	nd	nd	160	nd	nd
55-m stations					
I28	590	nd	680	nd	nd
I20	nd	nd	nd	nd	nd
I7	nd	nd	130	nd	23.6
I1	nd	nd	nd	nd	nd

B	tDDT (ppt)	BHC (ppt)	HCB (ppt)	tPCB (ppt)	tPAH (ppb)
ERL:	1580	na	na	na	4022
ERM:	46100	na	na	na	44792
19-m stations					
I35	nd	nd	nd	nd	nd
I34	nd	nd	nd	nd	nd
I31	nd	nd	1300	nd	nd
I23	170	nd	nd	nd	nd
I18	nd	nd	nd	nd	nd
I10	nd	nd	nd	nd	nd
I4	nd	nd	nd	nd	nd
28-m stations					
I33	110	nd	1500	nd	nd
I30	180	nd	nd	nd	nd
I27	150	nd	nd	nd	nd
I22	150	nd	85	nd	nd
I16	**nd**	**nd**	**nd**	**nd**	**nd**
I15	**110**	**nd**	**nd**	**nd**	**nd**
I14	**290**	**nd**	**nd**	**nd**	**nd**
I12	**nd**	**nd**	**nd**	**nd**	**nd**
I9	nd	nd	160	318	nd
I6	nd	nd	nd	nd	nd
I3	210	nd	180	nd	nd
I2	nd	nd	nd	nd	nd
38-m stations					
I29	410	nd	360	nd	37.6
I21	nd	nd	85	nd	nd
I13	nd	nd	nd	nd	nd
I8	130	nd	200	nd	nd
55-m stations					
I28	910	nd	nd	1392	nd
I20	nd	nd	nd	nd	nd
I7	nd	nd	96	nd	nd
I1	nd	nd	nd	nd	nd

Appendix D

Supporting Data

2008 SBOO Stations

Macrobenthic Communities

Appendix D.1

All taxa composing cluster groups A–E from the 2008 surveys of SBOO benthic stations. Data are expressed as mean abundance per sample (no./0.1 m^2). Values for the three most abundant species in each cluster group are in bold, (n)=number of station/survey entities per cluster group.

		Cluster Group				
Species/Taxa	Taxa	A (1)	B (17)	C (2)	D (6)	E (28)
Acidostoma hancocki	Crustacea		0.1		0.1	0.1
Acteocina cerealis	Mollusca				0.5	<0.1
Acteocina culcitella	Mollusca		0.1		0.1	1.0
Acteocina harpa	Mollusca		0.1		0.1	0.5
Acteocina sp	Mollusca		<0.1			0.1
Actiniaria	Cnidaria		<0.1	0.8	0.2	0.1
Adontorhina cyclia	Mollusca				0.3	
Aglaja ocelligera	Mollusca					0.1
Aglaophamus verrilli	Polychaeta				0.1	
Agnezia septentrionalis	Ascidiacea		1.2	0.3	0.1	
Alia carinata	Mollusca					<0.1
Alvania compacta	Mollusca					0.1
Alvania rosana	Mollusca				0.2	<0.1
Amaeana occidentalis	Polychaeta		<0.1		0.3	0.2
Amage anops	Polychaeta					<0.1
Amathimysis trigibba	Crustacea		<0.1			
Americhelidium shoemakeri	Crustacea		0.5	1.0		0.3
Americhelidium sp	Crustacea		<0.1		0.1	<0.1
Americhelidium sp SD1	Crustacea		0.4		0.1	<0.1
Americhelidium sp SD4	Crustacea			0.3	0.1	<0.1
Ampelisca agassizi	Crustacea		<0.1	0.3	7.2	1.2
Ampelisca brachycladus	Crustacea		0.2	0.8		1.7
Ampelisca brevisimulata	Crustacea				1.6	4.2
Ampelisca careyi	Crustacea		0.1		2.5	1.0
Ampelisca cf *brevisimulata*	Crustacea				0.5	0.1
Ampelisca cristata cristata	Crustacea		3.5	1.5	1.3	2.8
Ampelisca cristata microdentata	Crustacea		0.1	0.3	0.9	3.6
Ampelisca hancocki	Crustacea				0.1	
Ampelisca indentata	Crustacea				1.5	
Ampelisca milleri	Crustacea		<0.1			0.1
Ampelisca pacifica	Crustacea				0.3	<0.1
Ampelisca pugetica	Crustacea		<0.1		2.7	2.1
Ampelisca sp	Crustacea			0.3	0.3	0.1
Ampelisciphotis podophthalma	Crustacea		0.1		0.7	0.8
Ampharete acutifrons	Polychaeta				0.3	
Ampharete finmarchica	Polychaeta				0.1	
Ampharete labrops	Polychaeta	0.5	0.5	3.8	1.8	3.3
Ampharete sp	Polychaeta		0.1		0.6	<0.1
Ampharetidae	Polychaeta		<0.1		0.6	0.1
Amphicteis scaphobranchiata	Polychaeta				0.1	0.8
Amphicteis sp	Polychaeta				0.1	0.3
Amphideutopus oculatus	Crustacea				0.7	0.9
Amphiodia digitata	Echinodermata		0.1	0.3	1.9	0.6
Amphiodia psara	Echinodermata					<0.1
Amphiodia sp	Echinodermata		0.3	0.8	3.1	0.7

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Amphiodia urtica	Echinodermata		1.2		4.8	0.3
Amphioplus sp	Echinodermata					0.3
Amphioplus sp A	Echinodermata				1.9	0.4
Amphipholis sp	Echinodermata		<0.1			<0.1
Amphipholis squamata	Echinodermata				0.4	
Amphiporidae	Nemertea			0.3	0.2	<0.1
Amphiporus sp	Nemertea		<0.1		0.3	0.3
Amphissa undata	Mollusca		<0.1		0.6	<0.1
Amphitritinae	Polychaeta		0.1			
Amphiura arcystata	Echinodermata		0.1		0.3	
Amphiuridae	Echinodermata		0.4	0.5	4.4	1.6
Anchicolurus occidentalis	Crustacea			0.5		0.3
Ancistrosyllis groenlandica	Polychaeta		<0.1	0.3	0.1	0.1
Ancistrosyllis hamata	Polychaeta					<0.1
Anemonactis sp	Cnidaria		0.1			
Anobothrus gracilis	Polychaeta				2.4	<0.1
Anomura	Crustacea			0.3		
Anonyx lilljeborgi	Crustacea		<0.1		0.2	
Anopla	Nemertea		<0.1			0.1
Anoplodactylus erectus	Arthropoda		<0.1		0.5	<0.1
Anotomastus gordiodes	Polychaeta					0.2
Aonides sp SD1	Polychaeta		0.2	0.3	0.2	
Aoridae	Crustacea				0.1	
Aoroides exilis	Crustacea		<0.1			<0.1
Aoroides inermis	Crustacea		<0.1			
Aoroides sp	Crustacea				0.2	<0.1
Aoroides sp A	Crustacea				0.4	<0.1
Aoroides spinosa	Crustacea					0.1
Aphelochaeta glandaria complex	Polychaeta		<0.1		0.7	0.1
Aphelochaeta monilaris	Polychaeta		0.8	0.3	2.1	0.3
Aphelochaeta sp	Polychaeta		0.8		0.4	<0.1
Aphelochaeta sp LA1	Polychaeta		0.1		0.6	0.1
Aphelochaeta sp SD5	Polychaeta					<0.1
Aphelochaeta tigrina	Polychaeta				0.2	
Aphrodita sp	Polychaeta					0.2
Apionsoma misakianum	Sipuncula	0.5	0.4	1.0	1.4	<0.1
Apistobranchus ornatus	Polychaeta					<0.1
Apoprionospio pygmaea	Polychaeta		0.5	**25.8**	0.3	2.0
Araphura breviaria	Crustacea				0.1	
Araphura sp SD1	Crustacea				0.8	
Argissa hamatipes	Crustacea		0.1	0.3	0.3	0.1
Aricidea (*Acmira*) *catherinae*	Polychaeta		0.1	1.0	2.6	1.3
Aricidea (*Acmira*) *cerrutii*	Polychaeta		0.9			0.1
Aricidea (*Acmira*) *horikoshii*	Polychaeta					0.1
Aricidea (*Acmira*) *lopezi*	Polychaeta					<0.1
Aricidea (*Acmira*) *simplex*	Polychaeta		0.2		6.5	0.1
Aricidea (*Acmira*) sp	Polychaeta		<0.1			
Aricidea (*Aedicira*) *pacifica*	Polychaeta					<0.1
Aricidea (*Allia*) *hartleyi*	Polychaeta		0.1		0.1	<0.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Aricidea (*Allia*) sp A	Polychaeta				1.2	
Aricidea (*Allia*) sp SD1	Polychaeta		0.3			
Aricidea (*Aricidea*) *pseudoarticulata*	Polychaeta				0.4	
Aricidea (*Aricidea*) *wassi*	Polychaeta				0.2	0.2
Armandia brevis	Polychaeta		0.5	18.3	2.0	0.1
Artacamella hancocki	Polychaeta				1.3	<0.1
Aruga holmesi	Crustacea				0.1	0.1
Aruga oculata	Crustacea		0.2	0.3	0.3	0.3
Asabellides lineata	Polychaeta				0.3	
Ascidiacea	Ascidiacea		0.2		0.6	
Asteroidea	Echinodermata				0.1	
Asteropella slatteryi	Crustacea				0.2	
Astropecten sp	Echinodermata		0.1		0.1	0.1
Astropecten verrilli	Echinodermata		0.4		0.2	0.1
Autolytus sp	Polychaeta					<0.1
Axinopsida serricata	Mollusca				12.4	0.1
Axiothella sp	Polychaeta		1.6		0.4	1.8
Balanoglossus sp	Hemichordata		0.3			<0.1
Balcis micans	Mollusca					<0.1
Balcis oldroydae	Mollusca		0.1			0.1
Bathymedon pumilus	Crustacea					<0.1
Bemlos audbettius	Crustacea				0.1	
Bemlos sp	Crustacea		<0.1			
Bispira sp	Polychaeta				0.2	
Mollusca	Mollusca	0.5	0.1		0.3	0.1
Blepharipoda occidentalis	Crustacea			0.3		
Brada pluribranchiata	Polychaeta				0.1	<0.1
Brada villosa	Polychaeta					0.1
Branchiostoma californiense	Chordata	16.5	0.4			0.1
Bullomorpha sp A	Mollusca					0.1
Byblis millsi	Crustacea		0.1		2.8	<0.1
Byblis sp	Crustacea				0.1	
Caecognathia crenulatifrons	Crustacea		<0.1		1.4	1.1
Caesia perpinguis	Mollusca		0.1	0.3		0.4
Callianax baetica	Mollusca		1.4	4.5		0.6
Calyptraea fastigiata	Mollusca	0.5		0.5	0.1	<0.1
Campylaspis canaliculata	Crustacea		<0.1			0.1
Campylaspis hartae	Crustacea		<0.1	0.3		
Campylaspis rubromaculata	Crustacea		<0.1			0.1
Cancridae	Crustacea					<0.1
Capitella capitata complex	Polychaeta				0.3	<0.1
Capitellidae	Polychaeta					<0.1
Caprella californica	Crustacea				0.2	0.1
Caprella kennerlyi	Crustacea		<0.1			
Caprella mendax	Crustacea				0.7	0.1
Caprellidae	Crustacea					<0.1
Cardiomya pectinata	Mollusca		0.1		1.1	
Cardiomya planetica	Mollusca		0.1			
Carinoma mutabilis	Nemertea	2.0	1.9	12.5	0.1	2.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Caudina arenicola	Echinodermata				0.1	<0.1
Caulleriella alata	Polychaeta			0.5		
Caulleriella pacifica	Polychaeta	1.0				
Caulleriella sp	Polychaeta	7.0	<0.1			
Caulleriella sp SD2	Polychaeta		0.1			
Cephalaspidea	Mollusca				0.1	
Cephalophoxoides homilis	Crustacea		<0.1			<0.1
Cerapus tubularis complex	Crustacea		0.2		0.3	0.5
Cerebratulus californiensis	Nemertea		0.1		0.1	<0.1
Cerebratulus lineolatus	Nemertea				0.1	
Cerebratulus sp	Nemertea		<0.1			<0.1
Ceriantharia	Cnidaria		0.1		1.6	
Chaetozone corona	Polychaeta		<0.1		0.1	3.5
Chaetozone hartmanae	Polychaeta				1.3	
Chaetozone sp	Polychaeta		0.5	0.5	1.8	0.4
Chaetozone sp SD1	Polychaeta		0.1			0.2
Chaetozone sp SD2	Polychaeta		1.2		0.1	0.3
Chaetozone sp SD5	Polychaeta		0.9	1.3	1.8	1.0
Chauliopleona dentata	Crustacea				0.3	
Chiridota sp	Echinodermata				0.2	
Chloeia pinnata	Polychaeta		0.4		0.4	
Chone albocincta	Polychaeta		0.1		0.2	0.2
Chone bimaculata	Polychaeta		0.1		0.1	
Chone ecaudata	Polychaeta				0.4	<0.1
Chone paramollis	Polychaeta	1.5	0.5		0.4	0.5
Chone sp	Polychaeta		<0.1		0.1	<0.1
Chone sp B	Polychaeta		0.1		0.3	
Chone trilineata	Polychaeta		<0.1		1.1	
Chone veleronis	Polychaeta		0.2		3.7	4.1
Cirratulidae	Polychaeta	0.5			0.2	0.1
Cirratulus sp	Polychaeta					<0.1
Cirriformia sp	Polychaeta		0.1			
Cirrophorus branchiatus	Polychaeta		0.1			
Cirrophorus furcatus	Polychaeta		0.2		0.2	0.2
Clavadoce sp	Polychaeta					<0.1
Clymenella complanata	Polychaeta		1.7	0.5	0.4	<0.1
Clymenella sp	Polychaeta	0.5				<0.1
Clymenella sp A	Polychaeta		<0.1			
Clymenella sp SD1	Polychaeta				0.3	
Clymenura gracilis	Polychaeta				2.0	
Cnemidocarpa rhizopus	Ascidiacea		1.3	2.0	0.5	0.1
Compsomyax subdiaphana	Mollusca		<0.1		0.5	0.3
Cooperella subdiaphana	Mollusca		<0.1	0.5	1.0	1.8
Corophiida	Crustacea			0.3		<0.1
Corymorpha bigelowi	Cnidaria		0.1		0.1	0.2
Cossura candida	Polychaeta					0.4
Cossura sp	Polychaeta				0.2	0.3
Cossura sp A	Polychaeta				0.1	0.1
Crangon alaskensis	Crustacea					<0.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Crangon sp	Crustacea					0.1
Crangonidae	Crustacea		0.1			<0.1
Crepidula glottidiarum	Mollusca		<0.1			<0.1
Cryptocelis occidentalis	Platyhelminthes		<0.1			<0.1
Cryptonemertes actinophila	Nemertea			0.3		<0.1
Cumacea	Crustacea			0.3		
Cumanotus fernaldi	Mollusca					<0.1
Cyathodonta pedroana	Mollusca					<0.1
Cyclaspis nubila	Crustacea		0.5	0.3		<0.1
Cyclaspis sp C	Crustacea			0.3		
Cyclocardia ventricosa	Mollusca		0.3			
Cyclopecten catalinensis	Mollusca					<0.1
Cylichna diegensis	Mollusca		0.7		1.3	2.0
Cylindroleberididae	Crustacea		0.4			0.1
Deflexilodes norvegicus	Crustacea					<0.1
Deilocerus planus	Crustacea	0.5				<0.1
Delectopecten vancouverensis	Mollusca				0.1	
Dendraster terminalis	Echinodermata	3.0	2.3	0.8		0.3
Dendrochirotida	Echinodermata			0.3	0.3	0.2
Diastylis californica	Crustacea				0.1	0.1
Diastylis crenellata	Crustacea				0.3	
Diastylis santamariensis	Crustacea					<0.1
Diastylopsis tenuis	Crustacea			0.8		0.2
Diopatra ornata	Polychaeta					0.1
Diopatra sp	Polychaeta		0.1	0.5	2.0	0.8
Diopatra tridentata	Polychaeta				0.3	0.8
Dipolydora socialis	Polychaeta		0.1		1.2	0.7
Dipolydora sp	Polychaeta				0.2	0.1
Dorvillea (*Schistomeringos*) sp	Polychaeta	2.0				<0.1
Dorvilleidae	Polychaeta					<0.1
Doto sp	Mollusca				0.1	
Dougaloplus amphacanthus	Echinodermata					<0.1
Dougaloplus sp A	Echinodermata				0.3	
Drilonereis falcata	Polychaeta					0.2
Drilonereis longa	Polychaeta				0.1	<0.1
Drilonereis sp	Polychaeta				0.5	0.2
Drilonereis sp A	Polychaeta					<0.1
Echinoidea	Echinodermata		0.2			
Eclysippe trilobata	Polychaeta					<0.1
Edotia sp B	Crustacea		<0.1			
Edotia sublittoralis	Crustacea		0.9	2.3		0.7
Edwardsia sp G	Cnidaria	2.0	0.3	1.3		0.5
Edwardsiidae	Cnidaria		0.3	0.5		0.3
Ennucula tenuis	Mollusca				5.1	<0.1
Enopla	Nemertea		0.1			0.1
Ensis myrae	Mollusca		0.1			0.2
Enteropneusta	Hemichordata		<0.1		0.3	0.1
Eohaustorius barnardi	Crustacea		0.1			
Epitonium bellastriatum	Mollusca		0.1	0.3	0.1	0.3

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Epitonium sawinae	Mollusca		<0.1			
Eranno sp	Polychaeta					<0.1
Ericthonius brasiliensis	Crustacea					<0.1
Eteone leptotes	Polychaeta					<0.1
Eteone pigmentata	Polychaeta		<0.1		0.1	0.1
Euchone arenae	Polychaeta		0.8	0.3	0.7	0.1
Euchone hancocki	Polychaeta		0.2			
Euchone incolor	Polychaeta			0.3	4.3	<0.1
Euchone sp	Polychaeta				0.2	
Euclymeninae	Polychaeta		0.4		0.2	1.0
Euclymeninae sp A	Polychaeta		0.8	0.3	13.8	**12.8**
Eulalia californiensis	Polychaeta	4.5			0.3	
Eulalia levicornuta complex	Polychaeta				0.1	
Eulalia sp SD1	Polychaeta			0.8		
Eumida longicornuta	Polychaeta	7.5	0.2	0.8		0.2
Eunice americana	Polychaeta				1.8	0.1
Eunicidae	Polychaeta				0.1	
Euphilomedes carcharodonta	Crustacea		1.3	0.3	4.5	2.8
Euphilomedes producta	Crustacea					<0.1
Euphysa sp A	Cnidaria				0.2	0.2
Eupolymnia heterobranchia	Polychaeta					0.1
Eurydice caudata	Crustacea		2.2		0.6	0.1
Eurylepta aurantiaca	Platyhelminthes		<0.1			
Eusarsiella thominx	Crustacea					0.1
Eusyllis sp	Polychaeta		0.1			
Eusyllis sp SD2	Polychaeta		0.9		0.2	
Eusyllis transecta	Polychaeta	1.0			0.1	0.1
Exogone breviseta	Polychaeta		<0.1		0.1	<0.1
Exogone dwisula	Polychaeta		<0.1		1.4	0.8
Exogone lourei	Polychaeta		0.8			0.6
Exogone molesta	Polychaeta			0.5		0.1
Fabricinuda limnicola	Polychaeta				1.8	
Falcidens longus	Mollusca				0.7	<0.1
Flabelligeridae	Polychaeta				0.1	<0.1
Foxiphalus golfensis	Crustacea				0.1	0.7
Foxiphalus obtusidens	Crustacea		0.7	1.0	0.8	1.9
Foxiphalus similis	Crustacea				0.4	
Gadila aberrans	Mollusca		<0.1		4.4	3.3
Galathowenia pygidialis	Polychaeta				0.1	
Gammaridea	Crustacea		<0.1	0.3		
Gammaropsis thompsoni	Crustacea					<0.1
Mollusca	Mollusca		<0.1			0.1
Gastropteron pacificum	Mollusca		<0.1		0.1	
Gibberosus myersi	Crustacea			1.0		0.2
Glossaulax reclusianus	Mollusca					<0.1
Glottidia albida	Brachiopoda	0.5	0.1		0.2	0.3
Glycera americana	Polychaeta	0.5	0.1	0.3	0.1	0.5
Glycera macrobranchia	Polychaeta			1.0	0.1	0.9
Glycera nana	Polychaeta		<0.1		3.4	0.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Glycera oxycephala	Polychaeta		4.7	0.5		1.8
Glycera sp	Polychaeta					0.1
Glycinde armigera	Polychaeta		0.9	10.0	1.2	5.4
Glycymeris septentrionalis	Mollusca		0.1			<0.1
Glyphocuma sp A	Crustacea				0.1	
Goniada littorea	Polychaeta		0.3			0.2
Goniada maculata	Polychaeta		0.4		0.5	0.5
Goniada sp	Polychaeta		<0.1			
Gymnonereis crosslandi	Polychaeta				0.1	
Halcampa decemtentaculata	Cnidaria	1.0	0.4	0.3		
Halianthella sp A	Cnidaria		<0.1		0.1	
Halicoides synopiae	Crustacea		0.1		0.3	
Haliophasma geminatum	Crustacea		0.6		0.3	0.4
Halistylus pupoideus	Mollusca		<0.1			
Halosydna latior	Polychaeta					<0.1
Hartmanodes hartmanae	Crustacea		0.3		0.3	0.3
Hartmanodes sp SD1	Crustacea		0.1			
Hemilamprops californicus	Crustacea		1.7	4.8	1.2	3.2
Hemipodia borealis	Polychaeta	19.0	0.2	1.3		
Hemiproto sp A	Crustacea				0.1	
Heptacarpus stimpsoni	Crustacea					<0.1
Hesionidae	Polychaeta	1.0				
Hesionura coineaui difficilis	Polychaeta	**180.5**	1.1	0.5	0.6	
Heterocrypta occidentalis	Crustacea			0.5		0.1
Heteronemertea	Nemertea		0.1			
Heteronemertea sp SD2	Nemertea		0.2		0.3	0.1
Heterophoxus oculatus	Crustacea				0.1	
Heteropodarke heteromorpha	Polychaeta		0.2	0.5		
Heteroserolis carinata	Crustacea		<0.1			0.1
Heterospio catalinensis	Polychaeta					0.1
Hiatella arctica	Mollusca				0.1	
Hippolytidae	Crustacea			0.3		0.1
Hippomedon sp	Crustacea					<0.1
Hippomedon sp A	Crustacea		0.1		0.2	0.1
Hippomedon zetesimus	Crustacea		0.1			<0.1
Hoplonemertea sp A	Nemertea				0.1	
Hornellia occidentalis	Crustacea		<0.1	0.5		
Hyalinoecia juvenalis	Polychaeta				0.1	
Hydrozoa	Cnidaria			0.3		
Isocirrus longiceps	Polychaeta				0.2	
Jasmineira sp B	Polychaeta		0.2		0.6	<0.1
Kurtzia arteaga	Mollusca				0.2	0.1
Kurtziella plumbea	Mollusca		<0.1			1.2
Kurtzina beta	Mollusca				0.8	0.1
Lampropidae	Crustacea		<0.1			
Lamprops carinatus	Crustacea			0.3		
Lamprops quadriplicatus	Crustacea			1.8		<0.1
Lanassa venusta venusta	Polychaeta		2.3		1.6	<0.1
Lanice conchilega	Polychaeta		<0.1		0.1	

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Laonice cirrata	Polychaeta			0.3	0.2	2.6
Laonice nuchala	Polychaeta				0.1	
Lasaeidae	Mollusca					<0.1
Laticorophium baconi	Crustacea		0.3		0.1	
Leitoscoloplos pugettensis	Polychaeta			0.3	0.2	0.8
Lepidasthenia berkeleyae	Polychaeta				0.1	
Lepidasthenia longicirrata	Polychaeta		0.1			<0.1
Lepidepecreum serraculum	Crustacea		0.1			
Leptochelia dubia	Crustacea	10.5	1.0	0.3	6.8	1.1
Leptopecten latiauratus	Mollusca		<0.1		0.4	0.1
Leptoplanidae	Platyhelminthes			0.5		
Leptostylis abditis	Crustacea				0.3	
Leptosynapta sp	Echinodermata	6.5	1.0	8.3	0.1	0.2
Leucon subnasica	Crustacea				0.1	
Leuroleberis sharpei	Crustacea		0.2	2.3	0.3	0.2
Levinsenia gracilis	Polychaeta					0.1
Levinsenia sp B	Polychaeta		<0.1		0.8	<0.1
Limatula saturna	Mollusca		<0.1			
Limnactiniidae sp A	Cnidaria				0.3	<0.1
Lineidae	Nemertea	1.0	0.7	1.5	1.3	0.6
Lineus bilineatus	Nemertea		0.2		0.8	<0.1
Lineus sp	Nemertea		<0.1			
Lirobarleeia kelseyi	Mollusca		0.7			
Lirobittium larum	Mollusca				0.2	
Listriella goleta	Crustacea				0.1	0.1
Listriella melanica	Crustacea					<0.1
Listriolobus pelodes	Echiura				0.3	
Lovenia cordiformis	Echinodermata		<0.1			
Lucinisca nuttalli	Mollusca		0.2			0.3
Lucinoma annulatum	Mollusca				0.7	<0.1
Lumbrineridae	Polychaeta				0.3	
Lumbrinerides platypygos	Polychaeta	2.0	6.5	1.0	0.4	0.5
Lumbrineris cruzensis	Polychaeta		0.1		1.6	0.3
Lumbrineris japonica	Polychaeta				0.1	<0.1
Lumbrineris latreilli	Polychaeta	1.0	0.8	2.0	2.3	0.1
Lumbrineris lingulata	Polychaeta		1.0	0.3	2.4	0.5
Lumbrineris sp	Polychaeta	0.5	<0.1	0.5	0.2	0.1
Lumbrineris sp GROUP I	Polychaeta		0.6		2.7	0.5
Lumbrineris sp GROUP II	Polychaeta		0.2		0.8	0.3
Lyonsia californica	Mollusca		0.3		0.3	0.1
Lyonsiidae	Mollusca		0.3		0.2	0.2
Lysianassoidea	Crustacea					<0.1
Lysippe sp A	Polychaeta		0.1		1.3	0.3
Lysippe sp B	Polychaeta					<0.1
Lytechinus pictus	Echinodermata		0.1			<0.1
Macoma nasuta	Mollusca		0.1			
Macoma sp	Mollusca					0.1
Macoma yoldiformis	Mollusca		<0.1		0.3	1.2
Macrochaeta sp A	Polychaeta	0.5				

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Magelona berkeleyi	Polychaeta				0.1	0.2
Magelona hartmanae	Polychaeta					<0.1
Magelona sacculata	Polychaeta		0.4	1.5		1.5
Magelona sp	Polychaeta		<0.1			0.4
Magelona sp B	Polychaeta					<0.1
Malacoceros indicus	Polychaeta		0.1			
Maldane sarsi	Polychaeta				1.0	0.1
Maldanidae	Polychaeta		1.4	0.5	5.6	3.0
Malmgreniella baschi	Polychaeta		<0.1			<0.1
Malmgreniella macginitiei	Polychaeta	0.5	<0.1		0.2	0.1
Malmgreniella nigralba	Polychaeta				0.1	
Malmgreniella sanpedroensis	Polychaeta				0.2	
Malmgreniella sp	Polychaeta					<0.1
Malmgreniella sp A	Polychaeta		0.2	0.5		0.1
Marphysa disjuncta	Polychaeta					<0.1
Mayerella banksia	Crustacea		0.1	0.5	2.7	0.5
Mediomastus acutus	Polychaeta			0.3		0.1
Mediomastus sp	Polychaeta		1.1	1.8	11.3	7.0
Megalomma pigmentum	Polychaeta				0.2	0.2
Megalomma sp	Polychaeta		0.1		0.3	0.2
Megaluropidae sp A	Crustacea		0.1		0.1	
Megasurcula carpenteriana	Mollusca				0.1	
Melanella rosa	Mollusca				0.2	<0.1
Melinna oculata	Polychaeta				4.7	1.8
Melphisana bola complex	Crustacea		<0.1			<0.1
Mesolamprops bispinosus	Crustacea				0.6	
Metacarcinus gracilis	Crustacea					<0.1
Metamysidopsis elongata	Crustacea	0.5				
Metaphoxus frequens	Crustacea				0.1	
Metasychis disparidentatus	Polychaeta				1.6	1.2
Metatiron tropakis	Crustacea	0.5		4.5		
Metharpinia coronadoi	Crustacea		0.7			0.1
Metharpinia jonesi	Crustacea			0.3		
Metopa dawsoni	Crustacea		<0.1		0.1	0.1
Micranellum crebricinctum	Mollusca	0.5	0.6	0.8		0.1
Microjassa bousfieldi	Crustacea					<0.1
Microjassa litotes	Crustacea		<0.1			
Microjassa sp	Crustacea					<0.1
Microphthalmus sp	Polychaeta			0.5		
Micropodarke dubia	Polychaeta	43.0	<0.1	2.3	0.1	
Microspio pigmentata	Polychaeta		0.2			
Micrura alaskensis	Nemertea		<0.1		0.1	0.1
Micrura sp	Nemertea		<0.1	0.3		<0.1
Modiolus neglectus	Mollusca					<0.1
Modiolus sp	Mollusca					0.1
Molgula napiformis	Ascidiacea			0.3		
Molgula regularis	Ascidiacea				0.1	
Molgula sp	Ascidiacea		0.2		0.5	0.1
Molgula sp SD1	Ascidiacea				0.3	

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Monoculodes emarginatus	Crustacea				0.3	<0.1
Monostyliferoidea	Nemertea		0.3		0.6	0.1
Monticellina cryptica	Polychaeta		0.2	0.5	1.7	0.6
Monticellina siblina	Polychaeta		0.5	2.8	6.4	**41.4**
Monticellina sp	Polychaeta					0.1
Monticellina tesselata	Polychaeta			0.3	0.3	0.2
Mooreonuphis nebulosa	Polychaeta		0.2		**14.7**	3.4
Mooreonuphis sp	Polychaeta		2.8		0.3	0.1
Mooreonuphis sp SD1	Polychaeta		5.9		2.0	
Mooresamytha bioculata	Polychaeta				0.2	<0.1
Munnogonium tillerae	Crustacea				0.1	
Myriochele gracilis	Polychaeta				12.7	
Myriochele striolata	Polychaeta				5.4	1.3
Myriowenia californiensis	Polychaeta				0.1	
Mysella sp H	Mollusca		<0.1			
Mysidopsis intii	Crustacea				0.1	<0.1
Mystides sp	Polychaeta		0.4		0.2	
Mytilidae	Mollusca					<0.1
Myxicola sp	Polychaeta		0.1		0.3	<0.1
Nematoda	Nematoda	2.5	1.1	6.5	8.8	0.9
Nemertea	Nemertea	3.0	0.1			
Naineris uncinata	Polychaeta				0.1	0.3
Naticidae	Mollusca					0.1
Neastacilla californica	Crustacea				0.1	0.1
Nebalia daytoni	Crustacea					0.1
Nebalia pugettensis complex	Crustacea		<0.1			<0.1
Nemocardium centifilosum	Mollusca				0.3	
Neocrangon zacae	Crustacea					<0.1
Neomysis kadiakensis	Crustacea					0.1
Neosabellaria cementarium	Polychaeta				0.1	0.2
Neotrypaea sp	Crustacea				0.2	0.1
Nephasoma diaphanes	Sipuncula		0.1			
Nephtys caecoides	Polychaeta		0.3		0.8	1.2
Nephtys cornuta	Polychaeta			1.3	0.1	0.2
Nephtys ferruginea	Polychaeta				0.4	0.1
Nephtys simoni	Polychaeta				0.1	
Nephtys sp	Polychaeta					0.1
Nephtys sp SD2	Polychaeta		0.1	1.0		0.1
Nereiphylla sp 2	Polychaeta		0.1			<0.1
Nereiphylla sp SD1	Polychaeta					<0.1
Nereis sp	Polychaeta					<0.1
Nereis sp A	Polychaeta		1.9	0.5	1.0	8.8
Nodiscala spongiosa	Mollusca		<0.1			
Nothria occidentalis	Polychaeta				0.2	
Notocirrus californiensis	Polychaeta		<0.1		0.1	<0.1
Notomastus latericeus	Polychaeta		3.0		0.8	1.4
Notomastus lineatus	Polychaeta		<0.1		0.1	
Notomastus magnus	Polychaeta					<0.1
Notomastus sp	Polychaeta				0.3	0.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Notomastus sp A	Polychaeta				0.5	0.5
Nuculana hamata	Mollusca				0.6	
Nuculana penderi	Mollusca					0.1
Nuculana sp	Mollusca				0.2	<0.1
Nuculana sp A	Mollusca				0.1	
Nuculana taphria	Mollusca			0.3	0.9	2.1
Odontosyllis phosphorea	Polychaeta		0.1	0.3		0.2
Odostomia sp	Mollusca		0.1		0.2	0.3
Oedicerotidae	Crustacea				0.1	
Oerstedia dorsalis	Nemertea		0.3		0.5	0.1
Okenia sp A	Mollusca		<0.1			
Oligochaeta	Oligochaeta		0.3			
Onuphidae	Polychaeta		0.9	0.5	1.5	0.8
Onuphis elegans	Polychaeta			0.3		
Onuphis eremita parva	Polychaeta		0.1			0.1
Onuphis sp	Polychaeta		0.1	1.0	0.3	0.5
Onuphis sp A	Polychaeta	0.5	1.9	1.3	1.8	4.8
Ophelia pulchella	Polychaeta	2.0	2.1			0.6
Opheliidae	Polychaeta		<0.1			
Ophelina acuminata	Polychaeta				0.2	
Ophiodermella inermis	Mollusca		0.1		0.3	0.1
Ophiodermella sp	Mollusca					<0.1
Ophiodromus pugettensis	Polychaeta	1.0		1.8		
Ophiopsila californica	Echinodermata		<0.1			
Ophiothrix spiculata	Echinodermata					<0.1
Ophiura luetkenii	Echinodermata		0.2		0.2	<0.1
Ophiuroconis bispinosa	Echinodermata		2.4		2.2	0.6
Ophiuroidea	Echinodermata		<0.1			
Orchomene anaquelus	Crustacea					0.1
Orchomenella decipiens	Crustacea		<0.1			
Orchomenella pacifica	Crustacea		0.1			
Orchomenella pinguis	Crustacea					<0.1
Ostreoida	Mollusca					<0.1
Owenia collaris	Polychaeta		<0.1	0.8	0.1	0.1
Oxyurostylis pacifica	Crustacea					0.1
Phorona	Phorona			0.5	0.1	0.1
Pachynus barnardi	Crustacea		<0.1		0.1	0.1
Pacifacanthomysis nephrophthalma	Crustacea					<0.1
Paguridae	Crustacea					<0.1
Paguristes sp	Crustacea		<0.1			<0.1
Paguristes ulreyi	Crustacea	0.5				
Paguroidea	Crustacea			0.3		
Palaeonemertea	Nemertea	3.0	0.3			0.2
Pandora bilirata	Mollusca				0.1	
Pandora sp	Mollusca					<0.1
Paradiopatra parva	Polychaeta		<0.1		1.8	0.1
Paradoneis lyra	Polychaeta			2.0		<0.1
Paradoneis sp	Polychaeta		0.1			
Paradoneis sp SD1	Polychaeta				0.8	0.1

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Paranaitis polynoides	Polychaeta					<0.1
Parandalia fauveli	Polychaeta				0.2	<0.1
Paranemertes californica	Nemertea		0.1		0.7	0.4
Paraonidae	Polychaeta		0.1		0.2	<0.1
Paraprionospio alata	Polychaeta			0.3	0.8	3.0
Parasterope hulingsi	Crustacea				0.1	
Pareurythoe californica	Polychaeta	30.0		**20.8**	0.2	
Parougia caeca	Polychaeta				0.3	0.2
Parvilucina tenuisculpta	Mollusca		0.3		3.7	0.4
Parviplana californica	Platyhelminthes					<0.1
Pectinaria californiensis	Polychaeta			0.3	1.7	0.3
Pentamera lissoplaca	Echinodermata				0.2	0.1
Pentamera populifera	Echinodermata				0.1	
Pentamera pseudopopulifera	Echinodermata				0.1	0.1
Pentamera sp	Echinodermata		<0.1			0.1
Periploma discus	Mollusca				0.2	<0.1
Periploma sp	Mollusca					0.1
Petaloclymene pacifica	Polychaeta				4.4	1.1
Phascolion sp A	Sipuncula				2.6	0.1
Pherusa negligens	Polychaeta					<0.1
Pherusa neopapillata	Polychaeta		0.2		1.9	0.7
Philine bakeri	Mollusca					<0.1
Philinoglossa sp A	Mollusca	0.5		0.3		
Phisidia sanctaemariae	Polychaeta				0.7	0.2
Pholoe glabra	Polychaeta		0.1	0.3	1.0	0.1
Pholoe sp	Polychaeta		<0.1			
Phoronis sp	Phorona		1.1	2.0	2.3	0.3
Phoronis sp SD1	Phorona				0.4	<0.1
Phoronopsis sp	Phorona		0.1	0.8		<0.1
Photidae	Crustacea				0.1	
Photis bifurcata	Crustacea					0.1
Photis brevipes	Crustacea		0.4	0.3	0.8	0.5
Photis californica	Crustacea				4.6	
Photis lacia	Crustacea				0.3	0.1
Photis sp	Crustacea	1.0		1.0	1.0	0.3
Photis sp C	Crustacea				0.9	0.1
Photis sp OC1	Crustacea	1.0	0.3	10.8	0.2	2.0
Phoxocephalidae	Crustacea				0.1	<0.1
Phyllochaetopterus limicolus	Polychaeta		<0.1			
Phyllochaetopterus prolifica	Polychaeta				0.1	<0.1
Phyllodoce cuspidata	Polychaeta					<0.1
Phyllodoce groenlandica	Polychaeta		0.1		0.3	0.1
Phyllodoce hartmanae	Polychaeta		3.8	15.3	0.4	1.9
Phyllodoce longipes	Polychaeta		0.2	0.3	0.7	0.1
Phyllodoce medipapillata	Polychaeta	5.5	<0.1			<0.1
Phyllodoce pettiboneae	Polychaeta		0.2			0.1
Phyllodoce sp	Polychaeta		0.3	0.8		0.1
Phyllophoridae	Echinodermata					0.1
Phyllophoridae sp A	Echinodermata			0.3		

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Phylo felix	Polychaeta					0.1
Pinnixa forficulimanus	Crustacea		<0.1			
Pinnixa franciscana	Crustacea					0.1
Pinnixa hiatus	Crustacea					<0.1
Pinnixa longipes	Crustacea					0.4
Pinnixa occidentalis complex	Crustacea				0.3	
Pinnixa sp	Crustacea		0.6	16.3	0.3	1.2
Pinnotheridae	Crustacea					0.1
Pionosyllis sp SD2	Polychaeta		0.5		0.1	
Piromis sp A	Polychaeta				0.7	
Pisione sp	Polychaeta	**44.0**	0.3		2.3	
Pista brevibranchiata	Polychaeta				0.1	
Pista estevanica	Polychaeta		0.8		3.1	1.3
Pista moorei	Polychaeta				0.3	
Pista sp	Polychaeta		0.1	0.3	0.2	<0.1
Pista wui	Polychaeta		0.9	0.5	0.3	2.3
Platymera gaudichaudii	Crustacea		<0.1			
Platynereis bicanaliculata	Polychaeta		<0.1		0.1	0.2
Pleurobranchaea californica	Mollusca	0.5				
Pleusymtes subglaber	Crustacea				0.1	
Podarkeopsis glabrus	Polychaeta				0.3	0.2
Podarkeopsis sp A	Polychaeta					<0.1
Podocerus brasiliensis	Crustacea		<0.1			
Podochela hemphillii	Crustacea					<0.1
Poecilochaetus johnsoni	Polychaeta					0.1
Poecilochaetus sp	Polychaeta				0.1	<0.1
Poecilochaetus sp A	Polychaeta					<0.1
Polycirrus californicus	Polychaeta		0.2		0.1	
Polycirrus sp	Polychaeta	11.5	0.4	0.8	1.0	0.2
Polycirrus sp A	Polychaeta	0.5	2.3	0.3	1.0	0.8
Polycirrus sp I	Polychaeta	0.5	0.2		0.2	
Polycirrus sp SD1	Polychaeta		<0.1			
Polycirrus sp SD3	Polychaeta	**48.5**	0.2	0.5		
Polydora limicola	Polychaeta				0.2	<0.1
Polygireulima rutila	Mollusca		0.4			0.1
Polygordius sp SD1	Polychaeta			0.3		
Polynoidae	Polychaeta		<0.1		0.1	
Polyschides quadrifissatus	Mollusca		2.2	0.8	0.4	0.1
Postasterope barnesi	Crustacea				0.3	
Potamethus sp A	Polychaeta				0.4	
Prachynella lodo	Crustacea					<0.1
Praxillella pacifica	Polychaeta		0.5		1.4	2.1
Praxillura maculata	Polychaeta					<0.1
Prionospio (*Minuspio*) *lighti*	Polychaeta					0.2
Prionospio (*Prionospio*) *dubia*	Polychaeta				3.7	
Prionospio (*Prionospio*) *jubata*	Polychaeta		1.7	0.3	10.0	5.3
Prionospio (*Prionospio*) sp	Polychaeta		<0.1			
Procampylaspis caenosa	Crustacea				0.2	
Procephalothrix sp	Nemertea		<0.1	0.3		

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Proceraea sp	Polychaeta					<0.1
Proclea sp A	Polychaeta	0.5			0.8	
Protodorvillea gracilis	Polychaeta	26.0	2.7	11.8	0.3	0.3
Protomedeia articulata complex	Crustacea					<0.1
Protomystides sp SD1	Polychaeta		<0.1			
Prototrygaeus jordanae	Arthropoda		<0.1			0.8
Pseudopotamilla sp	Polychaeta					<0.1
Pyromaia tuberculata	Crustacea					<0.1
Randallia ornata	Crustacea					<0.1
Rhabdocoela sp A	Platyhelminthes	2.0				
Rhamphobrachium longisetosum	Polychaeta				0.3	
Rhepoxynius bicuspidatus	Crustacea					0.1
Rhepoxynius fatigans	Crustacea					0.2
Rhepoxynius heterocuspidatus	Crustacea		0.9	0.8		0.2
Rhepoxynius lucubrans	Crustacea				0.5	0.1
Rhepoxynius menziesi	Crustacea		0.1	1.0	0.1	1.7
Rhepoxynius sp	Crustacea					0.1
Rhepoxynius stenodes	Crustacea				0.5	1.6
Rhepoxynius variatus	Crustacea		0.2	0.3	0.1	0.2
Rhodine bitorquata	Polychaeta		<0.1		0.9	
Rictaxis punctocaelatus	Mollusca				0.3	1.6
Rochefortia compressa	Mollusca		<0.1	0.3		
Rochefortia sp	Mollusca					<0.1
Rochefortia tumida	Mollusca		2.4		4.3	1.3
Romaleon jordani	Crustacea					<0.1
Rudilemboides sp	Crustacea				0.2	
Rudilemboides sp A	Crustacea		0.1		0.3	
Rudilemboides stenopropodus	Crustacea		0.1			
Sipuncula	Sipuncula				0.1	
Sabellaria gracilis	Polychaeta				0.1	
Sabellidae	Polychaeta		<0.1		0.3	<0.1
Saccocirrus sp	Polychaeta	6.0				<0.1
Saccoglossus sp	Hemichordata		<0.1	0.3		0.2
Samytha californiensis	Polychaeta				0.2	
Saxicavella nybakkeni	Mollusca				0.1	
Scalibregma californicum	Polychaeta		0.1	7.3	0.7	0.2
Mollusca	Mollusca		0.2			0.1
Schistocomus hiltoni	Polychaeta					<0.1
Schistocomus sp A	Polychaeta			0.5		0.3
Schizocardium sp	Hemichordata					0.1
Scolelepis (*Parascolelepis*) sp SD1	Polychaeta		0.1			
Scolelepis (*Scolelepis*) *occidentalis*	Polychaeta		<0.1			0.1
Scoletoma tetraura complex	Polychaeta		<0.1	0.5	0.3	2.0
Scoloplos acmeceps	Polychaeta		2.2	1.0	0.1	0.7
Scoloplos armiger complex	Polychaeta	2.0	**8.5**	6.8	2.4	1.9
Scoloplos sp	Polychaeta		0.1			
Semele venusta	Mollusca		<0.1		0.1	<0.1
Sigalion spinosus	Polychaeta	1.5	0.9	0.3	1.2	2.3
Sigalionidae	Polychaeta				0.1	

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Sige sp A	Polychaeta		0.2		0.2	0.1
Siliqua lucida	Mollusca			0.5	1.3	0.1
Simomactra planulata	Mollusca	0.5	0.3			
Siphonolabrum californiensis	Crustacea			0.3	0.1	
Solamen columbianum	Mollusca		2.1		4.6	0.3
Solariella peramabilis	Mollusca		0.2			
Solemya reidi	Mollusca				0.8	<0.1
Solen sicarius	Mollusca		<0.1		0.2	0.2
Sphaerephesia sp	Polychaeta		<0.1			
Sphaerodoropsis biserialis	Polychaeta					<0.1
Sphaerosyllis californiensis	Polychaeta	3.0		0.8	0.3	<0.1
Sphaerosyllis ranunculus	Polychaeta		<0.1		0.1	
Spio filicornis	Polychaeta				0.7	
Spio maculata	Polychaeta	4.0	**9.9**	0.3	1.9	0.4
Spiochaetopterus costarum complex	Polychaeta		0.2		0.4	0.3
Spionidae	Polychaeta		0.2		0.1	<0.1
Spiophanes berkeleyorum	Polychaeta		1.2	0.3	9.4	7.6
Spiophanes bombyx	Polychaeta	5.5	**245.8**	**532.5**	**39.6**	**87.5**
Spiophanes duplex	Polychaeta		0.2	1.8	**19.1**	11.0
Spiophanes kimballi	Polychaeta					<0.1
Spiophanes sp	Polychaeta			1.0		0.1
Stenothoe frecanda	Crustacea				0.1	
Stenothoides bicoma	Crustacea				0.4	0.1
Stereobalanus sp	Hemichordata		0.1		0.5	<0.1
Sternaspis fossor	Polychaeta				2.2	0.2
Sthenelais sp	Polychaeta				0.5	<0.1
Sthenelais tertiaglabra	Polychaeta				0.8	0.4
Sthenelais verruculosa	Polychaeta			0.5		0.7
Sthenelanella uniformis	Polychaeta		<0.1		4.4	0.7
Stolidobranchiata	Ascidiacea					<0.1
Streblosoma crassibranchia	Polychaeta				2.2	
Streblosoma sp	Polychaeta		0.3		0.7	0.3
Streblosoma sp B	Polychaeta		0.3		1.6	0.5
Streblosoma sp SD1	Polychaeta				0.2	
Streblosoma sp SF1	Polychaeta		0.2			0.1
Stylatula elongata	Cnidaria					<0.1
Stylatula sp	Cnidaria					<0.1
Stylochus exiguus	Platyhelminthes					0.1
Syllidae	Polychaeta				0.1	
Syllides minutus	Polychaeta		0.1			
Syllis gracilis complex	Polychaeta				0.1	
Synidotea magnifica	Crustacea		0.1		1.4	0.3
Tanaidacea	Crustacea				0.1	
Tellina bodegensis	Mollusca		<0.1			
Tellina cadieni	Mollusca		<0.1		0.2	
Tellina carpenteri	Mollusca		0.1		2.7	0.1
Tellina idae	Mollusca					<0.1
Tellina meropsis	Mollusca		<0.1			
Tellina modesta	Mollusca		0.2	0.8	0.3	3.5

Appendix D.1 *continued*

Species/Taxa	Taxa	Cluster Group A	B	C	D	E
Tellina nuculoides	Mollusca		0.1			
Tellinidae	Mollusca		<0.1		0.3	0.1
Tenonia priops	Polychaeta		0.2	0.8	0.1	0.6
Terebellidae	Polychaeta	0.5	<0.1		0.2	0.1
Terebellides californica	Polychaeta				1.8	0.1
Terebellides sp	Polychaeta				0.1	
Terebra hemphilli	Mollusca					<0.1
Tetrastemma albidum	Nemertea					<0.1
Tetrastemma candidum	Nemertea	0.5	<0.1			<0.1
Tetrastemma nigrifrons	Nemertea					<0.1
Tetrastemma sp	Nemertea		<0.1	0.5		0.1
Thracia trapezoides	Mollusca				0.2	
Thraciidae	Mollusca				0.4	0.2
Thracioidea	Mollusca				0.2	<0.1
Thyasira flexuosa	Mollusca				0.8	<0.1
Thysanocardia nigra	Sipuncula		0.2		0.3	<0.1
Tiron biocellata	Crustacea		<0.1	0.8	0.3	0.7
Travisia brevis	Polychaeta		0.1		0.2	0.2
Travisia gigas	Polychaeta					<0.1
Trypanosyllis sp	Polychaeta	0.5				
Tubulanidae	Nemertea		0.1	0.3	0.3	0.2
Tubulanidae sp B	Nemertea		<0.1			<0.1
Tubulanidae sp D	Nemertea				0.1	<0.1
Tubulanus cingulatus	Nemertea				0.5	0.1
Tubulanus polymorphus	Nemertea	0.5	0.3	0.5	1.4	1.9
Tubulanus sp A	Nemertea				0.3	0.1
Turbonilla sp	Mollusca		<0.1			0.1
Turbonilla sp A	Mollusca	0.5	0.1		0.2	0.1
Turbonilla sp SD1	Mollusca		<0.1		0.2	1.2
Turbonilla sp SD2	Mollusca	0.5				0.3
Turbonilla sp SD6	Mollusca					0.1
Typhlotanais williamsi	Crustacea				0.1	
Typosyllis farallonensis	Polychaeta					0.7
Typosyllis heterochaeta	Polychaeta		0.2		2.8	0.4
Typosyllis hyperioni	Polychaeta		<0.1			
Typosyllis sp	Polychaeta		<0.1			
Typosyllis sp SD1	Polychaeta	36.0	3.0	0.5	1.8	<0.1
Typosyllis sp SD2	Polychaeta	1.0	3.8	2.0		0.1
Urothoe elegans complex	Crustacea					<0.1
Venerinae	Mollusca				0.4	0.3
Virgularia sp	Cnidaria					<0.1
Volvulella californica	Mollusca					<0.1
Volvulella cylindrica	Mollusca		0.3		0.1	0.1
Volvulella panamica	Mollusca				0.1	0.2
Volvulella sp	Mollusca		0.1			<0.1
Westwoodilla tone	Crustacea				0.8	0.2
Xenoleberis californica	Crustacea				0.2	

Appendix E

Supporting Data

2008 SBOO Stations

Demersal Fishes and Megabenthic Invertebrates

Appendix E.1

Summary of demersal fish species captured during 2008 at SBOO stations. Data are number of fish (n), biomass (kg, wet weight), minimum (Min), maximum (Max), and mean length (cm, standard length). Taxonomic arrangement and scientific names are of Eschmeyer and Herald (1998) and Allen (2005).

				Length		
Taxon/Species	**Common Name**	**n**	**BM**	**Min**	**Max**	**Mean**
RAJIFORMES						
Platyrhynidae						
Platyrhinoidis triseriata	thornback	1	1.2	58	58	58
Rhinobatidae						
Rhinobatos productus	shovelnose guitarfish	2	0.6	29	46	38
Rajidae						
Raja inornata	California skate	5	4.6	25	62	44
MYLIOBATIFORMES						
Urolophidae						
Urobatis haller	round stingray	1	0.7	36	36	36
AULOPIFORMES						
Synodontidae						
Synodus lucioceps	California lizardfish	175	5.8	8	24	13
OPHIDIIFORMES						
Ophidiidae						
Chilara taylori	spotted cusk-eel	1	0.1	12	12	12
BATRACHOIDIFORMES						
Batrachoididae						
Porichthys myriaster	specklefin midshipman	18	0.8	6	18	10
Porichthys notatus	plainfin midshipman	27	1.1	4	16	10
SYNGNATHIFORMIES						
Syngnathidae						
Syngnathus californiensis	kelp pipefish	6	0.3	15	22	20
SCORPAENIFORMES						
Scorpaenidae						
Scorpaena guttata	California scorpionfish	28	10.5	10	29	20
Sebastes dallii	calico rockfish	1	0.1	4	4	4
Hexagrammidae						
Zaniolepis latipinnis	longspine combfish	118	4.3	12	16	14
Cottidae						
Chitonotus pugetensis	roughback sculpin	630	6.2	4	12	8
Icelinus quadriseriatus	yellowchin sculpin	524	3.2	4	8	6
Agonidae						
Odontopyxis trispinosa	pygmy poacher	2	0.2	5	7	6
Liparidae						
Lipanis mocuosus	slimy snailfish	1	0.1	3	3	3
PERCIFORMES						
Serranidae						
Paralabrax nebulifer	barred sand bass	1	0.8	31	31	31
Sciaenidae						
Seriphus politus	queenfish	10	0.5	13	15	14
Umbrina roncador	yellowfin croaker	98	8.6	13	24	17
Embiotocidae						
Cymatogaster aggregata	shiner perch	2	0.2	8	11	10
Zalembius rosaceus	pink seaperch	4	0.3	5	12	8

Appendix E.1 *continued*

Taxon/Species	Common Name	n	BM	Length Min	Length Max	Length Mean
Clinidae						
Heterostichus rostratus	giant kelpfish	1	0.1	17	17	17
Chaenopsidae						
Neoclinus blanchardi	sarcastic fringehead	1	0.1	11	11	11
Labrisonidae						
Cryptotrema corallimun	deepwater blenny	1	0.1	3	3	3
Stromateidae						
Peprilus simillimus	Pacific pompano	485	6.3	6	10	8
PLEURONECTIFORMES						
Paralichthyidae						
Citharichthys sordidus	Pacific sanddab	2	0.2	15	16	16
Citharichthys stigmaeus	speckled sanddab	3659	32.9	3	13	8
Citharichthys xanthostigma	longfin sanddab	138	9.7	6	20	14
Hippoglossina stomata	bigmouth sole	4	0.5	17	23	19
Paralichthys californicus	California halibut	14	14.1	23	53	35
Xystreurys liolepis	fantail sole	7	1.3	18	25	21
Pleuronectidae						
Parophrys vetulus	English sole	89	7.7	8	26	15
Pluronichthys decurrens	curlfin sole	2	0.1	5	6	6
Pleuronichthys ritteri	spotted turbot	6	1.4	16	19	18
Pleuronichthys verticalis	hornyhead turbot	124	8.5	4	21	11
Cynoglossidae						
Symphurus atricauda	California tonguefish	33	1.8	7	16	11

Appendix E.2

Summary of total abundance by species and station for demersal fishes at the SBOO stations during 2008.

	January 2008							
Name	SD15	SD16	SD17	SD18	SD19	SD20	SD21	Total abundance by survey
Speckled sanddab	53	258	159	186	231	225	124	1236
Roughback sculpin	10	47	28	32	28	21	12	178
Longspine combfish		11	2	17	6	8	12	56
Hornyhead turbot		4	5	9	9	6	3	36
California lizardfish	1	5	1	7		12	2	28
English sole	1		5	5	4	2	3	20
Longfin sanddab		1	2	10				13
Specklefin midshipman		3	1		1	6		11
California halibut			4	1			2	7
California tonguefish			1	1	2	1	1	6
Kelp pipefish		2	3					5
Plainfin midshipman			2				3	5
California skate		1	1					2
Fantail sole	1						1	2
Yellowchin sculpin			2					2
California scorpionfish						1		1
Round stingray							1	1
Shiner perch							1	1
Shovelnose guitarfish					1			1
Thornback				1				1
Quarterly total	66	332	216	269	282	282	165	1612

Appendix E.2 *continued*

Name	April 2008							Total abundance by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Speckled sanddab	152	241	136	152	260	265	209	1415
Yellowchin sculpin	5	15	84	69	16	12	20	221
Roughback sculpin	24	39	39	26	42	35	9	214
Hornyhead turbot	8	16	6	4	6	4	6	50
Longspine combfish		34	3	5	2	2	4	50
English sole	3	3	7	13	7	13	2	48
Longfin sanddab		4	9	11	9	7	7	47
California tonguefish		3	2	1		3	7	16
Plainfin midshipman	1	12		1	2			16
California lizardfish		1	4	1	4		3	13
California scorpionfish	2		1		1		1	5
California halibut				1	1			2
Curlfin sole	2							2
Fantail sole	1	1						2
Pacific sanddab		1		1				2
California skate		1						1
Kelp pipefish					1			1
Pink seaperch							1	1
Sarcastic fringehead				1				1
Shovelnose guitarfish	1							1
Spotted cuskeel							1	1
Spotted turbot	1							1
Quarterly total	200	371	291	286	351	341	270	2110

Appendix E.2 *continued*

Name	July 2008							Total abundance by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Speckled sanddab	56	132	86	69	169	125	57	694
Yellowchin sculpin		11	81	31	28	20	14	185
Roughback sculpin	4	13	33		34	66	22	172
Longfin sanddab		4	7	4	14	12	14	55
California lizardfish	1	13	16	6	2	6	7	51
Hornyhead turbot	3	4	1	5	4	3	4	24
English sole	1			1	7	7	3	19
Longspine combfish					1	1	10	12
California scorpionfish			3	1		1	6	11
California tonguefish		2			1	3	1	7
Bigmouth sole			3			1		4
California halibut	1	1			1		1	4
Spotted turbot				2	1	1		4
Plainfin midshipman						3		3
Barred sand bass					1			1
Calico rockfish							1	1
California skate	1							1
Fantail sole		1						1
Giant kelpfish							1	1
Pink seaperch							1	1
Pygmy poacher							1	1
Slimy snailfish							1	1
Quarterly total	67	181	230	119	263	249	144	1253

Appendix E.2 *continued*

	October 2008							
Name	**SD15**	**SD16**	**SD17**	**SD18**	**SD19**	**SD20**	**SD21**	**Total abundance by survey**
Pacific pompano							485	485
Speckled sanddab	26	43	44	47	112	35	7	314
Yellowchin sculpin		4	37	20	38	15	2	116
Yellowfin croaker							98	98
California lizardfish	4	11	14	11	6	21	16	83
Roughback sculpin	2	8	10	5	25	16		66
Longfin sanddab		2	1	5	8	6	1	23
Hornyhead turbot	1	2	3	3	1	2	2	14
California scorpionfish			4	4			3	11
Queenfish							10	10
Specklefin midshipman			3		1	3		7
California tonguefish			1			2	1	4
Plainfin midshipman		1	2					3
English sole		1		1				2
Fantail sole	1					1		2
Pink seaperch							2	2
California halibut			1					1
California skate				1				1
Deepwater blenny			1					1
Pygmy poacher						1		1
Shiner perch							1	1
Spotted turbot	1							1
Quarterly total	35	72	121	97	191	102	628	1246
Annual Total	**368**	**956**	**858**	**771**	**1087**	**974**	**1207**	**6221**

Appendix E.3

Summary of biomass (kg) by species and station for demersal fishes at the SBOO stations during 2008.

	January 2008							
Name	SD15	SD16	SD17	SD18	SD19	SD20	SD21	Total biomass by survey
Speckled sanddab	0.4	1.5	1.4	1.7	2.3	1.8	1.0	10.1
California halibut			3.6	0.3			3.0	6.9
Longspine combfish		0.3	0.1	0.5	0.2	0.3	0.4	1.8
California skate		0.8	0.9					1.7
English sole	0.3		0.3	0.4	0.1	0.2	0.4	1.7
Hornyhead turbot		0.1	0.5	0.3	0.4	0.1	0.2	1.6
Roughback sculpin	0.1	0.3	0.2	0.3	0.3	0.2	0.1	1.5
Longfin sanddab		0.2	0.1	0.9				1.2
Thornback				1.2				1.2
California lizardfish	0.1	0.2	0.1	0.3		0.2	0.1	1.0
California scorpionfish						0.9		0.9
Fantail sole	0.4						0.3	0.7
Round stingray							0.7	0.7
California tonguefish			0.1	0.1	0.1	0.1	0.1	0.5
Specklefin midshipman		0.1	0.1		0.1	0.1		0.4
Kelp pipefish		0.1	0.1					0.2
Plainfin midshipman			0.1				0.1	0.2
Shiner perch							0.1	0.1
Shovelnose guitarfish					0.1			0.1
Yellowchin sculpin			0.1					0.1
Quarterly total	1.3	3.6	7.7	6.0	3.6	3.9	6.5	32.6

Appendix E.3 *continued*

Name	April 2008							Total biomass by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Speckled sanddab	1.2	2.0	1.1	1.5	2.5	2.1	1.7	12.1
Longfin sanddab		0.3	0.7	1.0	0.6	0.5	0.5	3.6
English sole	0.5	0.2	0.3	1.1	0.5	0.8	0.1	3.5
California scorpionfish	1.5		0.6		0.1		0.6	2.8
Hornyhead turbot	0.2	0.6	0.5	0.3	0.2	0.3	0.6	2.7
Roughback sculpin	0.2	0.3	0.2	0.2	0.5	0.3	0.1	1.8
Longspine combfish		0.9	0.1	0.1	0.1	0.1	0.1	1.4
Yellowchin sculpin	0.1	0.1	0.4	0.3	0.1	0.1	0.1	1.2
California lizardfish		0.1	0.2	0.1	0.3		0.2	0.9
California halibut				0.4	0.4			0.8
Shovelnose guitarfish	0.5							0.5
California tonguefish		0.1	0.1	0.1		0.1	0.1	0.5
Plainfin midshipman	0.1	0.2		0.1	0.1			0.5
Spotted turbot	0.3							0.3
Fantail sole	0.1	0.2						0.3
Pacific sanddab		0.1		0.1				0.2
California skate		0.1						0.1
Curlfin sole	0.1							0.1
Kelp pipefish					0.1			0.1
Pink seaperch							0.1	0.1
Sarcastic fringehead				0.1				0.1
Spotted cuskeel							0.1	0.1
Quarterly total	4.8	5.2	4.2	5.4	5.5	4.3	4.3	33.7

Appendix E.3 *continued*

Name	July 2008							Total biomass by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Speckled sanddab	0.7	1.4	1.0	0.8	2.0	1.4	0.6	7.9
California halibut	1.0	0.6			1.4		0.7	3.7
Longfin sanddab		0.3	0.4	0.3	0.9	0.7	0.8	3.4
California scorpionfish			1.2	0.3		0.2	1.4	3.1
Hornyhead turbot	0.2	0.5	0.1	0.7	0.5	0.3	0.5	2.8
Roughback sculpin	0.1	0.1	0.3		0.4	0.8	0.3	2.0
English sole	0.2			0.2	0.6	0.5	0.4	1.9
California skate	1.8							1.8
California lizardfish	0.1	0.3	0.2	0.1	0.2	0.2	0.3	1.4
Yellowchin sculpin		0.1	0.3	0.1	0.2	0.2	0.2	1.1
Longspine combfish					0.1	0.1	0.9	1.1
Spotted turbot				0.4	0.2	0.3		0.9
Barred sand bass					0.8			0.8
Bigmouth sole			0.3			0.2		0.5
California tonguefish		0.1			0.1	0.2	0.1	0.5
Plainfin midshipman						0.2		0.2
Calico rockfish							0.1	0.1
Fantail sole		0.1						0.1
Giant kelpfish							0.1	0.1
Pink seaperch							0.1	0.1
Pygmy poacher							0.1	0.1
Slimy snailfish							0.1	0.1
Quarterly total	4.1	3.5	3.8	2.9	7.4	5.3	6.7	33.7

Appendix E.3 *continued*

Name	October 2008							Total biomass by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Yellowfin croaker							8.6	8.6
Pacific pompano							6.3	6.3
California scorpionfish			1.3	1.7			0.7	3.7
Speckled sanddab	0.1	0.5	0.5	0.5	0.9	0.2	0.1	2.8
California halibut			2.7					2.7
California lizardfish	0.1	0.8	0.3	0.3	0.2	0.4	0.4	2.5
Longfin sanddab		0.1	0.1	0.4	0.4	0.4	0.1	1.5
Hornyhead turbot	0.2	0.1	0.3	0.2	0.2	0.2	0.2	1.4
California skate				1.0				1.0
Roughback sculpin	0.1	0.1	0.1	0.1	0.3	0.2		0.9
Yellowchin sculpin		0.1	0.1	0.1	0.3	0.1	0.1	0.8
English sole		0.4		0.2				0.6
Queenfish							0.5	0.5
Specklefin midshipman			0.2		0.1	0.1		0.4
California tonguefish			0.1			0.1	0.1	0.3
Fantail sole	0.1					0.1		0.2
Plainfin midshipman		0.1	0.1					0.2
Spotted turbot	0.2							0.2
Deepwater blenny			0.1					0.1
Pink seaperch							0.1	0.1
Pygmy poacher						0.1		0.1
Shiner perch							0.1	0.1
Quarterly total	0.8	2.2	5.9	4.5	2.4	1.9	17.3	35.0
Annual Total	**11.0**	**14.5**	**21.6**	**18.8**	**18.9**	**15.4**	**34.8**	**135.0**

Appendix E.4

Summary of the top three species that discriminate between each cluster group according to SIMPER analyses (i.e., dissimilarity ≥1.5). Values are average dissimilarity between groups for that species; CL=California lizardfish, CS= California scorpionfish, CT=Californina tonguefish, ES=English sole, HT=hornyhead turbot, LS=longfin sanddab, RS=roughback sculpin, SS=speckled sanddab, YS=yellowchin sculpin.

	A			B			C			D			E			F		
B	CL 22.34	YS 4.50	LS 4.21															
C	CL 26.75	SS 5.45	YS 5.09	LS 8.76	SS 6.64	CT 3.45												
D	CL 17.66	SS 7.33	YS 4.72	SS 8.19	YS 5.40	LS 4.67	YS 6.99	SS 5.52	RS 4.67									
E	CL 20.09	SS 7.98	YS 4.88	SS 10.11	CL 6.40	LS 4.70	SS 19.08	LS 9.17	CL 8.60	SS 17.64	YS 6.17	CL 5.27						
F	CL 29.81	SS 5.85	YS 5.44	LS 9.00	SS 8.14	CT 3.62	SS 18.21	CL 3.60	HT 3.51	SS 16.80	YS 7.66	CL 5.55	CL 10.28	LS 9.47	SS 5.36			
G	CL 27.43	SS 8.46	YS 5.80	SS 11.26	LS 9.35	HT 5.02	SS 23.51	CL 6.84	HT 4.53	SS 20.33	YS 8.18	RS 5.65	LS 9.90	CL 8.36	ES 6.22	CL 8.87	HT 5.41	SS 6.18

Appendix E.5

List of megabenthic invertebrate taxa captured during 2008 at SBOO stations. Data are number of individuals (n). Taxonomic arrangement from SCAMIT 2008.

Taxon/ Species	n
CNIDARIA	
ANTHOZOA	
ALCYONACEA	
Plexauridae	
Thesea sp B	1
PENNATULACEA	
Virgulariidae	
Stylatula elongata	1
MOLLUSCA	
GASTROPODA	
Calliostomatidae	
Calliostoma canaliculatum	1
Calliostoma gloriosum	1
Turbinidae	
Megastraea turbanica	1
HYPSOGASTROPODA	
Naticidae	
Euspira lewisii	1
Bursidae	
Crossata californica	2
Buccinidae	
Kelletia kelletii	5
OPISTHOBRANCHIA	
Philinidae	
Philine auriformis	5
Onchidorididae	
Acanthodoris brunnea	8
Arminidae	
Armina californica	1
Tritoniidae	
Tritonia diomedea	1
Dendronotidae	
Dendronotus frondosus	1
Dendronotus iris	1
Flabellinidae	
Flabellina iodinea	2
Flabellina pricei	1
CEPHALOPODA	
TEUTHIDA	
Loliginidae	
Doryteuthis opalescens	2
OCTOPODA	
Octopodidae	
Octopus rubescens	10

Appendix E.5 *continued*

Taxon/ Species	n
ANNELIDA	
POLYCHAETA	
ACICULATA	
Aphroditidae	
Aphrodita sp	2
Polynoidae	
Halosydna latior	5
ARTHROPODA	
MALACOSTRACA	
STOMATOPODA	
Hemisquillidae	
Hemisquilla californiensis	16
ISOPODA	
Cymothoidae	
Elthusa vulgaris	6
DECAPODA	
Sicyoniidae	
Sicyonia ingentis	1
Hippolytidae	
Heptacarpus palpator	1
Heptacarpus stimpsoni	1
Pandalidae	
Pandalus danae	2
Pandalus platyceros	2
Crangonidae	
Crangon alaskensis	2
Crangon alba	1
Crangon nigromaculata	62
Palinuridae	
Panulirus interruptus	1
Diogenidae	
Paguristes ulreyi	1
Paguridae	
Pagurus spilocarpus	2
Calappidae	
Platymera gaudichaudii	3
Leucosiidae	
Randallia ornata	4
Epialtidae	
Loxorhynchus crispatus	1
Loxorhynchus grandis	2
Loxorhynchus sp	1
Pugettia producta	3
Pugettia richii	1

Appendix E.5 *continued*

Taxon/ Species	n
Inachidae	
Podochela hemphillii	1
Inachoidaidae	
Pyromaia tuberculata	7
Parthenopidae	
Heterocrypta occidentalis	13
Cancridae	
Metacarcinus anthonyi	2
Metacarcinus gracilis	5
Romaleon antennarius	4
Pinnotheridae	
Pinnixa franciscana	1
ECHINODERMATA	
ASTEROIDEA	
PAXILLOSIDA	
Luidiidae	
Luidia armata	3
Astropectinidae	
Astropecten verrilli	353
FORCIPULATIDA	
Asteriidae	
Pisaster brevispinus	25
OPHIUROIDEA	
OPHIURIDA	
Ophiotricidae	
Ophiothrix spiculata	5
ECHINOIDEA	
TEMNOPLEUROIDA	
Toxopneustidae	
Lytechinus pictus	20
CLYPEASTEROIDA	
Dendrasteridae	
Dendraster terminalis	92
SPATANGOIDA	
Loveniidae	
Lovenia cordiformis	2

Appendix E.6

Summary of total abundance by species and station for megabenthic invertebrates at the SBOO stations during 2008.

	January 2008							
Name	SD15	SD16	SD17	SD18	SD19	SD20	SD21	Total abundance by survey
Astropecten verrilli	10	2	8	6	9	9	4	48
Crangon nigromaculata		14	2	2	11	8	7	44
Hemisquilla californiensis		3	1	2		1	1	8
Pisaster brevispinus	1			2			5	8
Romaleon antennarius			3			1		4
Elthusa vulgaris			2					2
Pyromaia tuberculata				2				2
Armina californica		1						1
Crossata californica	1							1
Euspira lewisii							1	1
Kelletia kelletii			1					1
Loxorhynchus crispatus		1						1
Lytechinus pictus					1			1
Megastraea turbanica		1						1
Pagurus spilocarpus		1						1
Thesea sp B	1							1
Quarterly total	13	23	17	14	21	19	18	125

Appendix E.6 *continued*

Name	April 2008							Total abundance by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Dendraster terminalis	83							83
Astropecten verrilli	56	4	1	6	4	5		76
Crangon nigromaculata		4					7	11
Hemisquilla californiensis					1	5	2	8
Pisaster brevispinus		1	1			1		3
Metacarcinus anthonyi					1	1		2
Crangon alaskensis	2							2
Lovenia cordiformis	2							2
Flabellina iodinea			1					1
Halosydna latior						1		1
Luidia armata						1		1
Octopus rubescens							1	1
Ophiothrix spiculata							1	1
Platymera gaudichaudii						1		1
Pyromaia tuberculata						1		1
Randallia ornata		1						1
Sicyonia ingentis							1	1
Tritonia diomedea	1							1
Quarterly total	144	10	3	6	6	16	12	197

Appendix E.6 *continued*

Name	July 2008							Total abundance by survey
	SD15	SD16	SD17	SD18	SD19	SD20	SD21	
Astropecten verrilli	79	4	2	8	5	5		103
Lytechinus pictus	4			5				9
Pisaster brevispinus			2	2	3		2	9
Octopus rubescens							6	6
Dendraster terminalis	4							4
Halosydna latior	1		1			1		3
Heterocrypta occidentalis			2	1				3
Kelletia kelletii			3					3
Ophiothrix spiculata			1				2	3
Pugettia producta							3	3
Pyromaia tuberculata	1						2	3
Elthusa vulgaris		1				1		2
Pandalus platyceros							2	2
Randallia ornata		2						2
Acanthodoris brunnea				1				1
Calliostoma canaliculatum					1			1
Crangon alba	1							1
Dendronotus frondosus				1				1
Flabellina iodinea			1					1
Loxorhynchus grandis							1	1
Loxorhynchus sp				1				1
Luidia armata				1				1
Pagurus spilocarpus				1				1
Pandalus danae							1	1
Pinnixa franciscana					1			1
Platymera gaudichaudii			1					1
Pugettia richii							1	1
Stylatula elongata			1					1
Quarter	90	7	14	21	10	7	20	169

Appendix E.6 *continued*

Name	October 2008 SD15	SD16	SD17	SD18	SD19	SD20	SD21	Total abundance by survey
Astropecten verrilli	58	18	14	13	13	2	8	126
Heterocrypta occidentalis				6	1		3	10
Lytechinus pictus			2	8				10
Acanthodoris brunnea			1	6				7
Crangon nigromaculata				1	3	3		7
Metacarcinus gracilis				3			2	5
Dendraster terminalis	2		1	2				5
Philine auriformis			2	2	1			5
Pisaster brevispinus		1		1		1	2	5
Octopus rubescens			2			1		3
Aphrodita sp				2				2
Elthusa vulgaris	2							2
Doryteuthis opalescens						2		2
Calliostoma gloriosum							1	1
Crossata californica					1			1
Dendronotus iris		1						1
Flabellina pricei				1				1
Halosydna latior	1							1
Heptacarpus palpator			1					1
Heptacarpus stimpsoni			1					1
Kelletia kelletii	1							1
Loxorhynchus grandis						1		1
Luidia armata				1				1
Ophiothrix spiculata			1					1
Paguristes ulreyi						1		1
Pandalus danae			1					1
Panulirus interruptus							1	1
Platymera gaudichaudii			1					1
Podochela hemphillii	1							1
Pyromaia tuberculata			1					1
Randallia ornata		1						1
Quarterly total	65	21	28	46	19	11	17	207
Annual Total	**312**	**61**	**62**	**87**	**56**	**53**	**67**	**698**

Appendix F

Supporting Data

2008 SBOO Stations

Bioaccumulation of Contaminants in Fish Tissues

Appendix F.1

Lengths and weights of fishes used for each composite sample (Comp) for the SBOO monitoring program during April and October 2008. Data are summarized as number of individuals (n), minimum (min), maximum (max), and mean values.

				Length (cm, size class)			Weight (g)		
Station	Comp	Species	n	min	max	mean	min	max	mean
April 2008									
SD15	1	Hornyhead turbot	7	14	21	17	68	244	134
SD15	2	Ca. scorpionfish	3	24	30	26	503	826	619
SD15	3	(no sample)							
SD16	1	Longfin sanddab	9	14	18	16	53	113	73
SD16	2	Longfin sanddab	8	14	20	16	42	176	85
SD16	3	Hornyhead turbot	6	14	21	18	57	254	155
SD17	1	Longfin sanddab	9	13	18	15	45	123	77
SD17	2	Longfin sanddab	10	13	18	15	41	117	63
SD17	3	Hornyhead turbot	6	17	20	19	130	210	176
SD18	1	Longfin sanddab	9	14	18	15	56	127	82
SD18	2	Longfin sanddab	11	14	18	15	48	128	70
SD18	3	English sole	5	20	24	22	128	215	167
SD19	1	English sole	4	21	26	23	110	235	168
SD19	2	Longfin sanddab	7	14	18	16	57	125	83
SD19	3	Longfin sanddab	10	14	19	16	48	122	71
SD20	1	English sole	5	21	24	22	127	173	148
SD20	2	Longfin sanddab	14	13	16	15	40	97	59
SD20	3	Longfin sanddab	14	13	17	15	37	84	56
SD21	1	Longfin sanddab	12	14	17	15	42	110	61
SD21	2	Longfin sanddab	11	14	17	15	54	112	68
SD21	3	English sole	4	23	27	25	171	268	219
RF3	1	Vermilion rockfish	3	27	35	30	507	1272	824
RF3	2	Brown rockfish	3	23	29	26	279	625	423
RF3	3	Brown rockfish	3	25	29	28	350	679	502
RF4	1	Ca. scorpionfish	3	24	29	26	490	632	549
RF4	2	Ca. scorpionfish	3	25	27	26	478	573	530
RF4	3	Ca. scorpionfish	3	25	28	26	492	679	614

Appendix F.1 *continued*

Station	Comp	Species	n	Length (cm, size class) min	max	mean	Weight (g) min	max	mean
October 2008									
SD15	1	Hornyhead turbot	8	14	19	17	83	224	135
SD15	2	(no sample)							
SD15	3	(no sample)							
SD16	1	(no sample)							
SD16	2	(no sample)							
SD16	3	(no sample)							
SD17	1	Hornyhead turbot	7	14	19	16	71	189	130
SD17	2	Longfin sanddab	10	13	18	15	43	111	61
SD17	3	Ca. scorpionfish	4	19	25	22	231	384	296
SD18	1	Hornyhead turbot	9	13	20	15	65	227	104
SD18	2	Longfin sanddab	5	16	18	17	71	111	85
SD18	3	Longfin sanddab	10	13	15	14	42	71	53
SD19	1	Hornyhead turbot	6	14	20	17	65	188	130
SD19	2	Longfin sanddab	7	13	16	15	45	79	63
SD19	3	Longfin sanddab	9	12	14	13	40	64	48
SD20	1	Hornyhead turbot	4	14	21	17	71	212	131
SD20	2	Longfin sanddab	6	13	17	15	47	110	72
SD20	3	Longfin sanddab	11	12	15	13	44	63	50
SD21	1	Longfin sanddab	10	12	15	13	37	73	52
SD21	2	Hornyhead turbot	8	12	20	16	48	194	121
SD21	3	Ca. scorpionfish	3	20	23	21	261	387	332
RF3	1	Brown rockfish	3	24	30	27	380	751	541
RF3	2	Brown rockfish	3	16	27	20	117	582	287
RF3	3	Brown rockfish	3	25	27	26	443	477	463
RF4	1	Ca. scorpionfish	3	26	30	29	550	767	656
RF4	2	Ca. scorpionfish	3	27	29	28	413	669	538
RF4	3	Ca. scorpionfish	3	24	27	25	479	570	513

Appendix F.2

Constituents and method detection limits for fish tissue samples analyzed for the SBOO monitoring program during April and October 2008.

	MDL			MDL	
Parameter	Liver	Muscle	Parameter	Liver	Muscle
Metals (ppm)					
Aluminum (Al)	3	3	Lead (Pb)	0.2	0.2
Antimony (Sb)	0.2	0.2	Manganese (Mn)	0.1	0.1
Arsenic (As)	0.24	0.24	Mercury (Hg)	0.03	0.03
Barium (Ba)	0.03	0.03	Nickel (Ni)	0.2	0.2
Beryllium (Be)	0.006	0.006	Selenium (Se)	0.06	0.06
Cadmium (Cd)	0.06	0.06	Silver (Ag)	0.05	0.05
Chromium (Cr)	0.1	0.1	Thallium (Tl)	0.4	0.4
Copper (Cu)	0.1	0.1	Tin (Sn)	0.2	0.2
Iron (Fe)	2	2	Zinc (Zn)	0.15	0.15
Chlorinated Pesticides (ppb)					
Aldrin	*	6.67	Hexachlorobenzene	13.3	1.33
Alpha (cis) Chlordane	13.3	2	Mirex	13.3	1.33
Alpha Endosulfan	167	33	o,p-DDD	13.3	1.33
BHC, Alpha isomer	33.3	2	o,p-DDE	13.3	1.33
BHC, Beta isomer	13.3	2	o,p-DDT	13.3	1.33
BHC, Delta isomer	20	2	Oxychlordane	66.7	6.67
BHC, Gamma isomer	167	3.33	p,p-DDD	13.3	1.33
Cis Nonachlor	20	3.33	p,p-DDE	13.3	1.33
Dieldrin	13.3	1.33	p,p-DDMU	13.3	1.33
Endrin	13.3	1.33	p,p-DDT	13.3	1.33
Gamma (trans) Chlordane	20	2	Toxaphene	3333	333
Heptachlor	33.3	3.33	Trans Nonachlor	13.3	2
Heptachlor epoxide	100	6.67			

* no MDL available for this parameter

Appendix F.2 *continued*

Parameter	MDL Liver	MDL Muscle	Parameter	MDL Liver	MDL Muscle
Polychlorinated Biphenyls Congeners (PCBs) (ppb)					
PCB 18	33.3	1.33	PCB 126	13.3	1.33
PCB 28	13.3	1.33	PCB 128	13.3	1.33
PCB 37	13.3	1.33	PCB 138	13.3	1.33
PCB 44	13.3	1.33	PCB 149	13.3	1.33
PCB 49	13.3	1.33	PCB 151	13.3	1.33
PCB 52	13.3	1.33	PCB 153/168	13.3	1.33
PCB 66	13.3	1.33	PCB 156	13.3	1.33
PCB 70	13.3	1.33	PCB 157	13.3	1.33
PCB 74	13.3	1.33	PCB 158	13.3	1.33
PCB 77	13.3	1.33	PCB 167	13.3	1.33
PCB 81	13.3	1.33	PCB 169	13.3	1.33
PCB 87	13.3	1.33	PCB 170	13.3	1.33
PCB 99	13.3	1.33	PCB 177	13.3	1.33
PCB 101	13.3	1.33	PCB 180	13.3	1.33
PCB 105	13.3	1.33	PCB 183	13.3	1.33
PCB 110	13.3	1.33	PCB 187	13.3	1.33
PCB 114	13.3	1.33	PCB 189	13.3	1.33
PCB 118	13.3	1.33	PCB 194	13.3	1.33
PCB 119	13.3	1.33	PCB 201	13.3	1.33
PCB 123	13.3	1.33	PCB 206	13.3	1.33
Polycyclic Aromatic Hydrocarbons (PAHs) (ppb)					
1-methylnaphthalene	27.9	26.4	Benzo[G,H,I]perylene	27.2	59.5
1-methylphenanthrene	17.4	23.3	Benzo[K]fluoranthene	32	37.3
2,3,5-trimethylnaphthalene	21.7	21.6	Biphenyl	38	19.9
2,6-dimethylnaphthalene	21.7	19.5	Chrysene	18.1	23
2-methylnaphthalene	35.8	13.2	Dibenzo(A,H)anthracene	37.6	40.3
3,4-benzo(B)fluoranthene	30.2	26.8	Fluoranthene	19.9	12.9
Acenaphthene	28.9	11.3	Fluorene	27.3	11.4
Acenaphthylene	24.7	9.1	Indeno(1,2,3-CD)pyrene	25.6	46.5
Anthracene	25.3	8.4	Naphthalene	34.2	17.4
Benzo[A]anthracene	47.3	15.9	Perylene	18.5	50.9
Benzo[A]pyrene	42.9	18.3	Phenanthrene	11.6	12.9
Benzo[e]pyrene	41.8	40.6	Pyrene	9.1	16.6

Appendix F.3

Summary of constituents that make up total DDT, total chlordane, and total PCB in each composite sample (Comp) collected as part of the SBOO monitoring program during April and October 2008.

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	RF3	1	Vermilion rockfish	Muscle	DDT	p,p-DDE	7.3	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	DDT	p,p-DDMU	0.4	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 118	0.3	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 138	0.4	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 149	0.3	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 153/168	0.6	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 180	0.2	ppb
2008-2	RF3	1	Vermilion rockfish	Muscle	PCB	PCB 187	0.3	ppb
2008-2	RF3	2	Brown rockfish	Muscle	DDT	p,p-DDE	2.3	ppb
2008-2	RF3	2	Brown rockfish	Muscle	PCB	PCB 138	0.2	ppb
2008-2	RF3	2	Brown rockfish	Muscle	PCB	PCB 153/168	0.3	ppb
2008-2	RF3	2	Brown rockfish	Muscle	PCB	PCB 180	0.1	ppb
2008-2	RF3	3	Brown rockfish	Muscle	DDT	o,p-DDE	0.8	ppb
2008-2	RF3	3	Brown rockfish	Muscle	DDT	p,p-DDD	0.4	ppb
2008-2	RF3	3	Brown rockfish	Muscle	DDT	p,p-DDE	7.4	ppb
2008-2	RF3	3	Brown rockfish	Muscle	DDT	p,p-DDMU	0.6	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 118	0.2	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 138	0.2	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 153/168	0.3	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 187	0.1	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 66	0.1	ppb
2008-2	RF3	3	Brown rockfish	Muscle	PCB	PCB 70	0.1	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	DDT	p,p-DDE	4.6	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 118	0.2	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 138	0.2	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 153/168	0.3	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 180	0.2	ppb
2008-2	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 187	0.1	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	DDT	p,p-DDE	8.5	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 118	0.3	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 138	0.3	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 153/168	0.6	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 180	0.2	ppb
2008-2	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 187	0.2	ppb
2008-2	RF4	3	Ca. scorpionfish	Muscle	DDT	p,p-DDE	3.3	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD15	1	Hornyhead turbot	Liver	DDT	p,p-DDE	76.0	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	DDT	p,p-DDMU	4.6	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 105	0.7	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 118	2.3	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 138	3.7	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 149	1.2	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 153/168	5.3	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 180	2.2	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 183	0.8	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 187	2.1	ppb
2008-2	SD15	1	Hornyhead turbot	Liver	PCB	PCB 52	0.7	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	Chlordane	Alpha (cis) Chlordane	5.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	Chlordane	Cis Nonachlor	6.4	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	Chlordane	Trans Nonachlor	13.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	DDT	o,p-DDE	2.9	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	DDT	p,p-DDD	10.2	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	DDT	p,p-DDE	665.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	DDT	p,p-DDMU	12.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	DDT	p,p-DDT	4.7	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 101	13.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 105	5.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 110	8.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 118	21.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 123	2.9	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 128	4.6	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 138	28.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 149	7.9	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 151	5.3	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 153/168	47.0	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 156	2.1	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 158	2.3	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 167	1.8	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 170	8.8	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 177	4.9	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 180	20.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 183	5.9	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 187	19.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 194	4.4	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 201	6.1	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 206	1.8	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 44	1.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 49	2.5	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 52	3.6	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 66	3.8	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 70	1.3	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 74	2.3	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 87	3.3	ppb
2008-2	SD15	2	Ca. scorpionfish	Liver	PCB	PCB 99	11.5	ppb
2008-2	SD16	1	Longfin sanddab	Liver	DDT	o,p-DDE	8.3	ppb
2008-2	SD16	1	Longfin sanddab	Liver	DDT	p,p-DDD	7.7	ppb
2008-2	SD16	1	Longfin sanddab	Liver	DDT	p,p-DDE	460.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	DDT	p,p-DDMU	17.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	DDT	p,p-DDT	5.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 101	7.8	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 105	4.5	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 110	5.4	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 118	18.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 123	2.2	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 128	5.1	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 138	28.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 149	5.9	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 151	3.7	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 153/168	45.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 156	3.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 158	2.2	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 167	1.5	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 170	7.8	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 177	4.3	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 180	18.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 183	5.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 187	19.0	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 194	4.3	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 201	6.7	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 206	2.4	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 28	0.8	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 52	2.8	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 66	2.4	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 70	1.5	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 74	1.6	ppb
2008-2	SD16	1	Longfin sanddab	Liver	PCB	PCB 99	12.0	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD16	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	2.4	ppb
2008-2	SD16	2	Longfin sanddab	Liver	DDT	o,p-DDE	12.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	DDT	p,p-DDD	6.4	ppb
2008-2	SD16	2	Longfin sanddab	Liver	DDT	p,p-DDE	600.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	DDT	p,p-DDMU	24.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	DDT	p,p-DDT	4.8	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 101	7.9	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 105	4.8	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 110	5.7	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 118	20.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 123	2.5	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 128	5.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 138	29.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 149	5.9	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 151	3.8	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 153/168	43.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 156	2.7	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 157	1.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 158	1.9	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 167	1.7	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 170	8.9	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 177	3.5	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 180	19.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 183	5.4	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 187	19.0	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 194	5.5	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 201	7.5	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 206	2.7	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 28	0.8	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 49	1.6	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 52	2.7	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 66	3.3	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 70	1.6	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 74	2.3	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 87	2.3	ppb
2008-2	SD16	2	Longfin sanddab	Liver	PCB	PCB 99	14.0	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	DDT	o,p-DDE	2.3	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	DDT	p,p-DDE	110.0	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	DDT	p,p-DDMU	7.6	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 105	0.9	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 118	2.7	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 138	4.5	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 149	1.4	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 153/168	7.5	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 170	1.3	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 180	4.1	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 183	1.4	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 187	3.2	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 49	1.0	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 52	0.7	ppb
2008-2	SD16	3	Hornyhead turbot	Liver	PCB	PCB 99	2.3	ppb
2008-2	SD17	1	Longfin sanddab	Liver	Chlordane	Alpha (cis) Chlordane	4.4	ppb
2008-2	SD17	1	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	8.4	ppb
2008-2	SD17	1	Longfin sanddab	Liver	DDT	o,p-DDE	12.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	DDT	p,p-DDD	9.5	ppb
2008-2	SD17	1	Longfin sanddab	Liver	DDT	p,p-DDE	810.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	DDT	p,p-DDMU	26.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	DDT	p,p-DDT	7.5	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 101	11.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 105	7.9	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 110	8.8	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 118	32.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 119	1.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 123	2.8	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 128	8.9	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 138	46.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 149	10.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 151	6.4	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 153/168	73.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 156	5.7	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 157	1.3	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 158	4.5	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 167	3.1	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 170	14.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 177	6.6	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 180	32.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 183	9.5	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 187	32.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 194	9.1	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 201	11.0	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 206	4.2	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 28	1.2	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 49	1.9	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 52	3.6	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 66	4.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 70	2.0	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 74	2.3	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 87	2.9	ppb
2008-2	SD17	1	Longfin sanddab	Liver	PCB	PCB 99	19.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	4.4	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	o,p-DDD	1.3	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	o,p-DDE	8.2	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDD	7.3	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDE	450.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDMU	16.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDT	5.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 101	10.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 105	5.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 110	6.4	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 118	20.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 123	2.3	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 128	5.2	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 138	28.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 149	8.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 151	4.4	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 153/168	47.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 156	3.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 157	1.1	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 158	2.3	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 167	1.9	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 170	8.5	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 177	4.4	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 180	18.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 183	5.5	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 187	20.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 194	5.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 201	6.3	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 206	3.1	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 28	0.8	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 44	0.9	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 49	2.0	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 52	2.9	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 66	3.7	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 70	1.6	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 74	2.2	ppb
2008-2	SD17	2	Longfin sanddab	Liver	PCB	PCB 99	14.0	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	DDT	o,p-DDE	2.0	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	DDT	p,p-DDD	6.6	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	DDT	p,p-DDE	140.0	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	DDT	p,p-DDMU	7.3	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 101	2.9	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 105	1.1	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 118	3.8	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 138	5.5	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 149	1.8	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 153/168	8.5	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 180	4.3	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 183	1.2	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 187	3.2	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 201	1.7	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 52	0.8	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 66	1.1	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 70	0.4	ppb
2008-2	SD17	3	Hornyhead turbot	Liver	PCB	PCB 74	0.5	ppb
2008-2	SD18	1	Longfin sanddab	Liver	Chlordane	Alpha (cis) Chlordane	3.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	5.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	DDT	o,p-DDE	10.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	DDT	p,p-DDD	8.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	DDT	p,p-DDE	660.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	DDT	p,p-DDMU	17.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	DDT	p,p-DDT	7.4	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 101	10.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 105	6.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 110	8.1	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 118	26.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 123	2.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 128	7.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 138	46.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 149	8.5	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 151	6.9	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 153/168	69.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 156	5.3	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 157	1.3	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 158	4.1	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 167	2.7	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 170	12.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 177	6.2	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 180	32.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 183	8.9	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 187	29.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 194	7.9	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 201	10.0	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 206	3.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 28	0.6	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 49	1.7	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 52	4.3	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 66	3.4	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 70	1.8	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 74	2.5	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 87	2.5	ppb
2008-2	SD18	1	Longfin sanddab	Liver	PCB	PCB 99	18.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	3.6	ppb
2008-2	SD18	2	Longfin sanddab	Liver	DDT	o,p-DDE	9.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDD	8.1	ppb
2008-2	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDE	530.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDMU	18.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDT	5.9	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 101	6.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 105	3.9	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 110	4.1	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 118	14.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 123	1.2	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 128	4.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 138	24.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 149	5.2	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 151	3.9	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 153/168	40.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 156	3.1	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 157	0.8	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 158	2.1	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 167	1.6	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 170	8.2	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 177	4.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 180	19.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 183	5.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 187	18.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 194	5.9	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 201	5.8	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 206	2.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 28	0.9	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 49	1.0	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 52	2.1	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 66	2.3	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 70	1.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 74	1.5	ppb
2008-2	SD18	2	Longfin sanddab	Liver	PCB	PCB 99	11.0	ppb
2008-2	SD18	3	English sole	Liver	Chlordane	Heptachlor	1.4	ppb
2008-2	SD18	3	English sole	Liver	DDT	o,p-DDE	11.0	ppb
2008-2	SD18	3	English sole	Liver	DDT	p,p-DDD	2.7	ppb
2008-2	SD18	3	English sole	Liver	DDT	p,p-DDE	260.0	ppb
2008-2	SD18	3	English sole	Liver	DDT	p,p-DDMU	15.0	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 101	5.4	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 105	1.8	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 110	2.7	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 118	6.7	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 138	7.4	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 149	4.0	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 151	1.8	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 153/168	14.0	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 170	2.2	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 177	1.8	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 180	5.1	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 183	2.0	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 187	5.3	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 194	1.6	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 206	0.9	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 28	0.9	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 49	1.6	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 52	1.3	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD18	3	English sole	Liver	PCB	PCB 66	2.4	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 70	1.6	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 74	1.3	ppb
2008-2	SD18	3	English sole	Liver	PCB	PCB 99	4.3	ppb
2008-2	SD19	1	English sole	Liver	DDT	o,p-DDE	5.5	ppb
2008-2	SD19	1	English sole	Liver	DDT	p,p-DDD	2.2	ppb
2008-2	SD19	1	English sole	Liver	DDT	p,p-DDE	140.0	ppb
2008-2	SD19	1	English sole	Liver	DDT	p,p-DDMU	4.4	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 101	4.2	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 105	1.8	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 110	2.8	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 118	6.4	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 138	7.5	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 149	3.3	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 151	1.4	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 153/168	11.0	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 170	1.7	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 177	1.5	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 180	4.2	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 183	1.4	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 187	4.9	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 194	1.6	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 201	1.6	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 49	1.2	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 52	0.8	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 66	1.9	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 70	0.9	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 74	0.8	ppb
2008-2	SD19	1	English sole	Liver	PCB	PCB 99	4.4	ppb
2008-2	SD19	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	5.4	ppb
2008-2	SD19	2	Longfin sanddab	Liver	DDT	o,p-DDE	10.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDD	10.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDE	850.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDMU	27.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDT	5.9	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 101	9.4	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 105	6.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 110	7.4	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 118	24.0	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 123	2.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 128	7.5	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 138	39.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 149	7.8	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 151	6.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 153/168	58.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 156	4.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 157	1.2	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 158	3.3	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 167	2.4	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 170	11.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 177	5.3	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 180	29.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 183	8.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 187	24.0	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 194	8.3	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 201	8.7	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 206	4.1	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 49	1.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 52	3.1	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 66	2.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 70	1.5	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 74	1.6	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 87	1.7	ppb
2008-2	SD19	2	Longfin sanddab	Liver	PCB	PCB 99	18.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	Chlordane	Alpha (cis) Chlordane	8.7	ppb
2008-2	SD19	3	Longfin sanddab	Liver	Chlordane	Cis Nonachlor	9.9	ppb
2008-2	SD19	3	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	13.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	o,p-DDD	4.3	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	o,p-DDE	20.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	o,p-DDT	2.3	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDD	16.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDE	1300.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDMU	28.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDT	12.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 101	22.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 105	14.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 110	15.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 118	53.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 123	5.4	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 128	17.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 138	97.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 149	24.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 151	14.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 153/168	110.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 156	11.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 157	2.4	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 158	7.6	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 167	6.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 170	27.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 177	15.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 180	68.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 183	19.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 187	61.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 189	1.7	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 194	17.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 201	20.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 206	9.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 28	1.8	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 49	3.4	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 52	7.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 66	6.0	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 70	2.6	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 74	3.5	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 87	4.8	ppb
2008-2	SD19	3	Longfin sanddab	Liver	PCB	PCB 99	36.0	ppb
2008-2	SD20	1	English sole	Liver	DDT	o,p-DDE	3.6	ppb
2008-2	SD20	1	English sole	Liver	DDT	p,p-DDE	90.0	ppb
2008-2	SD20	1	English sole	Liver	DDT	p,p-DDMU	3.4	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 101	2.9	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 105	1.2	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 110	1.8	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 118	3.6	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 138	5.3	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 149	2.8	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 153/168	7.4	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 180	2.4	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 183	1.1	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 187	3.0	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 28	0.6	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD20	1	English sole	Liver	PCB	PCB 49	0.8	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 66	1.3	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 70	0.8	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 74	0.7	ppb
2008-2	SD20	1	English sole	Liver	PCB	PCB 99	2.4	ppb
2008-2	SD20	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	6.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	o,p-DDD	2.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	o,p-DDE	13.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDD	10.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDE	960.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDMU	28.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDT	14.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 101	18.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 105	14.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 110	16.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 118	56.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 123	5.7	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 128	15.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 138	89.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 149	16.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 151	13.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 153/168	140.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 156	10.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 157	2.5	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 158	6.8	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 167	5.4	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 170	23.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 177	11.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 180	53.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 183	17.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 187	49.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 189	1.2	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 194	15.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 201	20.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 206	8.0	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 28	1.6	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 49	2.7	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 52	5.8	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 66	5.7	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 70	2.2	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 74	3.7	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 87	3.5	ppb
2008-2	SD20	2	Longfin sanddab	Liver	PCB	PCB 99	38.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	Chlordane	Alpha (cis) Chlordane	5.2	ppb
2008-2	SD20	3	Longfin sanddab	Liver	Chlordane	Cis Nonachlor	7.7	ppb
2008-2	SD20	3	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	10.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	o,p-DDD	3.1	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	o,p-DDE	16.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDD	12.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDE	1300	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDMU	30.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDT	11.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 101	15.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 105	11.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 110	11.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 118	43.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 123	4.8	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 128	15.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 138	82.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 149	17.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 151	11.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 153/168	140.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 156	8.6	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 157	2.4	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 158	6.5	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 167	5.1	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 170	24.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 177	12.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 180	58.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 183	16.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 187	56.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 189	1.9	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 194	16.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 201	20.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 206	8.5	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 28	1.6	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 49	3.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 52	5.9	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 66	6.0	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 70	2.7	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 74	3.7	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 87	2.6	ppb
2008-2	SD20	3	Longfin sanddab	Liver	PCB	PCB 99	32.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	5.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	DDT	o,p-DDE	10.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDD	8.8	ppb
2008-2	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDE	625.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDMU	21.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDT	6.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 101	20.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 105	12.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 110	16.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 118	50.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 119	1.6	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 123	6.2	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 128	16.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 138	86.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 149	17.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 151	9.9	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 153/168	130.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 156	8.4	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 157	2.6	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 158	7.1	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 167	4.9	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 170	19.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 177	10.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 180	45.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 183	13.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 187	47.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 189	1.7	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 194	14.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 201	16.0	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 206	7.8	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 28	2.1	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 49	4.1	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 52	7.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 66	6.4	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 70	2.5	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 74	3.8	ppb
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 87	4.1	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD21	1	Longfin sanddab	Liver	PCB	PCB 99	39.5	ppb
2008-2	SD21	2	Longfin sanddab	Liver	Chlordane	Cis Nonachlor	8.1	ppb
2008-2	SD21	2	Longfin sanddab	Liver	Chlordane	Trans Nonachlor	6.7	ppb
2008-2	SD21	2	Longfin sanddab	Liver	DDT	o,p-DDE	12.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	DDT	p,p-DDD	9.2	ppb
2008-2	SD21	2	Longfin sanddab	Liver	DDT	p,p-DDE	790.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	DDT	p,p-DDMU	21.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	DDT	p,p-DDT	8.7	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 101	24.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 105	17.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 110	19.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 118	66.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 119	1.8	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 123	6.8	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 128	17.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 138	110.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 149	18.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 151	12.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 153/168	150.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 156	9.5	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 157	2.8	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 158	8.7	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 167	5.7	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 170	23.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 177	12.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 180	55.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 183	16.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 187	57.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 189	1.8	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 194	16.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 201	21.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 206	9.2	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 28	2.2	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 49	3.5	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 52	7.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 66	7.8	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 70	3.0	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 74	4.4	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 87	4.4	ppb
2008-2	SD21	2	Longfin sanddab	Liver	PCB	PCB 99	47.0	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-2	SD21	3	English sole	Liver	DDT	o,p-DDE	11.0	ppb
2008-2	SD21	3	English sole	Liver	DDT	p,p-DDD	4.4	ppb
2008-2	SD21	3	English sole	Liver	DDT	p,p-DDE	230.0	ppb
2008-2	SD21	3	English sole	Liver	DDT	p,p-DDMU	11.0	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 101	4.0	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 105	1.5	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 110	2.7	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 118	5.1	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 138	7.6	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 149	3.3	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 151	1.5	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 153/168	12.0	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 158	0.9	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 170	1.6	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 177	1.7	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 180	2.8	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 183	1.0	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 187	5.0	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 194	1.3	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 201	1.4	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 206	0.6	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 49	1.2	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 66	1.9	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 70	1.1	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 74	0.8	ppb
2008-2	SD21	3	English sole	Liver	PCB	PCB 99	4.3	ppb
2008-4	RF3	2	Brown rockfish	Muscle	DDT	p,p-DDE	1.8	ppb
2008-4	RF3	3	Brown rockfish	Muscle	DDT	p,p-DDE	2.1	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	DDT	p,p-DDE	4.5	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 118	0.4	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 138	0.5	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 153/168	1.1	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 180	1.2	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 187	1.0	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 194	0.4	ppb
2008-4	RF4	1	Ca. scorpionfish	Muscle	PCB	PCB 201	0.6	ppb
2008-4	RF4	2	Ca. scorpionfish	Muscle	DDT	p,p-DDE	4.8	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	RF4	2	Ca. scorpionfish	Muscle	PCB	PCB 105	0.4	ppb
2008-4	RF4	3	Ca. scorpionfish	Muscle	DDT	p,p-DDE	1.7	ppb
2008-4	SD15	1	Hornyhead turbot	Liver	DDT	p,p-DDE	63.0	ppb
2008-4	SD15	1	Hornyhead turbot	Liver	PCB	PCB 153/168	6.7	ppb
2008-4	SD15	1	Hornyhead turbot	Liver	PCB	PCB 180	2.8	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	DDT	p,p-DDE	100.0	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	DDT	p,p-DDMU	5.8	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	PCB	PCB 138	4.4	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	PCB	PCB 153/168	8.6	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	PCB	PCB 180	3.1	ppb
2008-4	SD17	1	Hornyhead turbot	Liver	PCB	PCB 187	4.3	ppb
2008-4	SD17	2	Longfin sanddab	Liver	Chlordane	Gamma (trans) Chlordane	14.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDE	550.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDMU	8.1	ppb
2008-4	SD17	2	Longfin sanddab	Liver	DDT	p,p-DDT	5.9	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 101	5.8	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 105	4.5	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 118	18.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 128	6.1	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 138	31.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 149	4.8	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 153/168	47.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 170	8.9	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 177	4.3	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 180	22.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 183	7.2	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 187	26.0	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 194	6.7	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 201	8.2	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 66	2.5	ppb
2008-4	SD17	2	Longfin sanddab	Liver	PCB	PCB 99	11.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	DDT	p,p-DDD	5.2	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	DDT	p,p-DDE	340.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	DDT	p,p-DDMU	7.3	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	DDT	p,p-DDT	2.6	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 101	10.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 105	3.3	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 118	14.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 128	3.8	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 138	20.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 149	5.8	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 151	3.3	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 153/168	30.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 180	14.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 183	2.6	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 187	12.0	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 194	4.8	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 201	4.3	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 66	1.7	ppb
2008-4	SD17	3	Ca. scorpionfish	Liver	PCB	PCB 99	8.6	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	DDT	p,p-DDD	27.0	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	DDT	p,p-DDE	190.0	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	DDT	p,p-DDMU	9.0	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	DDT	p,p-DDT	11.0	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	PCB	PCB 138	6.1	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	PCB	PCB 153/168	8.6	ppb
2008-4	SD18	1	Hornyhead turbot	Liver	PCB	PCB 187	4.3	ppb
2008-4	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDE	180.0	ppb
2008-4	SD18	2	Longfin sanddab	Liver	DDT	p,p-DDMU	5.3	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 101	4.2	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 118	6.3	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 138	15.0	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 149	3.7	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 153/168	16.0	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 180	5.9	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 187	8.1	ppb
2008-4	SD18	2	Longfin sanddab	Liver	PCB	PCB 99	4.2	ppb
2008-4	SD18	3	Longfin sanddab	Liver	DDT	p,p-DDD	9.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	DDT	p,p-DDE	670.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	DDT	p,p-DDMU	16.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	DDT	p,p-DDT	7.6	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 101	8.1	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 128	7.3	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 149	7.4	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 153/168	64.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 170	13.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 180	31.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 187	28.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 194	7.2	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 201	12.0	ppb
2008-4	SD18	3	Longfin sanddab	Liver	PCB	PCB 99	15.0	ppb
2008-4	SD19	1	Hornyhead turbot	Liver	DDT	p,p-DDE	80.0	ppb
2008-4	SD19	1	Hornyhead turbot	Liver	PCB	PCB 153/168	5.0	ppb
2008-4	SD19	1	Hornyhead turbot	Liver	PCB	PCB 180	2.4	ppb
2008-4	SD19	1	Hornyhead turbot	Liver	PCB	PCB 187	2.5	ppb
2008-4	SD19	2	Longfin sanddab	Liver	DDT	o,p-DDE	9.5	ppb
2008-4	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDD	7.7	ppb
2008-4	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDE	850.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDMU	18.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	DDT	p,p-DDT	8.2	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 101	7.5	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 105	7.4	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 118	29.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 128	7.9	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 138	58.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 149	8.1	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 151	6.6	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 153/168	93.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 156	5.7	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 170	16.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 177	7.7	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 180	40.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 183	11.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 187	41.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 194	11.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 201	15.0	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 206	5.7	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 66	3.3	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 74	2.2	ppb
2008-4	SD19	2	Longfin sanddab	Liver	PCB	PCB 99	18.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	DDT	o,p-DDE	7.1	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDD	6.7	ppb
2008-4	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDE	740.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDMU	18.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	DDT	p,p-DDT	5.6	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 101	6.3	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 105	6.1	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 118	25.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 128	7.8	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 138	50.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 149	6.2	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 151	5.7	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 153/168	78.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 156	4.9	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 170	14.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 177	6.4	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 180	38.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 183	10.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 187	35.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 194	11.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 201	13.0	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 206	4.9	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 52	1.8	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 66	2.6	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 74	1.9	ppb
2008-4	SD19	3	Longfin sanddab	Liver	PCB	PCB 99	16.0	ppb
2008-4	SD20	1	Hornyhead turbot	Liver	DDT	p,p-DDE	31.0	ppb
2008-4	SD20	1	Hornyhead turbot	Liver	PCB	PCB 153/168	2.6	ppb
2008-4	SD20	2	Longfin sanddab	Liver	DDT	o,p-DDE	8.0	ppb
2008-4	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDD	5.2	ppb
2008-4	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDE	430.0	ppb
2008-4	SD20	2	Longfin sanddab	Liver	DDT	p,p-DDMU	14.0	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 101	8.1	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 105	3.4	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 110	4.4	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 118	18.5	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 128	4.3	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 138	26.0	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 149	7.1	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 151	3.8	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 153/168	42.0	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 170	6.9	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 177	4.1	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 180	15.5	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 183	4.3	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 187	17.5	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 194	4.3	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 201	6.5	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 52	2.3	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 66	2.4	ppb
2008-4	SD20	2	Longfin sanddab	Liver	PCB	PCB 99	11.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	DDT	o,p-DDE	7.3	ppb
2008-4	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDD	4.9	ppb
2008-4	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDE	530.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	DDT	p,p-DDMU	16.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 101	4.8	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 105	4.1	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 118	20.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 128	5.5	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 138	36.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 149	6.2	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 151	4.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 153/168	59.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 167	2.6	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 170	10.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 177	3.7	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 180	25.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 183	6.6	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 187	24.0	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 194	6.8	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 201	7.9	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 206	2.5	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 66	2.6	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 74	1.2	ppb
2008-4	SD20	3	Longfin sanddab	Liver	PCB	PCB 99	12.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDD	10.3	ppb
2008-4	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDE	640.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDMU	17.5	ppb
2008-4	SD21	1	Longfin sanddab	Liver	DDT	p,p-DDT	7.7	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 101	14.5	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 118	39.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 128	12.5	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 138	76.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 149	14.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 151	9.8	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 153/168	120.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 170	17.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 177	11.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 180	39.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 183	11.5	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 187	50.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 194	12.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 201	16.5	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 28	2.4	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 66	6.0	ppb
2008-4	SD21	1	Longfin sanddab	Liver	PCB	PCB 99	30.0	ppb
2008-4	SD21	2	Hornyhead turbot	Liver	DDT	p,p-DDE	90.0	ppb
2008-4	SD21	2	Hornyhead turbot	Liver	PCB	PCB 118	4.2	ppb
2008-4	SD21	2	Hornyhead turbot	Liver	PCB	PCB 138	8.3	ppb
2008-4	SD21	2	Hornyhead turbot	Liver	PCB	PCB 153/168	13.0	ppb
2008-4	SD21	2	Hornyhead turbot	Liver	PCB	PCB 187	5.7	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	Chlordane	Trans Nonachlor	10.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	DDT	o,p-DDE	7.1	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	DDT	p,p-DDD	12.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	DDT	p,p-DDE	720.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	DDT	p,p-DDT	5.8	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 105	14.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 110	20.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 118	51.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 128	13.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 138	67.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 149	19.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 153/168	110.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 170	16.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 177	14.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 180	43.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 183	11.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 187	39.0	ppb

Appendix F.3 *continued*

YR-QTR	Station	Comp	Species	Tissue	Class	Parameter	Value	Units
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 194	9.9	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 201	14.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 206	4.2	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 49	5.0	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 52	7.3	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 66	7.4	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 70	0.9	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 74	3.2	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 87	5.5	ppb
2008-4	SD21	3	Ca. scorpionfish	Liver	PCB	PCB 99	34.0	ppb